The Bioarchaeology of Life, Death, and Social Status in the Early Bronze Age Community at Ostojićevo, Serbia

by

Katherine M. Pompeani

B.A., Gettysburg College, 2010

Submitted to the Graduate Faculty of the

Dietrich School of Arts and Sciences in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2020

UNIVERSITY OF PITTSBURGH

DIETRICH SCHOOL OF ARTS AND SCIENCES

This dissertation was presented

by

Katherine M. Pompeani

It was defended on

December 4, 2019

and approved by

Dr. Margaret Judd, Associate Professor, Department of Anthropology

Dr. Josef Werne, Professor and Chair, Department of Geology

Dissertation Director: Dr. Jeffrey Schwartz, Professor Emeritus, Department of Anthropology

Dissertation Co-Director: Dr. Bryan Hanks, Associate Professor and Chair, Department of Anthropology

The Bioarchaeology of Life, Death, and Social Status in the Early Bronze Age Community at Ostojićevo, Serbia

Katherine M. Pompeani, PhD

University of Pittsburgh, 2020

This dissertation applies a biocultural approach to examine how gender, age, and social status shaped morbidity and mortality in the Late Maros (1930-1550 BCE) population at Ostojićevo, Serbia. Patterns in demography, paleopathology, trauma, and diet were considered in the context of larger political, economic, and social processes that affected the health and subsistence practices of Early to Middle Bronze Age communities in the Carpathian Basin. Information on burial treatment from site reports was compared with data from human skeletal analysis (n = 229). Age estimation and sex determination were used to assess demographic structure. Skeletal and dental pathology were used to evaluate population health. Comparative data on demography and dental disease from the nearby Early Maros (2100-1800 BCE) cemetery at Mokrin was adapted from published datasets. Stable isotope analysis of human bone collagen was conducted to examine dietary patterns in a subset of adults at Ostojićevo (n = 38) and Mokrin (n = 13).

Child mortality was ~42% for individuals <3 years-at-death at Ostojićevo. Among individuals >15 years, males died at a higher rate in their second and third decades, with only ~6% surviving past 50 years compared to ~21% of females. These differences can be attributed to a higher prevalence of perimortem trauma consistent with interpersonal violence in adolescent and young adult males. Dietary patterns also supported sex-specific disparities in health and behavior. Females exhibited significantly higher rates of dental disease indicating a more cariogenic diet than age-matched males at Ostojićevo but not at Mokrin. Furthermore, $\delta^{13}C$ and $\delta^{15}N$ values suggest young adult females consumed less animal protein than males and older females at Ostojićevo, whereas there was no significant difference in diet at Mokrin. This contrast in sex- and site-specific dietary patterns indicates local and diachronic differences in access to subsistence resources. Specifically, the health status of women of childbearing age at Ostojićevo reflects a greater trade-off between nutritional status, systemic health, and fertility than at Mokrin. Together, the emergence of

gendered differences in diet, interpersonal violence, and morbidity support conditions of increasing economic and political instability from the Early to the Middle Bronze Ages in northeast Serbia.

Table of Contents

List of Tables

List of Figures

Preface

This research would not have been possible without the support and advice of my academic mentors, family, and friends. First and foremost, I would like to extend my sincere thanks to my adviser Drs. Jeffrey Schwartz and co-adviser Dr. Bryan K. Hanks for their continued guidance and feedback during data collection, analysis, and writing. This was an ambitious research program that applied methods of human skeletal analysis, paleodemography, paleopathology, and paleoepidemiology within the theoretical scope of social archaeology grounded in regional culture history. Thank you to Dr. Schwartz for always holding me to the highest standards of scholarly writing, and challenging me to be rigorous and precise in my diagnoses and descriptions. The training I received under his guidance was exceptional both for its depth and diversity, and I draw on his insight and mentorship constantly in my teaching and writing. Dr. Hanks has been instrumental in devoting considerable time and energy to helping me move forward in my research and professional development. His continual support and encouragement have been pivotal in my evolution as a scholar. I cannot thank him enough for working with me through the final theoretical hurdles, helping me to sort through what at times seemed to be an impenetrable morass of idiosyncrasies. His guidance was essential in illuminating the key physical and cultural realities of the Early/Middle Bronze Age peoples buried at Ostojićevo.

I would like to recognize Dr. Margaret Judd for her instruction and expertise par-excellence in human osteology, especially paleopathology and trauma. I was able to directly adapt the training I received in her courses to my research. I am fortunate to have had exemplary scholars such as Dr. Margaret Judd and Dr. Josef Werne on my committee. I thank them for their willingness to read and comment on the dissertation, especially to dig into the minutiae of the methods and data. Their assistance in identifying discrepancies and offering advice on how to improve my presentation and interpretation of data contributed greatly in my development as a researcher and a scholar.

This research would not have been possible without the continued support of my colleagues in Serbia. I would like to thank Drs. Sofija Stefanović and Dušan Borić for directing me to the potential for bioarchaeological study of the Ostojićevo collection, and allowing me to be a part of the dynamic (bio)archaeological community in Serbia. My immense gratitude goes to Lidija Milašinović, Director of the Narodni Muzej Kikinda, not only for allowing me access to the collection and material support, but for her friendship and patience throughout this process. I would like to recognize Bata and Marica Budovalcev and Andy and Maja Konitzer for their kindness and hospitality. I spent many delightful hours reviewing and entering data in Bata and Marica's "bašta". I would also like to thank the BAKOTA project team, which invited me to participate in excavations near Békés, Hungary and introduced me to a number of remarkable Bronze Age scholars working in Hungary: Dr. Paul Duffy, Dr. Julia Giblin, Dr. Attila Gyucha, Dr. Lászó Paja, Györgyi Parditka, Dorottya Kékegyi, and Dr. Zsolt Bereczki. I would also like to thank Drs. John O'Shea and Amy Nicodemus for working with me to gain access to faunal specimens from Maros sites in Hungary and for their conversation and collaboration.

Funding for this research came from several sources. First and foremost, the Department of Anthropology at the University of Pittsburgh provided Teaching Assistantships and Fellowships, which supported my educational progress and allowed me to develop critical skills in undergraduate teaching and mentorship. I received an Andrew W. Mellon Predoctoral Fellowship in my third year that allowed me to prepare for my comprehensive exams. I also received a Foreign Language Acquisition Scholarship (FLAS) to support an academic year study of Bosnian-Croatian Serbian and Eastern European studies at the University of Pittsburgh. I was awarded a Social Sciences Dissertation Development (SSDD) Fellowship by the University of Pittsburgh to support data analysis and writing in my fifth year. Travel and fieldwork were supported by University of Pittsburgh Department of Anthropology Predisstertation Small Grants, Hungarian Committee Nationality Room Scholarship, and International Studies Fund Travel Grant. Support for conference travel was provided by several departments and offices at the University of Pittsburgh, including the Department of Anthropology, the Center for Russian, Eastern European, and Eurasian Studies (REEES), and Graduate and Professional Student Government (GPSG) Travel Grants.

I would like to acknowledge the support and training I received as the 2016-17 Graduate Student Teaching Initiative Teaching Fellow in the University Center for Teaching and Learning at the University of Pittsburgh. This position provided financial support during the early writing phase of my dissertation. It also allowed me to pursue additional training in best practices and novel approaches to pedagogy in higher education, and afforded opportunities to interact with graduate students, post docs, faculty, and staff throughout the University of Pittsburgh. This role was one of the highlights of my graduate career at the University of Pittsburgh. I especially thank Dr. Joel Brady for his guidance, candor, and personal support during this period.

In terms of my archaeological genealogy, I want to thank Dr. Carolyn Snively for giving me the opportunity to spend two field seasons in North Macedonia as an undergraduate, and allowing me to return as a graduate student. I would not be where I am today without the experiences I gained at Konjuh. I am forever grateful to her for introducing me to the vibrant and fascinating world of Balkan archaeology. I also thank Dr. Julia Hendon for her continued guidance and support. An impromptu discussion I had with Julie in 2016 provided the seed from which a large part of my discussion on gender identity, behavior, and social status grew. Carolyn and Julie – both of you have been integral in fostering and facilitating my transition from a student to a scholar in my own right.

Thank you to the Department of Sociology, Anthropology, and Social Work at Kansas State University in providing a place for me at KSU and allowing me to further develop my teaching skills and repertoire as an instructor. Drs. Marta Alfonso Durruty, Jess Falcone, Lauren Ritterbush, Amber Neeley, and Amber Campbell, your friendship and intellectual support have been critical in fostering my personal progress in teaching and writing. Thank you for listening and for sharing your experiences in and insights on anthropology, pedagogy, and scholarship.

Lastly, my friends and family have stood patiently by and supported me personally throughout this process. I thank Michael Bobrow, M.D., for his feedback and insight on establishing a differential diagnosis of bone disease or trauma for several atypical cases. Graduate student colleagues were a constant source of encouragement and inspiration: Dr. Robyn Wakefield-Murphy, Dr. Alicia Ventresca Miller, Amy

Karabowicz, Kelsey Cowles, Dr. Lauren Herckis, Dr. Rory McCarthy, Dr. Lizette Munoz, Dr. Matt Kesterke, Dr. Chi “Charles” Zhang, Deb Neidich, Sarah Jolly, and Sean Foley. I would be remiss if I did not thank departmental staff Phyllis Deasy and Lynn Lantz for their support. My friends Sara Coleman and Lee Gatto deserve special recognition for celebrating my successes and commiserating my setbacks. Most importantly, this dissertation would not have been possible without the constant encouragement of my parents, Michael and Cathy, brother Brian, and grandmothers Ann Marie and Rosemarie. I am incredibly fortunate to have a family that believes in me and who never doubted my ability to accomplish any task – no matter how daunting. Finally, to my husband Dr. David Pompeani, your brilliance, hard work, and dedication have been a continuous source of motivation and inspiration over the years. This process has been difficult and its success is partially due to your love, laughter, and reassurance. Thank you for being simply the best.

Ad astra per aspera.

1.0 Introduction

This dissertation explores concepts of Bronze Age social organization and culture change in the context of demography, health, and diet based on analysis of human skeletal remains from the Late Maros cemetery at Ostojićevo, Serbia (1930-1550 cal. BCE), which spans the transition from the Early Bronze Age (EBA) (ca. 2800-1900 BCE) to the Middle Bronze Age (MBA) (ca. 1900-1500 BCE) in the Carpathian Basin. The purpose of this research was to examine the interplay between population demographic parameters and individual health indicators in the context of regional and local scale processes of culture change (*i.e.*, economic, political, and social) at the end of the EBA and during the MBA. These important developments are related to the effects of shifts in regional exchange networks on local communities at the end of the Early Bronze Age in the Carpathian Basin (see Earle & Kristiansen, eds., 2010a; Kristiansen, 1998; Shennan, 1993a; 1993b). Furthermore, this dissertation integrates demography, paleopathology, and paleodiet through an analytical framework that considers how culture is embodied vis-à-vis intersections between social categories such as age, gender, and social status (Joyce, 2005; Sofaer, 2006a). Within this theoretical perspective, the human life course is mediated by biology, society, and the environment (see Agarwal, 2016; Sofaer, 2006b).

The archaeological case studies and interpretations presented within this dissertation are based on the results of the physical analysis of neonate, infant, child, adolescent, and adult human skeletal remains. Data collection included assessment of 229 skeletons from Ostojićevo for preservation (Chapter 4), survivorship (Chapter 4), signs of disease (Chapter 5), evidence of trauma (Chapter 6), and dental disease including alveolar changes and tooth loss (Chapter 7). Biological sex and stature from long bones were also assessed in individuals >18 years-at-death (Chapters 4 and 5). Bone samples were taken from a subset of adult (>18 years) individuals from the Late Maros cemetery at Ostojićevo (ca. 1920-1550 BCE) (n = 54) and the Early Maros cemetery at Mokrin (ca. 2100-1800 BCE) (n = 25). Samples were analyzed for stable isotopes of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) from bone collagen. These results were compared to bone collagen analysis of $\delta^{15}N$ and $\delta^{13}C$ from faunal (mammal) samples (n = 24) from Ostojićevo and two Maros settlements in southeastern Hungary, the Early and Late Maros village at Kiszombor (2500-2400 BCE, 2000-1700 BCE) and the Late Maros tell at Klárafalva (2300-2000 BCE, 1800-1500 BCE). Together, human carbon and nitrogen profiles relative to faunal baseline signatures provide additional insight into intra- and inter-cemetery variation in diet and subsistence at local and regional scales (Chapter 7).

In the following sections, I provide a brief overview of the research case study and the specific questions and hypotheses that structured my field research and laboratory analyses. A more detailed overview of the regional culture history and archaeology of the Bronze Age Carpathian Basin (and surrounding areas), and the main theoretical models that have been employed in this region, are provided in Chapters 2 and 3.

1.1 The Early to Middle Bronze Age Transition in Central Europe

The Bronze Age in central Europe (2800-800 BCE) has been actively discussed as a period of culture change and emerging social complexity that bridges egalitarian societies in the Neolithic and Copper Age with the emergence of stratified polities in the Iron Age (Harding, 2000; Kristiansen, 1998; O'Shea, 1996; Parkinson, 2002; Renfrew, 1982; Shennan, 1993a). It has been characterized as a time of economic innovation and intensification tied to the use of secondary animal products and increased interaction via long-distance networks of trade and exchange in exotic goods (*e.g.*, copper, tin, gold, salt, shell, amber, etc.) (Primas, 1997; Renfrew, 1982; Sherratt, 1982a, 1983). These interactions are believed to have promoted regionalization and an increased emphasis on land tenure and boundary maintenance through the construction of fortified tells and strategic placement of cemeteries and prestige object hoards (Champion, 1982; Harding, 2006; Parkinson & Duffy, 2007).

Arguably, a central theme guiding scholarship on social organization and change in the Bronze Age is the documentation and analysis of underlying causes driving regional transitions from egalitarian to stratified societies (Chapman, 2008; 2009). While Bronze Age scholars have moved beyond general models of social change predicated on historical materialism, there remains a preoccupation with studying economic and social processes via exchange mechanisms, industrial production, and settlement patterns, focusing on the roles and experiences of elites (Harding, 2006).

What is often missing from these approaches is a consideration of human agency in challenging social norms and inventing cultural practices. Rather than studying local manifestations and impacts of larger social and economic processes, this dissertation addresses how an EBA/MBA Maros community in northeast Serbia, represented by those buried at Ostojićevo, attempted to engage with problems of political economy and social stratification.

1.2 Metanarratives versus Local Scale Social Lives

Central to models of social complexity are the roles of elites in the organization and control of social, economic, and ritual life in the Bronze Age, especially mediating economic strategies linked to long-distance trade of metal and other exotic materials (O'Shea, 1996; Shennan, 1975; Treherne, 1995). However, this *elite versus commoner* dichotomy becomes less distinct at local scales of analysis. The reality of the Bronze Age is that social life centered on the myriad social relations and roles held by individuals as part of daily life in small-scale Bronze Age communities (Sofaer, 2006c, 2011; Sørensen & Rebay-Salisbury, 2009; Sørensen, 1997, 2010). For example, evidence recovered from domestic structures in the region indicates a vibrant domestic economy, with households and individuals engaged in feasting and competitive display, woodworking, bronze metallurgy, and textile and ceramic production (Michelaki, 2008; Sørensen, 2010).

Differences in household size and material assemblages were often subtle, and the importance of domestic contexts as arenas of competitive display varied regionally and over time (Budden & Sofaer, 2009; Michelaki, 2008; O'Shea, 1996). Mortuary analysis suggests that specific facets of Bronze Age social structures were idealized, reproduced, and reinforced in ritual practices surrounding death and burial. Material markers of social status interred with the deceased, especially items made from exotic (non-local) materials that could only be obtained through trade or conquest, and treatment and position of the body, suggest that rather than representing discrete groups of people, social identity in the Bronze Age was multiple, non-static, cross-cutting, and tied to cultural constructs of age and gender (Rega, 1995; 2000; Soafer-Derevenski, 1997; Sørensen, 1997).

Traditionally, as noted above, scholars studying social change in the Carpathian Basin have hyper-focused on regional exchange, social interaction, and social change by examining artifact distributions, settlement patterns, and grave goods (*e.g.*, Childe, 1929; 1930; Earle, 2002; Gimbutas, 1965; O'Shea, 1996; Parkinson, 2002). These approaches focus on how the production, exchange, and consumption of material objects and commodities reflect key aspects of social, economic, and political organization. With several exceptions, the impact of these larger processes at both the regional and local levels on human mobility, health, and life expectancy is largely unknown and has remained a significant gap in scholarship of the region (see Giblin, 2011; Giblin et al, 2013; Giblin & Yerkes, 2016; Porčić & Stefanović, 2009; Rega, 1995; 1997; 2000; Ubelaker & Pap, 1996). When taken in conjunction with mortuary evidence for individual differences in social status tied to gender, kinship, and occupation, the effects of changes in Bronze Age economies and social structures on daily life likely contributed to health disparities that may have eventually undermined social and political stability. At its most extreme, the breakdown of long-distance exchange relations that supported local political elites may have further exacerbated the health consequences of social inequality, such as unequal access to domestic animals (primary and secondary products) and interpersonal violence tied to competition between individuals within autonomous polities for privileged positions within emerging ritual economies (Kristiansen, 2012; Le Huray et al., 2006).

One of the key theoretical linkages of this dissertation is the investigation of the effects of regional scale long-distance trade relations and political economy on more localized processes of identity formation, social inequality, and disparities in health and nutrition among the EBA and MBA Maros. Specifically, it places material correlates of social status and identity in the context of demographic organization and skeletal evidence for diet and health at two Maros cemeteries from northeast Serbia: the well-documented Early Maros cemetery at Mokrin (ca. 2100-1800 cal BC) (Farkas & Lipták, 1971; Rega, 1995; 1997; 2000) and the Late Maros cemetery at Ostojićevo (ca. 2000-1500 BC), with my research focusing on Ostojićevo.

Mokrin and Ostojićevo represent the southernmost sites associated with the EBA/MBA Maros culture complex, located in the eastern Carpathian Basin in the area of the Pannonian Plain south of the Maros River and east of the Tisza River – an area that today spans northeastern Serbia, southeastern Hungary, and parts of eastern Romania (Figure 1.1). Settlements and cemeteries associated with the Maros group are dated to ca. 2800-1500 BCE (O'Shea, 1991; O'Shea et al., 2019). As a culture group, Maros settlements were politically autonomous with communities connected through a complex system of local and regional trade and exchange facilitated by control over and access to water routes (O'Shea, 2011). Shared practices and beliefs governing treatment of the deceased further distinguish the Maros from neighboring groups, such as the Nagyrév and Ottomány to the north, the Vučedol/Vinkovci and Encrusted Ware to the west, and the Vatin Group to the west and south (see Duffy, 2010; O'Shea, 1996).

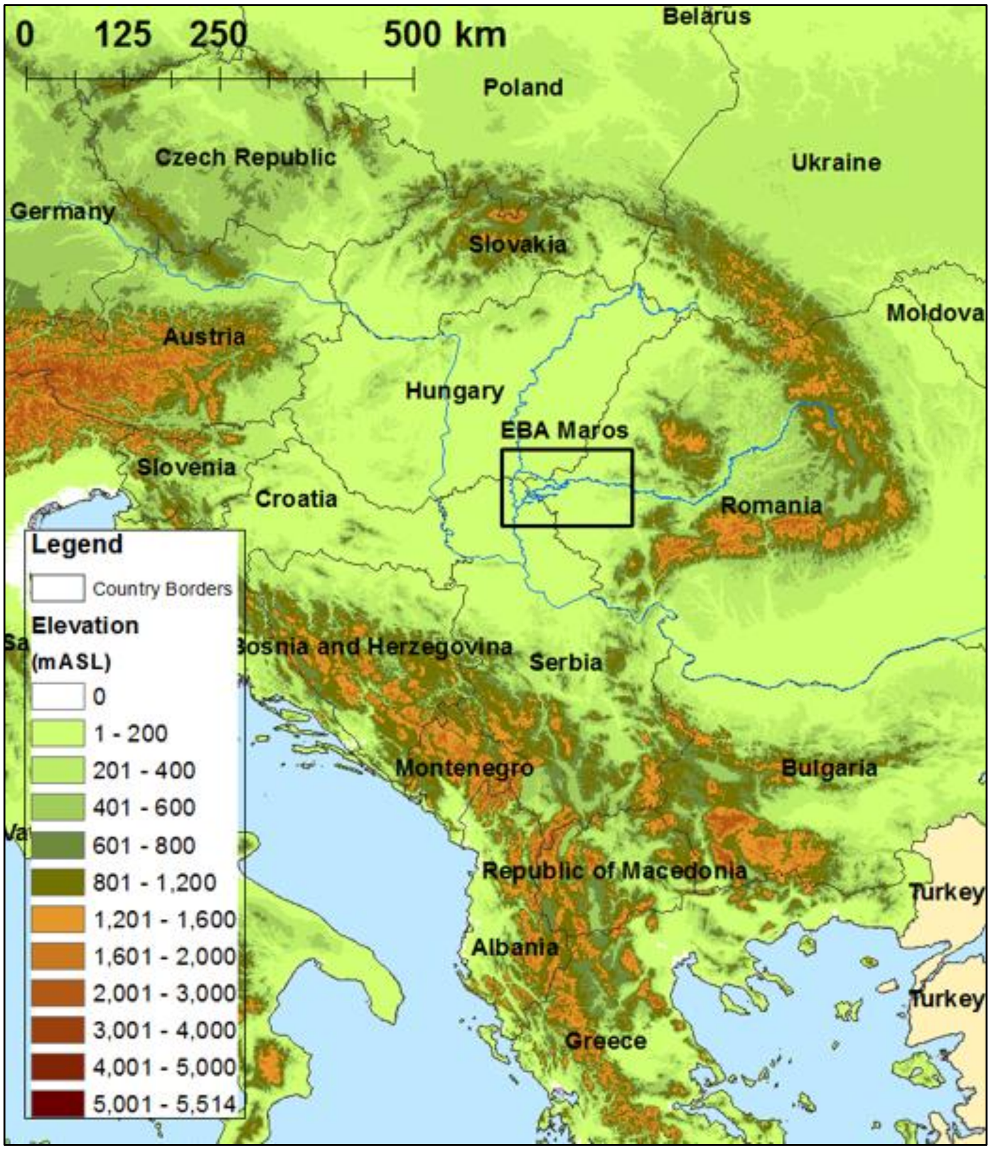


Figure 1.1 Geography of southeastern Europe. Rectangle indicates geographic extent of Early Bronze Age (EBA) Maros culture sites (2800-1500 BCE).

1.3 The Late Maros Cemetery at Ostojićevo

The cemetery at Ostojićevo is located to the left of the main road extending ca. 0.75 km north-northwest of the village of Ostojićevo in the North Banat District, Vojvodina Province, Serbia. The land on which the site is located is known as "Okruglica Kera bara" or "Stari Vinograd". It is situated on a terrace overlooking an extinct meander of the Tisza River (Milašinović, 2009). The site was discovered in 1959 during construction of a canal and was systematically excavated from 1981 to 1991 by archaeologists from the Narodni Muzej Kikinda led by Milorad Girić and Stevana Vojvodića (Girić, 2012 [1995]; Milašinović, 2009). These excavations constituted 136 trenches and uncovered 285 graves, with an average depth of 0.61 m and a maximum depth of 1.33 m below the modern surface (Girić, unpublished reports compiled by Milašinović, 2008).

Figure 1.2 Examples of Late Maros "baroque" vessels at Ostojićevo. Grave 25, cremation burial (left) and Grave 54, cenotaph (right).

Table 1.1 Overview of mortuary practices at Ostojićevo and Mokrin

	Mortuary Attribute	Mokrin		Ostojićevo	
Site Info.	Date	2074-1824 BCE		1920-1550 BCE	
	Period of use (years)	250		370	
	Maros Culture Phase	Early		Late - Final	
	Years excavated	1958-60, 1963-65, 1967-69		1981-1991	
	# of Graves	312		285	
		# Burials*	% Total	# Burials*	% Total
Burial Treatment	Primary single inhumation	266	85.3%	164	57.5%
	Double inhumation	4	1.3%	2	0.7%
	Inhumation urn burial	0	0.0%	85	29.8%
	Double urn burial	0	0.0%	3	1.1%
	Cremation	3	1.0%	1	0.4%
	Cenotaph	5	1.6%	4	1.4%
	Disturbed/No Data	34	10.9%	26	9.1%
		# Burials**	% Total	# Burials**	% Total***
Grave Offerings	Offering present	239	86.0%	125 (85)	74.0%
	Ceramic vessel	181	65.1%	115 (15)	68.0%
	Metal present	--	--	33 (0)	19.5%
	Metal head ornament	50	18.0%	22 (0)	13.0%
	Gold hair ring	12	4.3%	1 (0)	0.6%
	Copper hair ring	9	3.2%	3 (0)	1.8%
	Copper torque	10	3.6%	0 (0)	0.0%
	Copper bracelet	36	12.9%	4 (0)	2.4%
	Copper pin	13	4.7%	4 (0)	2.4%
	Copper or bronze arrow	1	0.4%	0 (0)	0.0%
	Copper or bronze dagger	6	2.2%	1 (0)	0.6%
	Copper or bronze ax	2	0.7%	0 (0)	0.0%
	Stone ax	4	1.4%	2 (0)	1.2%
	Stone bone, or shell beaded necklace	58	20.9%	8 (0)	4.7%
	Stone, bone, or shell beaded belt	12	4.3%	7 (0)	4.1%
	Bone needle	19	6.8%	4 (0)	2.4%
	Animal offering	24	8.6%	20 (2)	11.8%

Table 1.1 includes a summary of the archaeological context, mortuary treatment, and grave offerings at Ostojićevo. Girić (2012 [1995]) identified the graves as dating to the Early to Middle Bronze Ages based on the presence of Maros ceramics and grave goods, specifically Late Maros "baroque" vessels (Figure 1.2). Burial treatment and grave offerings were similar, if not identical, to those from the large well-documented Maros cemetery at Mokrin, located ca. 21.75 km northeast of Ostojićevo. Mokrin was excavated by Girić from 1958-1960, 1963-1965, and 1967-1969 (Girić, 1971). These excavations uncovered 312 graves, with the majority primary single inhumations (O'Shea, 1996:102, 111, 116, 126-128) (Table 1.1). Radiocarbon dating of human bone from seven graves at Mokrin showed it was used for at least 250 years, from ca. 2074-1824 BCE (O'Shea, 1991). Human remains and grave goods from both Ostojićevo and Mokrin are curated at the Narodni Muzej, Kikinda.

I conducted osteological analysis on human remains from Ostojićevo, including repackaging and labeling human skeletal material (see Chapter 4). Apart from selective sampling of human skeletal remains from Mokrin for stable isotope analysis, I did not conduct osteological analysis of the Mokrin material. All comparative demographic and paleopathological data from Mokrin included in this dissertation (*i.e.*, Chapters 4, 5, 6, and 7) was adapted from several published data sets (Farkas & Lipták, 1971; Rega, 1995; 1997; 2000).

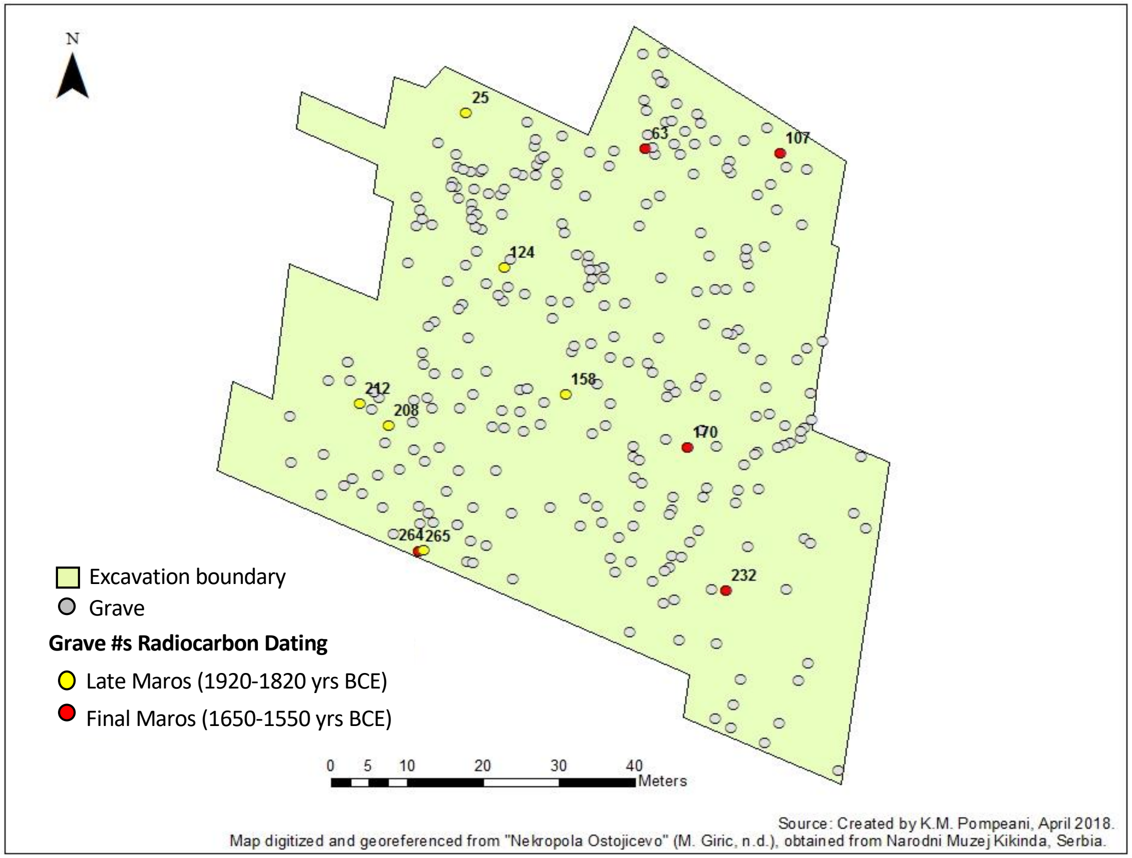


Figure 1.3 Graves sampled for radiocarbon analysis at Ostojićevo by O'Shea et al. (2019). Grave 25 represents burned human remains from a cremation burial that produced an anomalously young date. Dates concentrated into a "Late Maros" phase (yellow circles) and "Final Maros" phase (red circles). It is unclear whether the cemetery was abandoned or used intermittently from ca. 1820-1650 BCE.

1.4 Research Questions and Hypotheses

In this section I provide a set of questions that are related to specific alternative hypotheses that structured the data collection for my dissertation research. The efficacy of these questions and hypotheses are further validated in Chapters 2 and 3 through my examination of previous theories and models that have accounted for social, economic and political change during the Early and Middle Bronze Ages in the Carpathian Basin. However, it will be helpful to provide these at this stage in Chapter 1.

1.4.1 Question 1: Social Interaction, Health, and Diet

How did changes in regional scale interaction and integration through trade and political economy affect local populations in terms of health and diet in the Early and Middle Bronze Ages?

Hypothesis 1: Participation in regional exchange networks was partially motivated by social need (marriage, social status, economic, etc.). I predict that social integration and economic interaction had a positive influence on health as it decreased pressure on local communities to be entirely self-sufficient and provided the basis and support for economic specialization or intensification. Economically isolated populations, because of their precarious social position, were more susceptible to loss of land and resources through conflict and insufficient population size to meet the subsistence needs of its members. Compared to the wealthier Early Maros (ca. 2100-1800 BC) population at Mokrin, the population at the Late Maros (ca. 2000-1500 BC) cemetery at Ostojićevo will exhibit significantly higher frequencies of dental disease (*i.e.*, antemortem tooth loss (AMTL) and caries) and malnutrition (*i.e.*, cribra orbitalia and porotic hyperostosis) irrespective of biological sex.

Hypothesis 2 (alternative): The institutionalization of social hierarchies in the Early Bronze Age rooted in elite-control of exchange and distribution of luxury prestige goods and bulk commodities led to increased variation in diet and health within communities. Specifically, elite power – especially among high-status males - was underscored by privileged access to exotic trade goods (Shennan, 1993a; 1993b), which enabled them to amass greater wealth in the form of agricultural land and domestic animals (Harding, 1984; O'Shea, 1996). Thus, elite members of society enjoyed greater access to high-quality sources of animal protein. I predict that at Ostojićevo, males will exhibit significantly lower frequencies of age-specific dental disease (*e.g.*, abscesses and caries), malnutrition/non-specific infection (*i.e.*, cribra orbitalia, porotic hyperostosis, and linear enamel hypoplasia), and increased access to high-protein diets compared to women and children.

1.4.2 Question 2: Biocultural Implications of Social Complexity, Social Inequality, and Violence

What was the biocultural impact of increasing social complexity and social inequality on violence in the Carpathian Basin? How did the timing of fluctuations in the importance of the Carpathian Basin as a regional economic center affect the pattern and incidence of warfare and violence?

Hypothesis 1: I predict that interpersonal violence among the Late Maros was sporadic and not tied to a system of organized warfare or structural violence (*cf.* Helbling, 2006; Kelly, 2000; Kissel & Kim, 2018; Martin et al., 2010). This hypothesis is consistent with ethnographic evidence of violence associated with disputes and spontaneous raids in small-scale societies lacking centralized authority (Claessen, 2006; Helbling, 2006). Thus, men and women should show a similar prevalence of *violent trauma*, with no relationship identified between skeletal trauma, gender, and status at Ostojićevo.

Hypothesis 2 (alternative): I predict that the domination of social hierarchies by a warrior-male elite class in the MBA in the Carpathian Basin (ca. 1600-1400 BCE) will be correlated with increased evidence for trauma in male individuals associated with populations from these time periods, including Ostojićevo. In addition to testing the hypothesis that increased social complexity and inequality produced greater health disparities overtime, this hypothesis tests claims of the ubiquity of warfare based on secondary lines of evidence (*e.g.*, fortifications, weapon hoards) put forth by Kristiansen (1999; 2001) and others (Carman, 1999; Treherne, 1995; Vandkilde, 2006).

1.4.3 Question 3: The Intersection of Gender, Age, and Social Status on Morbidity and Mortality

How did diet, age, gender, and social status affect health at Ostojićevo versus Mokrin? How did fertility and childcare practices affect inter-cemetery and intra-cemetery patterns of morbidity and mortality in infants and children under five years and reproductive-age women (ca. 20-40 years)?

Hypothesis 1: I predict that both Ostojićevo and Mokrin will exhibit similarities in subsistence practices and longevity, with no difference in sex-specific caries and antemortem tooth loss. Diet, health, and childcare practices were homogenous among Early and Late Maros groups.

Hypothesis 2 (alternative): Resource stress in the Late Maros period contributed to an increase in dental caries and antemortem tooth loss, especially among women. Allocation of resources favored high-status individuals, especially males. Dental health in young women was further negatively affected by the role of women in caring for dependent infants and young children, which meant consuming lower value foods (*e.g.*, less animal protein) during periods of scarcity (Lukacs & Largaespada, 2006; Pelto & Armar-Klemesu, 2011; Pike et al., 2010). Prolonged moderate undernutrition or malnutrition would have increased adult female morbidity but not mortality, with a concommitant negative impact on fetal death and infant mortality (Conde-Agudelo et al., 2012; Winkvist et al., 1992).

1.5 Conclusion

Archaeological inquiry into prehistoric societies in central and southeast Europe provides not only a robust understanding of regional culture history, but also informs understandings of trajectories of social organization and complexity in the past in the context of technological innovation, economic relations and exchange, social identity and status, and demographic change and migration. These approaches enhance development of a more informed anthropological archaeology in examining the dynamic interplay between social, political, and economic processes at multiple scales (local, regional, and supraregional).

The focus of this dissertation, as outlined through the research questions and hypotheses above, is the integration of multiple lines of evidence, including demographic, paleopathological, and paleodietary analyses, to provide a more robust and nuanced reconstruction of social identity and biological health as they relate to emerging social and political inequality in the Early/Middle Bronze Age of the Carpathian Basin. This reconstruction of *social identity* will better contextualize the analyses and results of my study of health and diet and their relationship to economic foundations and behavioral consequences of emergent inequality within Bronze Age populations. The data achieved through this study will contribute importantly to a deeper and more empirically substantiated understanding of the economic, political, and environmental variables that contributed to and defined social organization and identity in Maros communities and the partial abandonment of the southern Pannonian plain at the end of the Middle Bronze Age (O'Shea, 1996; Tasić, 2003-2004).

2.0 Archaeological Perspectives of Culture Change and Social Complexity in Central Europe and the Carpathian Basin

As outlined in Chapter 1, a primary objective of this dissertation is to examine a priori assumptions of gender, age, and social status in a community in the southeastern Carpathian Basin that spans the period from the end of the Early Bronze Age (EBA) through the Middle Bronze Age (MBA). To this end, I will build on, and challenge, conventional models regarding trajectories of culture change and social complexity in prehistoric Central Europe.

In this chapter I examine the development of theoretical frameworks from regional and chronological/thematic perspectives. The first section compares the development of archaeology and physical anthropology as academic traditions in Serbia and Hungary. The second section looks at broader historical trends in the use of various models and interpretive frameworks to explain culture change, social complexity, and economic production and exchange among Bronze Age societies in Central Europe. In the third section of the chapter, I draw on recent trends in theoretical archaeology (*e.g.*, practice and agency theory, feminist and gender studies, etc.) that emphasize the reconstruction of daily life and social interactions at the local scale. I highlight these theoretical approaches so as to more fully examine local scale social processes that often have been overshadowed by the application of world systems analysis (WSA) that has been used to interpret broader regional and supra-regional scales of interaction in Central Europe. As I will argue, these three theoretical perspectives – social feminist and practice theory and WSA – provide a particularly useful framework for integrating my understanding of local communities of practice within their larger spatial and temporal context in prehistory.

In reviewing the historical trends of archaeological theory and practice that have informed the study of the Carpathian Basin and Central Europe more broadly, what emerges is the existence of competing archaeological narratives, often tied to modern social and political dynamics. For example, models of cultural diffusion stemming from V. Gordon Childe’s original work in the 1920s can be contrasted with

Serbian archaeologist Milutin Garašanin's contention that Neolithic Vinča culture represents autochthonous development of a metal-using society in the Middle Danube basin that predates Near Eastern and Mediterranean traditions (Garašanin, 1951; 1973; Palavestra, 2013). Prior to influences from the Processualist/New Archaeology school of thought that emerged in the United States and Britain in the 1960s, Serbian (Yugoslav) and Hungarian archaeologists applied a culture history framework to document increasingly fine-grained archaeological cultures based on shared material culture (*e.g.*, ceramics) and cultural practices (*e.g.*, burial traditions) (Palavestra, 2013; Vékony, 2003). Researchers often distinguished between culture groups as indigenous/autochthonous developments versus external migrations from the north and west (Barić, 2011; Srejović, 1994).

Since the 1980s, there has been a shift from characterizing and comparing single sites, to developing more synthetic models of change in cultural practices and socio-economic interactions over time in the context of testing and refining neo-evolutionary models of social complexity (see Bogucki & Grygiel, 1993; Renfrew & Shennan, eds., 1983; Renfrew, 1968; 1969; Shennan, 1993a). The Carpathian Basin, because of its well-documented archaeological record and well-defined geographic boundaries, presents an excellent case study and region for examining important questions such as: How and why did social complexity develop in Europe? When did institutionalized complexity emerge and what form did it take? Did such developments happen simultaneously over large areas due to the formation of regional interaction spheres tied to exotic or specialized commodity exchange? Or, were these trends linked to more localized adaptations that reflected changing cultural, political, and environmental factors, thus producing a patchwork of autonomous culture groups who differed in their spiritual beliefs, sociopolitical organization, and economic practices?

These questions reflect long standing issues within archaeological research of the region that have yet to be more fully addressed and answered within studies completed to date. As I will discuss below, these questions can be addressed by focusing on local social dynamics, changes in the organization and identity of communities and individuals, and through a more comprehensive evaluation of human skeletal remains from the region. Previous research has focused primarily on a top-down approach to understanding the lifeways of Bronze Age populations rather than a bottom-up examination of individuals who actually lived – and died - in the region at this time.

2.1 Historical Background: Archaeological Theory and Practice in the Carpathian Basin

Historical processes have influenced, and continue to influence, the practice of archaeology in central and southeast Europe. Spanning nine countries, the Carpathian Basin is defined geographically by the Carpathian, Alpine, and Dinaric mountain ranges (Figure 2.1) (Duffy, 2010).

This region over the past 200 years has experienced major geopolitical divisions and shifting borders (and languages), notably the Austro-Hungarian Empire, Kingdom of Serbia, Soviet Union, Yugoslavia, and a network of independent nation-states. The modern political history of the region has contributed to the formation of different archaeological traditions that correspond to state boundaries and language communities. Importantly, political factors have influenced the types of projects funded by national and local governments. The importance of archaeology in the construction of national-pasts that supported worldviews and authority of political regimes has led to state-level nationalizations of archaeology throughout most of Europe (Diaz-Andreu, 2007; Trigger, 1984). According to Dietler (1994), ideology has shaped the practice of European archaeology, especially prehistoric archaeology, as a tool to legitimize modern political regimes and ethnic communities in three contradictory ways: (1) unification of disparate communities into a pan-European identity; (2) constructing enduring, and distinct, national identities; and (3) promoting ethnic or regional resistance to national hegemony.

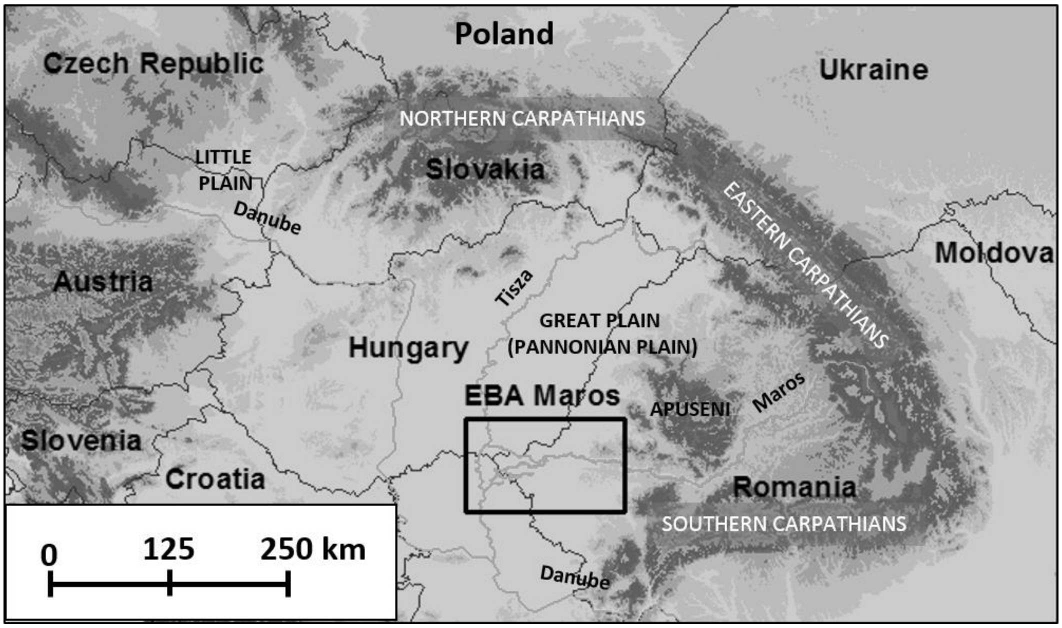


Figure 2.1 Geography of the Carpathian Basin (Pannonian Plain) and bordering countries. Black rectangle indicates primary area of study within this dissertation. The Pannonian Plain is referred to as the Great Hungarian Plain in Hungarian literature. "Pannonian Plain" is used here as the full extent of this region encompasses eastern Hungary, western Romania, and northeastern Serbia.

The legacy of nationalism in Europe means that the influence of political regimes and ideological trends led to the systematic privileging of certain types of sites, periods, and archaeological finds over others. Parts of the archaeological record that support nation-building and provide foundations for construction and normalization of national identities are often privileged over those with peripheral value to the goals of the state (Arnold, 1990; Diaz-Andreu, 2007; Kohl, 1998). Thus, what emerges is a skewed representation of the past that corresponds to historic and modern geopolitical boundaries. These political divisions are further compounded by linguistic differences that create what Harding (2000:4) refers to as "…artificial divisions in the cultural story…". Taken together, the influence of political processes and national discourses on archaeology in Europe presents considerable logistical hurdles for scholars of European – especially central and southeastern European – prehistory. This is apparent in the documentation, curation, and publication of sites and finds, and incongruities in local and regional traditions of archaeological theory and practice.

2.1.1 Historical Foundations of Paleopathology in Hungary

Historically, human skeletal remains from archaeological sites in the Carpathian Basin have been understudied vis-à-vis mortuary attributes such as grave goods, body position, and grave type/construction. Publications frequently omitted references of human skeletal remains beyond basic descriptions of body position, number, and general identification as 'adult' or 'subadult'. Additionally, prior to the 1970s, many cemetery excavations did not accommodate long-term storage of human skeletal remains, resulting in disposal of skeletal material apart from well-preserved crania (Farkas and Lipták, 1971; Rega, 1989). This is due both to archaeologists' lack of training in human skeletal anatomy and the disciplinary interests of European physical anthropologists. To paraphrase Jarcho (1966:5), the preoccupation with studying the crania at the expense of the rest of the body seemed to suggest most researchers were under the assumption that diseases stopped at the foramen magnum.

The study of physical anthropology in Europe, as it pertains to analysis of human remains from archaeological sites, was heavily influenced by the 19th century French physician Pierre Paul Broca and German anatomist Rudolph Virchow (Boas, 1902; Márquez-Grant et al., 2016). Broca was one of the first to report on evidence of disease and trauma in ancient human remains, including the occurrence of cranial trepanation in the Neolithic (Broca, 1876). Like other practitioners of that time, who were generally trained in human anatomy and medicine, Virchow's work focused on documenting and interpreting human variation in the context of 'racial' studies (Roberts & Manchester, 2007). However, he differed from his contemporaries in concluding that there is no connection between anatomical form and nationality/ethnicity in either living populations or ancient skeletons. He argued that human types, when identified, cross-cut language and culture (Boas, 1902). Despite Virchow's assertions that comparative human anatomy is a poor predictor of ethnic identity, the primary motivation for the study of archaeological skeletal remains was analysis of anatomy and morphology as it applied to identification of cranial typologies useful for past migrations and the origins of modern Europeans (see Shapiro, 1959:373). It was not until the second half of the 20th century that physical anthropologists in Europe moved towards the development and use of standardized methods, became more interested in the study of human disease in the context of past human populations, and stressed the importance of retaining and studying complete skeletons (Roberts & Manchester, 2007; Márquez-Grant et al., 2016).

The publication of György Acsádi's and János Nemeskéri's book *History of Human Life Span and Mortality* (1970) represented a turning-point in central European physical anthropology. Their work – published 14 years before Cohen and Armelagos' (1984) groundbreaking *Paleopathology at the Origins of Agriculture* - represents one of the first comprehensive studies of paleodemography and paleoepidemiology in the context of ancient economies and social life. Their data collection and analysis was based on three main components: (1) systematic and comprehensive excavation of cemeteries with collection of all skeletal elements; (2) development and application of standardized methods to estimation of sex and age; and (3) comparative synchronic and diachronic demographic analysis. In addition to their theoretical contributions, Acsádi & Nemeskéri developed the "complex method" of determining adult age (Acsádi & Nemeskéri, 1970) and the "sexualization index" for biological sex estimation (Acsádi & Nemeskéri, 1970) based on comparison with control skeletons of known age-at-death and sex from historic cemeteries. The goal of their study was to document and understand temporal and geographic variability in mortality over time from the Neolithic to late 19th century in populations from Hungary and central Europe (Acsádi & Nemeskéri, 1970). Arguably one of their most significant findings was the identification of regional differences in mortality and decline in female life expectancy beginning around 2000 BCE. This shift is coincident with archaeological evidence for the appearance of gender-based social inequality in the area. Their findings support changes in political economy, social life, and belief systems in the EBA and that these appear to have had a negative impact on the health and life expectancy of women and children.

The methodological and theoretical contributions of *History of Human Life Span and Mortality* (Acsádi & Nemeskéri, 1970) built on and inspired a strong legacy of paleodemographic research in Hungary through systematic excavation and analysis of human skeletal remains. While practitioners retained a strong focus on describing and classifying morphological features in living and ancient populations as a proxy for past human migration and population interaction (see Schwidetzky, 1980; Zoffmann, 2000), researchers began placing greater analytical emphasis on contextualizing human variation in terms of broader historical processes. The primary focus of what can ostensibly be referred to as the "Hungarian school of physical anthropology" included analysis of age, sex, and disease in skeletal samples to understand the effects of migration, living conditions, and subsistence practices on health and demographic composition of prehistoric and historic populations in the Carpathian Basin. Notable examples include the analysis of the Late Bronze Age cemetery at Tapé near the Tisza-Maros confluence in southeastern Hungary (Farkas and Lipták, 1971), the analysis of the EBA cemetery at Mokrin, Serbia (Farkas and Lipták, 1972; Lengyel, 1972), and the analysis of mortuary and skeletal remains from the large Copper Age cemetery at Tiszapolgár-Basatanya in northeast Hungary (Skomal, 1980). While these early studies served as a foundation for understanding local variation and long-term changes in population structures in the Carpathian Basin, they were limited in their theoretical and methodological approaches. Since the 1990s, there has been a shift away from paleodemography to increased emphasis on interdisciplinary approaches to paleopathology and paleoepidemiology that integrate traditional approaches to skeletal analysis with new methods from the fields of molecular biology, microbiology, genetics, and radiology (Marcsik and Pap, 2000).

Recent Hungarian scholarship builds on a robust legacy of paleodemographic and paleopathological research, and interdisciplinary approaches to the study of health as a product of biological, social/behavioral, and environmental factors (Marcsik & Pap, 2000). For example, Douglas Ubelaker and Ildikó Pap (1996; 1998; 2008; 2009; Ubelaker et al., 2006) applied a combined paleodemographic and paleopathological approach to examine temporal changes in morbidity and mortality in northeastern Hungary through analysis of skeletal samples from well-documented sites dating from the Neolithic to the early Middle Ages. Additionally, research into the trajectory of specific diseases has documented the antiquity and prevalence of joint disease and enthesopathies (Paja, 2013), trephination

(Bereczki and Marcsik, 2005), tuberculosis (Masson et al., 2015; Pósa et al., 2015), and malignant tumors (Molnar et al, 2009). Finally, stable isotope analysis of human and animal remains has provided insights into the evolution of past diets and subsistence practices and assisted in spatially mapping patterns of individual mobility regionally and overtime in the Carpathian Basin (see Gerling et al, 2012; Giblin & Yerkes, 2016; Giblin et al., 2013; Giblin, 2009; Hoekman-Sites & Giblin, 2012).

2.1.2 Historical Foundations of Paleopathology in Serbia

For most of the 20th century, there was limited scholarly interest (or formal training) in physical anthropology in Serbia (Mikić, 1998). Physical anthropology as a field of study was limited to a few practitioners who received formal training in Germany or Austria, and whose research focused on documenting the bioanthropological characteristics of ethnic groups in the western Balkans. Two of the earliest and most influential Serbian physical anthropologists were Jovan Cvijić (1865-1927) and Vladimir Dvorniković (1888-1950). The works of both Cvijić and Dvorniković were notable for breaking with the genetic determinism that dominated physical anthropological thinking in the United States and Germany prior to World War II. In stark contrast to many of their contemporaries who were interested in discriminating between racial types, they were interested in how the environment (geography and climate) and social and historical factors, such as migration, social structure, and endogamy/exogamy, influenced physical variation in modern populations (Cvijić, 1922; Dvorniković, 1939). However, most physical anthropological inquiry in Serbia was restricted to the study of living populations. A single exception was Branko Šljivić (1895-1963), an anatomy professor at the Medical Faculty in Belgrade. Šljivić's (1935) work on analysis of human remains from the Iron Age cemetery at Trebeništa in North Macedonia represents one of the earliest studies of disease and demography in an ancient population in Serbia or North Macedonia.

The onset of World War II and the misuse of physical anthropology to support Nazi racial ideologies, coupled with the formation of Yugoslavia as a nation of "Brotherhood and Unity" that sought to downplay historic ethnic distinctions, led to the effective demise of physical anthropology as a cohesive area of study in Serbia (Mikić, 1998). In Croatia, Slovenia, and Bosnia-Hercegovina, physical anthropology was more established, but remained synonymous with anthropometry as evidenced by many of the articles published in *Glasnik Antropološkog Društva Jugoslavije* [Journal of the Anthropological Society of Yugoslavia] (1964-2007). Furthermore, physical anthropology as a discipline was part of the Institute of Anatomy at the Medical Faculty in Belgrade rather than the Faculty of Philosophy, which housed the departments of archaeology and ethnography. This did not change until the late 1980s, which under the direction of Dr. Živko Mikić and others, saw a shift towards a greater emphasis on adopting an integrated and interdisciplinary approach to physical anthropology, with a specific focus on archaeological applications to studying disease, demography, and behavior in historic and prehistoric populations.

Paleopathology as a separate research area within physical anthropology is a relatively recent development in Serbia. As a result, skeletal remains housed in museum collections either from isolated finds or planned excavations are often incomplete, poorly studied, and unpublished. The breakup of Yugoslavia in 1991 and the resulting conflicts meant there was little funding or resources available for archaeological excavation or research. However, the presence of international forensic specialists working with Serbian medical personnel in identification of victims from the wars in Serbia, Bosnia, Croatia, and Kosovo sparked a growing interest in applying forensic and archaeological methods to researching health, violence, and migration in the past (Djurić et al., 2006; Djurić-Srejić, 2001). Since the early 2000s, there has been a renaissance of research in paleopathology, paleodemograpy, and bioarchaeology in Serbia, with most of the academic interest and scholarly pursuits related to paleopathological and isotopic analysis of remains from Mesolithic and Neolithic burials from sites in the Danube Gorges region of eastern Serbia (*e.g.*, Borić & Stefanović, 2004; Nemeskéri, 1969; Radović & Stefanović, 2013; Roksandic et al., 2006; Villotte et al., 2014). In addition to research on Mesolithic and Neolithic health, diet, and mobility, researchers such as Djurić-Srejić have focused on documenting health in medieval populations from northern Serbia (*e.g.*, Djurić-Srejić & Roberts, 2001; Djurić et al., 2010), while several studies have been conducted that examine relationships between health, status, and activity in EBA populations from northeastern Serbia (see Rega, 1995; 1997; 2000; Macintosh et al, 2015; Macintosh et al., 2014; Porčić & Stefanović, 2009; Stefanović & Porčić, 2011). However, Serbia remains largely a blank space in terms of understanding long-term variation in health and demography linked to biosocial, economic, and environmental influences.

2.1.3 Historical Foundations of Archaeological Theory and Practice in Hungary

The historic trajectory of archaeological theory and practice in Hungary differs markedly from that in Serbia. This is despite geographic proximity and shared history under Ottoman and later Austro-Hungarian imperial rule. Archaeology in Hungary has a long and well-established history, with German, Austrian, and Hungarian archaeologists regularly undertaking systematic excavations by the early 20th century (László, 2009). Beginning with Childe's publication (1925), *The Dawn of European Civilization*, excavation and research of prehistoric sites in Hungary has been pivotal for developing, testing, and refining models of social change in Europe (Chapman, 1994; Early & Kristiansen (Eds.), 2010; Parkinson, 2002; Sherratt, 1993).

Prior to the 20th century, "archaeology" in Hungary focused on documentation of numismatics and antiquities – Roman and Hunnic (Árpád). Despite the proliferation of archaeological societies and museums throughout the country and the establishment in 1868 of the scholarly journal *Archaeologiai Értesítõ* [Archaeological Reports], archaeological exploration involved unscientific collection and display of finds ranging from prehistory to the Migration Period (Hungarian Conquest). Important developments in the emergence of archaeology as a coherent scholarly discipline in Hungary include early planned scientific excavations by Lajos Márton (1867-1934) at the Bronze Age settlement at Tószeg and Ference László's survey and excavation of Neolithic settlements in southeast Transylvania (László, 2009; Vékony, 2003). The dissolution of the Austro-Hungarian Empire following World War I and the stipulations laid out in the Treaty of Trianon greatly reduced the geographic extent of Hungary. Hungary's territorial losses at this time included Transylvania, which became part of Romania, and Vojvodina, which was given to the Kingdom of Yugoslavia (Serbia).

The annexation of Hungarian territories to various successor states resulted in the cessation of funding to or closure of many regional museums and universities that were previously active in sponsoring archaeological research. Despite this, the Hungarian National Museum in Budapest, in conjunction with private foundations and municipalities, sponsored several important excavations throughout the 1920s and 30s. These included excavations of prehistoric cemeteries by János Érdy at Bodrogkeresztúr and Pusztaistvánháza in northeast Hungary, Ferenc Tompa's work at Tószeg as well as the stratified Bronze Age tell site of Füzesabony in the area of the Upper Tisza, and János Banner's projects in the area around Hódmezõvásárhely near the Tisza-Maros confluence in southeast Hungary (Vékony, 2003). By the 1930s and 40s, a cohesive picture of Hungarian culture-history began to emerge. Several edited volumes and monographs were published that compiled and synthesized archaeological knowledge up to that point on the Neolithic, Copper Age, Scythian Age, Avar Period, and the Conquest Period, notably the monograph series *Archaeologia Hungarica* edited by Nándor Fettich.

As in Serbia, much of this early work was focused on artifacts, with most of the discussion centered on description and classification of artifact (primarily ceramic and metal) typologies. There was little engagement with broader theoretical or methodological discourse regarding the relationship between people and things. Culture-historical archaeology in Europe - especially central Europe - was heavily influenced by German archaeologist Gustav Kossinna's (1858-1931) concept of the Kultur-Gruppen, or the idea that distribution of archaeological material culture areas corresponded to discrete ethnolinguistic (Völker) groups. In Germany, archaeological excavation and inquiry in the late 19th and early 20th centuries sought to trace back in time the ancient homelands and geographic distribution of contemporary ethnic groups, based on assumptions of cultural continuity (Kristiansen, 1998). Kossinna's particularistic framework favored ethnic and racial characteristics as the primary determinants of historical processes over social and economic factors. Change, when it happened, was attributed to diffusion or migration of otherwise stable cultural and racial entities. This approach had far-reaching political consequences, as archaeological “evidence” was appropriated to support nationalist narratives of ethnic and racial supremacy. While influential archaeologists in England and Scandinavia, such as V. Gordon Childe, rejected these chauvinistic applications, prehistorians retained Kossinna’s concept of archaeological cultures. Childe favored diffusion of ideas (and occasionally people) over politico-military invasion and replacement; however, he failed to critically evaluate assumptions underlying a priori correlation between material culture, language, and ethnicity in reconstructing causes and patterns of migration, trade, and exchange in the past (Kristiansen, 1998).

The 1950s saw the incorporation of Hungary as a Soviet satellite state. In addition to transforming the political system, this period saw major reforms to university curricula and formation of the National Centre of Museums and Monuments, which oversaw funding for research and personnel. While regional museums retained a degree of independence, funding priority was given to excavate sites in advance of large-scale construction projects (Banner, 1955). These excavations often exposed large areas; however, the demands placed on archaeologists meant they were often given insufficient time to plan excavations or document finds (Vékony, 2003). The sociopolitical changes occurring in Hungary during the 1950s and 60s mirrored those happening elsewhere in eastern and central Europe. Despite this, Hungary maintained a degree of social, political, and intellectual autonomy compared to other Soviet states. Hungarian archaeologists, such as János Banner, Sándor Bökönyi, István Bóna, and others were influenced by and contributed to larger discourses in the study of prehistoric European archaeology.

In contrast to the particularizing and diffusionist perspectives that characterized Serbian archaeology in the 20th century, Hungarian archaeology relied on a more generalizing framework based in evolutionary and functionalist paradigms (Kristiansen, 1998:36-37). Despite these theoretical differences, archaeological narratives in Serbia and Hungary both emphasized discontinuity between prehistoric and contemporary populations. This differed from nationalistic frameworks elsewhere in central and eastern Europe that sought to support specific political agendas by establishing a direct connection between the ancient past and current regime (Kohl, 1998; Shnirelman, 1996). Instead, Hungarian as well as Serbian scholars posited migration or invasion with limited diffusion as the primary drivers of prehistoric cultural change (Bóna, 1958; 1975; Kemenczei, 1984 *in* Kristiansen, 1998:21; Mozsolics, 1957; see Nicodemus, 2014:92).

Theoretical foundations of archaeological thought in Hungary prior to the 1990s were rooted in a culture-history approach. Despite this, Marxist ideology can be seen as indirectly influencing two trends: Sándor Bökönyi's work on changes in domestic animal exploitation overtime and Acsádi and Nemeskéri's research on economic, social, and environmental influences on health overtime. Bökönyi (1971) applied a comparative approach to analyzing faunal assemblages to identify shifts in exploitation of domestic animals as sources of food, commodities, and/or labor. Based on changes in body size and faunal composition, Bökönyi concluded that Bronze Age people were raising animals for milk, traction, and wool. He interpreted the introduction of new domesticates as evidence for migration and invasion rather than local adoption of new technologies. However, he stopped short at suggesting Neolithic, Bronze, and Iron Age peoples valued animals or animal-products beyond fulfilling the needs of the local political economy.

Starting in the 1980s and 1990s, the Carpathian Basin became a focus for testing models of social change based on settlement pattern analysis. The influence of "social archaeological" perspectives, spearheaded by British archaeologists Colin Renfrew (1968; 1973), Steven Shennan (1975), and Jonathan Friedman (1974), ushered a movement away from migration and diffusion-based models of culture change. Emphasis was instead placed on the concept of political economy as key to reconstructing social relations in the context of economic production and exchange. The development of radiocarbon-based chronologies, such as by Raczky et al. (1994) and O'Shea (1991) for Bronze Age sites in Hungary, called into question material-based cultural sequences, and provided evidence for the independent development of complex Bronze Age societies in the region. Since the late 1990s, several large scale multidisciplinary, international collaborative research projects have studied the ecological and social effects on regional patterns of political and economic organization in prehistoric societies in the Pannonian Plain (Duffy, 2010; Giblin & Yerkes, 2016; Gyucha et al., 2013; Parkinson & Gyucha, 2012; Parkinson, 2006) and Transdanubia (Earle & Kristiansen, eds, 2010). Additionally, the publication of the edited volume *Hungarian Archaeology at the*

Turn of the Millennium (Kiss, ed., 2003) provided a comprehensive overview of archaeological research in Hungary, with chapters divided into major cultural periods from the Paleolithic to the Post-Medieval period.

More recently, several authors have examined a range of topics related to social identity, relations of power, and political economies. For example, Budden and Sofaer (2009) and Michelaki (1999; 2008) studied social dimensions of production and identity formation among Bronze Age potters. Analysis of grave goods and mortuary practices by Sørensen (1997) and Sørensen & Rebay-Salisbury (2009) demonstrated the importance of Bronze Age funerary rituals for social performance and display tied to individual and regional identities. Finally, Gyucha et al. (2013) and O'Shea (2011) illustrated how prehistoric settlement in the Pannonian Plain was influenced by a combination of environmental and cultural factors that contributed to the formation of symbolic and strategic landscapes.

2.1.4 Historical Foundations of Archaeological Theory and Practice in Serbia

Prior to V. Gordon Childe's (1929) landmark publication *The Danube in Prehistory*, prehistoric archaeology in the Carpathian Basin and along the Danube was confined to reporting case studies and chance finds in local journals. Similar to the development of archaeology as a distinct discipline elsewhere in central Europe during the 19th and early 20th centuries, the advent of archaeology and systematic excavation in the Carpathian basin was closely tied to imperial (Austro-Hungarian) scholarship and emerging nationalism (Vékony, 2003). Professional scholarship was often underscored by growing national interest and sentiment in central Europe and the central Balkans in constructing national pasts aligned with the cultivation of a pre-Imperial regional historic consciousness (Barić, 2011:295). The construction of national identities rooted in ancient pasts often reflected contemporary conflicts between elites and commoners, imperial (central) and regional (peripheral) interests, and Orthodox and Catholic religious perspectives.

Serbian archaeology has its roots in fostering political discourse and national sentiment opposed to Austro-Hungarian imperial interests. This is evident in the work of the German-educated art historian and architect Mihajlo Valtrović (1839-1915), who was one of the first to apply scientific methods to systematically analyzing and documenting Serbian cultural heritage (Makuljević, 2013; Palavestra, 2013). Work by Valtrović and others, such as Viennese art historian Josef Strzygowski (1862-1941), sought to dispel negative western perceptions of Serbian cultural contributions to art and history. These scholars focused their research on the documentation of medieval Orthodox churches, manuscripts, and paintings in the territory of Serbia. Specifically, these efforts were important for countering Austro-Hungarian perceptions of Serbia and Serbians tied to general Orientalizing discourses of Balkan peoples as culturally primitive, historically backwards, and having a propensity for violence compared to the more "civilized" western European nations (Makuljević, 2013). In addition to showcasing medieval Orthodox cultural heritage as a point of national pride, research published primarily in French and German sparked both international and national interest in art historical research focused on the influence of historic cultural exchange on visual culture in the Balkans (Makuljević, 2013; Preradović, 2016).

Interest in prehistoric cultural heritage, and the development of archaeology as a discipline that combined scientific methods with art historical interests, can be tied to Miloje Vasić (1869-1956). Often referred to as the "Father of Serbian archaeology", Vasić carried out the first major excavations in 1908 at the site of Vinča, a major Neolithic settlement on the Danube east of Belgrade (Palavestra, 2013). Based on comparisons of material finds from Vinča, Vasić initially concluded the site represented a Bronze/Iron Age Aegean (Ionian) colony in Serbia (see Palvestra & Babić, 2016). Vasić was arguably the most important and influential figure in Serbian archaeology prior to World War II. However, as Palavestra (2013:685) noted, while Vasić was the leading voice in Serbian archaeology during the interwar period, his work was conducted largely outside of major scholarly spheres of influence that dominated European archaeology at the time. Vasić's contributions to Serbian archaeology were more practical than theoretical. He was responsible for training the first generation of Serbian archaeologists in systematic excavation and comparative artifact analysis. Many of his findings and interpretations of links between the Serbian Neolithic and Mediterranean Bronze Age (the "Ionian Colony") were later overturned with the publication of *Hronologija Vinčanske Grupe* (1951) [The Chronology of the Vinča Group] by his student Milutin

Garašanin. Significantly, Garašanin rejected Vasić's chronology, instead positing Vinča as an autochthonous culture group that predated Bronze and Iron Age cultures in the Aegean.

The post-World War II generation of Serbian archaeologists practiced a more integrated and collaborative approach to studying the past, albeit one that posited cultural change as resulting from a combination of diffusion and invasion/migration (Srejović, 1994). However, limited spontaneous local development was acknowledged in the case of groups such as the Neolithic Vinča or EBA/MBA Maros. This approach focused on constructing regional culture histories based on excavation and systematic comparative stylistic analyses of artifact assemblages. These efforts culminated in the publication of the massive edited volume *Praistorija Jugoslavenskih Zemalja* (1979-1987) [The Prehistory of Yugoslavia], which stands as one of the most complete and comprehensive overviews of regional culture history in the central Balkans (Serbia, Montenegro, and Bosnia and Hercegovina) spanning the Paleolithic to the Iron Age. Furthermore, most of the analytical focus lies in interpreting stylistic changes as evidence for exogenous influences through migration, conquest, or autochthonous development. Notably, there is minimal theoretical engagement in understanding the archaeological record in the context of models of economic intensification/specialization, increased social complexity, or cultural change in small-scale pre-industrial societies.

The mechanisms by which agriculture and animal husbandry spread throughout Europe, and the resulting political, social, and economic changes that characterized early farming communities, remain a major research focus in European archaeology (BEAN, 2017; Greenfield, 1986; Zvelebil, 1986). By the 1970s and 1980s, it was clear that the central Balkans – particularly along major river corridors such as the Danube-Sava and Morava – were critical for testing wave of advance versus acculturation models for the spread of agricultural practices and lifeways. As a result, there was a need for hard evidence from well-documented excavation of early Neolithic sites. This led to a surge of international interest in the region focused on developing improved regional chronologies in which to spatially and temporally contextualize the cultural evolution of Neolithic societies, and studying variation in settlement structure and organization as a means of documenting processes of socioeconomic transformation in early farming communities

(Milisauskas, 1992). Notably, excavations at Selevac (1976-1978) led by Ruth Tringham and sponsored by Harvard, Berkeley, and the National Museum of Belgrade (Tringham & Krstić, 1990) and Divostin (1967-1970) led by Alan McPherron of the University of Pittsburgh and Dragoslav Srejović of the University of Belgrade (McPherron & Srejović, 1988) greatly expanded archaeologists' knowledge of Neolithic (Early Neolithic Starčevo and Late Neolithic Vinča) social organization and subsistence practices in the lower Morava Valley.

Compared to well-documented excavations of Neolithic sites in central and eastern Serbia, the Bronze Age remains understudied (Bankoff et al., 2011; Zotović, 1985). In an attempt to provide insight into what they referred to as the "post-Neolithic" prehistory of the central Balkans, Arthur Bankoff from Brooklyn College with Dušan Krstić of the National Museum of Belgrade directed a project over two seasons (1977, 1980) that included regional survey and preliminary excavation of Bronze Age sites in the lower Morava valley in central Serbia (Bankoff et al., 1980; Bankoff & Winter, 1982; Bankoff & Winter, 1990). While the limited excavations precluded in-depth analysis of settlement structure and organization, analysis of paleobotanical and faunal remains in conjunction with stylistic analysis of ceramic, metal, and stone finds provided valuable insights into cultural evolution, subsistence practices, and the scale and types of socio-economic interaction in Bronze Age societies. To date, paleobotanical and faunal analyses, specifically from the site of Novačka Ćuprija, present some of the only direct evidence for Bronze Age subsistence practices anywhere in Serbia. There has been limited excavation or research on Copper, Bronze, and Iron Age societies in Serbia since the late 1980s. Exceptions to this include John O'Shea's (1996) book *Villagers of the Maros*, largely unpublished excavations at Ostojićevo by M. Girić in the 1980s, and several recent analyses on stable isotope signatures of tin to identify zones of metal extraction versus distribution (see Mason et al., 2016; Powell et al., 2017), This includes an almost complete absence of (published) radiocarbon dating of Copper, Bronze, and Iron Age sites; to date, radiocarbon dating has been carried out at the EBA cemetery at Mokrin (O'Shea, 1991; O'Shea et al., 2019) and several dates from the Morava Valley region in central Serbia summarized in Bankoff and Winter (1990:188) (see also Glumac & Todd, 1991). Thus, culture change associated with the emergence of Bronze Age cultures in Serbia both north and south of the Danube, including those with large-scale well-documented excavations such as Gomolava near Novi Sad, are based largely on site-stratigraphy and ceramic evidence, with little to no verification of relative dating techniques with radiocarbon-based chronologies (Srejović, 1994; Tasić, 2005; Tasić, 2003-2004).

The incomplete publication of major excavations and surveys of prehistoric sites in central and northern Serbia during the 1980s and 1990s remains a major issue in accessibility of archaeological finds for analysis and review by scholars both within and outside Serbia (*e.g.,* Bankoff & Winter, 1982; 1990; Girić, 1987; 2012[1995]). This includes much of the excavations by Milorad Girić (1930-2011) in the southern Banat region of northeast Serbia in the area defined by the Maros, Tisza, and Zlatica rivers. From the 1950s until the 1990s, Girić conducted major excavations at several prehistoric and historic sites, notably the EBA Maros cemetery at Mokrin (Girić, 1971; ed., 1972) and EBA/MBA Maros cemetery at Ostojićevo (see Girić, 2012[1995]; Milašinović, 2009), and the Maros settlement at Popin Paor (Girić, 1989). Recently, a selection of the late Serbian archaeologist Milorad Girić's works originally published in regional journals were collected and reproduced in a single volume (2012) *Milorad Girić: Putovanje u Praistoriju* [Milorad Girić: Travels in Prehistory] (Čemere, ed., 2012). Additionally, several major Serbian journals have digitized their collections and are now open access, including the primary publication of the Archaeological Institute in Belgrade (*Starinar*) and the annual publication of the Institute for Balkan Studies of the Serbian Academy of Arts and Sciences (*Balcanica*).

Political instability and conflict in the 1990s led to a drastic reduction in state and international funding for archaeology. Despite this, several influential archaeological monographs and edited volumes were published at this time. *The Yugoslav Danube Basin and the Neighbouring Regions in the 2^nd^ Millennium B.C.* was released in 1996 (Tasić, ed.) and serves as an abridged and updated companion to the earlier *Praistorija*. It also represents one of the first contemporary volumes of Serbian archaeology accessible to a broader community, with most of the articles published in English or German. Another significant publication with several articles on recent research from Serbia is the edited volume *Technology, Style and Prehistory: Contributions to the Innovations between the Alps and the Black Sea in Prehistory*

(Nikolova, ed., 2000). Two important multi-author museum monographs are *Muzej Vojvodina: Stalna Postavka* [Museum of Vojvodina: Permanent Collections] (Cerović, Kumović, & Smiljanić (eds.), 1997), and *Niš: Kulturni Stratigrafija Praistorijskih Lokaliteta u Niškoj Regija* [Niš: The Culture History of Prehistoric Sites in the Niš Region] (Stojić & Jocić (eds), 2006) published in collaboration with the Archaeological Institute in Belgrade and the Museum in Niš. These resources provide an overview of historic sites, excavations, and isolated finds in their respective administrative regions, plus a brief overview of regional culture history based on pottery styles, settlement types, mortuary practices, subsistence strategies, and metallurgy.

It is only within the past decade that there has been a resurgence of excavation of prehistoric sites and reanalysis of museum collections in Serbia. Encouragingly, there is a movement toward greater international collaboration and use of cutting-edge technology that goes beyond surface-level analysis of artifacts. The purpose of this research is to produce more nuanced understandings of social life in the past. Furthermore, recent research into Mesolithic and Neolithic sites in eastern and central Serbia indicate the importance of reexamining simple explanations of external stimuli – diffusion or migration - as the primary agents of cultural and economic change (see Borić & Price, 2013). Rather, there is a need to consider more dynamic models of social and economic relations and cross-cultural interactions in small-scale societies, and to move beyond adherence to Childean models of dialectical change (see Chapman & Dolukhanov, 1992; Tringham, 1983; 2000).

2.2 The European Bronze Age: Theoretical Models of Culture Change and Social Complexity

The beginning of the Bronze Age cultural sequence in the Carpathian Basin is poorly defined. Many EBA (2800-2100 BCE) "cultures" exhibited general continuity with the Late Copper Age (LCA) (3500-2800 BCE) tradition of small, dispersed undifferentiated settlements indicative of a locally-focused agropastoral economy (Duffy, 2010; Kulcsár, 2003). The period from ca. 2500-2000 BCE was marked by rapid, large-scale reorganization in settlement patterns and emergence of new stratified social institutions (Earle & Kristiansen, 2010; Parkinson & Gyucha, 2012). These changes were concomitant with the appearance of new metallurgical technologies and traditions in the region and focused on copper-tin, copper-arsenic, or copper-tin lead alloys (Greenfield, 1999; Harding, 2000; Radivojević et al., 2013).

The rapid spread of major innovations at this time provided evidence for the interconnectedness of polities through regional exchange networks both inside and outside the Carpathian Basin (Kristiansen, 1998; Shennan, 1993a; Sherratt, 1982a). These connections – or exchange networks - contributed to the emergence of heterogeneous archaeological culture groups, characterized by differences in ceramic styles, dress, and burial practices. Despite this material and cultural heterogeneity, the prevailing view of social and economic change in the EBA in temperate Europe emphasized several key features that connect Bronze Age economic and social systems.

The significant changes discussed above can be condensed into four general categories: (1) increased importance of exotic prestige goods; (2) decreased symbolic significance of domestic economies; (3) intensification of specific local economies with site-specific or regional specialization; and (4) development of social ranking and stratification as regional exchange became an increasingly important aspect of Bronze Age social, political, and economic lifeways (Gilman, 1981; Shennan, 1993a; Sherratt, 1982a).

2.2.1 Paradigm of Culture Change: Diffusion-Migration

Several major debates have arisen concerning the causative mechanisms underlying the adoption and spread of new technologies and understanding the patterns (and trajectory) of culture change in the EBA and MBA. The first scholar to propose a model of economic and social change in European prehistory was the Australian-British archaeologist V. Gordon Childe (1892-1957). Childe's groundbreaking books *The Dawn of European Civilization* (first edition, 1925) and *The Danube in Prehistory* (1929) were the first to present a synthesis of the Neolithic, Copper Age, and Bronze Age in the Aegean and central Europe (Chapman, 2009).

According to Childe, a diffusion of ideas and new technologies from the Near East drove social evolution and economic change among prehistoric societies in the Aegean and central Europe. This interpretation of the archaeological record – as it existed at the time – relied on a historical materialist perspective rooted in Marxist theory (Tringham, 1983). Thus, in developing a general theory of change in prehistoric Europe, Childe cited external stimuli rather than internal social change and economic innovation as the primary agent of culture change.

This perspective placed analytical emphasis on the interplay between mode of production, social organization, and ideology. Culture change was viewed as a progressive phenomenon whereby change was cumulative, constant, and progressive. The major weaknesses of Childe's model are his lack of well-provenienced primary data, especially from the western Balkans, and reliance on developing central European chronologies by cross-referencing relative sequences from the Near East. The development of radiocarbon-based chronologies in the 1970s and 1980s challenged this picture of the timing and magnitude of changes in Europe relative to the Near East (Ammerman & Cavalli-Sforza, 1984; Renfrew, 1969a; Zvelebil & Rowly-Conwy, 1986).

Despite the rejection of Childe's model of external forces of technological innovation and knowledge diffusing from the Near East into Europe, his work continues to influence how researchers think about and study the Bronze Age (Chapman, 2009; Kristiansen, 1998). For example, Childe's (1929) binary classification of tells and flat sites was understood to reflect clear divisions between permanent mixed-farming and mobile cultivation strategies. These two categories were associated with greater and lesser forms of social complexity, respectively, based on interpretations of settlement form and function. Additionally, his interpretation of Neolithic autonomy and self-sufficiency compared to Bronze Age integration, and the inverse correlation between settlement mobility and economic intensification, remain important in framing debates on the economic and social roles of prehistoric settlements and communities (Chapman, 2009; Kienlin, 2012; Sherratt, 1982b, 1983). Finally, Childe's focus on technology, specifically the role of metal and metalworking in shaping Bronze Age economy and society, remains a focal point of debate and research today (Harding, 2000).

Childe relied on the concept of archaeological cultures borrowed from the German philologist and historian Gustav Kossinna (1858-1931) despite rejecting the politicization of archaeological data vis-à-vis conflation of the material record with ethnic and national interpretations (Kristiansen, 1998). Kossinna argued that archaeological material cultures (Kultur-Gruppen) represent discrete ethnic entities (Völker), that the archaeological record supports cultural continuity between antiquity and the present, and serves as a means to trace the history and origins of modern ethnic groups (Kristiansen, 1998:20). Within this culture-historical framework, culture - defined as a recurring assemblage of artifact types (especially metal and pottery), houses, and burials – acted as material representations of “real” ancient social and ethnic groups (Champion, 2009:3). While Kossinna focused on connecting modern Germans to an unadulterated superior race of Indo-European-speaking peoples that preserved their cultural and racial purity over time, Childe applied the concept of archaeological cultures to map ancient interaction via migration and conquest (Champion, 2009; Trigger, 1984). Within the culture-history paradigm, change was seen as the influence of one group on another; interpretations of these interactions mirrored modern political and military histories in Europe (Champion, 2009).

This Germanic culture-historical approach dominated central and eastern European archaeology for most of the 20th century. The act of doing archaeology focused on the creation of increasingly fine-grained artifact typologies. Analysis frequently centered on determining the spatial distribution of pottery and metal types and developing chronological sequences based on homologies between artifacts, houses, and burials. While Childe sought to establish a link between Europe and the Near East, other practitioners adopted this approach to affirm links between modern ethnic and linguistic groups and ancient inhabitants. For example, Romanian archaeologists posited descent of modern Romanians from Iron Age Dacian populations, especially in Transylvania (Bader, 1978; Nicodemus, 2014). In Hungary and Serbia, an opposing viewpoint took hold. While archaeological cultures were interpreted as salient ethnohistoric entities, culture change and the introduction of new technologies in the Bronze Age were seen as the result of an influx of new populations from the east (Late Copper Age) and west (Late Bronze Age) interacting with and, in some instances, replacing local communities (Bóna, 1975; Csányi, 2003a). Both migration periods, characterized by rapid large-scale social change and site abandonment, were interpreted as disrupting centuries of relative social stability and consolidation in the Carpathian Basin.

The Lithuanian-American archaeologist Marija Gimbutas (1921-1994) popularized a migrationist model of prehistoric cultural change in central and eastern Europe. The work of P. Bosch-Gimpera strongly influenced Gimbutas' theoretical model (Gimbutas, 1963a). Bosch-Gimpera's book *Les Indo-Européens: Problems Archéologiques* summarized and evaluated several hypotheses to produce a general model of Indo-European origins and cultural development from the Mesolithic to the Iron Age. Much of Bosch-Gimpera's arguments for ancient origins and migrations centered on linguistic evidence superimposed onto archaeological cultures. In her review of Bosch-Gimpera, Gimbutas (1963a) examined the archaeological evidence from the Soviet Union in support of east-west flow of people, things, and cultural influences that led to large scale social and economic reorganization in the Copper Age (Chalcolithic). Specifically, the disruption of longstanding Neolithic societies in the third and second millennia because of the spread of "Indo-Iranian vagabonds" from the Eurasian steppes into central Europe (Gimbutas, 1963a:816). Gimbutas built on Bosch-Gimpera's model in positing that horse-breeding Kurgan cultures from the lower Volga River area around the Aral Sea to the Altai mountains (present-day Kazakhstan and Uzbekistan) expanded north of the Black Sea into the lower Dnieper River region (present-day eastern Ukraine) around 2400-2300 BCE (uncalibrated). This expansion led to abrupt cultural changes associated with cultural and demographic domination of the local North Pontic/Mariupol culture by "Kurgan people". The Kurgan culture introduced domesticated horses, wheeled vehicles, and new burial practices (*i.e.,* contracted inhumation in pits under earthen barrows marked by stone stelae) and lived in fortified hill settlements (Gimbutas, 1963a:821). From the Pontic steppes, elements of the Kurgan culture spread southwest to the Carpathian Basin and southeast along the Black Sea coast around 2400-2200 BCE (uncalibrated). Evidence for this is based on early Kurgan graves that are contemporaneous with Middle Copper Age Bodrogkeresztur sites in Hungary and western Romania, classic Tripolye culture in eastern Romania and western Ukraine, and Salcuţa culture in Romania and Bulgaria. According to Gimbutas (1963a:827) the Kurgan culture ultimately conquered two-thirds of the European continent, in the process overthrowing and destabilizing local Neolithic cultural practices, economies, social structure, and belief systems.

Gimbutas's model, known as the "Kurgan hypothesis" (Gimbutas, 1963a; 1965), was subsequently modified to reflect advances in radiocarbon dating, organizing it around three waves of migration: Wave 1 (4400-4300 cal. BCE), Wave 2 (3400-3200 cal. BCE), and Wave 3 (3000-2800 cal. BCE) (Gimbutas, 1977). The movement of warlike horse-riding pastoralist invaders from the Eurasian steppes characterized each of these waves, leading to widespread upheaval and cultural change in eastern and central Europe. In describing pre- vs. post-migration Europe, Gimbutas (1977:281) characterized the condition of "Old Europe" as one of sedentary egalitarian horticulturalists who lived in large well-planned towns, worshipped a lunar mother-goddess, and were matrilineal and matrilocal. The socially stratified Kurgan system, which was patrilineal and based on stockbreeding and grazing, replaced Neolithic worldviews and belief systems. They were attracted to the grasslands of eastern Hungary as conducive to an economic system focused on stockbreeding, including horse husbandry. Kurgan communities lived in small villages or hamlets and worshipped a warrior-male sun deity. Superior technology in the form of domestic horses, wheeled vehicles, and bronze weaponry aided the adoption of the Kurgan system over local Neolithic traditions. The culture historical model posited fourth and early third millennium invasions of Kurgan peoples into the Carpathian Basin and central Balkans leading to cultural hybridization and coexistence in some areas, and to displacement in others. For example, Gimbutas (1977:311) suggested the central Balkan Vinča culture and the western Hungarian Lengyel group were forced west and north, respectively. In contrast, she interpreted the Early Copper Age Tiszapolgar as an indigenous group that easily adapted Kurgan pastoralism to the grasslands of eastern Hungary, and in the process embraced their customs and belief systems.

2.2.2 Paradigm of Culture Change: Processualism

The "Kurgan hypothesis", coupled with Gimbutas's thorough and encyclopedic synthesis of Eurasian and eastern European culture history, shifted focus from a Near-Eastern/Mediterranean origin for Bronze Age cultures in Europe to a Central Asian one. Subsequent criticisms of Childe's diffusionist perspective and Gimbutas' migration hypothesis challenged reliance on externally driven models to account for divergence in cultural trajectories of the Neolithic, Copper, and Bronze Ages (Chapman, 2009). Beginning in the 1970s, there was a shift in the study of prehistoric archaeology in Europe to examining the roles of internal economic and social processes coupled with environmental factors that produced culture change in the past. This movement was spearheaded by early proponents of processualism in Europe, notably British archaeologist Colin Renfrew (1968; 1969a; 1969b; 1974). The advent of radiocarbon dating and the shift away from the application of traditional relative chronologies based on Aegean and Near Eastern sequences supported arguments for an autonomous development of Bronze Age societies.

Renfrew promoted this perspective in his 1968 article, "Wessex without Mycenae". In this landmark study, he used radiocarbon evidence to argue against the supposed synchronicity of EBA sites in southern England with the Aegean Late Bronze Age. He demonstrated that in contrast to traditional chronologies, early evidence for metallurgy and social differentiation from England and central and northern Europe predated sites in the Aegean by several centuries, thus precluding the spread of Mycenaean cultural influences as the cause of cultural change in the EBA. Similarly, Renfrew applied this approach to deconstructing Childe's holistic culture-history narrative of the central and southeast European EBA (*e.g.*, Neolithic Vinča culture, EBA Unétice culture) as stemming from the spread of cultural and technological innovations from Troy I sites in the Aegean into the western Balkans (Renfrew, 1969b). Based on these findings, Renfrew (1969b:13) proposed an alternative hypothesis: Troy I and the Aegean EBA postdated Copper and EBA cultures in Bulgaria, Romania, Hungary, and Serbia, therefore metallurgy in these areas developed independently from Aegean and Anatolian cultural and ideological influences.

Renfrew's work marked a turning point in how scholars constructed and viewed cultural trajectories in prehistoric Europe, shifting the focus away from that of the civilizing influence of Oriental civilization on European barbarism to a new perspective that recognized the prehistoric inhabitants of Europe as cultural and technological innovators in their own right. The untenability of the diffusionist perspective, in light of this important new scientific evidence realized through radiocarbon dating, meant scholars now had to consider alternative causes to explain patterns of culture change in the archaeological record of central and southeast Europe (Renfrew, 1974). Expanding on this approach, Renfrew (1969a; 1974) applied a "social archaeological" perspective to study internal social and economic causes of culture change. He drew from theoretical contributions of American archaeologists working in the Processual/New Archaeology framework (Binford, 1965; Willey & Phillips, 1958). Processualism emphasized a neo-evolutionary approach to developing generalizing, explanatory, hypothetico-deductive models of social development and cultural change. This contrasted with the prevailing culture-history paradigm in Europe that saw cultures as indivisible units and culture change as a unilineal process. Rather than mapping absolute cultural units in space and through time, and interpreting changes in the material record as evidence of "influences" (*i.e.*, invasion, migration, or diffusion), Renfrew (1969a:153) proposed shifting the analytical focus away from "things" and towards "systems". He argued that cultures constitute an aggregate of economic and social systems and subsystems, including subsistence (agriculture, stock-rearing, fishing, hunting, etc.), productive economy (metallurgy, decorative pottery, etc.), trade, and social organization. Among these, he saw trade and exchange as playing central roles in influencing the organization and evolution of prehistoric economies and social systems.

Renfrew (1969a:154) differentiated between trade in material commodities with restricted geographic distribution (*e.g.*, salt, tin, copper, amber, obsidian, etc.), and products whose production required specialized skill and knowledge (*e.g.*, Hittite iron, Egyptian faience, silk). An important caveat to this is that trade, exchange, and production – like other systems – are inherently social. Thus, it is a false dichotomy to separate the material and environmental from the underling social, political, and spiritual milieu. In adopting a "social anthropological" approach to archaeology, Renfrew (1974:70-71) identified the need to integrate documentation of prehistoric subsistence and technology into broader theoretical models that consider social change and demographic growth in the context of economic, political, and social processes and networks. In this regard, changes occur *within* culture systems due to "…the consequences of processes operating locally" (Renfrew, 1974:71). Instead of change being introduced via external cultural agents, it was brought about by positive feedback between the various subsystems that comprise a culture, something Renfrew called the "multiplier effect" (Renfrew, 1972:37). Thus, economic progress and social change do not operate in a vacuum, independent of one another. Rather, two conditions must exist for the "multiplier effect" to operate to produce culture change: (1) a society must cultivate innovation and adopt ideologies that promote economic and demographic; and (2) investments in a new idea, resource, or technique require adequate social support to be sustained and transmitted.

Culture thus functions as a regulatory mechanism that can enhance or hinder growth, defined here as demographic increase, adoption or invention of new ways of doing, and/or creation of new relationships. Conversely, economic and cultural practices rather than environmental conditions limit growth, especially food production combined with social rules and pressures. Another key element of this concept of growth harkens back to Childe's Marxist progressivism – these changes are irreversible; human societies cannot revert to previous forms. Additionally, human societies vis-à-vis the *multiplier effect* are not limited by the Law of Diminishing Returns. According to Renfrew (1972; 1974), unlike natural systems, which experience a condition of relative stasis following rapid growth, sustained growth in human societies is possible as long as connections are established across cultural subsystems through the adoption of new technologies or ideas, formation of new social categories, and/or development of new trade relations. For Renfrew (1972:40), this approach could be applied to test two complementary hypotheses related to the development of early complex societies: (1) namely, that improvements in food production techniques (*e.g.*, irrigation, traction, etc.) and storage arose prior to development of social stratification or religious specialization; and (2) that increase in trade and the development of new trade relations does not in and of itself lead to growth unless it intersects with other subsystems such as social organization.

2.2.3 Paradigm of Culture Change: Towards a Study of Middle-Range Societies

Renfrew was one of the first archaeologists to go beyond simple migration and diffusion models of social change, and consider the role of internal social and economic processes mediated by cultural values and beliefs on the adoption of new technologies, development of economic and social relations, and ultimately, emergence of social stratification in prehistoric Europe. Expanding on Renfrew's concept of the *multiplier effect*, several researchers began examining the underlying causes of change in specific social systems and subsystems to examine the emergence of and variation in social and economic complexity in prehistoric middle-range societies in Europe. Two major, somewhat complementary theoretical trajectories, explain the social and economic mechanisms driving the emergence of social complexity in prehistoric Europe: Stephen Shennan's core-periphery model and Andrew Sherratt's subsistence specialization model (see Renfrew & Shennan, eds., 1982).

It is important here to define *middle-range societies* in the context of archaeological theory and practice. The term arose in response to the prevalence of unilinear social frameworks to classify and compare societies based on supposed universal typologies, such as tribe, chiefdom, state, or civilization (see Service, 1962; Fried, 1967). Broadly, middle-range societies refer to an organizational category between 'tribe' and 'chiefdom'. Middle-range societies are segmented, being comprised of successively more inclusive social units, but lack the specialized administration political control characteristic of state-level societies (Duffy, 2010:45-46; Earle, 1987). Segmentation in middle-range societies take the form of vertical or horizontal social distinction. Horizontal social distinctions correspond to membership affiliations, such as kinship and occupation that do not confer advantages in terms of wealth or status (Parker Pearson 1999). Vertical distinction is defined as political differentiation derived from economic control tied to rank and status, which Earle (1987:290) referred to as an "incipient aristocracy". To this end, patterns of wealth distribution in burials that crosscut horizontal categories, such as age or gender, are seen as ritual behavior that reflect vertical social distinctions (Binford, 1971; Peebles & Kus, 1977; Saxe, 1970; Shennan, 1982). Importantly, middle-range societies do not exist as an absolute structural entity, but rather constituted

"…a spectrum of political and economic possibilities between unsegmented societies and states" (Duffy, 2010:50).

In developing a theoretical model to explain why some societies develop position of valued social status – or rank – that is restricted to certain privileged members, Fried (1967) distinguished between wealth and prestige. This distinction was crucial to differentiating between stratified and non-stratified ranked societies. For example, in stratified societies, institutionalized social rank translates to wealth differences in the form of the use of prestige goods to acquire productive resources such as food, labor, and land. In contrast, in non-stratified ranked societies the accumulation of or association with prestige among certain groups or individuals, often displayed materially or behaviorally in culturally proscribed ways (*e.g.*, dress, ritual, architecture), is due to their privileged position within spheres of exchange rather than success at accumulating material wealth. Additionally, high-ranking members of non-stratified societies continue to function as part of the general labor pool, the division of which according to Fried (1967:115) often follow age and sex. Key characteristics identified by Fried (1967) that unite ranked compared to egalitarian and stratified societies include: dependence on domesticated foods; redistribution through reciprocal exchange; village pattern of settlement; kinship-based social organization (lineage ethos); minimal division of labor beyond age and sex; and authority recognized in decision-making (*e.g.*, when to plant, when to harvest, conflict management and resolution) and religious/ceremonial activities. A central component of stratified compared to unstratified ranked societies is the explicit politicization of certain activities and institutions, for example division of labor based on social status, gender, and age (Fried, 1967:129-131).

Subsequent practitioners studying middle-range societies departed from this traditional interpretation of "ranked" societies. While Service's (*i.e.*, band, tribe, chiefdom, and state) and Fried's (*i.e.*, egalitarian, ranked, and stratified societies) terminology continued to be used, Renfrew, Shennan, and others rejected the use of ideal types as ignoring and trivializing the realities of cultural diversity and social variability observed in both the ethnographic and archaeological records (see Renfrew & Shennan, eds, 1982). Rather, social models of complexity were posited as hypotheses to be tested rather than absolute characterizations of societies in the past and present. Central to the neoevolutionary perspective ensconced in approaches to studying middle range societies was the recognition of these societies as being not quite egalitarian, but not entirely class-based. They included a combination of horizontal and vertical social distinctions, the manifestation of which varied overtime at regional and local levels. In this regard, despite their variability, these societies act as important resources for studying and identifying the factors – demographic, technological, and social - that contributed to the development of increasingly inclusive groupings characterized by some degree of specialized political or economic control (see Duffy, 2010:45; Kelly, 2000).

2.2.4 Sherratt and Economic Intensification and Specialization

Sherratt's study of social change in the context of the evolution of social complexity in prehistoric Europe focused on two key economic factors: resource intensification and economic specialization. According to Sherratt, the evolution of societies in prehistoric Europe was marked by cycles of increasing and decreasing social and economic complexity rather than unilinear progression from egalitarian early farmers to increasingly stratified polities (Sherratt, 1982a). For most of the Neolithic and Copper Age in Europe, Sherratt (1982a:15) noted that early agricultural communities were capable of operating and maintaining large-scale exchange networks in the absence of social hierarchy. The question then remains: *in the absence of clearly defined social hierarchies, what factors – economic and social - enabled the formation of complex European trade networks beginning in the 5th millennium BCE?*

Focusing on the Carpathian Basin as a geographically and culturally delineated regional system, Sherratt (1982b) concentrated on changes in settlement patterns, subsistence practices, material culture, ritual (*e.g.*, funerary), and exchange (*e.g.*, quantity and variety of imported resources) from ca. 6000 to 3500 BCE. Based on diachronic comparisons, he developed a model to explain the apparent contradiction between lack of clear evidence for social inequality and the emergence of regional exchange systems. This model focused on the intensification of cattle breeding in the Carpathian Basin during the Neolithic and increased consumption of a wider range of exotic goods acquired through regional exchange relationships as they led to the transformation of cattle from a purely subsistence resource to a form of negotiable wealth. Social organization and membership were based on affiliation with local lineages or moieties, which were often in a state of fluctuating coalitions and alliances that affected social and economic relationships. While integration was ultimately horizontal through descent groups, political negotiations and control of (regional) economic transactions were under the purview of males. Alliances were formed and maintained through exchange of not only valuable subsistence and material commodities, but also marriageable women and associated bridewealth (Sherratt, 1982a:22). Sherratt's conclusions regarding the social context of economic exchange were based, in part, on concentrations of non-local grave goods (*e.g.*, spondylus ornaments, copper, amber) in burials of senior males at the late Bandkeramik cemetery at Nitra in Slovakia, and a similar, though not as pronounced, pattern at the Middle Copper Age cemetery at Tiszapolgár-Basatanya in Eastern Hungary (see also Chapman, 2005; for a criticism of this interpretation, see Derevenski-Sofaer, 1997). Complementarity underscored trade between regions and localities at this time, with some utilitarian items (*e.g.*, stone axes) taking on prestige associations for the purposes of gift-giving and reciprocal exchange.

Changes in resource use and subsistence strategies have been proposed as one of the major causes of changes in settlement organization and social structure in European prehistory (Renfrew, 1982; Sherratt, 1982a, 1983). The role of agricultural intensification and exploitation of secondary animal products on variables such as social complexity, group size, population mobility, and inequality were inferred indirectly from settlement and household evidence for social integration, interaction, and productive economy (Champion, 1982; Parkinson, 2002; Renfrew, 1982; Sherratt, 1982a, 1983). Much of this was rooted in Sherratt's (1983) model of post-Neolithic developments in animal husbandry, which he referred to as the "secondary products revolution". This model posited a shift in the Copper Age and Early Bronze Age to a greater emphasis on a secondary exploitation of domestic animals that went beyond meat consumption (see Giblin, 2011; Giblin et al., 2013; Greenfield, 2010; Hoekman-Sites & Giblin, 2012). This included use of animals for traction for field cultivation, dairying, transport and trade, and use of wool for textile production (Greenfield, 2010; Sherratt, 1983). These alternatives to raising domestic animals solely for their meat would have had major implications for stock-raising and herd management in prehistoric communities. Growth of herd size would have required greater area for grazing, culling of juveniles as part of a dairying strategy, and changes in sheep harvesting profiles to reflect the retention of adults for wool production (Greenfield, 2010; Sherratt, 1982a). Additionally, raising animals as breeding stock, for milk, traction, or wool may have required greater exploitation of cultivated crops, gathered foods, hunting, and fishing as part of a mixed-subsistence regime. According to Sherratt (1983), adoption of a mixed-pastoral and farming economy characterized by specialized forms of animal husbandry allowed for an increase in population size and precipitated changes in land-use and land-tenure that had structural implications for local economies and social systems (Sherratt, 1983:100). These changes laid the foundations for urbanization in the Fertile Crescent, and contributed to regional, local, and individual differences in wealth and status in Europe. This was apparent from recent excavation of the EBA/MBA Maros settlement at Pecica-Santul-Mare in Romania, which showed evidence for specialization in horse breeding that contributed to the site emerging as a regional economic center while maintaining political autonomy (Nicodemus, 2014).

2.2.5 Shennan, Kristiansen, and Regional Systems

Asymmetric relations of production and political economy rooted in structural Marxism figured prominently in explanatory models of emerging social and economic complexity in the Bronze Age (see Kristiansen, 1991; Sherratt, 1993a; 1993b). Central to these models was the production and exchange of metal, especially arsenical bronze. The idea that bronze was central to social and economic life can be traced to Childe's emphasis on elite control of metal and metalworking as enabling concentrations of power in local and regional centers in the Near East (see Duffy, 2010; Harding, 2000). For Shennan, copper, tin and bronze served as the material basis around which Bronze Age regional exchange systems developed (Shennan, 1993a; 1993b). Access to these metal commodities varied geographically, with regions and locales serving as either production cores or peripheries. Borrowing from Mary Douglas' (1978) concept of 'grid' and 'group' analysis to assess the relative openness of social and economic boundaries, Shennan

(1993b) emphasized that social categorization and participation in regional exchange systems – not social complexity – were instrumental in reducing social and political barriers that allowed for the formation of long-distance exchange. This process created a widespread demand for copper, tin and bronze as commodities that were simultaneously widespread and desired, yet restricted in their source as a natural resource and function as special items of production and consumption in the form of personal adornment and ornamentation (Shennan, 1993b:61). During the central European Copper Age, and throughout the EBA, metal functioned primarily for social display by emergent local elites rather than a commodity valued for its material properties of durability and malleability.

Shennan (1993a:149) characterized the central European EBA (ca. 2300-1500 BCE) as a period of major social and economic change leading to the establishment of social ranking and settlement hierarchies. The mid- to late-3rd millennium BCE in Central Europe (including the Danube Valley and the Carpathian Basin) saw the coalescence of dispersed farmsteads into large settlements, the shift from households and settlements to large cemeteries as the principal arena of ritual practice, and the increased importance of plow agriculture, horse breeding, and stock-rearing for local economies. Apparent material inequalities, especially between men and women, also appeared at this time as evidenced by the types of ornaments and costumes found in male versus female burials (see also Neustupný, 1973; and Susan Shennan, 1975). Shennan (1993a) interpreted this distinction as resulting from the devaluing of the domestic sphere, and a predominance of a generalized male ethos that celebrated masculine activities and values such as hunting, warfare, and exchange of and control over exotic prestige goods and materials. Shennan's (1993a; 1993b) characterization of broad social and economic change in the EBA was one of male-control over prevailing spheres of social, political, and economic interaction, and diminished authority of women, with cultural practices and beliefs favoring patterns of female exogamy, bridewealth, and patrilineal inheritance.

The major debate centered not on a general pattern of change, but what underlying factors precipitated the cultural, economic, and political patterns that differentiated EBA societies from Neolithic and Copper Age groups in Central Europe. In contrast to Gimbutas' emphasis on Eurasian Steppe migration in Central Europe via the Pontic Steppes, Shennan (1993a; 1993b; 1999), Sherratt (1983a; 1997), and others

(Chapman, 1994; Kristiansen, 1998) downplayed migration as a unilateral cause of culture change in the EBA. In the context of Corded Ware and Bell Beaker cultures in northern and central Europe, Shennan (1993a:141) argued:

> Discussions in the mechanisms of change involved in the appearance of these two phenomena have been paradigmatic of the theoretical changes which have occurred in European prehistory over the last 20 years with long-standing migration models replaced by explanations in terms of emulation, prestige, and risk minimization arising from changing patterns of production.

According to Shennan's (1993a) core-periphery model of economic and cultural change, the emergence of a new economic pattern provided the basis for the development of social ranking and stratification through individual control over and between-group competition associated with production and exchange of prestige goods (*e.g.*, metal, amber, salt). In contrast, Sherratt (1991) argued that it was the introduction of new subsistence technologies and practices, and their adoption by local communities that led to new forms of resource control. According to Sherratt's (1997) model, specialized local production (*e.g.*, cattle and cattle products in the Carpathian Basin) served as valuable resource reservoirs controlled by powerful local agents, such as lineage heads, that could be exchanged for the purposes of creating or maintaining alliances with neighboring groups. Exchange relations were likely governed by ritual as well as political and economic components. Thus, circulation, acquisition, and control of exotic prestige goods (and people) likely occurred in the context of ritual negotiations of social relations and status, such as marriage/bridewealth, gift-giving ceremonies, and funerals, as well as conflict through intermittent raiding, abduction, and capture. Additionally, the relative uniformity of prestige good types over large areas suggests broader recognition of material correlates of competitive display and social status (Kristiansen, 1998).

While Shennan (1993a; 1993b) and Sherratt (1983a) emphasized the spread of innovations and ideas, Kristiansen (1988:2) focused on the interplay between center-periphery relations in the formation of a "competitive European tradition". This "competitive tradition" was instrumental in leading to the rise of organizational complexity, technological innovation, and regional traditions that informed the cultural framework in which society was reproduced and upheld through politically-mediated economic exchange. Kristiansen (1998: 2-3) and Earle and Kristiansen (2010:12,16) cited factors such as alliances and trade, movement of people, and processes of materialization that underscored how certain material culture through its association with symbolic meaning and institutions of power, acquired significance within regional political and ritual economies. To this end, Earle and Kristiansen (2010:16) identified "three pillars of Bronze Age economies": (1) ritual economy (ritual chiefs, metal production and deposition, ceremonies); (2) political economy (warrior chiefs, alliances, exchange and trade, warfare); and (3) domestic economy (farmsteads, storage, production). Linking and maintaining these pillars was an economy based on exchange of metal and prestige goods (rather than staples), and the flow of tribute (goods and people), labor, cattle, and warriors. According to Kristiansen, Bronze Age Europe was sustained by regional and interregional dependencies maintained via trade and strategic alliances, but ultimately resistant to the formation of larger state-level polities. The EBA and MBA represented periods of interregional dependency, but not consolidation and regional supremacy. To address this, Kristiansen (1998), drawing on Renfrew and Shennan (eds., 1972), proposed a World Systems model for Bronze Age societies characterized by a series of economic and political attributes: politically autonomous regional economic systems; regional exchange networks superseded individual political units; cyclical fluctuations in social strategies and ritual consumption (*e.g.*, destruction versus deposition of wealth); dependence of (successful) political economies on preserving open and competitive systems; and existence of long-distance exchange networks *in absentia* of economic centers (nodes) and peripheral territories.

Kristiansen (1998:365) identified two copper mining and metalworking centers in the EBA (ca. 2000-1500 BCE): an Atlantic operation in the west marked by small-scale metallurgical centers from Ireland through Iberia to Central Europe, and a more widespread central European-Danubian-northern European network with sources in the Western Carpathians. Beginning around 1700 BCE, there was an expansion in the variety of metal items produced and circulated along these long-distance trade networks, shifting from simpler axes, daggers, and coils/rings, to more complex ornaments, swords, and lances. Earle and Kristiansen (2010:21), in their introduction to *Organizing Bronze Age Societies: The Mediterranean, Central Europe, and Scandinavia Compared*, stated: “Following an economic setback in the Near East in the late 3rd millennium BCE, a new expansion and search for tin, gold, and copper began. A metallurgical explosion took place in Europe; within a few generations, large-scale mining and mass production of tin bronze reached high levels.” This statement relates to, and expands on, Kristansen’s earlier work (see Kristiansen, 1998), which posited that the emergence of new metallurgical centers throughout central and western Europe were the catalyst for the formation of long-distance continental exchange networks focused on exotic prestige items (*e.g.*, Baltic amber appearing in Wessex or Mycenae, central European tin in the eastern Mediterranean). Concomitant with the formation of these exchange networks were broad social changes throughout Europe in the EBA. These changes included the appearance of ‘princely graves’ and cemeteries as important sites of social performance and economic competition, a general pattern of emerging settlement hierarchies marked by fortified settlements dominated by chiefly residences surrounded by smaller open settlements, and local economic changes such as division of labor, commoditization of metal, and metallurgical specialists. This characterization was overly generalizing, with subsequent comparative analyses showing the reality to be much more heterogeneous, with most regions having weak evidence for clearly delineated settlement hierarchies in the EBA (see Duffy, 2010; Harding, 2000; Earle & Kolbe, 2010; O’Shea, 2011). Somewhat contradictory to his larger World Systems model of Bronze Age economies was Kristiansen’s (1998:368) identification of the appearance of small bronze-producing groups along the Danube and into Switzerland and eastern France in the EBA. These groups were marked by small villages or hamlets (often near rivers or lakes), burial of the dead in communal cemeteries, and a subsistence economy focused on grain cultivation and cattle herding. The existence of a common stylistic repertoire of metal ornaments and weapons provided evidence of an active regional and local metallurgical industry.

In discussing the extent of social and economic transformations in Europe from the 3rd to the 1st millennia BCE, in the context of world system center-periphery relations, Kristiansen (1998:415-16) identified two geopolitical regularities or “systems”: (1) formation of regional hierarchies in Europe due to intensification of indirect economic relations between the Near East and Mediterranean, and central and northern Europe marked by the appearance of new production and distribution centers (*e.g.*, Otomani and Late Hallstatt cultures in central Europe) and trade centers (*e.g.*, Mediterranean); and (2) subsequent political fragmentation in the Mediterranean resulting in collapse of existing north-south center-periphery relations, resulting in a reorientation of exchange networks to east-west during the Urnfield and Middle La Téne periods. A third pseudo-system represented a transitional phase between these two dominant geopolitical systems, characterized by the emergence of warrior societies in response to influences from the eastern steppe and/or internal conflict and reorganization arising from the collapse of established exchange relations. Local shifts (both rapid and long term) in economic relations and social organization took place within these larger world-historical changes, which from 2000 to 150 BCE cycled between regional systems dominated by heterarchical peer-polity interactions and those characterized by hierarchical patterns of center-periphery dependence. This dynamic between local versus regional changes overtime best represents the central tenet of Kristiansen's world systems approach, which argued for interdependence between local processes and regional systems. Kristiansen has summarized this relationship (1998:416-17):

> We should also be aware that local processes of evolution and devolution always occurred. Such local declines and rises were inherent features of the reproduction of larger regional systems. In the long run the balance between such multiple local processes determined the developmental potential of the regional system. Dominance, exploitation, and the emergence of hierarchies, whether local or regional, were normally the result of multiple local processes of centre-periphery relations…whether they were warrior aristocracies (raiding, taking tribute and trading = wealth finance), sedentary agricultural communities (tribute = staple finance), or commercial centres of metal production and supply (trade = wealth finance).

To summarize, while local processes were integral to the reproduction of larger systems, this effect was cumulative and multiple (*e.g.*, disruption in a single locality likely would not have collapsed an entire system). Rather, regional dominance and consolidation of multiple local systems were key to the formation of economic and political centers overtime. Breakdown of economic and social relations in one locale could lead to the formation of a new center. Kristiansen (1998:417) used evolution and devolution to refer to cycles of more or less rigid social differentiation and settlement hierarchy in different locales or regions. During the EBA, the emergence of the Carpathian Basin as a regional center was closely associated with its proximity to sought-after natural resources (*e.g.*, salt, copper, tin, gold) in the neighboring Carpathian and Apuseni mountains. However, it was the lowlands adjacent to these regions with limited natural resources of their own that rose to dominance in the EBA, utilizing a rich network of waterways to move goods in and out of the Pannonian Plain (O'Shea, 2011). Within the Carpathian Basin, The Maros culture group benefitted from their proximity to and control over both staple (*e.g.*, horse breeding, salt) and wealth (*e.g.*, gold, tin, copper) finance (Duffy, 2010; Nicodemus, 2014; O'Shea, 2011). Despite this, there is no evidence that Maros settlements were integrated into a single dominant polity. At this early stage, wealth did not translate to regional political and/or economic power. Evidence for status vis-à-vis material wealth differences occurred primarily between individuals, as evidenced by mortuary patterns from large Maros cemeteries, such as the Early Maros (2100-1800 BCE) cemetery at Mokrin (O'Shea, 1996; Rega, 1997). Within settlements, there was some evidence for wealth differences between households based on variation in household ceramics (Michelaki, 2008). Most likely, the Maros had privileged access to highly valued trade goods, which allowed them to sustain mutually beneficial peer-polity relations with neighboring groups. This privileged position seemed to breakdown by the Late Maros period (1700-1500 BCE). This breakdown was roughly coincident with the emergence of the Alpine region as a metallurgical center with trade relations with northern and western Europe. The question remains: was the "decline of the Maros" associated with larger geo-political changes in regional systems occurring across Europe at this time, or is there evidence for local conflict and instability due to social or ecological issues that resulted in apparent marginalization of the southeast Carpathian Basin in the MBA?

Shennan (1993a) disagreed with Sherratt's (1993) and Kristiansen's (1998) assertions that control over metal surplus led to the formation of local and regional centers of powerful chiefdoms, and that production and circulation of prestige goods in peripheral areas was driven by elite competition (see Duffy, 2010). Rather, bronze metallurgy resulted from technological development and not social demand, with metal consumption stimulating economic activity and intergroup competition in different regions in the form of access to wealth rather than political control and domination (Duffy, 2010; Sherratt, 1993). In contrast, Kristiansen emphasized changes in the demand for metals and organization of metal production as contributing to the transformation from centralized sedentary elite controlled centers in the Bronze Age to decentralized warrior societies in the Iron Age (see Harding, 2000:421). The debate over the changing role of metallurgy in local and regional economies focused on differentiating between ore extraction, metal processing, and exchange between metal-producing and metal-consuming areas. Shennan (1993b) proposed that small autonomous groups living in geographic proximity to natural ore deposits carried out copper mining and smelting. Additionally, mining might have been a seasonal activity, with households participating during winter months when labor demands from agriculture were low. As Shennan (1993b:66) noted: "Obtaining copper from its sulphide ores was an arduous and complex activity, carried out in remote places, and the metals seems to always have moved in smelted from rather than as the ore…". While both Shennan (1993b) and Kristiansen (1999) argued for a central European-Carpathian metal producing core and northern and western periphery during the EBA, the Carpathians as a major source of copper and tin declined in the late EBA/early MBA. Proximity of central Germany to copper sources of the eastern Alps did not translate to a concentration of wealth during the EBA. This pattern deviates from that seen in the Carpathian Basin during the EBA, whereby proximity afforded privileged access to prestige copper items acquired from neighboring regions. Rather, central Germany likely relied more on exchange of salt than metal in supporting small-scale local hierarchies.

As the case of the Carpathian Basin as an emerging regional network in the EBA suggests, while concentrations of wealth in certain regions did occur, inequalities seemed to emerge between individuals rather than polities. Thus, control over and competition for metals occurred in the context of individuals rather than institutions. Metals and other exotic trade goods provided a means to expand social relations and influence (prestige) through exchange. In the Carpathian Basin, O'Shea's analyses of mortuary variation (O'Shea, 1996) and settlement pattern and layout (O'Shea, 2011) among the Maros provides tentative support for this hypothesis. O'Shea concluded that despite apparent inter- and intra-cemetery wealth differences and variation in settlement size and layout (*e.g.*, fortified tells versus unfortified open sites), settlements represented autonomous political units integrated through cultural affiliation rather than political control. In contrast, to the north in the Körös River valley, Duffy (2010) found little indication of individual or settlement differences in wealth or status. Additionally, Riebe (2016) found evidence of variation in local ceramic exchange systems during the Late Neolithic (ca. 5000-4500 BCE), with some groups or polities interacting regularly, while others appearing more isolated.

Synthesizing the overlapping and often competing models for the emergence of social and economic complexity for the EBA is a daunting task. A key theme that links Shennan's, Sherratt's, and Kristiansen's models is the significance of the development of regional economies in fostering the emergence of social complexity, individual and local/regional specialization, and incipient socio-political hierarchies in the EBA.

A useful synthesis has been provided by Duffy (2010), who proposed a model for analyzing and comparing attributes of prehistoric European Middle-Range Societies. Duffy's model focuses on the relationship between environmental, economic, and ideological factors that influenced Bronze Age site size and composition in the Körös River valley in eastern Hungary. This model draws on the ethnographic and archaeological records, especially Goody's (1976) comparison of inheritance customs and rules as a major cultural difference between Eurasian and African societies, and Childe's (1954) argument that the generation of agricultural surplus following the introduction of the plough drove changes in individual and household inheritance. Duffy (2010:54-55) proposed eight social dimensions underlying social change and increased complexity in Middle Range Societies: primary unit of production/consumption, segmentation, household distinction, access to exotics, craft production, demographic scale, intensification of food production, and regional consolidation. He hypothesized that changes in one or more of these dimensions precipitated a shift to increased complexity, with the numbers representing the relative magnitude of each dimension in this process (*e.g.*, changes in the primary unit of food production/consumption were likely to have a smaller effect than that of regional consolidation). Duffy's model drew on Renfrew's (1972; 1974) concept of the *multiplier effect* to explain how interaction between systems (and subsystems) led to growth and produces change over time, acknowledging that certain changes were likely to have a bigger impact (magnitude) than others. Central to both Duffy's social dimensions and Renfrew's subsystems was that no single causal factor can explain social change in Middle-Range societies throughout space or over time. Importantly, and as Duffy (2010:55) noted, these dimensions correspond to material correlates and are testable using the archaeological record.

Duffy's model is useful for studying the diverse organizing components that underlie middle range societies; specifically, the utility of middle range societies as analytical and theoretical units to test hypotheses and develop models of social complexity in prehistoric central Europe. The underlying assumption is that Middle Range societies, and by extension changes in middle-range trajectories, show considerable variation in their social and political organization. Perhaps most useful for bioarchaeological analysis focused on intersections between health, diet, and social status are segmentation (social stratification), access to exotics (grave goods), demographic scale (fertility, mortality, and demographic composition of Maros communities), and intensification of food production (sources of dietary protein and individual variation in animal protein consumption).

2.3 Contemporary Theoretical Paradigms: New Approaches to the Study and Interpretation of Culture Change and Social Complexity in the Carpathian Basin

In this section I will build on and relate to new insights into prehistoric life in the Carpathian Basin gained from the application of new methods allowing for testing (and retesting) of existing theories (outlined above), thus refining understandings of social organization and economic interaction in the past. Scholarship in the Carpathian Basin since the 1980s has greatly expanded our knowledge of these issues and worked to challenge conventional models about societies in the Bronze Age through reanalysis of existing datasets, use of archaeometric techniques, and regional surveys. For example, scholars have shown that in contrast to the general homogeneity of Copper Age lifestyles and cultural practices, the EBA and MBA in the Carpathian Basin were characterized by cultural diversity. Neighboring groups exhibited differences not only in ceramic styles, but also in forms of dress, burial rites, domestic architecture, and settlement pattern and organization (Duffy et al., 2014; Sorensen & Rebay-Salisbury, 2009).

Chapter 3 of this dissertation provides a more nuanced overview of culture history of the Pannonian Plain from the Copper Age to the Late Bronze Age, spanning the periods prior to and following the emergence of the Maros culture group in the southern Pannonian Plain. The following sections summarize some of the novel methods and approaches that have shaped more contemporary understandings of prehistoric peoples and society in this study region, which have provided the important foundation for this dissertation research. Content focuses on research organized chronologically (by archaeological time period) within three major archaeological domains: settlements, households, and mortuary.

2.3.1 Settlements

Recent research on prehistoric settlement patterns in the Carpathian Basin, specifically the Pannonian Plain, has focused on two central themes: (1) the influence of social transformations on the prehistoric landscape; and (2) relationship between physical (local ecology) and cultural landscapes. These reflect broader theoretical influences from landscape archaeology on settlement study and analysis (see Chapman, ed., 2010; O'Shea, 2011). In particular, how humans adapted to and modified the natural environment and diachronic reuse and reordering of landscapes in the context of changing social, economic, and symbolic practices and beliefs (Guttmann-Bond & Kluiving, 2012). One of the major challenges to understanding settlements in the context of paleoenvironments in the Pannonian Plain was the systematic 19th century canalization, levee construction, and drainage of this area, which rerouted or destroyed the preexisting fluvial landscape (Gyucha et al., 2011). This is especially important in light of evidence that the slow, meandering rivers and streams that cut across the marshland in the Körös and Maros-Tisza river basins served as key resources for transportation (O'Shea, 2011) and sources of food (Nicodemus, 2014) in prehistory.

Parkinson (2002) identified several major changes in settlement patterns, settlement types, households, and mortuary practices in the Pannonian Plain from the Late Neolithic (LN) (ca. 5000-4500 BCE) to the Early Copper Age (ECA) (ca. 4500-4000 BCE). He argued that these changes reflect significant social transformations influencing the structural organization and makeup of communities. Parkinson asserted that there is no evidence of institutionalized social ranking during this time (Parkinson, 2002:391). He noted major changes across several analytical dimensions, principally the spatial scale of cultural groups, predominant settlement type and organization, settlement number and location, trade networks, and mortuary practices. Briefly, in contrast to the nucleated settlement pattern comprised of large tell sites, tell-like mounds, and flat sites, extended family dwellings in multi-room longhouses, and burial in settlements in the LN, there was shift in the ECA to dispersed more ephemeral flat sites, single-room houses, and burial in formal cemeteries not associated with a single settlement. Parkinson (2002:394) points to changes in integration (processes that bring people together to create formalized units, often with a decision-making function) and interaction (general, more diffuse social processes occurring at the group and individual level).

In the absence of an institutionalized central authority, small-scale societies retain a high degree of social flexibility contributing to a phenomenon known as "tribal cycling" (Johnson, 1982). The LN pattern of integration and interaction saw the establishment of large tells as focal points in the landscape, often strategically located at or near major waterways. The clustering of LN houses within settlements suggests pooling of resources and labor among extended kin groups or lineages. The ECA saw a shift to increased residential mobility, with people inhabiting small, single-generation settlements. These new settlements were generally dispersed, but they did cluster in previously unoccupied or sparsely inhabited areas during the LN. Interestingly, ECA cemeteries were frequently located near established LN settlement clusters, suggesting a degree of continuity in symbolic or ritual associations with the LN landscape. Parkinson (2002:415) interpreted this pattern to reflect the emergence of a less complex settlement and co-residential system characterized by more permeable and fluid social boundaries. Additionally, the ECA village served a similar function to LN household clusters in terms of resource pooling. However, these later relations were marked by a greater degree of residential transience and mobility, suggesting less integrated but more interactive social units.

The onset of the EBA (2800-1900 BCE) was marked by a reversal of this general pattern with a shift to nucleated, fortified settlements and settlement clusters characterized by a large tell and several satellite sites (Parkinson & Gyucha, 2010; Parkinson, 2002). Despite the apparent settlement hierarchy, there is no evidence for functional differences between stratified tell sites and shallow, open sites. Rather, settlements represented autonomous villages integrated through kinship, economic relations, and shared cultural practices and beliefs (Duffy, 2010; O'Shea, 2011; Parkinson, 2002). Another marked difference between the Copper Age and EBA is an increase in cultural heterogeneity throughout the Carpathian Basin and the Pannonian Plain. Whereas the preceding Copper Age was characterized by relatively homogenous culture groups that spread across the region with no clear boundaries between material culture traditions and cultural practices (*e.g.*, the ECA Tiszapolgár group, the Middle Copper Age (MCA) Bodrogkeresztúr group, and the Late Copper Age (LCA) Baden and Kurgan groups), there was an efflorescence of material culture diversity in the EBA (Horváth & Virág, 2003). The beginning of the 3rd millennium BCE included abandonment of small Copper Age hamlets and emergence of tell-based communities following a resurgence of metallurgy and introduction of arsenical bronze and horses into the Carpathian Basin (especially the Pannonian Plain) (Poroszlai, 2003).

The period of ca. 3000-2000 BCE saw the appearance in the Pannonian Plain of the Maros in the Maros-Tisza confluence, the Nagyrév to the north in the Middle Tisza, the Ottomány in the Körös region, and the Hatvan in the Northern Tisza. In neighboring regions, the Vučedol and later the Encrusted Wares cultures emerged in Transdanubia, the Únětice in the northern and western Carpathian Basin, the Glina-Schneckenberg to the east in Romania, and the Bubanj-Hum to the south in Vojvodia (Poroszlai, 2003; O'Shea, 1996). These changes in settlement structure, settlement organization, and spatial scale of culture groups were reminiscent of LN culture groups. As Parkinson (2002) and others (Csányi & Tárnoki, 2003;

Poroszlai 2003) note, substantial differences in the size and organization of households, mortuary practices, subsistence strategies, and craft production differentiated LN from EBA lifeways. Nevertheless, this pattern corresponds to a general phenomenon of 'tribal cycling' documented by Parkinson (2003) for the Carpathian Basin, with nucleated settlements representing integrative units interacting intensively in a small area and loosely integrated dispersed communities interacting extensively over a large area. Interpretation of culture change in the context of 'tribal cycling' (see Anderson, 1990) represents a major contribution to the understanding of intrinsic culture change in middle range societies and shapes a large part of the contemporary discussion of underlying causes of cultural transformation in the Carpathian Basin.

The major MBA (2100-1600/1500 BCE) culture groups in the Pannonian Plain included the Füezesabony in the Middle and Upper Tisza region and the Gyulavarsánd in the Körös region. Beyond this, the Vatya culture emerged in the Danube-Tisza interfluve, the Verbicioara group in Romania and southeast Serbian Banat, and the widespread Vatin group throughout northern and western Serbia and parts of northeast Bosnia and the Morava Valley in Romania. Settlements in these regions tended towards a pattern of nucleation and fortification, with smaller open settlements often clustered around tell sites (Csányi & Tárnoki, 2003; Parkinson & Gyucha, 2012; Poroszlai, 2003; Szathmári, 2003). Groups in the Middle and Upper Tisza and Körös regions showed general cultural continuity with preceding EBA inhabitants. In contrast, the previously sparsely occupied Danube-Tisza interfluve transitioned to a regional center in the MBA, whereas the Tisza-Maros interfluve was largely uninhabited. By ca. 1500 BCE, Maros sites – both tells and open sites – were abandoned. Furthermore, whereas metal (tin, copper, and gold) was highly circulated among the EBA Maros and found at both settlements and cemeteries (Girić, 1971; O'Shea, 1996; O'Shea et al., 2011), exotic trade items figure less prominently in both settlement and mortuary assemblages (Poroszlai, 2003). As Poroszlai (2003:151) noted for the Vatya settlement pattern:

> Their settlements included both single layer stratified sites, as well as a chain of 'fortifications'…that in part protected the settlements and in part controlled the major Danubian fording places…. These hillforts acted as the agricultural and trade centres of a smaller region. Lying in an area far from the ore resources, its population owed its

> prosperity to the fertile loess: agricultural produce and livestock were exchanged for bronze and gold articles.

Poroszlai also notes that while local elites controlled trade along the Danube, via a series of fortified hillforts, the Vatya economy was agrarian in nature and focused on the production of grain surplus and cattle and sheep husbandry (Vretemark, 2010).

More recently, there has been an increased focus on ecology and landscape archaeology for this region of Europe. Specifically, the location of sites in relation to natural resources, such as major waterways, arable land, and pasture land (see Duffy, 2010; O'Shea, 2011; Parkinson & Gyucha, 2012; Quinn & Ciugudean, 2017). For the EBA/MBA Maros, O'Shea (2011) illustrated the importance of river networks for connecting communities and enabling regional trade and exchange through the position of major settlements. Meandering waterways served as the principal network paths for transportation of goods (and people) and their importance increased throughout the EBA. The majority of Maros settlements were surrounded by fortification ditches (O'Shea, 1996; O'Shea, 2011). Analysis and reconstruction of paleoenvironments on the Pannonian Plain have identified another key factor in site location: availability of year-round dry land (Duffy, 2010; Parkinson & Gyucha, 2012). In a region with limited topography, and a high water table, flooding was often a seasonal event.

2.3.2 Households

From a regional perspective, dramatic changes occurred in household size, composition, and organization from the LN to the EBA/MBA. Whereas LN communities occupied longhouses comprised of extended families, CA and EBA/MBA were characterized by small single-room dwellings that likely housed a single nuclear family. Parkinson (2002) interpreted LN household clusters within tell and open settlements as the equivalent of ECA villages.

Thus, throughout the Copper Age, individual villages and farmsteads included one or two extended families spread out over several houses. The cycling from small, dispersed sites to settlement nucleation and reoccupation of tells in the EBA influenced household organization. While houses remained small - one or two room structures built from wood and mudbrick - the layout of houses within villages changed. Evidence from settlements throughout the Carpathian Basin show a preference for planned settlements that emphasized standardization and uniformity in house size and orientation (Csányi, 2003b; Csányi & Tárnoki, 2003; Sørensen, 2010). Two general house arrangements characterized EBA and MBA settlements: (1) organized in rows facing streets, with houses separated by narrow alleys (see Csányi & Tárnoki, 2003); and (2) clustered around a central courtyard (see Sørensen, 2010; O'Shea et al, 2011; Tárnoki, 2003). Except for an intriguing clay platform at the EBA/MBA Maros tell settlement at Pecica in Romania (O'Shea et al, 2011), and occasional larger ca. 5 m x 12-14 m 'communal structures' at Füzesabony settlements, non-residential structures were uncommon. These observations are overwhelmingly based on limited excavation of complete or partial residences at select major tell sites. Less is known about the layout and composition of houses and other structures at open sites, smaller villages, or hamlets. There is a need for further careful systematic excavation of representative samples of houses from different types of settlements, as well as inter-residential comparisons of house construction, material assemblages, duration of use, and timing of abandonment.

There has been comparatively little scholarship on households compared to settlements and cemeteries. Most discussions of households focus on either regional generalizations of residential architecture and household form and function or descriptions of single house structures. Key exceptions to this include analysis of houses as social, economic, and symbolic spaces at the MBA tell site at Százhalombatta-Földvár in central Hungary (Sofaer, 2006; Sørensen, 2010) and the EBA/MBA Maros tell site at Pecica in Romania (O'Shea et al., 2011). Recent scholarship by Michelaki (2008) and Sofaer (2006) show the potential for detailed comparison of household ceramic assemblages in investigating the relationship between domestic life, craft production, and social status in EBA and MBA communities. For example, comparison of pottery at two Maros sites in southeastern Hungary - the Early Maros open site at Kiszombor-Új-Élet (ca. 2600-2000 BCE) and the Late Maros tell at Klárafalva-Hajdova (ca. 2000-1700 BCE) – revealed intriguing changes in ceramic style and specialization over time as well as variation in assemblages between households (Michelaki, 2008). Briefly, communities overtime placed increased emphasis on the production and circulation of more technically complex ceramic forms. Somewhat paradoxically, the more complex forms displayed less evidence for production error, suggesting the work of highly skilled potters. For example, highly burnished forms represent 25% of the ceramic assemblage at Klárafalva-Hajdova compared to 8.5% at Kiszombor-Új-Élet. Burnishing, which is a labor-intensive process, provided vessels with a "sheen" reminiscent of polished metal. The aesthetic quality of these later vessels was further enhanced by the addition of 'Baroque' elements, such as highly stylized rims, handles, bases, and incised-impressed decoration. The emergence and recognition of a potter's skill would have added further value to the vessel beyond its aesthetic qualities. Furthermore, differences in diversity and type of vessel forms between houses at Klárafalva-Hajdova, especially storage and serving vessels, indicated household status was communicated via social display in terms of subsistence wealth. These observations point to an increased importance of ceramics in signaling household wealth and status during the Late Maros period. This evidence for the construction of more elaborate ceramic forms and the increasing importance of households as centers of social display signaling differences in status and wealth contrasts with the decline of the quantity and quality of grave goods in Maros cemeteries (O'Shea, 1996; 1998).

These insights show the importance of careful and systematic analysis of residential assemblages and refuse to identify social and ideological processes embedded within the archaeological record. Placing these observations in a broader comparative context with related settlements and cemeteries has the potential to illustrate subtle, yet culturally meaningful, shifts in local lifeways over time as communities changed and adapted to new social, economic, and environmental circumstances.

2.3.3 The Mortuary Domain

Insight from settlement structure and organization and cemeteries and mortuary practices represent the two arenas in which social complexity and culture change have been studied in the Carpathian Basin.

Several key sites and studies stand out. These include detailed analysis of EBA Maros funerary customs with an emphasis on the well-documented and archaeologically rich cemetery at Mokrin (Girić, 1971; O'Shea, 1996; 1998), the EBA cemetery at Branc in Slovenia (Shennan, 1975), the Copper Age cemetery at Tiszapolgár-Basatanya cemetery in eastern Hungary (Sofaer Derevenski, 1997), the EBA/MBA Vatya cemetery at Dunaújváros-Dunadülö in central Hungary (Sørensen & Rebay-Salisbury, 2009; Vicze, 2003; 1992), the EBA/MBA Encrusted Ware cemeteries at Ménfõcsanak and Mosonszentmiklós in central and northern Hungary (Sørensen & Rebay-Salisbury, 2009; Uszoski, 1963), and MBA Füzesabony cemeteries in northern eastern Hungary at Tiszafüred-Majoroshalom, Mezõtárkány–Kettõshalom, and Pusztaszikszó (Csányi, 2003b; Hänsel & Kalicz, 1986; Kalicz, 1968; Sørensen & Rebay-Salisbury, 2009).

More recently, the BAKOTA (Bronze Age Körös Off-Tell Archaeology) project has undertaken excavation of an MBA cremation cemetery in eastern Hungary (Duffy et al., 2014). The ongoing BAKOTA project is especially notable for its application of archaeometric techniques in both excavation and laboratory analysis, including magnetometry and ground penetrating radar, photogrammetry, microexcavation of burial urns in controlled laboratory setting, aDNA extraction and analysis, etc. (http://bakota.net/, 2017).

In contrast to the uniformity of settlements and households, cemeteries showed incredible diversity in funerary treatment and mortuary practices during the EBA and MBA throughout the Carpathian Basin. In contrast to the dearth of evidence for ritual activities from settlements, cemeteries were central to ritual life and acted as an important arena for social performances associated with power, prestige, and inheritance (O'Shea, 1996). The comparative study of MBA funerary variation by Sørensen & Rebay-Salisbury (2009) highlights how this variation in burial customs reflects the different ways in which prehistoric social actors constructed and negotiated distinct corporate and individual identities. It was not uncommon for neighboring culture groups to engage in vastly different funerary practices, despite similar settlement, household, and subsistence lifeways. For example, inhumation was the most common custom in the Füzesabony region, whereas Vatya communities practiced burial of cremains in urns, and scattering cremains in a burial pit predominated in the Encrusted Ware tradition. For all three culture groups, cemeteries were located separate from, but within the vicinity (a few hundred meters to a few kilometers) of, established settlements. This distinction between communities of the living and communities of the dead has its origins in the ECA and continued throughout the Bronze Age. However, with the exception of newborns and young infants, which were occasionally buried in houses or middens, the composition size of EBA and MBA cemeteries suggests inclusive use of cemeteries by a single village or multiple settlements (O’Shea, 1996; Ubelaker & Pap, 1998). An underrepresentation of adult males has been observed for several sites (*e.g.*, the MBA cemetery at Tiszafüred-Majoroshalom in northeastern Hungary, and the EBA cemetery at Mokrin in northeastern Serbia), which may indicate an increased likelihood that young and middle-aged adult males died away from settlements and were buried elsewhere (Rega, 1995; Ubelaker & Pap, 1998).

Apparent wealth differences between burials, especially the presence of exotic trade goods, has been taken as evidence for the emergence of social rank and stratification in the EBA (O’Shea, 1996; Shennan, 1975). Furthermore, discrepancies in grave good assemblages between males and females were often interpreted as evidence for the privileged position of males in society relative to females, with wealthy female graves interpreted as representing their bridewealth or items given as gifts by a socially powerful husband (see Shennan, 1975). Several authors have criticized this interpretation (see Chapman, 2005; Rega, 2001; Sofaer Derevenski, 1997). In her bioarchaeological analysis of age, gender, and social status in the EBA Maros cemetery at Mokrin, Rega (1997; 2001) concluded that while social status was heavily gendered, differences between men and women represented a system of gender complementary. Thus, she suggested that health and behavioral differences in high versus low within-gender categories were more important than between-group comparisons. These observations were supported by Porčić and Stefanović (2009) through research that analyzed differences in musculoskeletal stress markers between males and females. In this study, the authors found no correlation between status as inferred from grave goods and labor intensity. Males, however, showed a positive correlation between social status and upper limb and shoulder rugosity, whereas females showed a negative correlation for the same traits. These results further reinforce the need to challenge a priori assumptions about what constitutes meaningful comparisons between intra-group and inter-group variation.

The economic role and social status of women represents an important study area in reconstructing Bronze Age lifeways. Increasingly, scholars have challenged traditional conceptions of gender binaries in mortuary and human skeletal analysis (Fuglestvedt, 2014; Moral, 2016; Sofaer, 2009). Looking further afield, recent reanalysis of skeletal remains of supposed high status warrior males from Iron Age contexts in Central and Southern Europe have shown that these 'males' may have been biologically female (Arnold, 1995; Hanks, 2008). These observations are important in highlighting the necessity for analytical and interpretive distinctions between biological sex versus gender as a social and ideological construct (Sofaer, 2009). Spector and Whelan (1991) argue for distinguishing between gender identities (how an individual self-identifies), gender roles (culturally specific behavioral expectations that govern what men and women do), gender attribution (specific biological, social, and material criteria important in constructing culturally specific gender categories), and gender ideology (meaning assigned to gender differences and gender roles in a society that informs behavioral norms and expectations that structure gender relations). These distinctions allow gender identities to be conceptualized in a way that acknowledges performativity and intersectionality. Cross-culturally, gender roles and attributions are likely to be marked through material correlates, which may influence how an individual is represented in death irrespective of their biological (chromosomal) sex (Arnold, 1991; Conkey & Spector, 1984; Parker Pearson, 1999). The application of feminist and queer theory to investigate constructions and categories of gender represents areas where mortuary and bioarchaeological analyses have much to offer in studying how genders were constructed and renegotiated in response to political, cultural, and economic transformations.

2.4 Conclusion

Despite over a century of extensive and intensive study of Bronze Age social organization and political economy in central Europe, this period remains highly contested in terms of the specific factors contributing to culture change at regional and local levels. Specifically, what factors – internal or external – contributed to the emergence of cultural diversity and incipient social stratification at this time? Perhaps more intriguing is the question of why did groups such as the EBA/MBA Maros resist vertical integration at the regional level, with settlements remaining autonomous and largely self-sufficient despite participation in long-distance trade to acquire metal and other items that held a high social – if not also economic – currency (Primas, 1997; Shennan, 1993b). Arguably, it was not until the Middle and Late Bronze Ages in central Europe (ca. 1400-800 BCE) that gold, copper, and amber began to be hoarded, suggesting increasing associations between material wealth, social prestige, and political power (Harding, 2000).

In the Carpathian Basin, despite funerary evidence for status differences between individuals, the extent to which 'status', as inferred from grave goods, is an accurate reflection of the identity and accomplishments of the deceased in life remains unclear. Additionally, the contrast between homogeneity of households and autonomy of settlements with highly structured Maros funerary practices raises questions about the relationship between communities of the living and communities of the dead. A shared conceptual model is necessary to identify specific and culturally meaningful differences between individuals and larger socio-political entities in the past. These must also have clear material correlates. By adopting this framework, I seek to characterize the social dimensions at Ostojićevo with that documented at other Maros settlements and cemeteries to identify which social dimensions were instrumental in influencing the nature of social change overtime in the Maros region. Additionally, this data is critical for comparing socio-cultural, political, and economic factors contributing to local variation and change overtime in social organization, subsistence, and health in the Pannonian Plain. For example, how did variation in subsistence practices and socio-political interaction (*e.g.*, participation in larger economic and social networks) affect health overtime? What role did larger social and economic factors have on local representations and constructions of gender and status in the Carpathian Basin? How does archaeological evidence from mortuary practices coupled with physical evidence for health, demography, and diet from human skeletal remains relate to interpretations of social organization and subsistence from settlement exaction and analysis? These represent several core questions that I will address through detailed analysis of human skeletal remains and funerary practices at a Late Maros cemetery in the context of social dimensions of individual and community health, social status, and subsistence.

3.0 Background to Prehistoric Societies of the Carpathian Basin

In this chapter, I provide a review of the culture history of the Carpathian Basin and its surrounding regions in order to highlight the crucial need for more informed bioarchaeological studies. Importantly, past work in the region has set a solid chronological foundation and highlighted key economic and subsistence trends and underscored the role of trade and exchange in local and regional political economies. Many scholars have focused on issues of gender and status relative to social organization but these have rarely been informed by more detailed studies of human remains. Quality of life and the character of the lifecycle of these early populations also has not been examined effectively in terms of health, nutrition, and variability in stress indicators. Nevertheless, much important work has been achieved and this dissertation study has endeavored to build upon this important previous scholarship by focusing more intently on ontological perspectives of individuals and their lifeways as embedded within localized social, economic and political conditions.

3.1 Regional Chronologies

The construction of a cohesive relative chronology for the prehistory of the Carpathian Basin and surrounding regions is complicated by a legacy of separate national archaeological programs (*e.g.*, Hungarian, Romanian, Serbian, Bulgarian, Slovakian, and German) (Duffy, 2010). It was not uncommon for different labels to be applied to describing the same archaeological culture, reflecting a legacy of separate archaeological traditions, interpretations, and motivations. For example, the Maros culture in Serbia (Banner, 1931; O'Shea, 1995; Tasić, 1972) has been variously referred to as the Perjamos group by Childe (1929), the Szöreg group by Hungarian scholars (Bóna, 1975), and the Periam-Pecica culture by Romanian scholars (Sandor-Chicideanu & Chicideanu, 1989). For the purpose of this dissertation (Table

3.1), I use the labels most often encountered in the literature for the Carpathian Basin (Duffy, 2010; O'Shea, 1996; Parkinson, 2006; Kiss, ed., 2003), central Balkans (Bankoff & Winter, 1990), and central Europe (Harding, 2000; Kristiansen, 1998; Shennan, 1993a).

Additional information on relative chronologies for the Bronze Age has been published for Hungary (Bóna, 1965, 1975, 1994), northern Serbia (Tasić, 2003-2004; Uzelac, 1995), Transylvania (Popescu, 1944), and Romania (Nestor, 1933; Roska, 1926-1928, 1941).

The most widely used relative chronology for central Europe was developed by Paul Reinecke (1872-1958). The Reinecke typology was based on cemeteries and hoards from Bavaria and has been integrated into regional chronologies in Germany, Austria, Slovakia, Hungary, Romania, and Ukraine (Harding, 2000: 10-11; Kristiansen, 1998). Reinecke divided 'Bronze Age' (Bronzezeit, Br.) into four stages labelled A, B, C, and D, with additional subdivisions (Table 3.1). The developments of most relative typologies are based on ceramic styles, metal traditions, and/or mortuary customs. The extent to which these artifact-based divisions reflect how people in the past identified themselves can never be known. Nevertheless, traditional typologies are useful for the purposes of synchronic and diachronic comparisons of archaeologically-defined groups united through shared material culture and/or social, economic, and ritual practices.

Most regional relative chronologies were established prior to the development of absolute dating methods. Most absolute dates of archaeological deposits in Europe are based on calibrated radiocarbon dates, though dendrochronology has been used in regions with good preservation of wood (*e.g.*, northern Europe, the Alpine region, southern Germany) (Harding, 2000). While radiocarbon dating has been a fixture of archaeological practice for the past several decades, certain areas in Europe lack high-precision dates from carefully excavated, well-contextualized samples (see Tasić, 2003-2004). Additionally, absolute dates do not always uphold regional chronologies based on material typologies (Shennan, 1993a). Despite potential disagreement between regional typologies and absolute dates, the practice in European archaeology has been to apply absolute dating to establish a temporal context (range of dates) that adhere to traditional taxonomic sequences (Duffy, 2010; O'Shea, 1996; Shennan, 1993a). Finally, many sites in the Carpathian Basin and throughout central Europe were excavated in the late-19th and early-20th centuries. As a result, potentially dateable material was either destroyed or inaccessible (see O'Shea, 1995, 1996; Rega, 1989). Recent efforts have been made to acquire absolute dates for prehistoric sites on the Pannonian Plain (O'Shea, 1991; O'Shea et al., 2011; O’Shea et al., 2019; Parkinson et al., 2010; Raczky et al., 1994) (for a complete list, see Duffy, 2010: 404-409). However, this disconnect between well-dated and temporally constrained context from modern excavations, coupled with few or no dates for older excavations, means that an understanding of change overtime is restricted to blocks of several hundred years or more.

Table 3.1 Regional culture history and absolute chronology

Absolute Chronology (BCE)*	Period	Reinecke (Central Europe)	Central Serbia	Transdanubia	Central and Southern Plain		Northern Plain	Eastern Plain (Körös-Berettyó)	Transylvania
					Lower Tisza	Middle Tisza	Upper Tisza	Körös Region	
3500-2800	Late Copper Age		Baden Bubanj (Eplat III)		Boleráz Baden Kurgan			Boleráz Baden Makó	Coţofeni
2800-1900	Late Copper Age / Early Bronze Age (Hungary)	Br. A1a/EBA I (2300-1950 BCE)	Bubanj-Hum II Kostolac Vučedol	Bell Beaker Vučedol Nagyrév	Perjamos / Early Maros	Nagyrév Hatvan	Late Baden	Makó	Makó-Coţofeni III-Glina
1900-1500	Middle Bronze Age (Tumulus period in Hungary and Slovakia)	Br. A1b/EBA II Classical Unetice (1950-1700 BCE Br. A2/EBA III (1700-1600 BCE) Br. 1/Tumulus (1600-1500 BCE)	Dubovac-Žuto Brdo Vatin Vinkovačka	Encrusted Ware Vatya	Late Maros	Hatvan Koszider Vatya	Hatvan Füszesbony Koszider Ottomány	Nyírség Ottomány Gyulavarsánd	Gornea-Orleşti

***Note*. *The absolute chronology presented here is a simplification of the true chronological extent of the culture groups listed. Many groups (*e.g.*, Baden, Maros) overlap several periods.**

3.2 Geography and Climate

Central Europe is defined by the Rhone and Rhine rivers to the west, Hungary and the Carpathian Mountains to the east, southern Poland to the north, and the Alps to the south (Shennan, 1993a). This area in prehistory maintained connections to culture groups in eastern and southeastern Europe, including Romania (Transylvania and Moldavia) and the central Balkans (Serbia, western Bulgaria, and North Macedonia). The Danube served as the major east-west corridor through central Europe, extending from north of the Alps to the Black Sea. Central Europe functioned as a major north-south trade axis linking the metal-rich Carpathians and Alpine Region with Scandinavia in the Bronze Age (ca. 2000-1000 BCE) (Harding, 2000; Kristiansen, 1998). Beyond the Mediterranean, temperate broadleaf forests have dominated most of continental Europe since the mid-Holocene, with the Carpathian Basin and most of eastern Europe classified as dry temperate prairie-steppe with hot summers and cold winters (Kristiansen, 1998). Despite its prairie-steppe climate, the Pannonian Plain remains well-irrigated due to frequent flooding in the broad, low-lying regions along the Danube and Tisza-Körös-Maros river systems (Sherratt, 1982b).

The Carpathian Basin (Fig. 3.1) is dominated by a low-relief plain bounded by the Carpathian Mountains to the north (Western Carpathians), east (Eastern Carpathians), and south (Southern Carpathians). It is divided into three geographic subregions: (1)the mountainous regions that form the basin's rim, (2) the forests and foothills of Transdanubia, and (3) the Pannonian Plain to the east, which encompasses an area of 100,000 km^2 and is one of the largest alluvial plains in Europe (Duffy, 2010). Three major passes link the basin to Austria to the northwest, Upper Poland and Ukraine to the southeast, and the Balkans to the south (Duffy, 2010).

In addition to these natural land routes, contact with outside groups in prehistory was facilitated by an extensive network of large rivers and smaller waterways. The Danube enters the Carpathian Basin to the northwest, flowing north-south/southwest and exiting the Basin through the Iron Gates region of the Southern Carpathians. The Tisza is the largest tributary of the Danube and is divided into three main sections: the Upper Tisza north of the Ukrainian-Hungarian border, the Middle Tisza in eastern Hungary, and the Lower Tisza south of the Hungarian-Serbia border (ICPDR, 2014). Several important tributaries empty into the Middle Tisza, including the Bodrog and Sajö, the Körös River system, and the Maros. Prior to large-scale river regulation in the 19th century that altered the hydrology of the Carpathian Basin and the Pannonian Plain, these broad, meandering river systems were prone to frequent flooding (O'Shea, 1996, 2011). The combination of frequent flooding, and the flat, poorly drained landscape of the Pannonian Plain facilitated the development of thick fans of redeposited loess soils and the formation of permanent and seasonal marshes across large portions of the low-lying areas near rivers (O'Shea, 2011). Settlements from the Neolithic to the Middle Ages were located on small areas of high ground, referred to in Hungarian as “sziget” [islands], within the marshy floodplains of the Tisza-Maros-Körös drainage system (Duffy, 2010; Gyucha et al., 2011; O'Shea, 1996).

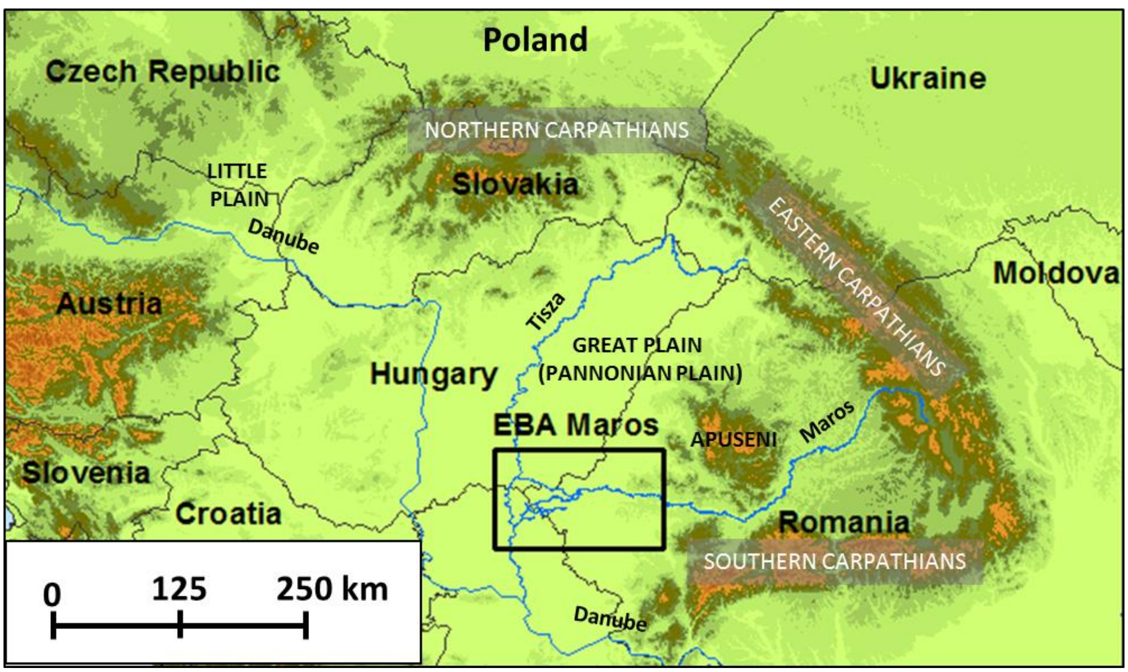


Figure 3.1 Map of central and southeastern Europe showing major mountain ranges surrounding the Carpathian Basin

Prior to 18th and 19th century canalization and drainage by the Hapsburg Empire, flooding along the Tisza occurred twice a year: in the early spring following snow melt from the Carpathians, and during the fall due to increased precipitation. Seasonal flooding contributed to the expansion and contraction of wetlands (Duffy, 2010; Gyucha et al., 2011). Soils in the Pannonian Plain reflect differences in drainage conditions as a result of minor fluctuations in topography (Gyucha et al., 2011). Meadow soils (*i.e.*, meadow clays) are poorly drained soils characterized by thick, fine-textured, homogenous black clay that form the most common soil type in the Pannonian Plain. Meadow clays predominate in low-elevation flats and depressions, and can be farmed, but overly wet conditions hinder crop growth (Duffy, 2010). Solonetzes are well-drained soils with a high salt content and comprise the second most common soil type in the Pannonian Plain (Duffy, 2010; Gyucha, 2011). They form due to the stagnation and evaporation of groundwater during the hot summer months. While solonetzes cannot be farmed, they provide good pasture and are found at intermediate elevations between meadow clays and chernozems (Duffy, 2010). Finally, chernozem is a humus-rich, black soil superior for farming. This soil type is uncommon in the Körös basin, but is found throughout the Maros fan to the south and parts of Transdanubia (Duffy, 2010; French, 2010; Sherwood et al., 2013). In the Körös basin arable land rather than pasture was the major limiting resource in a mixed-farming economy due to fluctuations in the year-round availability of farmable land (Duffy, 2010). The amount of land under cultivation varied as a result of soil type, minor changes in topography (*i.e.*., less than several meters), and severity and frequency of flooding. In contrast to claims that fishing played a minor role in Bronze Age economies both within and outside the Carpathian Basin (Greenfield, 1986; Nehlich et al., 2010; Vretemark, 2010), O'Shea (1996; 2011) emphasizes the importance of riparian resources (*e.g.*, mussels, pike, carp, bream, perch, and zander) for the Maros.

The impact of river channel migration, flood frequency, and climate change on settlement patterns and subsistence strategies represents a major research focus for scholars studying prehistoric societies on the Pannonian Plain (Gulyás & Sümegi, 2011a, 2011b; Gyucha et al., 2011; Sherratt, 1982b; Sherwood et al., 2013). For example, faunal and soil data provide evidence for a period of intense flooding, and shift to cooler, wetter conditions during the Late Neolithic Tisza Phase I in southeast Hungary (ca. 5200-5000 BCE)

(Gulyás and Sümegi, 2011a). This period is associated with a marked intensification in exploitation of aquatic resources compared to the Late Neolithic generally.

The Early Neolithic to Middle Copper Age (ca. 6200-3800 BCE) corresponds to the Atlantic period, which shifted from humid and warm to dry and warm around 4000 BCE. Dry conditions persisted into the subsequent Subboreal period (ca. 3700-600 BCE) coupled with a cooling trend that began at the end of the Atlantic phase (ca. 3800 BCE) when mean summer temperatures dropped from 20-23 to 17-18 degrees Celsius (Duffy, 2010; Sümegi et al., 2003). The climate and environment stabilized until ca. 1600-1400 BCE (Duffy, 2010; Sherwood et al., 2013). The presence of a ca. 50-80 cm fine-grained grey soils covering Middle Bronze deposits at the tell site of Pecica has been interpreted as a period of increased aeolian deposition due to increased aridity around 1700 BCE (Sherwood et al., 2013).

The Tisza-Maros region was virtually abandoned in the Late Bronze Age as there was a trend towards population dispersal in the broader Pannonian Plain with the emergence of the Late Bronze Age Tumulus and Urnfield cultures (Artursson, 2010; O'Shea, 1996, 2011). Paleoenvironmental data from the Benta Valley in central Hungary and the Körös Basin in eastern Hungary indicate a period of increased soil erosion associated with increased land clearance around 2000-1000 BCE (peaks from 1200 to 1100 BCE in the Benta Valley) (Duffy, 2010; French, 2010). This pattern of increased land clearance, coupled with settlement preferences for the first time shifting away from major waterways in the Late Bronze Age/Early Iron Age, was associated with a transition to large-scale animal husbandry in the Carpathian Basin. This transition prompted the need for access to open, dry pastures to maintain large herds of cattle and horses (Gyucha et al., 2011).

3.3 Culture History of the Carpathian Basin

3.3.1 Early Copper Age (4500-4000 BCE), Middle Copper Age (4000-3600 BCE), and Late Copper Age (3600-2500 BCE)

Early Copper Age (ECA) settlements in the Pannonian Plain consisted of a few small houses organized into hamlets or farmsteads (Parkinson, 2002, 2006; Parkinson et al., 2010; Yerkes et al., 2007). There was a dramatic increase in the number of sites compared to Late Neolithic (LN), with settlements becoming more diffuse and uniformly distributed across the landscape (Parkinson, 2002; Parkinson & Gyucha, 2012). While the largest LN settlements (*i.e.*, tells and horizontally distributed settlements) were abandoned in the ECA, mean settlement size did not change, decreasing slightly from 2.66 ha in the LN to 2.52 ha in the ECA. However, settlement size and organization were more homogenous in the Early Copper Age, with most locales occupied for less time compared to the multigenerational habitation and reuse of tells in the LN (Parkinson, 2002). Many small, single component Copper Age settlements were surrounded by small shallow ditches that may have served in controlling/corralling livestock, in contrast to the presumed defensive function of larger 'fortification' ditches present at many Neolithic tells (Parkinson et al., 2010; Parkinson, 2002; Yerkes et al., 2007). This transition from centralized, autonomous tell sites to dispersed, more ephemeral, regionally integrated hamlets reflected the more permeable nature of social boundaries and adoption of a more mobile lifestyle (Giblin et al., 2013; Hoekman-Sites & Giblin, 2012; Parkinson, 2002). Houses, and by extension households, also decreased in size in the ECA. Small (ca. 26 m^2) single-room wattle-and-daub structures with dirt floors and outdoor ovens replaced the larger (ca. 59 m^2) multiroom Neolithic longhouses with plastered clay floors and interior hearths and ovens (Parkinson, 2002). Parkinson (2002:418) has argued that ECA settlements replaced the Neolithic house cluster as the basic economic and social unit. These settlements would have included several nuclear family households perhaps forming an extended family and exhibiting a degree of residential mobility. Rather than several extended families or lineages occupying a single site, small social groups (lineages or extended families) formed dispersed autonomous hamlets inhabited for at most one or two generations (Giblin, 2011; Parkinson, 2002).

Interpretations of Copper Age transformation in the Carpathian Basin and elsewhere in central and southeastern Europe emphasize a variety of factors, including demographic change (Shennan, 1993a), resource competition and increased reliance on pastoral lifeways (Arnold & Greenfield, 2006; Bankoff & Winter, 1990; Giblin, 2011; Greenfield et al., 1988; Sherratt, 1982b, 1983), climate change (Gulyás & Sümegi, 2011a, 2011b; Horváth & Virág, 2003; Shennan, 1993a), and/or foreign migration/invasion (Gimbutas, 1977; Horváth & Virág, 2003; Tasić, 1983). Evidence of increased mobility has been supported by increased variability in strontium isotope values derived from human tooth enamel of Copper Age individuals compared to their Neolithic predecessors in the Pannonian Plain (Giblin, 2011; Giblin et al., 2013). This general pattern persisted into the Middle Copper Age (MCA) Bodrogkeresztúr complex (4000-3500 BCE), with an increase in cultural diversity and the appearance of kurgan burials in the poorly documented Late Copper Age (LCA) Baden-Boleráz groups (3500-2800 BCE) (Duffy, 2010; Parkinson, 2006). The ephemeral, small-scale nature of Copper Age settlements mean they are less visible archaeologically. As a result, there is a lack of information on intra-settlement and household social dynamics compared to the Neolithic (for recent geomorphological survey of Copper Age sites see Parkinson et al., 2004, 2010; Yerkes et al., 2007). Nevertheless, the Copper Age represents a period of technological innovation and changes in social structure, ideology, mortuary practices, and trade networks (Giblin et al., 2013; Parkinson, 2002; Sherratt, 1982a).

In addition to regional surveys, archaeological evidence for Copper Age communities has come from excavation of formal cemeteries, which are often associated with nearby settlements (Duffy, 2010; Parkinson, 2002). The practice of burying the dead in formal cemeteries first appeared in the ECA in the Carpathian Basin. Mortuary analysis has provided evidence of the emergence of social differences according to gender and age during this period. Weapons (*e.g.*, copper or stone axes and daggers) associated with adult males have been interpreted as marking male social dominance and authority. "Wealthy" female burials are frequently viewed as the expression of male status though grave artifacts representing bridewealth (Shennan, 1975, 1982; Sherratt, 1982b). Alternatively, Sofaer Derevenski (1997) has argued that mortuary practices in the ECA reflected perceptions of the deceased by the living rather than social identity or wealth disparities (see Chapman, 2005; Parkinson, 2002).

Cold hammered and smelted copper objects appeared during the ECA, such as those found in burials of the Tiszapolgár culture in the Pannonian Plain, and from Cucuteni-Tripolye sites to the north and east in Ukraine and Romania (Moldavia and the eastern Carpathians) (Chernykh, 1992). Metallurgy consisted primarily of small copper ornaments, such as beads, dress fittings, and spiral bracelets and rings, though tools such as axes, awls, and fishhooks were also produced (Chernykh, 1992). Metal production (gold and copper) became increasingly widespread during the MCA Bodrogkeresztúr culture in eastern Hungary, with the emergence of a large metallurgical province that included the Carpathian Basin and parts of southeastern Europe (Giblin, 2011; Horvath & Virag, 2003). Finally, the appearance of four-wheeled carts and kurgan burials provides evidence of the movement of groups from eastern Europe and the north Pontic steppe into the Carpathian Basin (especially the Pannonian Plain) during the LCA (Horvath & Virag, 2003). The prevailing perception of the LCA (3600/3500-2600/2500 BCE) is one of cultural and ideological unity between groups in the Carpathian Basin, eastern Europe, and Central Balkans (Giblin, 2011). This included the Baden-Boleraz culture that inhabited upland and lowland locations throughout the Carpathian Basin, the Vučedol culture in southeastern Transdanubia, Kostolac groups in western Hungary, the (Steppen) Kurgan culture in the Pannonian Plain, and Bubanj-Hum groups to the south and southeast in Serbia and Bulgaria (Bankoff & Winter, 1990; Horvath & Virag, 2003).

3.3.2 Early Bronze Age (2800/2500-2100 BCE)

The transition from the LCA to Early Bronze Age (EBA) in the Pannonian Plain and northern Serbia is poorly understood (Duffy, 2010; Uzelac, 1995). There are few sites known from this period, and many of these remain unexcavated. Cultural diversity reemerged at this time, however, little is known about the social and economic interactions between overlapping archaeological cultures distinguished by ceramic styles and burial customs (Gerling et al., 2012). These included the Early Makó in the Körös basin and Middle Tisza, Cotofeni (Livezille/Glina) to the south and east in the Carpathians and Apuseni mountains, Late Baden in the Upper Tisza, Late Baden/Kostolac and Zók-Vučedol to the west in Transdanubia, and Later Vučedol to the southwest in Serbia (Gerling et al., 2012; Gogaltan, 1996; Uzelac, 1995).

The question of whether groups from the Pontic Steppes migrated into eastern Hungary between 3100 and 2400 BCE remains uncertain (Gerling et al., 2012; Gimbutas, 1977). Recent analysis of genomic data from LN and Bronze Age populations from northern and central Europe, including Hungary, identified a cline of genetic affinity with Yamnaya samples, with Corded Ware and Únětiče groups the highest, Bell Beaker intermediate, and Hungarian (Vatya) the lowest (Allentoft et al., 2015). While there was some Yamnaya admixture, the Bronze Age Hungary samples were most genetically similar to Neolithic farmers from central Europe, denoting limited gene flow into the Carpathian Basin during the third millennium BC. The appearance of kurgans in Romania, Bulgaria, Serbia, and Hungary has been attributed to migration of the nomadic Yamnaya culture into the Carpathian Basin and Lower Danube. However, only a few of the thousands of known kurgans have been systematically excavated, and even fewer associated with radiocarbon dates (Duffy, 2010). Recent strontium isotope analysis of enamel and dentine and radiocarbon dates from eight individuals buried in the large (ca. 50 m diameter) kurgan at Sárrétudvari-Örhalom indicated the kurgan was in use for over 500 years (ca. 3300 -2700 BCE), with burials corresponding to two phases. Strontium values from the earlier burials were consistent with local signatures from the Pannonian Plain. The signatures of four adult males buried in the later phase (ca. 2800-2600 BCE) identify them as migrants from the Carpathian or Apuseni mountains to the east (Gerling et al., 2012).

Three major events/processes characterize the EBA in the Carpathian Basin: 1) the introduction of the horse, the earliest evidence for which is from the Bell-Beaker site of Csepel-Háros near Budapest, Hungary (see Bökönyi, 1980; Duffy, 2010; Harding, 2000; Kienlin, 2012); 2) greater variation in settlement size and type, and reoccupation of tells (Artursson, 2010; Earle & Kolb, 2010; Parkinson, 2002); and 3) diversification of social groups into distinct local cultures associated with unique ceramic traditions and funerary customs (Duffy, 2010; O'Shea, 2011a). Despite being referred to as the ‘Early Bronze Age’, metallurgy did not play a major role in cultural change and development at this time, though several new metal items appear, including single-edged copper shaft-hole axes, daggers, and elaboration of metal ornaments (Batora, 2002; Duffy, 2010; Kienlin, 2012).

Compared to the diffuse nature of Copper Age cultures and the relative absence of social boundaries, the EBA was marked by the expression and negotiation of diverse regional identities through formalized distinctions in material culture (Bankoff, 2004; Kienlin, 2012; O'Shea, 1996; Sørensen & Rebay-Salisbury, 2009). The Nyírség were a little-studied group that occupied the alluvial fan of northeast Hungary and northwest Romania. They are considered to be contemporaries of the Makó group in this area. To the south in the lower Tisza, two cultural complexes emerged: the Perjámos, the precursors to the Maros, along the Maros River, and the Pitvaros in the area around the modern city of Szeged in southeast Hungary. In the Upper Tisza, the Makó culture, which had been pushed northwards from the Middle and Lower Tisza, developed into the Hatvan culture (Duffy, 2010; Kienlin, 2012; O'Shea, 1996). To the west in central Hungary, the emergent settlement hierarchy of tells, villages, hamlets, and farmsteads of the Nagyrév complex replaced the small, single-component settlements and cemeteries of the Makó culture. There is some evidence for expansion of the Bell Beaker tradition from the west into the Carpathian Basin based on the discovery of Bell Beaker pottery in sites from the Budapest-Csepel area (Artursson, 2010; Poroszlai, 2003). Finally, Bubanj-Hum III pottery demonstrated stylistic influences and by extension social ties with Early Bronze Age groups in Macedonia and the Carpathian Basin, and has been found throughout central and northern Serbia (Bankoff & Winter, 1990).

Bronze Age tell communities appeared as early as the Vučedol period in the mid-3rd millennium BCE along the Danube and Tisza rivers (Poroszlai, 2003). However, it was not until the later part of the EBA associated with the Nagyrév, Hatvan, Ottomány, and Perjámos/Maros culture groups that tells became widespread (Kienlin, 2012; Poroszlai, 2003). Most tell sites in the Carpathian Basin were first occupied sometime between 2300 to 1950 BCE (Kienlin, 2012). While tell sites were notable as fortified, highly visible places on the landscape that were occupied for generations, EBA and Middle Bronze Age (MBA) populations inhabited a variety of settlement types, including open sites that were often larger than tells in both area and population size (Artursson, 2010; Kienlin, 2012; Poroszlai, 2003). Though Bronze Age tells extended further north and west into Transdanubia near Budapest and the Hron and Ipel' valleys in Slovakia, there was considerable overlap in the spatial distribution of Bronze Age and Neolithic tell-building communities (Kienlin, 2012). Many tells were occupied by successive groups or cultures throughout the Bronze Age, though whether the appearance of 'new' groups corresponded to migrations or indigenous/local developments is unclear (Bóna, 1965, 1994; Duffy, 2010; Kienlin, 2012). Tells of the Nagyrév and Hatvan cultures were often placed in naturally elevated positions. In the former, tells were distributed along the Danube in naturally defensible areas and often reinforced with ditches, whereas the latter were surrounded by open settlements (see Artursson, 2010; Kienlin, 2012). To the east in the area defined by the Tisza, Maros, and Zlatica Rivers, Early Maros settlements were divided into small, highly stratified tell settlements near major rivers, and more dispersed, larger, and less stratified open sites (O'Shea, 1996, 2011a). At this stage of cultural development, settlements in the Carpathian Basin were generally smaller, more variable, and less internally structured compared to their MBA counterparts (Artursson, 2010).

3.3.2.1 Maros Chronology and Settlements

The local development of the Perjámos/Early Maros group in the Tisza-Maros confluence (Fig. 3.2) was concurrent with the evolution of the Nagyrév complex along the Danube west of the Tisza (Bóna, 1994; Duffy, 2010). Early and Late Maros settlements, cemeteries, and material culture demonstrated greater cultural affinities with contemporary groups in the Carpathian Basin than in the central Balkans (Fischl, 2003; O'Shea, 1996; Rega, 1995). The entire Maros culture sequence spanned a millennium, from 2700 BCE to 1650 BCE based on calibrated radiocarbon dates (O'Shea, 1991; O'Shea et al., 2011). This sequence has been further divided into an Early (ca. 2700-2000 BCE) and Late (ca. 2000-1600 BCE) Maros phases, which corresponds to the EBA and MBA in the Carpathian Basin, respectively (Fig. 3.3) (Michelaki, 2008; O'Shea, 1996).

Figure 3.2 Maros settlements (triangles) and cemeteries (circles)

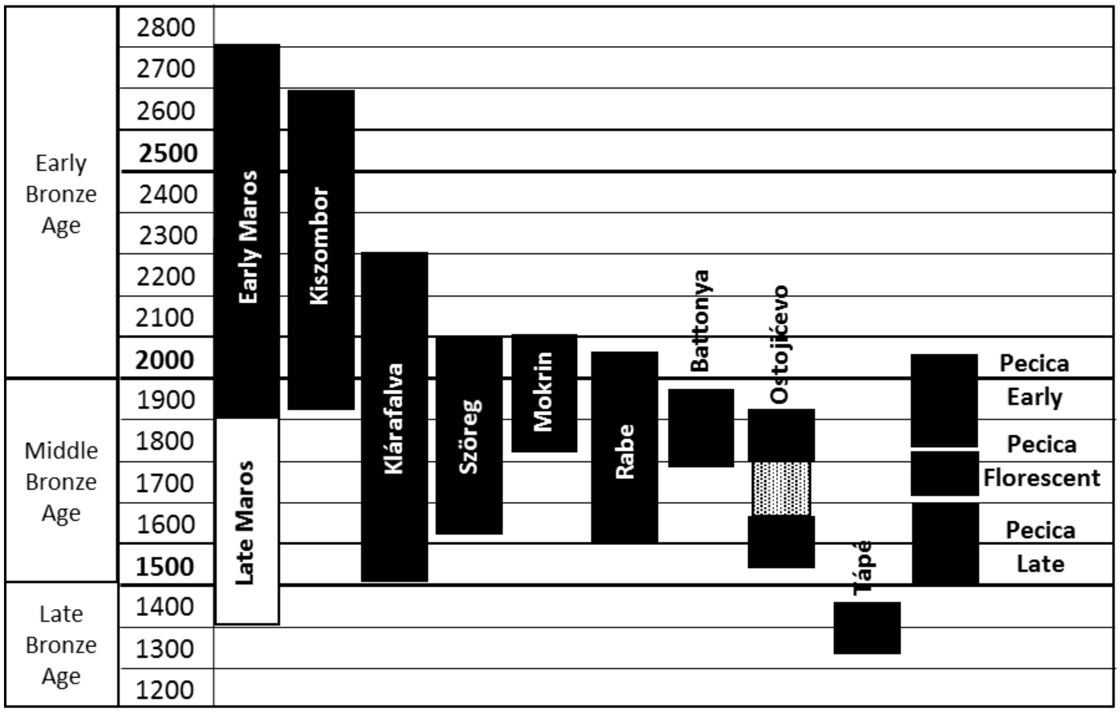


Figure 3.3 Radiocarbon chronology of Maros sites (calibrated BCE). Adapted from O'Shea et al. (2019).

Excavation of Maros sites began in the late 19th century; however, only seven settlements (Table 3) and nine cemeteries (Table 4) have been explored (Bóna, 1965, 1975; Girić, 1959, 1971, ed. 1972, 1987; Michelaki, 2008; O'Shea, 1996; O'Shea et al., 2011). Among these, only the settlements at Klárafalva and Kiszombor in Hungary (Michelaki, 2008; O'Shea, 1996; Smith, n.d.), Pecica/Santul Mare in Romania (Nicodemus, 2010; 2014.; O'Shea et al., 2011b; Oas, 2010; Sherwood et al., 2013), Popin Paor in Serbia (Girić, 1987), and the cemeteries at Mokrin (Girić, 1971, ed., 1972; O'Shea, 1996; Rega, 1995) and Ostojićevo (Girić, 1959; Milašinović, 2009) have been systematically excavated using modern methodology and most of the material retained.

In contrast to the uniformly scattered contemporary Nagyrév settlements to the north, most Maros settlements were clustered on small 'islands' of high ground in the marshland adjacent to major rivers. Tell sites, formed through the buildup of stratified deposits through long-term dense occupation, were more likely to be found in areas where dry land was scarce. In contrast, sites established in the large areas of dry land situated inland from the major river systems, such as at Deszk and Szöreg, tended to be more spread-out and less stratified (O’Shea, 1996:40). Fortification ditches have been found at both tell and open sites, though it was unclear whether the principle purpose of these features was to protect against seasonal floods or act as effective defensive systems (O’Shea, 1996, 2011; for a discussion of Neolithic and Bronze Age fortifications see Duffy, 2010; Kienlin, 2012; Parkinson & Duffy, 2007). The proximity of Maros settlements to marshland and small and large waterways, and a scarcity of year-round dry land near settlements in riparian settings, meant that the Maros may have supplemented their diet with aquatic resources in addition to raising domestic animals and cultivating a variety of domestic cereals (including millet) and legumes (Nicodemus, 2014; O'Shea, 2011; Oas, 2010).

Villages were largely autonomous and there is no evidence for a functional settlement hierarchy in the Maros region. The Maros were integrated on the basis of a distinct shared regional identity expressed materially through mortuary patterns and localized traditions of ceramic and metal production, with villages and cemeteries exhibiting slight variation according to local customs and norms (Michelaki, 2008; O'Shea, 1996, 2011). Despite an absence of clear evidence for enforcement of social and economic cooperation across Maros communities by a central authority, O’Shea (2011:168-170) argued that Maros tells served as strategic nodes, or “choke-points”, for trade along the Maros and Tisza Rivers. These waterways likely served as an important trade corridor for the movement of raw ore, stone, timber, and perhaps salt from Transylvania in the Pannonian Plain (Fig. 3.4). This water-based exchange network peaked around 2000 BCE, with Maros settlements reaching their greatest extent along the Maros and Tisza Rivers before consolidating into a pattern of fewer, but larger settlements during the Late Maros phase (O’Shea, 2011; O’Shea et al., 2011).

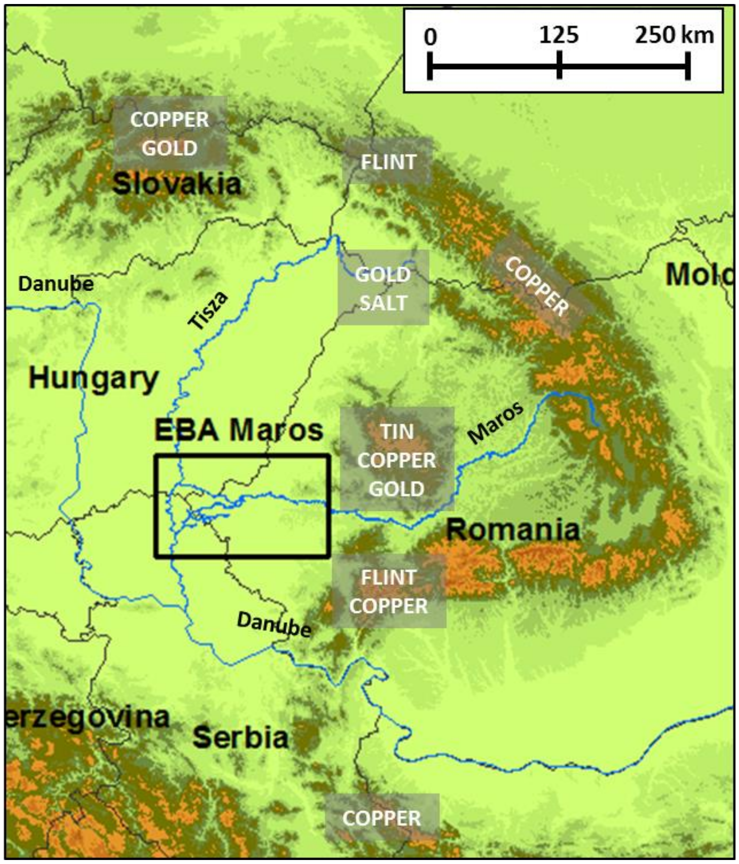


Figure 3.4 Location of Maros sites relative to major raw material sources in the Carpathian and Apuseni Mountains and the Pannonian Plain.

3.3.2.2 Maros Subsistence Economy

Data on Maros subsistence economy comes from analysis of faunal and paleobotanical remains from three settlements along the Maros River, two in southeastern Hungary near the Tisza-Maros confluence (Kiszombor Új Élet and Klárafalva Hajdova) and one in western Romania (Pecica Şanţul Mare). Briefly, Klárafalva is a tell site that includes three occupation phases, including two corresponding to the Early Maros (2300-2000 BCE) period and one Late Maros (1800-1500 BCE) phase (Nicodemus, 2014; O'Shea, 1996). The site is located within a wooded floodplain ca. 350 m from the Maros River. Despite its strategic location on a major regional waterway, the inhabitants would have had limited access to year-round dry, arable land (O'Shea, 1996; 2011). Kiszombor is a stratified open site located ca. 9 km southeast of Klárafalva and occupied during two phases in the Early Maros period (2500-2400 BCE and 2000-1700

BCE). The settlement was situated within a 1-1.5 km strip of dry steppe-forest areas adjacent to the Porgány Creek. This land, which is bounded by marshes and wet meadows, is characterized by highly productive loess soils that are well-suited to agriculture and herding (Nicodemus, 2014). Finally, Pecica Şanţul Mare is a large tell site encircled by a series of fortification ditches and positioned on a loess terrace overlooking the Maros River in western Romania near the ore producing region of the western Carpathians (Nicodemus, 2014). Pecica is a multicomponent site, with Bronze Age occupation associated with the Maros culture and marked by five successive architectural phases indicating continuous occupation during the Late Maros period from ca. 2000 to 1600 BCE (O'Shea et al., 2011). The environment surrounding the settlement included a mosaic of grassland on the terrace, gallery forest along the Maros River, and seasonal wetlands in the floodplain situated between the terrace and the river (Nicodemus, 2014). Nicodemus (2014:133) cites the modern use of the floodplain for grazing livestock and harvesting hay fodder.

The relative proportions of domestic and wild mammals and freshwater animals exploited at Kiszombor and Klárafalva are summarized with stable isotope data in Chapter 7 (section 7.8.1; Tables 7.24, 7.25, and 7.26). Faunal data from Pecica (Table 3.2) demonstrates differences in animal exploitation strategies compared to the Maros settlements near the Tisza-Maros confluence in southeastern Hungary (Nicodemus, 2010; O'Shea, 1996; O'Shea et al., 2011; Smith, n.d.). The prevalence of sheep at all three sites and material evidence for textile production, including ceramic spindly whorls, loom weights, and possible shuttles from settlements, and bone needles in 'female' burials, provides indirect evidence for the cultural and economic important of Maros weaving and textiles (O'Shea, 1996). At Pecica, Nicodemus (2010) observed that 75% of cattle reached physical adulthood, defined as 4 years. The culling of cattle after reaching maturity indicates cattle were exploited for meat, traction, and milk, and represented a versatile source of subsistence and economic wealth in Maros communities. The high proportion of adults is even more striking for ovicaprids and horses. This demonstrates that sheep were valued for milk and wool, and horses for transportation and traction. After the Late Copper Age, there is little evidence for raising horses for consumption in central Europe, and the small frequency of horses in faunal assemblages attests to their importance as marker of wealth and status in Bronze societies (Bökönyi, 1980; Harding, 2000). Over 33% of pigs were slaughtered within their first year at Pecica, and none survived beyond 3 to 3.5 years, reinforcing the use of pigs as an important source of meat in the southern Pannonian Plain. Finally, non-domestic animals and aquatic resources are rare at Pecica (Nicodemus, 2014; O'Shea et al., 2011) compared to Maros settlements to the east near the Tisza-Maros confluence. Carp and pike were recovered in considerable quantities at Klarafalva. Fish were less common at Kiszombor, but this is likely due its inland location and reduced access to riparian resources. The importance of fishing and shellfish collection in supplementing Maros diet is unclear. In light of its proximity to a major river, the dearth of fish remains at Pecica is surprising. However, the absence of small rodent remains, which should be numerous in a densely occupied prehistoric agricultural settlement, suggests recovery techniques at the site did not allow for the systematic collection of fish and other small vertebrates (Nicodemus, n.d.). The abundance of mollusks at Pecica belonging to mussels demonstrates that aquatic resources were an important part of the Maros economy (Nicodemus, 2010; 2014).

Preliminary archaeobotanical analysis from Pecica sheds light on Maros crop production strategies (Table 3.2) (see Nicodemus, 2014; Oas, 2012). At Pecica, crops predominate (%NISP = 66.6%) over wild seeds (%NISP = 33.4%) (summarized in Nicodemus, 2014:268-273). The overwhelming majority of crops included cereals, with einkorn wheat (Triticuum monococcum) the most common followed by barley (Hordeum vulgare). Domestic legumes (*i.e.*, fava beans (Vicia faba), pea (Pisum sativum), and lentil (Lens culinaris)) comprise only 1.0% of cultigens. No fiber or oil plants (*e.g.*, flax (Linum usitatissimum)) were identified at Pecica. Additionally, wild plant foods, such as raspberry (Rubus cf. idaeus), dewberry (Rubus caesius), elderberry (Sambucus sp.), and wild strawberry (Fragaria vesca/potenilla), are uncommon and no nut species were identified.

Table 3.2 Pecica combined on- and off-tell faunal and archaeobotanical remains by number of identifiable/individual specimens (%NISP) (adapted from Nicodemus, 2014: 259, 270). %NISP of group total; groups identified in bold.

Faunal Remains			Archaeobotanical Remains		
Taxon	Common Name	%NISP	Taxon	Common Name	%NISP
Ovicapridae	Sheep/Goat	33.2%	*Triticum monococcum*	Einkorn wheat	53.2%
Sus scrofa	Pig	26.5%	*Trtiticum dicoccum*	Emmer wheat	2.3****
Bos taurus	Cattle	17.5%	*Triticum aestivum*	Bread wheat	
Equus caballus	Horse	22.8%	*Hordeum vulgare*	Barley	12.8%
Domestic Total	n/a	82.5%	*Panicum miliaceum*	Common millet	0.3%
Cervus elaphus	Red deer	79.4%	*Vicia faba*	Fava beans	
Capreolus capreolus	Roe deer	15.2%*	*Pisum sativum*	Pea	1.0%*****
Sus scrofa ferus	Wild boar		*Lens culinaris*	Lentil	
Wild Mammal Total	n/a	13.6%	Total Legumes	n/a	1.0%
Mollusk Total**	n/a	11.1%	Total Cereals	n/a	99.0%
Fish Total***	n/a	1.5%			

Note. *** Categorized together as "other large game"; ** Most abundant mollusk species is *Unio* spp. (river mussel) with several other snail species reported in small numbers; *** fish species from most to least abundant include *Cyprinus carpio* (common carpo), *Siluris glanis* (wels catfish), and *Esox Lucius* (northern pike); Grouped as "other wheat"; ***** Grouped as "domestic legume".**

3.3.2.3 Maros Households

There was little temporal or spatial variation in Maros domestic architecture or the range of productive activities carried out at Maros settlements (O'Shea, 1995; Michelaki, 2008). The Maros constructed small rectangular (ca. 3-4 m wide and 8-14 m long) houses with interior divider walls. Houses were built using light wattle and daub walls over a framework of wooden posts with thatched roofs. Floors and walls were regularly replastered with pressed clay. Most houses included a large hearth or oven and subterranean storage pits. Additional features found on Maros settlements included exterior ovens, large bell-shaped storage pits, kilns, and prepared clay living surfaces (Michelaki, 2008; O'Shea, 1996). Like other EBA and MBA societies in the Carpathian, the small size of houses is consistent with a single nuclear family (see Duffy, 2010; Sofaer, 2006b; Sørensen, 2010b). Artifacts recovered from Maros settlements and cemeteries provide evidence for sewing and weaving, ceramic manufacture, and metallurgy. Ceramic spindle whorls, large loom weights, and possible bone and antler shuttles were known primarily from settlements, while bone needles placed near the head or torso in female burials have been interpreted as part of a personal sewing kit (O'Shea, 1996; Rega, 1995, 1997). Evidence of metalworking at settlements is provided by crucibles, tuyères, moulds, and slag. Apart from the single discovery of a whetstone in an adult male burial at Deszk, and a clay axe mould in the right hand of a juvenile (12-15 years-at-death) oriented with their head to the north at Ostojićevo (Grave 185), metallurgists were not buried with their toolkits. Metal artifacts are primarily known from funerary contexts and were likely more important for social display than utilitarian purposes (O'Shea, 1996). Metal (copper) tools included flat and shaft-hole axes, triangular daggers, and small awls. Other materials, such as flaked stone (which is not local to the Pannonian Plain), animal bone, and wood were used in the manufacture of agricultural implements.

Ceramics represent the most abundant artifact type found in settlements and cemeteries (Michelaki, 2008; O'Shea, 1996). Maros ceramics were locally produced using locally acquired clays. Ceramics correspond to four general types based on shape and size: liquid containers (cups, amphora, and beakers), bowls, storage jars, and special purpose types (O'Shea, 1996). Michelaki (2008:376) has proposed that the luster produced through burnishing and smudging was meant to be redolent of polished bronze. Burnishing is a labor-intensive process, and it is interesting to note that biconical bowls and large storage containers were the vessel types most likely to have received this treatment.

In identifying communities of practice through analysis of technical skill and complexity, Michelaki (2008:374-375) argued that biconical bowls and storage jars required a greater degree of skill and experience, and were valued by Maros households to display subsistence wealth. While mortuary ceramics are similar in form to those found in settlements, they often lack burnishing and appear to be more expediently produced. Finally, except for the burial of newborns, infants, and young children in storage jars at Ostojićevo, this vessel category was largely absent from Maros funerary assemblages (Girić, 2012 [1995]; O'Shea, 1996).

3.3.2.4 Maros Cemeteries

The Maros communities are known primarily through their large, formal inhumation cemeteries. Apart from their importance as the final resting place for the majority of the Maros population (see Rega, 1995, 1997), cemeteries were a dynamic part of the social and cultural landscape (O'Shea, 1996). Cemeteries, like most settlements, would have been visible from major waterways (O'Shea, 1996). There was, however, no direct relationship between cemeteries and settlements, which O'Shea (1996:44) took to mean that a given cemetery was used by several villages. Recent radiocarbon analysis of three Maros cemeteries was carried out by O'Shea et al. (2019): Szöreg-C near the Tisza-Maros confluence in southeastern Hungary, Battonya-Vörös in Hungary located 65 km west of the Tisza-Maros confluence, and Ostojićevo in Serbia located 40 km south of the Tisza-Maros confluence. Radiocarbon dates for the Mokrin cemetery, located ca/ 20 km east of Ostojićevo, were reported by O'Shea (1991). The results of radiocarbon dating of Maros cemeteries in the context of the Maros culture sequence are summarized in Figure 3.3. Range of cemetery use spans from less than 200 years at Battonya to almost 500 years at Szöreg-C. There is little evidence, radiocarbon or ceramic, for internal phasing at the Maros cemeteries (O'Shea, 1996). Median radiocarbon dates from Ostojićevo show it was established at the end of the EBA/Early Maros phase ca. 1920 cal. BCE, with decreased use or a possible hiatus from ca. 1820-1650 cal. BCE, followed by a period of increased activity prior to abandonment in the Late Maros/MBA phase between 1650-1550 cal. BCE (O'Shea et al., 2019). Otherwise, all other cemeteries seem to have been in continuous use, respectively, for several centuries.

At Ostojićevo, the occurrence of Late Maros 'baroque' pottery styles and fewer nonceramic grave goods compared to Mokrin, has been taken to indicate its use during the Late Maros phase (Girić, 1959; Milašinović, 2009). There is no clear spatial organization of graves at Maros cemeteries, though Rega (1995, 1997) argued for a quasi-linear north-south arrangement of burials at Mokrin, Őszentiván, and Óbéba. Additionally, if grave markers did exist, they have not preserved. Nevertheless, despite the presence of hundreds of graves at Mokrin, Szöreg, and Ostojićevo, burial customs adhered strictly to individual inhumations, with successive burials respecting and not cutting into previous graves.

In general, most individuals were aligned north-south in a flexed position with their face toward the east, with a minority of graves oriented east-west with the face toward the south or north (O'Shea, 1996). There was a strong correlation (94% at Mokrin) between body position and biological sex, with females placed on the right side with their head toward the south, and males on the left side with their head toward the north. This treatment extended to children older than three years-at-death (Rega, 2000). Due to gaps in excavation reports from many Maros cemeteries, and the tendency to only record the most noteworthy finds (*e.g.*, metal implements, ornaments), social implications of mortuary differentiation among the Maros are largely based on the robust archaeological, grave goods, and osteological dataset from Mokrin (O'Shea, 1996:131).

Grave goods were present in 20% of the burials at Mokrin, with ceramics representing the most common category of funerary offering (O'Shea, 1996, 1998; Rega, 1995, 1997). The Maros funerary repertoire consisted of ceramic vessels, body and dress ornaments (metal bracelets, torques, beads, pendants, finger and hair rings, animal teeth, bone, and shell), and small tools (bone needles, metal pins, metal awls, stone and metal axes, and metal daggers). Metal and non-metal ornaments and jewelry were often combined to form elaborate headdresses or belts.

Copper Age groups in the Carpathian Basin (and central Europe generally) almost exclusively buried their dead in large inhumation cemeteries separate from, but often associated with, a single settlement (Giblin, 2011; Shennan, 1993a; Sofaer Derevenski, 1997). While large cemeteries did not appear until the end of the EBA in the southeast portion of the Carpathian Basin, variability in mortuary practices highlighted ritual and ideological differences among neighboring groups in the EBA (Kulcsár, 2003; O'Shea, 1996, 1998; see also O'Shea et al., 2019). Maros cemeteries demonstrated many similarities with those from the preceding Copper Age Tiszapolgár culture, such as the large cemetery at Tiszapolgár-Basatanya in eastern Hungary. These similarities included the use of body orientation and grave goods that reflect different categories of people based on gender and status, respectively (O'Shea, 1996; Sofaer Derevenski, 1997).

A new type of funerary practice and burial custom appeared in the Early Bronze Age – cremation of the deceased and burial of the burned remains in urnfield (cremation) cemeteries. Cremation and urn burials were characteristic of Nagyrév and Nyírség cemeteries to the north and west of the Maros. In general, cremation was more common in the northern and eastern parts of the Carpathian Basin, whereas inhumation was the norm in the south (Kulcsár, 2003). O'Shea (1996:140) argued that contrasting mortuary patterns, in addition to differences in ceramic styles, represented active ways in which boundaries between neighboring culture groups were maintained in the Bronze Age. The contrast between large inhumation cemeteries of the Maros and large cremation urnfields of the Nagyrév highlights the importance of mortuary customs in demarcating cultural boundaries within a social landscape. These sharp contrasts in cultural traditions did not extend to the area south (Vatin culture) and east (Verbicioara culture) of the Maros (O'Shea, 1996; Uzelac, 1995).

3.3.3 Middle Bronze Age (2100-1600 BCE)

The onset of the MBA corresponded to the period of "classical" Bronze Age cultures in the Carpathian Basin (see Table 3.1) (Harding, 2000). The period from 2000 to 1500 BCE aligned with the EBA in central, northern, and western Europe (Kristiansen, 1998). At this time, the Carpathian Basin emerged as an important cultural and economic center. Raw ores were imported into the Basin from the Apuseni and Carpathian Mountains (Fig. 3.4) (Duffy, 2010). Larger tell sites functioned as metallurgical centers, as evidenced by the presence of crucibles, tuyères, molds, slag, and bronze artifacts (Duffy, 2010; Giblin, 2011; Sofaer, 2006b).

Waterways functioned as important exchange routes, and a desire to control access to trade routes and by extension imported material such as metal and stone is evidenced by the strategic location of fortified tell sites along major rivers that connect the Pannonian Plain to raw material sources in the surrounding mountains (Bogdanovic, 1996; Duffy, 2010; Gogaltan, 1996; O'Shea, 2011). Other important economic and social developments in the MBA included the emergence of horse breeding as a regular part of the productive economy, the spread of fortified tells across central and eastern Hungary along the Middle Danube and Tisza rivers, and the appearance of large cemeteries isolated from settlements as part of the social and ritual landscape (Artursson, 2010; Giblin, 2011).

A comparison of settlement patterns, subsistence practices, and mortuary customs, indicates that there was considerable continuity between the EBA and the MBA via the local consolidation and expansion of pre-existing groups (Artursson, 2010; Poroszlai, 2003; Sørensen & Rebay-Salisbury, 2008). Despite variation in subsistence strategies between microregions, most MBA societies practiced a mixed ‘peasant’ economy that focused on agriculture (cereals cultivation, *i.e.*, wheat, barley, oat, rye, millet; legumes, *i.e.*, lentils, beans, peas, bitter vetch; fodder, *i.e.*, oat, clover, and millet; and wild fruits and vegetables, *i.e.*, apples, elderberry, blackberry, cucumber, mustard seed, and turnips) and animal husbandry (*i.e.*, cattle, pigs, sheep, goats, and horses), supplemented by wild resources such as red deer, wild boar, and occasionally aurochs (Arnold & Greenfield, 2006; Giblin, 2011; Greenfield, 1986; Poroszlai, 2003).

Fishing and shellfish collection also contributed a significant part of the diet based on the discovery of objects such as net weights, fish scales, antler hooks, and harpoons at settlements, and faunal evidence for regular exploitation of aquatic resources such as mussels, carp, pike, and catfish, and to a lesser extent bream, perch, and zander (Nicodemus, 2010; O'Shea, 1996, 2011).

The cultural diversity recognized for the MBA makes it challenging to provide a clear-cut sequence of culture development during this period. Here, I will focus primarily on well-documented cultural complexes for the region. The Únětiče culture that extended throughout central Europe, including the Czech Republic, eastern Germany, central and southern Poland, and northern Austria, spread into the northwest corner of the Carpathian Basin in the MBA (ca. 2000-1800 BCE) (Harding, 2000; O'Shea, 1996). While there is no evidence of direct interaction between the Maros and Únětiče groups, Únětičian cemeteries from Bohemia and Moravia had the greatest similarities to Maros funerary practices in terms of specific patterns of body placement and orientation (O'Shea, 1996). However, the majority of Únětiče graves indicate no relationship between body orientation and gender, with the bodies of the deceased uniformly placed in a flexed position on their right side facing east with their heads to the south (Bátora, 1990; Harding, 2000).

In central Hungary and Transdanubia, three distinct cultural complexes emerged during the MBA: the Vatya, Encrusted Ware, and Füzesabony. All three exhibited changes over time in geographic distribution, thereby suggesting a pattern of shifting boundaries as they expanded, contracted, or moved into new areas (Sørensen & Rebay-Salisbury, 2009). Further, each developed directly from pre-existing EBA groups: the Vatya from the Nagyrév, Encrusted Ware from the Gáta and Kisapostag, and Füzesabony from the Koštany with influences from the Hatvan and Otomani cultures (Bóna, 1975; Sørensen & Rebay-Salisbury, 2009).

The Vatya are known from settlements (fortified tells and unfortified villages, hamlets, and isolated farmsteads) and urnfield cemeteries (typically 20-200 graves) on either side of the Danube in central Hungary. The Vatya culture group eventually spread southwest as far as the Danube-Tisza interfluve (Artursson, 2010; Sørensen & Rebay-Salisbury, 2009). Well-documented Vatya sites include the large fortified tell at Százhalombatta-Földvár (5.5 ha) on the Danube, the large unfortified open settlement at Tárnok (12.75 ha), and the large urnfield cemetery at Dunaújváros-Dunadulo (1000+ graves) (Artursson, 2010; Bóna, 1975; Sofaer, 2011; Sørensen & Rebay-Salisbury, 2009). While tells served as centers of social and economic interaction through long-term occupation and community participation, most of the population inhabited unfortified, open settlements that varied in size, density, and duration of occupation (Artursson, 2010). Nevertheless, the lives of the inhabitants of fortified tells were distinguished from those in unfortified open settlements by differences in spatial organization of households, and types and range of activities carried out at the site (Sofaer, 2011; Sørensen, 2010b; Vretemark, 2010). For example, faunal and macrobotanical evidence from Százhalombatta demonstrate that while animals were slaughtered, butchered, and consumed at the site, the absence of large-scale storage of fodder suggests most of the food consumed was brought in from other sites (Vretemark, 2010).

To the west, the Encrusted Ware Culture, so named for their production of elaborate lime-encrusted ceramics, occupied the hilly region of Transdanubia around Lake Balaton (O'Shea, 1996; Sørensen & Rebay-Salisbury, 2009). In contrast to the large, permanent Vatya settlements to the south, Encrusted Ware sites are considerably smaller, less dense, and impermanent (Sørensen & Rebay-Salisbury, 2009). Most

Encrusted Ware settlements consisted of single-layer villages or hamlets, though small fortified hillforts were also constructed at this time. Few houses have been identified, likely due to the use of construction methods whereby posts were not inserted into the ground to support a timber house (Artursson, 2010). Hunting and herding were more important for the Encrusted Ware peoples compared to the Vatya, due to the paucity of ideal land for cultivation (Kiss, 2003b). While the Encrusted Ware culture had some elements of a full-time nomadic, pastoral society, the importance of cattle rearing, emphasis placed on production of elaborate pottery, and low frequency of horses in the faunal record are more consistent with a semi-sedentary, seasonally pastoral society.

Regarding mortuary practices, the Encrusted Ware, like the Vatya communities, cremated their dead and buried the remains in flat cemeteries, typically with fewer than 100 graves (Bóna, 1975). The deceased were cremated elsewhere, placed on pyres in a crouched position, and all burnt remains collected for burial (Bándi & Nemeskéri, 1971). However, rather than placing the cremains in an urn, they were scattered over the surface of an oval or rectangular pit, with ceramic pots covering or outlining the 'body' (Kiss, 2003b; Sørensen, 2010a; Sørensen & Rebay-Salisbury, 2009).

The Füzesabony culture is found in the foothills of the Carpathians in northeastern Hungary and southeastern Slovakia, north of the Tisza-Bodrog confluence (Sørensen & Rebay-Salisbury, 2009). In the late MBA, the Füzesabony spread south along the left bank of the Tisza to the Körös, and to the west as far as the Danube near Budapest, adjacent to the Vatya culture (Bóna, 1975). Like the Vatya, the Füzesabony occupied fortified tells located on natural highs along the loess banks of major rivers (the Tisza and its tributaries). However, Füzesabony tells consisted of a core settlement surrounded by defensive ditches, earthen ramparts, and occasionally stone walls, with a scattered village located outside this fortified space (Bóna, 1975; Sørensen & Rebay-Salisbury, 2009). Many settlements established during the EBA by the Hatvan group were subsequently reoccupied by the Füzesabony. However, several large settlements, such as the unfortified open settlement at Füzesabony–Öregdomb associated with ca. 2.5 m of accumulated habitation deposits, show no evidence of occupation prior to or after the Füzesabony (Szathmári, 2003). Like most EBA and MBA groups in the Carpathian Basin, Füzesabony houses were small (ca. 4-6 m wide x 5-12 m long), rectangular structures made of wattle and daub supported on wooden posts, and housed a single nuclear family (Szathmári, 2003; see also Csányi & Tárnoki, 2003; Michelaki, 2008; O'Shea, 1996; Sofaer, 2006b; Sørensen, 2010). In contrast to cremation as the predominant funerary treatment in the Vatya and Encrusted Ware cultures, the Füzesabony interred their dead in rectangular or oval pits (Csányi, 2003; Sørensen & Rebay-Salisbury, 2009).

Over 2000 Füzesabony graves have been excavated, with body placement adhering to a strict set of rules whereby the deceased was placed in a contracted-fetal position. Males were placed on the right side with their head toward the south and their face toward the east, and females on the left side with their head toward the north and their face toward the east (Cśanyi, 2003b). Infants and children were treated similarly, however, there has been little systematic analysis to validate the postulated correlations between orientation, depth, and biological sex (Bóna, 1975; Sørensen & Rebay-Salisbury, 2009). Cemeteries were located a few kilometers from settlements and were interpreted as sites that contained the remains of extended families or kin-groups (Csányi, 2003b).

The Gyulavarsánd culture bordered the Füzesabony to the southeast in the Berettyó-Körös region. Interaction between these two cultural groups is evidenced by similarities in ceramic styles and motifs (see Bóna, 1975; Csányi & Tárnoki, 2003). Additionally, many Gyulavarsánd settlements were originally inhabited by the Ottomaní groups (Bóna, 1975; Csányi & Tárnoki, 2003; Duffy, 2010). Houses on Gyulavarsánd settlements were small (25 to 65 m^2), constructed using wattle and daub supported by wooden posts, and included interior storage pits and clay ovens (Duffy, 2011:272). Duffy (2010:275-276) has argued that the small size (ca. 45 m^2), architecture (wattle and daub on a wooden frame), and evidence of food preparation and storage inside the house suggests that houses were occupied year-round by four to five people. These variables are consistent with nuclear families acting as self-sufficient units within a decentralized society (Barlett, 1980; Duffy, 2010). Gyulavarsánd settlements, like other MBA groups in the Carpathian Basin (*e.g.*, Vatya, Gáva, Kyjatice), were organized hierarchically (Earle & Kolb, 2010; Giblin, 2011; Parkinson & Gyucha, 2012; Vretemark, 2010). These hierarchies support the existence of asymmetrical relations between large fortified tells and unfortified villages and hamlets, with the former controlling regional economic production and exchange. While this center-hinterland relationship was conditionally supported for the Vatya culture based on excavations at the tell site of Százhalombatta, Duffy's (2010) comparison of Gyulavarsánd tell and "off-tell" settlements based on eight socio-economic dimensions (regional consolidation, segmentation, primary unit of food production/consumption, household distinctions, access to exotics, craft production and specialization, demographic scale, and intensification of food production) did not find evidence for differences in economic production or access to exotic goods between fortified tells versus unfortified open sites (see also Giblin, 2011: 49-50).

In the Berettyó-Körös region, Duffy (2010:356) identified a total of 12 fortified tells and 105 open (single and multicomponent) MBA Gyulavarsánd settlements. Fortified sites range from 1.19 to 25.79 ha, and open sites from 0.58 to 17.56 ha. About 54% of open sites occurred within 7 km of a fortified site (compared to 61% of open sites in the LN). In both the LN and MBA, most of the population lived in small, open settlements, clustered within a 7 km radius of large tell or open settlement (Duffy, 2010; Parkinson, 2002, 2006). A major limitation of this study, and prehistoric settlement studies in general, is an absence of chronological data on when different sites were occupied and for how long. Nevertheless, while the clustering of settlements around a 'central' fortified site lends support to a settlement hierarchy model in which site size and presence or absence of fortifications could be used as a proxy for social and economic difference, Duffy's (2010) exhaustive analysis of Körös settlements has challenged this model. Rather, settlements represented autonomous productive units, with no evidence for inequalities between settlements, consolidation of settlements into a regional polity governed by inhabitants of fortified tells, or craft specialization and control of trade by larger sites (Duffy, 2010:381).

3.3.3.1 The Late Maros Culture Transition and Abandonment

The Late Maros phase was marked by the abandonment of earlier settlements, and consolidation of the population into fewer, but larger settlements spread along the Maros River (Fischl, 2003; O'Shea, 1991, 1996). The majority of cultural elements that defined Maros regional identity in the Early Bronze Age continued into the Late Maros/MBA, including the preservation of single inhumations as the (almost) exclusive burial rite (O’Shea, 1996). There were, however, several major changes in the production and distribution of material culture that distinguished the Late from the Early Maros phase: the appearance of more technically complex, labor-intensive ‘baroque’ pottery styles in household contexts, and a sharp decline in the use of metal objects in funerary dress and grave offerings (Fischl, 2003; Michelaki, 2008; O’Shea, 1996).

These changes reflect a shift in the primary context of competitive display from funerary rituals to households, with greater emphasis placed on production and consumption of food and beverages in signaling wealth and fulfilling social obligations between members of different households. The significance of this trend towards less funerary elaboration is that exotic goods and materials remained in circulation rather than being removed from social life. Excavations at the Late Maros settlements at Kiszombor and Pecica/Santul Mare found evidence of economic intensification in metal production and horse rearing (O’Shea, 2011; O’Shea et al., 2011). Taken together, these changes suggest a disruption in water-based exchange networks that linked the Maros to raw material sources in the southern Carpathians, and a shift to a greater reliance on overland trade routes to the north and northwest (O’Shea, 2011). This would have brought the Maros into greater contact with Gyulavarsánd settlements in the Körös region to the north and Vattina communities to the south (O’Shea, 2011).

Though the exact nature of interactions between neighboring groups in the Late Maros phase are unknown, both Gyulavarsánd and Vattina finewares appeared at Maros sites at this time. In addition, classic Maros finewares have been found at Gyulavarsánd and Vattina settlements (Bóna, 1975). Tell settlements along the Middle and Lower Maros were completely abandoned by 1500 BCE, with no evidence of intensive reoccupation until the Early Iron Age (EIA) (Tasić, 2003-2004). Contrary to O’Shea’s (1996:368) interpretation of increased social and economic stability due to heightened warfare and conflict at this time, there is no evidence of catastrophic destruction of Maros settlements. Increased reliance on a north-south trade axis and climate change [a transition to increased aridity between 1700-1600 BCE] likely played important roles in the economic and social marginalization of the Maros-Tisza region after the early MBA and into the Late Bronze Age (LBA) (O'Shea, 2011; O'Shea et al., 2011; Sherwood et al., 2013).

3.3.4 The Late Bronze Age (Tumulus period: 1500-1200/1300 BCE; Urnfield Culture: 1200-800 BCE)

Shennan (1993a:157) describes the period from 1600 to 1500 BCE in central Europe as "…the peak of a growth process producing increased population and prosperity, albeit with evidence of growing competition and warfare." This evolutionary trajectory of increased growth and complexity was not maintained, and the beginning of the LBA was marked by a break with previous traditions. At this time, craft production and domestic activity shifted to fortified settlements, and hillforts arose as a new type of dominant settlement (Osgood, 2001a). Like in the preceding EBA and MBA, settlements tended to be located along major river valleys, lake shores, or placed on strategic hilltops. Defensive systems – comprising fortifications and enclosures - became more substantial during the LBA, moving from a system of banks and ditches that partially enclosed a few sites, to elaborate palisades and ramparts fully enclosing both hillforts and lower elevation sites (Harding, 2000; Osgood, 2001a).

The Late Bronze Age also saw changes in ritual activity and the adoption of new metallurgical techniques (Harding, 1999, 2006; Primas, 1997). In contrast to the inclusion of metal as grave goods in the EBA and MBA, the majority of metal in the Late Bronze were recovered from hoards deposited in a variety of contexts (rivers, caves, fields, settlements) often in and around boundary zones between two cultural traditions (Harding, 2000, 2006; Kristiansen, 1998). Kristiansen (1998:80-85) identified several categories of hoards: scrap metal and misfired or broken metal for recycling; production and distribution hoards containing a series of standardized/identical objects, ingots, or scrap metal for trade; personal hoards consisting of single objects or a combination of personal ornaments, weapons, or tools; and community hoards that may reflect the burial or 'sacrifice' of communal property or wealth. Some authors have sought to 'gender' hoards based on the inclusion of 'male' (weaponry, razors) or 'female' (jewelry, ornaments, dress fittings) objects, interpreted as representing an individual warrior or elaborate female costume (Harding, 2000; Kristiansen, 1998). These associations are based on analogy with the types and combinations of objects associated with the materialization of individual male and female identities from funerary contexts (Sørensen, 1997; Treherne, 1995).

Specialized metal weapons in the form of rapiers first appeared in the MBA associated with the post-Únětice Tumulus culture in central Europe (Harding, 2006; Osgood, 2001a), though spears appeared earlier at the end of the EBA (Harding, 2000). Swords became larger and more elaborate in the subsequent Urnfield period (Harding, 2000; Osgood, 2001a). As weapons, swords were more versatile and advantageous compared to daggers, rapiers, and spears. While most Bronze Age weaponry, except arrows, were only effective in close-quarter hand-to-hand combat (daggers and rapiers were restricted to deep thrusting), swords were used to deliver heavier blows via cutting, slashing, and thrusting (Harding, 1999; Kristiansen, 2002). Use-wear evidence on swords recovered from graves and hoards range from pristine to heavy resharpening, which suggests that many were never used in combat and may have been produced as ceremonial items for use in social and ritual contexts of competitive display (Harding, 1999, 2000; Kristiansen, 2002). Whether swords and metal defensive armor, such as shields, helmets, corselets, and greaves, were intended for actual combat, their interpretation as symbolic markers of male power and prestige has led to the characterization of LBA cultures as "warrior societies" controlled by an elite male warrior class (Harding, 1999; Kristiansen, 1998; Osgood, 2001a; Treherne, 1995).

While metal throughout the Bronze Age was as an important vehicle for the visualization and display of social differences according to status and gender, evidence of the social life of weapons and ornaments preclude them from being tied to prestigious individuals (Harding, 2000, 2006). Rather, there is a disconnect between form and function in Bronze Age weaponry that was related to symbolic/ceremonial versus utilitarian use, and deposition in anonymous hoards versus individual graves (see Harding, 2000, 2006; Sørensen, 1997). Overall, there was a trend toward increasing standardization as well as elaboration of all categories of metal artifacts during the LBA (Primas, 1997; Sørensen, 1997). Despite this apparent homogenization, separate pieces were combined to form unique combinations of "warrior dress" that communicated an individual's social position and prestige. Supraregional commonalities in the types of materials and objects connected to prestige were widely circulated throughout Europe. In this way, objects such as swords cross-cut cultural boundaries in how they were valued in the context of social interaction, trade, and social display (Kristiansen, 1998; Primas, 1997; Sørensen, 1997).

Culture development in the Carpathian Basin paralleled that recognized for most of central Europe in the LBA. The beginning of the LBA in the Carpathian Basin corresponded to the MBA Tumulus period in central Europe (Artursson, 2010; Duffy, 2010). The Tumulus period in the Carpathian Basin is enigmatic, and principally marked by the widespread abandonment of long-occupied tell settlements and emergence of a distinct Transdanubian metalworking tradition (Duffy, 2010; Kemenczei, 2003). The prevailing interpretation posits that the advent of the Tumulus culture corresponds to the invasion of 'kurgan cultures' from forest steppe of southeastern Poland and northeastern Slovakia south into the Carpathian Basin and west into Germany and Austria (Csányi, 2003b; Gimbutas, 1965; Harding, 2000). As the name implies, the most striking characteristic of the Tumulus culture is the rich inhumation burials located beneath barrows, though inhumation in flat cemeteries continued as the dominant burial practice during this period (Harding, 2000). Tumulus settlements consisted of single farms, small hamlets, or villages and included several two- or three-aisled houses surrounded by smaller buildings (Artursson, 2010).

Cremation became the predominant practice with the emergence and expansion of the Urnfield cultural complex across most of central Europe in the LBA (Harding, 2000; Kristiansen, 1998). Urnfield cemeteries were large, containing hundreds or even thousands of burials. Body treatment included the burial of cremains in an urn. Despite the size of Urnfields, and the importance of cemeteries as arenas of social display and power in the preceding EBA and MBA, cemeteries lacked a clear spatial organization and grave goods were uncommon (Harding, 2000, 2006; Sørensen, 1997). The increase in cemetery size in the Urnfield period was paralleled by an increase in the number of settlements (Kristiansen, 1998). The earliest Urnfield settlements were concentrated on the most productive soils. Later settlements appeared on secondary and tertiary soils within river valleys. Over time, as regions became increasingly settled and more densely populated, there was a trend toward increased population concentration and political hierarchization that spread from eastern to central Europe (see Kristiansen, 1998: 102). Urnfield settlements are well known from the Rhine-Main basin and Lausitz region of eastern Germany and Poland (Osgood, 2001a). A number of house plans have been documented for Urnfield settlements at Zedau, Ostmark in Germany, and Lovčičky in Moravia (see Harding, 2000:49-54). Houses were small semi-subterranean rectangular structures, ranging in size from 24 to 36 m^2, with timber walls supported by posts. Internal divisions and hearths were present in some houses. This uniformity in house size, plan, and construction was documented for Urnfield settlements in the Benta Valley of central Hungary (Artursson, 2010). In contrast to the regular rows of densely packed houses in the Early and Middle Bronze Age, houses on Urnfield settlements in the Benta Valley were less organized and more dispersed.

In the sections below, I provide an overview that focuses on more specific themes of archaeological and bioarchaeological research as these largely have helped to frame my own dissertation study and data collection. These themes also connect importantly with the chosen methods and theory of my research, which is discussed in more detail in Chapter 4.

3.4 Thematic Overview

3.4.1 Demography and Paleopathology

Osteological analysis of human remains from Bronze Age cemeteries has traditionally and overwhelmingly focused on demographic reconstruction. Assuming most burial samples are representative of actual mortality rates, and certain individuals were not systematically excluded on the basis of sex, gender, or age, demographic reconstructions showed a general pattern of high perinatal and infant mortality (ca. 15-35%) with few people (ca. 5-15%) surviving beyond 50 years (Harding, 2000: 378; see also Rega, 1995, 1997). Thus, cemeteries in which newborns or young infants were rare or absent likely reflect cultural practices in which individuals dying before a certain age were not buried. For example, demographic reconstruction at Mokrin based on biological sex for individuals >18 years-at-death, and body orientation for subadults, has indicated equal representation between the ‘sexes’ for all age groups, with the exception of the youngest (1-3 years-at-death) (Rega, 1995, 1997).

Compared to a hypothetical expected mortality profile for prehistoric societies in Europe, survivorship at Mokrin (and Ostojićevo) reflect a pattern of natural attrition and forms a representative sample of death in a typical Maros community (Rega, 1995). This conclusion is contrary to those published by Farkas & Lipták (1971) and O’Shea (1995), which found that young adult males were underrepresented at Mokrin. For the youngest age class (3-6 years), there was a statistical significance between ‘male’ and ‘female’ burial orientations, with ‘female’ position being almost twice as common (Rega, 2000). Without evidence from aDNA, whether this represented selective infanticide of male infants, or differences in socialization of male and female infants, remains unclear.

Few studies have systematically analyzed human skeletal remains for evidence of trauma, pathology, degenerative disease, or metabolic disease (Ubelaker & Pap, 2009). This is due in part to factors such as preservation and scarcity of intact skeletons, but also due to research questions and strategies that see osteological analysis as a means of providing basic details on age and sex for mortuary analysis.

Evidence of infectious or chronic diseases at Mokrin has been confined to a few sentences by Rega (1997:238), which attest to low rates of skeletal pathologies, degenerative disease, and trauma. The anthropological report by Farkas & Lipták (1971:252-259) presents several cases of trepanation or cranial trauma at Mokrin. Older studies, such as that by Farkas & Lipták (1971) for Mokrin, focused primarily on craniometric analysis to construct racial taxonomies. At Mokrin, 44% of crania from Mokrin were classified as belonging to the ‘Nordic’ race, with brachycephalic ‘Taurids’, doliocephalic ‘Mediterraneans’, and proto-European ‘Cro-Magnoids’ also represented. Rega (1995) used diet, tooth-specific rates of dental caries and AMTL, and NSIS (non-specific indicators of stress) - porotic hyperostosis, cribra orbitalia, and enamel hypoplasias - to evaluate differences in quality of life between males and females, adults and subadults, and individuals with and without prestige goods.

Results from the dental and dietary analyses are discussed in more detail below. No significant differences were found for any of the NSI variables in relation to the categories described. Cribra orbitalia and enamel hypoplasias were present in both children and adults; porotic hyperostosis was virtually absent. Recently, a study by Stefanović & Porčić (2011) applied cluster analysis to compare activity among "high" and "low" status males and females at Mokrin using musculo-skeletal markers (MSM) from upper and lower limbs as an index of physical activity. While they found no correlation between labor intensity and social status, they did find a positive correlation between high status males and more pronounced muscle attachments on the upper arms and shoulders, and a negative correlation between upper arm use and social status in females. While life was not more demanding or strenuous in terms of physical demands among different categories of adults at Mokrin, the results suggested physical strength and capabilities were highly valued moreso in males than females.

Despite claims that "warfare was certainly an important part of the lives of Bronze Age inhabitants of central and eastern Europe" (Osgood, 2001a:65), and several books and edited volumes that discuss the supposed ubiquity of warfare in the Bronze Age (Carman & Harding, 1999; Keeley, 1996; Osgood, Monks, & Toms, 2001), there is limited direct evidence of violent trauma from human skeletal remains (Aranda-Jimenez et al., 2009; Chapman, 1999). While some authors claim an abundance of evidence of skeletal trauma (Osgood, 2001a, 2001b; Vandkilde, 2006), they fail to cite systematic studies and rely solely on anecdotal evidence. Most evidence of warfare and violence in the Bronze Age comes from artifacts, settlements, and burials. Specifically, use-wear evidence from swords and armor, presence of fortifications, and discovery of 'warrior' graves (Kristiansen, 2002; Treherne, 1995; Vandkilde, 2006). Few studies have systematically analyzed trauma in skeletal populations, especially in cemeteries in which a percentage of burials have been interpreted to be of 'elite warrior males' (see Aranda-Jimenez et al., 2009; Hårde, 2005, 2006).

The discovery of human remains in a ditch at the LBA site of Cezavy Hill at Blučina in Moravia has been interpreted as evidence of a massacre (Osgood, 2001a). While some of the remains bear cut marks, Harding (2000:292, 334) questioned the interpretation of the assemblage as resulting from a massacre, arguing instead that secondary burial practices cannot be ruled out as a possible explanation. He supported this alternative interpretation by referencing the practice of burying the dead in fortification ditches at sites in eastern Bohemia (Harding, 2000:292). Similarly, the discovery of dismembered human remains under a destruction level at the MBA site of 'Skalka' at Velim in Bohemia have been interpreted as votive deposits tied to secondary burial practices rather than massacre victims (Harding, 2000; Osgood, 2001a); however, several human skeletal elements were identified at Velim that displayed perimortem trauma. Cut marks associated with penetrating injuries made by a sharp knife were found on a rib and femur, respectively, with a chop mark to the left mandible in an adult male interpreted as a decapitation injury (Knüsel et al., 2007).

Artursson (2010: 109) described the discovery of the "butchered remains of women and children" deposited in refuse pits at a MBA Vatya settlement in central Hungary. However, no citation was provided. Finally, violent death has been inferred from skeletal remains from burial contexts throughout central Europe. These include the discovery of a skeleton of an adult male from the EBA site of Hernádkak in northeastern Hungary with a bronze spearhead embedded in his pelvis (Bóna, 1975; Osgood, 2001a). A skeleton from the Tumulus site of Klings in Germany was found with a bronze arrowhead embedded in the vertebral column, and a bronze arrowhead was also found lodged in the humerus of a skeleton from Stetten in Germany (Osgood, 2001a). Finally, an adolescent (ca. 12 to 13 years-at-death) from the Urnfield site of Stillfried in Austria exhibited four large circular perforations on the cranium, interpreted as blunt force trauma, showed similarities to published images of possible "trephination" from Mokrin (Bergerbrant, 2007; Farkas & Lipták, 1971; Osgood, 2001a).

3.4.2 Dental Disease, Stable Isotopes, and Diet

There are surprisingly few studies of the Bronze Age in central Europe that utilized analyses of dental pathology, tooth wear, nutritional deficiency, and/or bone chemistry to reconstruct diet from human remains (Bonsall et al., 2004; Nehlich et al., 2010; Oelze, 2012; Tafuri et al., 2009). Previous studies have primarily focused on examining evidence of diachronic change in diet, rather than the importance of food consumption in defining social categories within a population. Most studies that have investigated stable isotopes from human bones and teeth focused on strontium signatures as an indicator of mobility (Oelze et al., 2011; Price et al., 2004). There is even less data on tooth wear and dental disease for Bronze Age populations (Molnar & Molnar, 1985; Rega, 1995). Studies on human dental health from prehistoric populations in the Pannonian Plain by Molnar & Molnar (1985) concluded dental health was relatively good in the Bronze Age, with low frequencies of caries frequency, antemortem tooth loss (AMTL), enamel hypoplasia, and age-related progression of periodontal disease.

In contrast, Rega (1995; 1997) found a high prevalence of dental disease in permanent dentition at Mokrin, with the prevalence (TPR) of caries in permanent molars ranging from 6 to 23% in females and 3 to 12% in males (higher values for maxillary molars). Additionally, AMTL of molars ranged from 2 to 22% in females and 3 to 24% in males at Mokrin. Rega (1995) also conducted preliminary analysis of diet from human bone using trace metal concentrations of strontium and barium from bone apatite, and stable isotope ratios of $\delta^{13}C$ from bone apatite and $\delta^{13}C$ and $\delta^{15}N$ from bone collagen. Strontium and barium concentrations have been shown to be unreliable indicators of diet as they do not accurately reflect the relative proportions of different sources of food in the diet (Burton & Price, 2000; Katzenberg, 2008). On the basis of mean isotopic values, Rega (1995) concluded there was no statistical difference in diet between males and females, but there was a statistical difference between individuals associated with high or low status burials, with an increase in $\delta^{13}C_{apatite\text{-}collagen}$ spacing indicative of a more plant-based diet in higher status individuals (see Kellner & Schoeninger, 2007).

In general, stable isotope analysis of $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ from human bone collagen has demonstrated that Bronze Age people consumed high levels of animal proteins and relied primarily on C_3 crops such as wheat, barley, and legumes, rather than C_4 cultigens such as millet (Bonsall et al., 2004; Oelze, 2012). Compared to Iron Age populations from central Europe, which demonstrated preferential access to animal protein among elite males buried with weapons (Le Huray et al., 2006), there is no evidence for sex-based differences in diet for Copper Age (Hoekman-Sites & Giblin, 2012; Lillie et al., 2011) or Bronze Age (Oelze, 2012) populations. Additionally, terrestrial sources formed the bulk of dietary protein in Copper Age and Bronze Age groups in the Pannonian Plain. Exploitation of aquatic resources decreased significantly after the Mesolithic in the Iron Gates region of the Danube and ceased to be a major part of the diet from the Neolithic through the Middle Ages (Nehrlich et al., 2010).

3.4.3 Gender, Age, and Social Status

Gender and age-at-death are perhaps the two most critical factors that governed Bronze Age mortuary practices (Harding, 2000; O'Shea, 1995; Rega, 1997; Sørensen & Rebay-Salisbury, 2009). Status and occupation as social categories were fundamentally tied to and expressed within the context of gender and age as social constructs and biological realities (Rega, 1997; Sofaer Derevenski, 1997, 2000; Sofaer, 2009, 2011). Kinship is more difficult to identify, though formal cemeteries likely corresponded to corporate groups comprised of one or more extended families. Additionally, funerary customs were important in communicating regional identities by reinforcing cultural and political boundaries (O'Shea, 1996; Sørensen & Rebay-Salisbury, 2009). Gender was often assigned to burials and grave goods based on biological sex, which Sofaer (2009) and Rega (1997, 2000) have argued ignores the myriad ways in which bodies become gendered. This practice of inferring "gender" from "biological sex" has served to underlie problematic assumptions about the relationship between sex, sexuality, and gender in prehistory. It also ignores the role of children in society due to methodological limitations in estimating sex from subadult remains (Rega, 2000). As an alternative, Sofaer (2009) and Rega (1997) advocate the use of the skeletal body as a frame of reference for the cultural construction and representation of social categories through associations with material culture, body treatment, and body position. For example, Rega (1995, 1997) observed 94% correspondence between biological sex and body orientation in the EBA cemetery at Mokrin. While she contended that this is well within the expected methodological range of error for sex determination from the skeleton, the possibility that in certain cases males were buried in a stereotypically 'female' style and vice versa has important implications for assuming gender in the Bronze Age.

Variation in sex-dependent burial practices, such as burial rites, body position and orientation, and the use of grave goods, were common features in EBA and MBA inhumation cemeteries (Harding, 2000).

A lack of associated osteological data beyond identification of age and sex has resulted in a distorted view of social inequality in the Bronze Age (Aranda-Jimenez et al., 2009; Rega, 2000; Sofaer Derevenski, 1997). Susan Shennan's (S. Shennan, 1975) landmark study of funerary variation in relation to age and sex in the EBA cemetery at Branč in Slovakia influenced subsequent studies of prehistoric social organization in central Europe (see Chapman, 2005). Her analysis focused on the correlation between grave goods, body position/orientation, and sex and age to answer three key questions: (1) To what degree, if at all, were local communities socially stratified in the Bronze Age?; (2) What was the nature of social stratification, or rank, and was high status achieved or inherited?; (3) What were considered material markers of wealth and status and how were they displayed in relation to the deceased?

Underlying these questions was a series of assumptions including no change over time in burial customs, a burial population that was a representation cross-section of everyone who died, and that exotic grave goods marked status and wealth. To calculate a wealth score, "rich" graves were identified based on the presence and quantity of different artifact types. Wealth scores were then compared between males and females across eight age groups (sex of subadults was inferred from grave orientation) (Shennan, 1975:285). Overall, more female graves than male were identified as "rich". Based on these findings, Shennan (1975:285) proposed two hypotheses to explain the "problem" of "rich" female and child burials: female wealth was achieved through marriage to wealthy husbands, and "rich" female subadults reflected a tradition of arranged marriages. Furthermore, polygyny, in which elite males had multiple wives, was offered as an explanation for the greater number of "rich" female burials. The possibility was not considered that "rich" female infant burials reflected ascribed female status in a community that recognized matrilineal descent and female children were valued for their role in ensuring group continuity.

Sofaer Derevenski (1997) observed a similar correlation between age, sex, body position, and grave goods at the ECA-MCA (4500-3600 cal BCE) cemetery at Tiszapolgar-Basatanya in eastern Hungary. However, Sofaer Derevenski (1997) argued that variability in grave assemblages between males and females supports the construction of gender identities along a continuum that was distinct from binary sex. Additionally, gendered artifacts such as worked stone and metal blades exhibited age-related changes in type and distribution. Based on this patterning, and the assumption that mortuary practices reflected social perceptions rather than the identity of the deceased, Sofaer Derevenski concluded that gender and status were fundamentally tied to changes in social and economic activities at different stages in the life cycle.

The role that certain objects may have had in mediating links between sex and gender changed as individuals took on different roles and identities throughout their lifetime, which in turn influenced how they were represented and perceived in death. A similar conclusion was reached by Rega (1995, 1997) for age-dependent differences in the materialization of engendered status through mortuary practices at Mokrin. This contrasted with O'Shea's (1996, 1998) conclusion that female status was achieved through marriage to powerful men. Exclusive or predominantly male grave goods, such as copper daggers, axes, and ceramic cups, were ranked above female items (*i.e.*, stone and bone beads, stone mace, bone needles, copper pins, and copper bracelets) as reflecting a cultural divide between *maleness-weaponry-leadership* over *femaleness-display-marriage*.

The greater proportion of females compared to males buried with metal, stone, and bone offerings has often interpreted as bridewealth or gifts from high status husbands (*e.g.*, O'Shea, 1996; Shennan, 1975). This androcentrism and overemphasis of male arenas of power, often tied to the association of men as warriors, ignores evidence that suggests gender roles were more variable than simply male versus female, and the multiple social roles and personas individuals acquired throughout their life or were recognized at birth (*e.g.*, Rega, 1997; Sofaer Derevenski, 1997). This approach also undervalues the contributions of women and children to prehistoric society, and how 'female' domains of wealth and prestige may have complemented those of 'males'. Finally, in the absence of detailed osteological analysis beyond estimation of sex and age, the extent to which associations drawn between people and things reflects actual self-categorization and the implications for perceived social differences in access to resources, nutrition, physical activity, and mobility remains unknowable.

3.5 Conclusion

As discussed in Chapters 1 and 2, my doctoral dissertation research focuses on a population associated with the EBA/MBA Maros society that inhabited a region in the southeastern corner of the Carpathian Basin. Ostojićevo dates to the end of the Maros sequence and represents the southernmost Maros site (Girić, 2012[1995]; Milašinović, 2009). Maros settlements and cemeteries represent ideal locations in which to study the impact of social and economic transformation on local communities.

Over a century of archaeological research and excavation has been conducted in this region, providing a detailed picture of both variation and change over time in local customs and practices. Despite this, there are several barriers to conducting research in this region. These include the fact that Maros sites are spread out over three countries (Romania, Hungary, and Serbia) with different traditions of archaeological scholarship. Additionally, sites such as the settlement at Popin Paor, Serbia or the cemetery at Ostojićevo, Serbia remain largely unpublished. Fortunately, in the case of Ostojicevo, the National Museum in Kikinda, Serbia retains the entire skeletal and grave goods collection, as well as excavation notes and documentation, allowing for detailed systematic reanalysis of the material using modern approaches. While the original context can never be recovered, the level of documentation and state of preservation provide an excellent opportunity for studying health, status, diet, and demography, and for conducting comparative analysis with the well-documented Maros skeletal and mortuary collection from the nearby (albeit chronologically earlier) cemetery at Mokrin, Serbia.

Explanations of culture change, especially in the context of social and political organization and subsistence economy, must be predicated on an understanding of conditions prior to and following the archaeological culture group and period under study. In this way, preceding Copper Age and enigmatic MBA groups in this region provide insight into the nature and scope of change. This contributes to the formation of a larger social trajectory of human communities related both genetically and culturally. This likely consanguinity makes changes and regional and local idiosyncrasies even more compelling. For example, the burial of newborns and infants in urns occurs at a high proportion at Ostojićevo, but is rare at other Maros cemeteries. Furthmore, whereas the Maros almost solely practiced inhumation (with a few exceptions) with considerable diversity in grave goods according to age-at-death and gender, mortuary practices in the Koros region to the north favored burial of cremains in urns with offerings limited to one or two ceramic cups.

In taking a bioarchaeological approach to understanding social organization, health, and subsistence, my data collection and analysis focuses on a single Early/Middle Bronze Age population from northeastern Serbia. Going beyond this, this dissertation investigates assumptions regarding relationships between people within as well as between communities as part of larger networks of social interaction and economic exchange. That these networks changed overtime is well-documented in the archaeological record, as I have outlined above. Moving beyond regional and macroregional perspectives, however, leads to the question of what we actullay know about these processes and how they affected the social relations and health of real individuals that were enmeshed within the larger scale communities. For example, were changes in mortuary practices, specifically the relative wealth of burials in terms of exotic items such as bronze, gold, shell, or stone, simply the result of local differences in beliefs regarding the importance of funerary rites in ritual performance or more complex attributes of social display and identity? Did economic and social marginalization undermine the stability of Maros communities, and by extension local elites, ultimately contributing to declines in biological health, access to exotic trade goods (and attendant spheres of interaction), thus increasing subadult mortality through disease and conflict? Questions such as these, unfortunately, remain unanswered through the previous studies that have been reviewed in this chapter.

4.0 Taphonomy and Demography

Between the summers of 2011 and 2014, I conducted an in-depth skeletal analysis of human remains curated at the Narodni Muzej Kikinda from the Late Maros EBA/MBA cemetery at Ostojićevo. A total of 237 individuals were analyzed from Ostojićevo, including 106 subadults (0-20 years-at-death) and 123 adults (>20 years-at-death)[1]. No skeletal remains could be located for 61 out of a total possible 280 graves, excluding symbolic and cremation burials (Table 4.1). Additionally, several graves included mislabeled skeletons or skeletons likely commingled post-excavation This category includes those associated with a grave label that does not "match" excavation records (*e.g.,* discrepancies in age, number of individuals) or were designated "BB" or "bez broj" (without number) (Table 4.2). "BB" remains were recorded but excluded from demographic or paleopathological analysis. Prior to this analysis, skeletal remains had been poorly labeled and stored in plastic grocery bags. Paper labels had been placed in each bag. Frequently, crania were stored separate from postcrania. Subadults were placed in separate boxes from adults. When possible, an attempt was made to match mislabeled or commingled skeletons to the correct grave based on excavation reports and osteological comparability.

My analysis involved the laying out in anatomical order of one skeleton at a time to minimize the risk of damage or commingling. The cranium was typically laid out and analyzed first followed by the postcrania. Following data collection, bones were placed in acid-free plastic bags labeled with grave and element type/category (*e.g.,* extremities, ribs, vertebrae, os coxae). Site name and grave number were written directly on long bones, taking care to avoid obscuring morphology. Following completion of skeletal analysis, remains were curated in durable cardboard boxes by museum director Lidija Milašinović.

---

[1] 1. "Adult"s defined as >18 years for dental analysis (n = 147). This was done to allow for comparison with published data on dental disease (*i.e.,* caries and tooth loss) by Rega (1995) for the Maros cemetery at Mokrin.

Each box was labeled with site name and grave number(s), with subadult remains boxed separately from adults. All human skeletal remains were stored together in single storage room at Narodni Muzej Kikinda.

Table 4.1 Summary of graves for which remains could not be located (Ostojićevo)

Grave Type	n	Grave #(s)
Flexed inhumation	7	9, 65, 93, 138, 140, 221, 257
Urn inhumation	47	3, 11, 22, 27, 33, 43, 44, 45, 46, 50, 55, 61, 62, 74, 75, 80, 83, 85, 90, 97, 99, 103, 118, 122, 125, 132, 134, 137, 142, 144, 151, 168, 172, 174, 178, 196, 200, 201, 206, 211, 239, 253, 254, 259, 262, 267, 271
Cremation	4	8, 25, 31, 143
Double flexed inhumation	1	47A, 47B
Disturbed	5	40 (urn), 109 (urn), 152 (urn), 175 (urn), 180
Cenotaph	1	54

Table 4.2 Summary of disturbed or mislabeled graves (Ostojićevo). Includes disturbed graves, graves lacking provenience, and graves mislabeled/commingled post-excavation. "BB" graves excluded from demographic and paleopathological analysis.

Grave Type	n	Grave #(s)
Disturbed	24	35, 101, 110, 117, 123, 131, 148, 164, 166, 169, 186, 188, 190, 193, 215, 225, 233, 234, 242, 255, 272, 273, 283, 285
No Record	6	17B, 108B, 162B, 170B, 222B, 238B
Mislabeled or commingled in storage	15	23, 95, 139 (crania A), 139 (crania B), 139 (crania C), 141/138 (crania A), 141/138 (crania B), 141/138 (crania C), 141/138 (postcrania A), 138/141 (postcrania C), 171 (postcrania C), 219, 215/220 (postcrania A), 215/220 (postcrania B), 281
No burial number ("BB")	8	BB 82A, BB 82B, BB 83A, BB 83B, BB 83C, BB 83D, BB 83/88A, BB 84A

4.1 Methods: Ostojićevo Inventory and Preservation

4.1.1 Skeletal Inventory

Each adult was inventoried by assessing each bone for presence and completeness. This allowed for calculation of elemental minimum number of individuals (MNI). Calculating individual MNI is important as it accounts for differential preservation in conducting statistical analyses, especially when analyzing frequency of pathological conditions in a skeletal population. Completeness was scored for the bones of the cranium, axial skeleton, vertebrae, and extremities (Appendix Figure 1). Long bones were divided into five sections (Judd, 2002): the proximal articulation, proximal diaphysis, mid-diaphysis, distal diaphysis, and distal articulation. Complete bones or parts of long bones received a score of 1, incomplete bones received a score of <1, and missing bones received a score of 0.

Completeness scores were used to calculate Prevalence Rate (PR) and Mean Preservation Index (MPI) for major skeletal elements in “adult” >20 years. PR measures percent “present” versus “expected” for a given element or element category. MPI measures preservation quality, with 0.9-1.0 = excellent, 0.75-0.9 = very good, 0.5–0.75 = good, 0.5-0.25=poor, and <0.25 = very poor. The use of both PR and MPI provides insight into whether more common elements were also better preserved, or vice versa.

A general description of preservation and bone presence/absence was provided for subadults. Due to the fragmentary nature of many of the subadult remains, especially neonates and infants, individual skeletal elements were not inventoried. Long bones were divided into presence/absence of proximal epiphyses, body, and distal epiphyses, rather than assessed as single elements. Finally, vertebral bodies were inventoried separate from neural arches. Rather than pooling individuals to examine overall preservation quality and rate, subadult preservation was assessed relative to age-at-death, with the sample divided into four age cohorts: neonate (<1 year), infant I (>1-3 years), infant II (>3-6 years), child I (>6-9 years), child II (>9-12 years), juvenile I (>12-15 years), and juvenile II (>15-20 years). Subadult age classes and intervals are adapted from Buikstra and Ubelaker (1994) to reflect uncertainty in age estimation from macroscopic analysis of subadult remains as it relates to stages of postnatal human growth and development. Subadult age classes for the Ostojićevo sample were also developed to compare with those used by Rega (1995) for Mokrin. Section 4.2.3 features a more in-depth discussion of subadult aging criteria.

4.1.2 Taphonomy and Preservation

Each skeleton was evaluated for general preservation. These descriptions were not intended to be comprehensive but to provide information about preservation status broadly. Adult and subadult crania, dentition (mandibular and maxillary), and postcrania were assessed based on a modified Behrensmeyer (1978) scale (Table 4.3). Categories included Excellent, Very Good, Good, Poor, and Very Poor. Intermediate stages (*e.g.*, good/very good, poor/good) were used to identify crania and postcrania that exhibited a mixture of taphonomic processes. For example, postcrania categorized as good/very good might include almost excellent preservation of long bones, but poorly preserved or absent vertebrae, os coxae, extremities, etc.

Table 4.3 Criteria for assessing skeletal preservation. Modified from Behrensmeyer (1978).

Stage	Description
Excellent =	90 to 100% of skeletal elements present in good condition, with little weathering. (Behrensmeyer, 1978: Stage 0)
Very good =	75 to 90% of skeletal elements present in good condition, with little weathering. Mostly complete bones, few fragments. (Behrensmeyer, 1978: Stage 0)
Good =	50 to 75% of skeletal elements present, some cortical weathering. Long bones mostly present and intact, though some os coxae, scapulae, sternum, vertebrae, and extremities may be fragmentary or incomplete. (Behrensmeyer, 1978: Stage 1-2)
Poor =	25 to 50% of skeletal elements present, frequently with intermediate cortical weathering. Long bones fragmentary or absent, with limited preservation or presence of other postcrania. (Behrensmeyer, 1978: Stage 2-3)
Very Poor =	<25% of skeletal elements present, often with extensive cortical weathering obscuring skeletal features (*e.g.* muscle attachments, joint surfaces, etc.). (Behrensmeyer, 1978: Stage 4-5). Also includes remains that are well-preserved (Behrensmeyer, 1978: Stage 0-2), but preserve few or no cranial or postcranial elements.

4.2 Methods: Ostojićevo Demography

4.2.1 Biological Sex

Biological sex was estimated for individuals >20 years-at-death at Ostojićevo. Subadult biological sex was not measured due to issues of preservation and methodological inaccuracies (Molleson et al., 1998). Estimation of biological sex was based on nonmetric macroscropic analysis of the skull, mandible, and os coxae according to criteria outlined in Buikstra and Ubelaker (1994) and Acsádi and Nemeskéri (1970). When present, the Phenice (1969) criteria were applied to assessing sexual dimorphism in the pubic and subpubic region, specifically characteristics of the ventral arc, subpubic angle, and ischiopubic ramus. A general description of sexually dimorphic traits was recorded for each adult individual. Following analysis, each adult skeleton was assigned to one of five categories that reflect variation in morphology and preservation: M (male), MI (probable male), FI (probable female), F (female), or I (indeterminate adult).

Research by Walrath et al. (2004) showed considerable interobserver error and inaccuracies in estimation of biological sex from the crania. In general, the os coxa is a more reliable indicator of biological sex, as sexually dimorphic features are less affected by activity and age (Rogers & Saunders, 1994; Spradley & Jantz, 2011). Variation in sex determination accuracy has been reported for classification rates based on visual evaluation without logistic regression or discriminant function. For the cranium, Rogers (2005) recorded a classification rate of 89.1% for a historic sample of known sex and age-at-death from Canada, with an overall intraobserver error of 12.2%. Rogers (2005) ranked features based on accuracy (correct identification) and precision (intrasobserver error). The highest ranked features included nasal aperture shape/size, malar size and rugosity, supraorbital ridge size, and presence of zygomatic extension (location of posterior root relative to supramastoid crest and temporal line), followed by chin form, nuchal crest rugosity, and mastoid size. The least reliable features were orbit shape, frontal and parietal bossing, size of occipital condyle, and general tooth size (excepting molars).

Expanding on these analyses, Williams and Rogers (2006) assessed accuracy and precision of 21 discrete morphological cranial characteristics from individuals of European ancestry with known age-at-death and sex obtained from the William M. Bass Donated Skeletal Collection at the U. of Tennessee, Knoxville. They observed overall rates of 96% accuracy and 92% precision, with no significant differences in either precision or accuracy due to age. Six of the 21 craniofacial features were identified as meeting or exceeding criteria for levels of precision or accuracy (≥80%): skull size and architecture, mastoid size and shape, supraorbital ridges, mandible gonial angle, zygomatic extension, and nasal aperture size and shape (Williams and Rogers, 2006: 734). Importantly, both Rogers (2005) and Williams and Rogers (2006) found that several features commonly used to estimate sex from the adult cranium were problematic based on accuracy and/or precision, especially the presence or size of frontal and parietal eminences, forehead shape, palate shape/size, and orbit shape/size. While these two studies demonstrate the reliability of sex determination from the cranium, they reveal two important limitations of cranial sex estimation: (1) decreased accuracy due to population-specific variation in morphology of individual craniofacial features; and (2) the unreliability of using individual indicators, and importance of incorporating multiple indicators to achieve accuracy rates ≥80%. Furthermore, Walrath et al. (2004) observed statistically significant differences in interobserver determination of relative "maleness" and "femaleness" based on visual assessment, but not overall sex determination. The authors suggest providing clear definitions rather than maximizing number of character traits to maintain consistency and comparability.

Sex determinism based on craniofacial morphology in the current study emphasized characteristics of the mastoid process, supramastoid region, supraorbital ridges, and mandible. Other features such as overall size, supraorbital margin, external occipital protuberance, and zygomatic arch were used to support sex determination in cases in which two or more of the primary features were indeterminate or missing. Crania with only one of the primary features or regions preserved were assigned to probable-male, probable-female, or Indeterminate to reflect limitations of relying on single-feature estimation. Due to inconsistencies in preservation and post-excavation reconstruction, orbit shape and nasal aperture shape and size were not assessed.

Several studies have compared reliability of sex estimation based on cranial and pelvic morphology (*e.g.*, Konigsberg & Hens, 1998; Spradley & Jantz, 2011). A review of published data on percent correct classifications by Konigsberg and Hens (1998) found crania (excluding studies focused only on the mandibular ramus) to range from 81.4% to 89.8% for males and 77.5% to 92.0% for females. Percent correct classification from the pelvis was reported to range from 95.6% to 100.0% for males and 70.8% to 100.0% for females. Using a Late Mississippian sample from Illinois, which included a large proportion of incomplete cranial remains, Konigsberg and Hens (1998) found that when compared to pelvic morphology, there was a tendency to misclassify female crania as male. Among individuals with well-preserved crania, correspondence with sex-determination based on pelvic morphology was 91.9% for males and 64.1% for females, with a combined classification correspondence of 79.0%.

These observations underline important biases in sex-determination. Assumptions about 'idealized' male and female skeletons become complicated as a result of developmental and behavioral factors that influence expression of dimorphism in individuals and populations. For example, cranium and mandible size and shape are susceptible to modification from repeated biomechanical stresses such as grinding grain (Molleson, 2007), carrying heavy loads on the head or back (Bridges, 1994; Geere et al., 2010), artificial cranial deformation (Fletcher et al., 2008), or limited gendered-division of labor (Blakey, 1998; Mack & Blakey, 2004; Sofaer Derevenski, 2000). Thus, behavioral factors can affect the appearance of traits used to assess sexual dimorphism in the skull, especially muscle attachments such as the external occipital protuberance, mastoid process, and supramastoid crest, and result in misclassification. Additionally, Walker (1995:33-40) notes significant age-related changes in cranial sexual dimorphism, especially in the supraorbital area. Both males and females exhibit a trend towards increased supraorbital robusticity with increased age. This results in a tendency to misclassify young adult males as female, and older females as male. More research is needed to understand the effect of tooth loss and alveolar resorption on craniofacial morphology as it relates to sexual dimorphism. However, the loss of a single mandibular molar has been shown to have a masculinizing effect on the female mandible, with edentulous mandibles exhibiting more extreme morphological transformations (Loth & Henneber, 1996).

Rogers and Saunders (1994) identified six morphological characters of the os coxae that when used as single-trait determinants of sex produced low interobserver error (<5%) and high accuracy (>83%): ventral arc, obturator foramen shape, true pelvic size and shape, sacrum shape, subpubic concavity, and pubis shape. Conversely, the least effective traits for sex determination included auricular surface shape and size, ischiopubic ramus shape, ilium shape, pelvic inlet shape, and number of sacral segments. Applying the Phenice (1969) criteria produced an overall combined accuracy of 88%, with variation in effectiveness reported for the ventral arc (86.9% accuracy, 0.0% intraobserver error), subpubic concavity (83.8% accuracy, 3.2% intraobserver error), and ischiopubic ramus (80% accuracy, 11.3% intraobserver error) (Rogers and Saunders, 1994: 1054). Rogers and Saunders (1994) only reported combined accuracy and intraobserver error for individual and combined traits. However, a review of the Phenice method by Volk and Ubelaker (2002:20) found this approach was more accurate in correctly estimating sex in females (97.0%) than in males (79.8%). This discrepancy in correct classification of males and females disappeared when the Phenice methods was used in conjunction with other non-metric pelvic traits (*e.g.*, sciatic notch, subpubic angle, auricular area, acetabulum, and general size and shape), producing an overall accuracy of 96.5%. Among incorrectly identified individuals, body size was found to be the primary factor in misidentification for both males (abnormally small) and females (abnormally large).

Both Volk and Ubelaker (2002) and Rogers and Saunders (1994) found age-at-death to have little effect on correct sex-determination from the pelvis. Based on these observations, the current study relied on pelvic morphology for sex-determination whenever possible, especially application of the Phenice method combined with the sciatic notch, preauricular sulcus, and general size and morphology. For individuals with sufficient preservation, it was indicated whether the crania, os coxae, or both were used for sex assessment. In cases of disagreement between sex estimation from the crania versus os coxae, or ambiguity in cranial sexual dimorphism, final determination was based on pelvic morphology. Following suggestions of Walker (1995) and Volk and Ubelaker (2002), and when preservation allowed, features of the os pubis were weighted most heavily in sex determination.

In selection and application of methods, the current study sought to consider variation in expression of nonmetric traits due to sex, size, and individual developmental differences (Schwartz, 2007). Ultimately, sex determination reflects an average of the overall number of traits considered relative to age-at-death, body size, and familiarity with population-specific variation in expression of sexually dimorphism. While metric criteria have been shown to have accuracy rates ≥90% (see Albanese, 2003; Decker et al., 2011; Gonzalez et al., 2009), the fragmentary and incomplete nature of cranial and postcranial elements, as well as artificial distortion from both taphonomic processes and post-excavation reconstruction in the Ostojićevo collection precludes application of these methods.

4.2.2 Age-at-Death (Adults)

Estimation of adult age-at-death at Ostojićevo was based on documented age-related changes in the auricular surface (Lovejoy et al., 1985) and/or pubic symphysis (Brooks and Suchey, 1990). When present, union of the spheno-occipital synchondrosis, sacral segments, or late-fusing epiphyses (*e.g.*, sternal clavicle, iliac crest, humeral head) were used to confirm or adjust ages among young adults. Rather than assign a point age estimate, individuals were assigned to one of eight age categories (Table 4.4). These categories were based on: (1) utility in conducting comparative demographic analysis, especially with published age-at-death data from Mokrin; (2) reflect important developmental landmarks; and (3) incorporate methodological limitations of greater uncertainty with increased age. Several intermediate categories (*i.e.*, Juvenile II/Adult I, Adult I/II, and Adult III/IV) were developed to account for individuals with conflicting or ambiguous evidence for age-at-death. Finally, an Adult (A) category was used for individuals with insufficient preservation for determination of age-at-death, but who exhibited complete fusion of extant epiphyses indicating an age greater than ~22 years.

Table 4.4 Adult age-at-death categories (Ostojićevo)

Category	Abbreviation	Age Range (years)
Adult I	AI	>20-30
Adult I/II	AI/II	>20-40
Adult II	AII	>30-40
Adult II/III	AII/III	>30-50
Adult III	AIII	>40-50
Adult III/IV	AIII/IV	>40
Adult IV	AIV	>50
Adult	A?	>22

The selection of methods used for the current study considered replicability, preservation, and accuracy and precision. Macromorphological changes in the pubic symphysis, such as the Todd (1920; 1921) and Suchey-Brooks (Brooks & Suchey, 1990) criteria, are considered two of the most reliable methods for ageing adult human remains (Buikstra & Ubelaker, 1994; Lovejoy et al., 1985). Development of standards for the estimation of age-at-death has focused on identifying regions of the skeleton that exhibit a well-defined, consistent pattern of change that corresponds to distinct chronological ranges. Since Todd's (1920, 1921) identification of macroscopic age-related changes in the os pubis, much research has focused on the adult os coxa. Subsequent research on the pubic symphysis has largely reinforced Todd's (1920; 1921) pattern of age-related morphological changes in this joint (see Brooks & Suchey, 1990; Gilbert & McKern, 1973; McKern & Stewart, 1957). The contributions of these later studies lie largely in reducing the number of phases, readjusting the timing of the commencement and completion of successive phases, and accounting for sexual dimorphism.

A major weakness of Todd's model, which Todd himself noted (1920:289), was an irregular age-curve due to the tendency for death certificates to estimate or round age up or down. As a result, reported ages were frequently off set from the actual age by several years, and resulted in demographic 'peaks' at five-year intervals (Brooks & Suchey, 1990). The Suchey-Brooks model preserves Todd's description of maturational changes, but condensed Todd's ten phases into six. While a single set of descriptions regarding key age changes can be applied equally to males and females, the current study implemented the following criteria to further refine age estimates (see Brooks & Suchey, 1990:232; Buikstra and Ubelaker, 1994:23-24):

- Dorsal lipping was disregarded as an age-related change in females due to its uncertain association with pregnancy.
- Phases I and II have the narrowest ranges and are most useful in determining an upper age limit (30 years), whereas phases V and VI have the widest ranges and supply lower age limits (40 years).
- Transverse organization and appearance of deep ridges and furrows are generally present in individuals <24 years, whereas the formation of an ossific nodule on the upper extremity occurs in individuals <30 years.
- Presence of incomplete ventral rampart formation indicates an age of <40 years.
- Formation of a distinct symphyseal rim, depression of the pubic face, and/or breakdown of rim with increasing irregularity and porosity generally occurs in individuals >40 years.

Research demonstrates that age-related changes in the subchondral bone of the auricular surface can be attributed to an increase over time in the proportion of fibrocartilage irrespective of osteoarthritic or osteophytic changes (Buckberry & Chamberlain, 2002; Lovejoy et al., 1985). Unlike models developed for the pubic symphysis, there is no corresponding appearance of a 'latent epiphysis' (ventral rampart) in the auricular surface. Thus, the separate features used to document change in the auricular surface (porosity, surface texture, marginal changes, and transverse organization), develop independent of one another (Lovejoy et al., 1985). Rather than generating age ranges that reflect distinct phases in the metamorphosis of the auricular surface, Lovejoy et al. (1985) organized the data into eight modal age categories. While this method has shown to be effective in estimating age-at-death in individuals >60 years (Falys et al., 2006), several authors have criticized the age categories as being too narrow and fail to account for individual variation in timing of attribute appearance (Buckberry & Chamberlain, 2002; Jackes, 2000). The following criteria were considered in applying the Lovejoy et al. method based on their recommendations and Schwartz (2007:238). Individuals exhibiting pathologic (*e.g.*, DISH, ankylosing spondylitis) or traumatic changes to the sacroiliac joint were excluded from analysis:

- Age assessments were based primarily on aspects of transverse organization, surface texture and granularity, and porosity. Changes to auxiliary regions - apical margin and retroauricular area - were used to adjust ages up or down accordingly.
- While the criteria are applicable to both males and females, the presence of a deep preauricular sulcus characteristic of some females has been shown to accentuate changes to the apical margin. Thus, marginal changes were disregarded in these individuals.
- Combinations of two consecutive stages were used to represent individuals that exhibited transitional characteristics (*e.g.*, an auricular surface exhibiting marked striae and coarse granularity but no porosity was scored as Stage 3/4, or 30 to 40 years).

4.2.3 Age-at-Death (Subadults)

Estimation of age-at-death in subadults at Ostojićevo relied on a combination of methods in assessing deciduous and permanent tooth formation and eruption, fusion of the metopic suture and mandibular symphysis, appearance of epiphyses, unification of the os coxa, and epiphyseal fusion. In contrast to adults, subadult age-at-death can be calculated with greater precision and accuracy as skeletal and dental elements undergo well-established sequences of postnatal growth and development. However, the exact rates at which these individual elements manifest, as regards to timing and pattern, can vary under normal conditions of growth and development due to sex, and variation between individuals and populations (Schwartz, 2007). External factors such as metabolic stress brought about by physical environment, diet, psychological trauma, or injury or disease can also prolong or retard ‘normal’ growth and development (Norgan et al., 2012; Schell et al., 2012; Steckel, 2012). To reflect this uncertainty, individuals 3 to 15 years-at-death at Ostojićevo were assigned to 3-year age-categories rather than calculating point estimates. These were reduced to one- (neonates = birth to 1 year-at-death) and two-

(infant I = >1 to 3 years-at-death) year age ranges for the two youngest age cohorts, and expanded to five-year age range (>15-20 years) for the "oldest" subadult age cohort. Table 4.5 provides a summary of subadult age categories used at Ostojićevo.

Table 4.5 Subadult age-at-death categories (Ostojićevo)

Category	Abbreviation	Age Range (years)
Neonate	Neon	Birth-1
Infant I	In I	>1-3
Infant II	In II	>3-6
Child I	Ch I	>6-9
Child II	Ch II	>9-12
Juvenile I	Juv I	>12-15
Juvenile II	Juv II	> 15-20

Schwartz (2007:217) identified five stages of postnatal tooth growth and eruption: toothless phase (birth to 7 months); teething phase initiated by eruption of deciduous teeth above gum line (7 months to 2 years); use phase of deciduous teeth (2 to 6 years); mixed dentition phase marked by eruption of permanent dentition and exfoliation and replacement of deciduous teeth (6-12 years); and use phase of permanent dentition (>12 years). Dental age as an assessment of physiological age has been shown to be less affected by environmental, genetic, and physiological factors compared to other types of skeletal growth, notably long bone length and epiphyseal fusion sequence and timing (Cardoso, 2007; Lampl & Johnston, 1996; Sciulli, 2007). Dental eruption reflects physiologic age (developmental stage) and is not a reliable indicator of chronological age due to timing variation between individuals and populations (Demirjian, 1978; Saunders, 2008). Additionally, published data on eruption timing from living populations primarily uses gingival eruption rather than emergence of the crown above the alveolar margin (see Dean & Cole, 2013; Parner et al., 2002). There is also a need to distinguish between emergence of the tooth through the gingivae into the oral cavity, and eruption to functional use/occlusal contact with opposing tooth. These distinctions are often obvious when dealing with dry bone, especially isolated deciduous or permanent teeth.

Several authors suggest relying on dental formation as a better indicator of physiologic maturity and chronologic age (Liversidge et al., 2010; Saunders, 2008). For example, Dean and Cole (2013) showed a lack of correlation between peak root growth spurt and eruption in a sample of modern and archaeological permanent human dentition. In contrast, Liversidge and Molleson (2004) analyzed crown and root formation and tooth eruption for deciduous dentition in a living sample from Scotland and an archaeological (19^{th} century) population from London. They found that despite individual and population variation in crown and root formation and eruption times, overall deciduous teeth grow at a faster rate and are a better predictor of infant and early childhood age compared to permanent teeth (Liversidge & Molleson, 2004: 178). Furthermore, they observed a closer correlation between deciduous tooth development and eruption compared to published data on permanent teeth.

For the current study, permanent or deciduous teeth were scored as 'erupted' when it could be determined that they were in functional occlusion based on in-situ preservation of opposing tooth, or at least ¾ root formation (based on observations reported by Dean & Cole, 2013: 11). Several methods were combined to estimate age-at-death based on tooth formation (Smith, 1991; Ten Cate, 1989 *in* Schwartz, 2007:222-223; Ubelaker, 1999). The maximum developmental stage was recorded for each deciduous and permanent tooth based on criteria outlined in Moorrees et al. (1963a, 1963b). Third molars were excluded from age assessment due to their variability in crown and root formation. As sex was unknown, an upper and lower limit was calculated for each individual considering minimum and maximum possible mean age for each method irrespective of sex. Preference was given to age estimations based on Ten Cate (1989) and Smith (1991) in assigning individuals to age categories.

Age estimation for those dying during the juvenile to young adult period, marked by the onset of puberty and culminating in skeletal maturity, is often based on analysis of physiologic age from the appearance and union of bony epiphyses (Saunders, 2008). Growth refers to progressive and incremental changes in size and morphology. The timing at which individuals reach given developmental milestones – their physiologic or biological age – is often but not always positively correlated with chronological age (Scheuer & Black, 2000). Postnatal human growth can be subdivided into three general phases, also known as the ICP model: Infancy – Childhood – Puberty (Karlberg, 1989). Human growth velocity is non-linear, with growth rates fluctuating both within and between these three phases. The human growth curve is characterized by rapid growth in the first year of life, especially during the first six months. This is followed by a steep deceleration in growth up to ca. three years. The rate of decelerated growth decreases from three years until the onset of the adolescent growth spurt (Lejarraga, 2012).

Height is usually genetically determined, but growth velocity or the rate of growth is influenced by environmental and behavioral factors such as low birth weight due to perinatal problems, malformation or deformation, malnutrition, chronic disease (*e.g.*, malabsorption, respiratory disorders, congenital heart disease), endocrine disorders, and psychosocial deprivation (Lejarraga, 2012). While growth delays can result in short stature, the impact on adult height and ability to respond to catch-up growth are dependent on the duration, intensity, age of onset, and cause of the delay. Genetic factors also play an important role in an individual's ability to respond to and withstand environmental or physiologic stress, as well as absolute height during growth and at maturity. These factors not only modify the normal human growth curve but can result in disparities between chronological age and physiologic age (Cardoso, 2007). Furthermore, the application of growth standards obtained from healthy living children may not be applicable to archaeological skeletal samples, which are comprised of children who did not survive to adulthood (Johnston, 1962; Maresh, 1970; Moorrees et al., 1963a). While acute causes of childhood mortality would not affect growth rate, mortality in this age cohort reflects differential selection related to preexisting conditions or underlying factors contributing to higher morbidity, which would create a growth bias between survivors and nonsurvivors (Saunders & Hoppa, 1993).

Preservation of dentition was sufficient for estimation of age-at-death in individuals ca. <12 years-at-death, though presence of identifiable postcranial epiphyses and fusion of vertebral elements was also recorded. For individuals based on dental development and general size that corresponded to Juv. I, Juv. II, and AI, age-at-death was further refined using a combination of methods that account for timing and sequence of fusion of postcranial epiphyses (secondary ossification centers) to primary ossification centers (diaphysis) at the metaphysis. Standards selected reflect data from modern Europeans (Cardoso, 2007;

Ferembach et al., 1980; Vallois, 1960 *in* Schwartz, 2007:229). Epiphyses were further scored for fusion stage: (1) open, no fusion; (2) partial fusion, ossification encompasses 1/4th to 3/4th of circumference; (3) fusion complete but metaphyseal line still visible around circumference; (4) fusion complete, obliteration of metaphyseal line. These stages could be adapted to each method, where stage 1 corresponded to ≤ lower age limit for each element, stage 2 to ≥ lower age limit and ≤ upper age limit, and stages 3 and 4 ≥ upper age limit. Since sex was unknown, minimum and maximum combined ages for males and females were used in determining lower and upper age limits for each element. While this decreased precision, it allowed for increased accuracy in that on average the pubertal growth spurt is initiated two years earlier in girls (~11-13 years) than boys (Hauspie & Roelants, 2012).

In general, ossification of the ilium, ischium, and pubis along the triradiate cartilage commences around 11 years in females and around 14 years in males (Schwartz, 2007:230). While there is considerable individual variation and overlap between separate epiphyses, the sequence of fusion usually proceeds from the elbow and hip to the ankle, knee, wrist, and shoulder (Stewart & Kerley, 1979 *in* Schwartz, 2007:230). Complete coalescence of late-fusing epiphyses such as the sternal end of the clavicle or iliac crest can occur as late as the mid-twenties in both males and females (Ferembach et al., 1980; Vallois, 1960). In determining age-at-death for juveniles and refining estimates for AI, the current study employed the following considerations:

- Assumption that fusion corresponds generally to the following sequence: elbow + hip → ankle → knee → wrist → shoulder.
- At minimum, individuals assigned to Juv. I (>12-15 years) should exhibit partial to complete eruption of upper and/or lower second molars (if isolated tooth, should exhibit ½ to ¾ root formation). At maximum, acetabular coalescence and/or partial fusion of distal humerus.
- At minimum, individuals assigned to Juv. II (>15-18 years) should exhibit complete fusion of the acetabulum (hip), distal humerus and proximal radius (elbow), and distal fibula and tibia (ankle), and partial to complete fusion of proximal and distal femur, and proximal fibula and tibia, and partial fusion of distal radius and ulna (wrist), and ischium.

- Late-fusing epiphyses consistent with AI (>20-30 years) include proximal humerus, iliac crest, and sternal clavicle. Remnants of metaphyseal line may still be visible for femoral head, distal radius and ulna (wrist), and ischium.
- It is recognized that there is considerable individual variation in the timing and sequence of fusion of individual skeletal elements. Thus, final age determination will be based on overall consensus, with outliers used to adjust estimates slightly up or down.

Estimation of age-at-death from both adult and subadult skeletal remains is complicated by the fact that growth, maturation, and degeneration are progressive processes, but skeletal references and standards rely on discrete itemized categories. For subadults, the use of age categories rather than point estimates allows for the general seriation of individuals based on similar growth stage. Thus, while it is possible an individual classified as Juv. I may have died as early as 11 years and as late as 16-18 years, their classification reflects a degree of skeletal growth consistent with an individual who had reached the onset of puberty. Ultimately in a prehistoric agricultural society like the Maros, it is these relative physiologic changes rather than actual chronologic age that likely held cultural value in mediating the subadult lifecourse.

4.3 Methods: Mokrin Demography

Information on biological sex and age-at-death from the Early Maros EBA cemetery at Mokrin was adapted from data presented in Rega (1995). Individuals analyzed by Farkas and Lipták (1971) but not include in Rega (1995) were excluded from paleodemographic analysis as the broad age ranges used by the former were not conducive to survivorship reconstruction and comparison. No direct demographic analysis of human skeletal remains from Mokrin was undertaken as part of my study. A comparison of age-at-death categories for Ostojićevo with Mokrin are presented in Table 4.6 for adults and Table 4.7 for subadults. Rega's (1995: 87) subadult age categories for Mokrin are identical to the Ostojićevo categories outline in section 4.2.3, with the exception that “Child” is subdivided into Child I (>6 to 9 years) and Child II (>9 to 12 years) at Ostojićevo. For comparative purposes and survivorship analysis, individuals from Ostojićevo and Mokrin were reclassified into 10-year age cohorts, excluding individuals of indeterminate age-at-death: 0-10, 10-20, 20-30, 30-40, 40-50, and >50.

Table 4.6 Overview of adult age-at-death categories (Mokrin)

Farkas and Liptak (1971)* category	Age range (years)	Rega (1995)** age category	Age range (years)
Adultus (Ad.)	22-40	Young Adult (YA)	>18-30
Maturus (Mat.)	40-60	Prime Adult (PA)	>30-40
Senium (Sen.)	>60	Mature Adult (MA)	>40-50
		Old Adult (OA)	>50

***Note*. * Estimation of age-at-death based on endocranial suture closure and dental attrition; ** Estimation of age-at-death based on modified 10-stage dental attrition scale, root dentin transparency, pubic symphysis (Katz & Suchey, 1986), auricular surface (Lovejoy et al., 1985), and/or ectocranial suture closure (Meindl & Lovejoy, 1985).**

Table 4.7 Overview of subadult age-at-death categories (Mokrin)

Farkas and Liptak (1971)* category	Age range (years)	Rega (1995)** category	Age range (years)
Infantia I (Inf. I)	birth-7	Neonate	birth-1
Infantia II (Inf. II)	7-14	Infant A	>1-3
Juvenis	14-18(22)	Infant B	>4-6
		Child	>7-12
		Juvenile 1	>12-14
		Juvenile 2	>15-18

***Note*. *Method(s) undefined; ** Estimation of age-at-death based on dental development averaged for sex (Moorees et al., 1963a; 1963b; Smith, 1991), long bone length relative to dental development, and/or epiphyseal fusion stage (Steele & Bramblett, 1988; Chamberlain, 1994).**

4.4 Methods: Statistical Analysis

Data organization and calculation of variable counts and frequencies was conducted in MSExcel. All statistical analyses were carried out in IBM-SPSS v. 23, unless otherwise specified.

4.4.1 Correlations

The bivariate Pearson Correlation test was used to assess the relative strength of the relationship between the two-preservation metrics – index and rate. *Pearson's r* (ρ) measures the correlation between two variables as a function of the square root of r^2 (Drennan, 2010). Values of ρ range from -1 (negative correlation) to 0 (no correlation) to +1 (positive correlation) corresponding to the strength of the relationship between variables X and Y.

4.4.2 Survivorship

Estimation of demographic parameters based on the Ostojićevo and Mokrin skeletal samples utilized comparison of model to sample life tables. Life tables were constructed in Microsoft Excel following standard definitions and calculations (Ubelaker, 1989; Weiss, 1975). Adults who crossed age categories were split equally between two successive age intervals. Additional modifications to the standard life table include the use of narrower age intervals to highlight variation in subadult mortality.

Individuals >10 years-at-death were assigned to ten-year age intervals. Due to uncertainties in estimating age-at-death in individuals >50 years, this was the maximum age interval included in the life table. As some individuals likely survived beyond 50 years, there is a bias towards younger ages in adults in calculating mean life expectancy (e°x). The proportion of known subadult urn burials was used to estimate the distribution of age-at-death among unknown subadult urn burials. Assignment of burial treatment was based on Girić's unpublished grave descriptions compiled by Milašinović (2008). The estimated number of unknown urn burials was added to the number of known urn burials to calculate totals for neonates, infant I, infant II, and child I.

Model life tables provide insight into mortality, fertility, and demographic change in typical or ideal populations (Chamberlain, 2009; Paine, 1989). The utility of model life tables to compare an unknown to an 'ideal' population is based on the compilation and averaging of age-specific mortality rates from historic populations. Deviations between the model and sample life table can be applied to identifying potential stochastic variations or irregularities due to demographic disruption (*e.g.*, disease, warfare) or differential burial practices. =

Weiss (1975) observed that the effect of stochastic fluctuations or sporadic demographic disturbance would be mitigated in large cemetery samples, and thus have a minimal effect (estimated 2 to 10%) on calculation of stable age distributions using model life tables. Model like tables provide a summary of mortality in an ideal population (Chamberlain, 2006). Comparison of sample to model (ideal) life tables allows for the identification of possible stochastic variations in or external influences (*e.g.*, warfare, disease) on populations. The most commonly used model life tables are those developed by Coale and Demeny (1983) based on data compiled by the Office of Population Research at Princeton University. The 'west' model life tables are taken to be the most representative of mortality in developing countries, and thus applicable to pre-industrial populations (Chamberlain, 2006:32). Specific life tables are based on average female life expectancy and vary in life expectancy at birth from 20 years (Level 1) to 80 years (Level 25), with an increase in life expectancy at birth of 2.5 years between levels. Variation in infant and childhood mortality explain most of the differences between mortality levels.

The identification of appropriate model life tables (MT) for comparison is based on similarities in adult mortality (i) and juvenile mortality (j) so that:

$$\text{MT: i-j}$$

For example, MT: 40-60 signifies $E(15) = 40$ and $l(15) = 60$, where $E(15)$ represents adult mortality level of life expectancy at 15-years and $l(15)$ juvenile mortality schedule or survivorship at 15-years (see

Weiss & Wobst, 1973:36). Additional comparisons can be made between adult survivorship (S), or the percentage of adults surviving to 50-years after attaining 15-years. This statistic is calculated as:

$$S = 100\ (\ l(50)\ /\ l(15)\ )$$

Model life tables provide insight into additional demographic parameters that may be difficult to reconstruct due to the incomplete nature of the archaeological-osteological record. These include: the dependency ratio (*DPCY*), which measures the ratio of non-reproductive (juvenile and elderly) to the reproductive population; μ-age, which is the average age of all individuals in a given population assuming 5-year age groupings; μ-adult age, defined as average age among individuals who have attained at least 15-years; *F*, or mean family size, defined as the mean number of male and female offspring birthed by women 15- to 50-years; *T* generation length based on mean reproductive age assuming a stable population; and proportion of population <15-years, 15 to 50-years, and >50-years, designated *C*(min, max). Furthermore, model life tables provide a check on whether *B*(X), fertility required to maintain zero growth, is close to the hypothesized maximum fertility for human populations. Acsádi and Nemeskéri (1970) estimated an upper limit for human fertility at *B*(25) = 0.35, which corresponds to an average female reproductive rate of 0.35 daughters per year. Granted that a certain segment of the female population is non-reproductive due to infertility or cultural factors, and childbirth mortality, it is unlikely that a population can sustain a fertility rate > *B*(25) = 0.4 for more than a few years.

Survivorship (lx) refers to the probability that an individual from a given birth cohort is still alive at the beginning of the next age interval. As all individuals are alive at the beginning of the first age interval, the value of lx at $l_0 = 1$, and declines with each successive age category. In contrast, the age-specific probability of death (dx) is calculated based on the proportion of individuals surviving (lx) and proportion of individuals dying (dx) at the start of each age interval, so that:

$$qx = dx\ /\ lx$$

A Kaplan-Meier estimate was used compare within-group differences in male and female survivorship, and between-group differences in total survivorship at Ostojićevo and Mokrin. Individuals were regrouped into 10-year age cohorts to allow for comparability between cemetery samples. Data on age and sex for Mokrin were compiled from Rega (1995). Normality was assessed using the Kolmogorov-Smirnoff statistical test (Margerison & Knüsel, 2002), which is a nonparametric test that evaluates the normality of a given distribution (Siegel & Castellan, 1988). Age intervals were expanded to include 50 to 60-years and 60 to 70-years, with the proportion of individuals assigned to each interval corresponding to those from MT 20:40. Comparison of survivorship and mortality at Ostojićevo and Mokrin assumed a stable population structure with limited in- or out-migration and periodic demographic disturbances masked by multigenerational cemetery use.

4.5 Results: Ostojićevo Taphonomy and Preservation

4.5.1 Adult Preservation

Data on PR (Preservation Rate) and MPI (Mean Preservation Index) is presented for craniofacial and postcranial elements (Figure4.1 and 4.2, respectively). No major differences in preservation were observed between males and females (Appendix Tables 1 and 2). For craniofacial elements, males exhibited slightly higher TPR.

Comparison of preservation by adult age class (Appendix Tables 3 and 4) showed higher MPI values for Adult I individuals; Adult II individuals had the highest TPR values. Adult IV individuals exhibited the lowest PR and MPI values. Pearson correlation coefficients were used to assess the strength and direction of the association between TPR and MPI (Table 4.8). Coefficient (r) values close to +1 or -1 indicate a strong correlation. Positive or negative r values reflect the direction of the association.

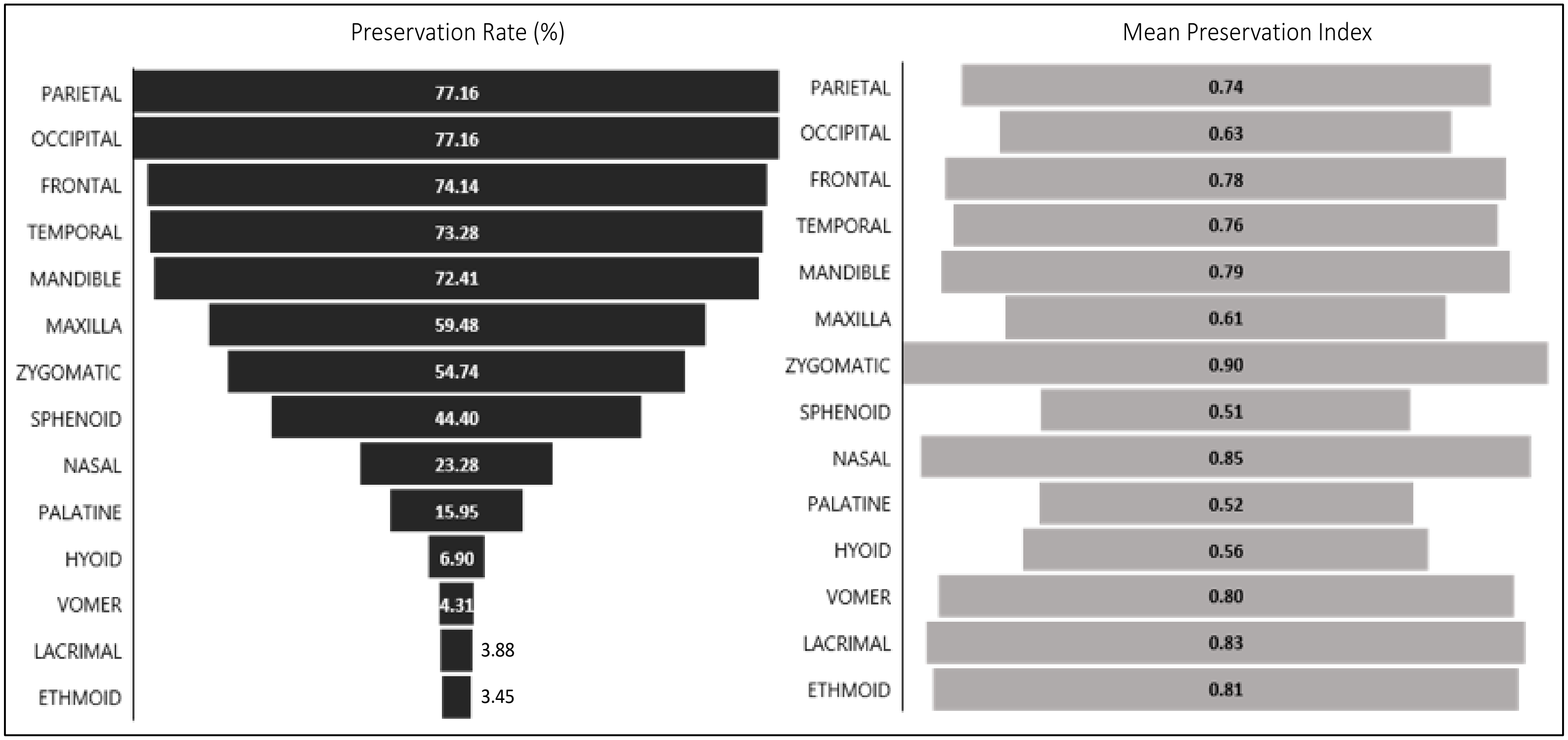


Figure 4.1 Adult craniofacial preservation at Ostojićevo. Comparison of adult craniofacial PR (left) versus MPI (right). Pooled left and right sides.

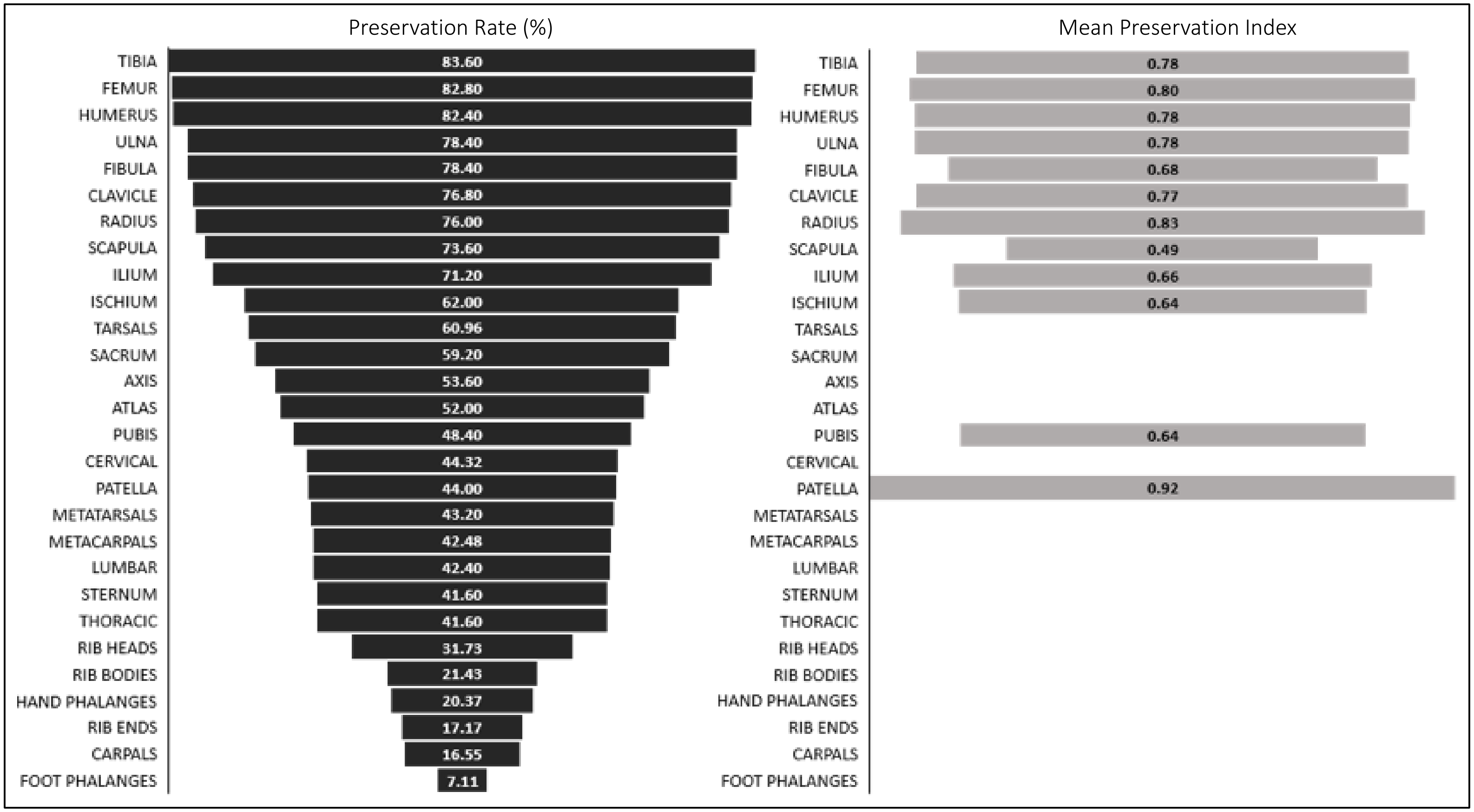


Figure 4.2 Adult postcranial preservation at Ostojićevo. Comparison of adult postcranial PR versus MPI at Ostojićevo. MPI only recorded for major appendicular elements. Pooled left and right sides.

Table 4.8 Pearson's r scores for adult crania and postcrania. Values closer to -1 or 1 indicate a stronger correlation between sex- or age-specific preservation quality and preservation rate.

Category	Cranial		Postcranial	
	r	Strength of Association	*r*	Strength of Association
Male	.45	Moderate	-.19	Weak
Female	-.24	Weak	-.05	None
Adult I	-.30	Moderate	-.21	Weak
Adult II	.08	None	-.06	None
Adult III	.53	Moderate/Strong	-.16	Weak
Adult IV	.70	Strong	.04	None
Total	.01	None	-.01	None

4.5.2 Subadult Preservation

A complete overview of preservation quality and rate can be found in Appendix Tables 5 and 6. Briefly, subadult TPR and MPI increase with age-at-death. On average, juveniles showed the highest TPR and MPI values across all subadult and adult age classes. Correlation coefficients for TPR and MPI are reported in Table 4.9.

Table 4.9 Pearson's r scores for subadult crania and postcrania. Values closer to -1 or 1 indicate a stronger correlation between preservation quality and preservation rate.

Category	Cranial		Postcranial	
	r	Strength of Association	*r*	Strength of Association
Neonate	.38	Moderate	.71	Strong
Infant I/II	.70	Strong	-.41	Moderate
Child I/II	.76	Strong	-.31	Moderate
Juvenile I/II	.63	Strong	-.12	Weak

4.5.3 Taphonomy

Among adults, Adult I and Adult II remains were most resistant to postmortem skeletal deterioration (*e.g.*, fragmentation, cortical weathering, missing elements). Across all age classes, juvenile (10-20 years-at-death) remains were the best preserved and most complete. The interment of 90.2% of neonates and 67.6% of infants I/II in urns likely enhanced both their preservation and recovery, though this was not tested.

The presence of unfused epiphyses and small bones of hands and feet suggests that recovery methods emphasized the entire skeleton, rather than prioritizing certain elements such as crania or long bones. Attempts were made in the past to reconstruct fragmentary cranial remains (Figure 4.3). Despite the fragmentary nature of cranial and many postcranial remains, preservation was sufficient for assessment of the biological profile and paleopathological analysis. The major limitations posed by differential preservation relate to presence/absence of key elements needed to estimate age-at-death or biological sex and the reliability and accuracy of morphometric analyses, especially of craniofacial measurements from both fragmentary and reconstructed remains.

Macroscopic analysis revealed some evidence of cortical weathering from water damage and postmortem damage during excavation and storage (Figure 4.4). Incidences of rodent gnawing were uncommon, though several were observed affecting long bone diaphyses (Figure 4.5). Green staining (Figure 4.6) was noted for skeletal elements associated with copper grave goods. Most adults exhibited at least one case of a bisected femoral and/or humeral head, presumably to assess age-related changes in trabecular structure.

Figure 4.3 Reconstructed cranium (Ostojićevo). Anterior (left) and superior (right) views, Grave 68, Adult IV probable-male.

Figure 4.4 Cortical weathering on a long bone (Ostojićevo). Area of light-colored bone to right shows characteristics of cortical weathering from flaking and erosion, anterior aspect of distal end of left fibula, Grave 230, Adult I, male.

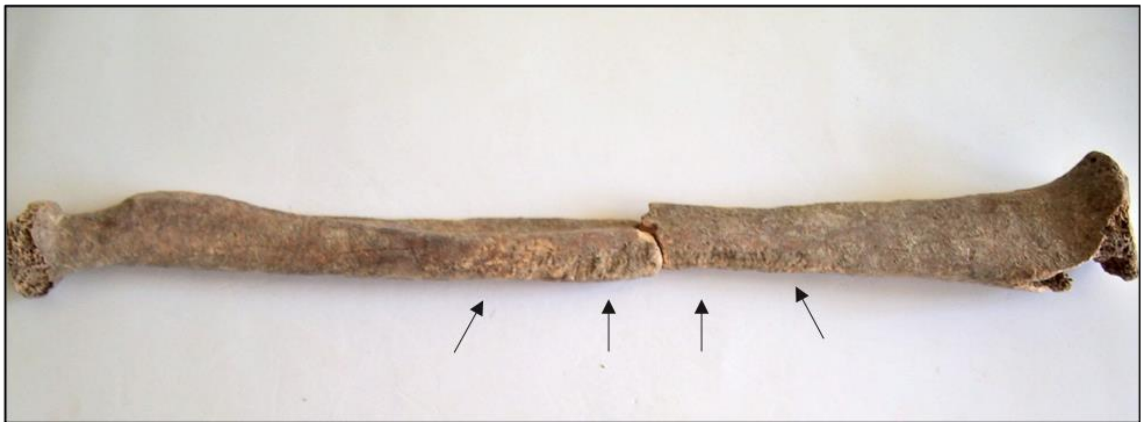


Figure 4.5 Rodent gnawing (Ostojićevo). Toothmarks present on mid-lateral border (arrows) of right radius, Grave B.B. 84 A, Adult.

Figure 4.6 Green staining from copper (Ostojićevo). Right-superior aspect of occipital, Grave 250, Child I.

4.6 Results: Ostojićevo Paleodemography

Age range and number of individuals assigned to subadult age classes are reported in Table 4.10; age range and number of individuals assigned to adult age classes are reported in Table 4.11. Figure 4.7 illustrates the distribution of individuals by age-at-death. A complete record of individual age-at-death, sex, and body orientation based on head location is presented in Appendix Tables 7 and 8.

Table 4.10 Ostojićevo subadult age-at-death (years). Numbers in parentheses based on relative proportions of known neonate, infant I, and infant II urn burials to estimate age-at-death for missing urn burials.

Age Category	Abbreviation	Age Range (yrs)	Total Count
Neonate	Neon.	0 to 1	37 (77.1)
Infant I	Inf. I	>1 to 3	14 (23.7)
Infant II	Inf. II	>3 to 6	8 (13.2)
Child I	Ch. I	>6 to 9	9
Child II	Ch. II	>9 to 12	5
Juvenile I	Juv. I	>12 to 15	7
Juvenile II	Juv. II	>15 to 20	17
Subadult Indeterminate	ISA	0 to 18	9
TOTAL			106 (161)

Table 4.11 Ostojićevo adult age-at-death (years)

Age Category	Abbreviation	Age Range (yrs)	Total Count
Adult I	A I	>20 to 30	24
Adult II	A II	>30 to 40	24
Adult II/III	A II/III	>20 to 40	1
Adult III	A III	>40 to 50	16
Adult III/IV	A III/IV	>30 to 50	4
Adult IV	A IV	>50	14
Adult Indeterminate	IA	>18	40
TOTAL			123

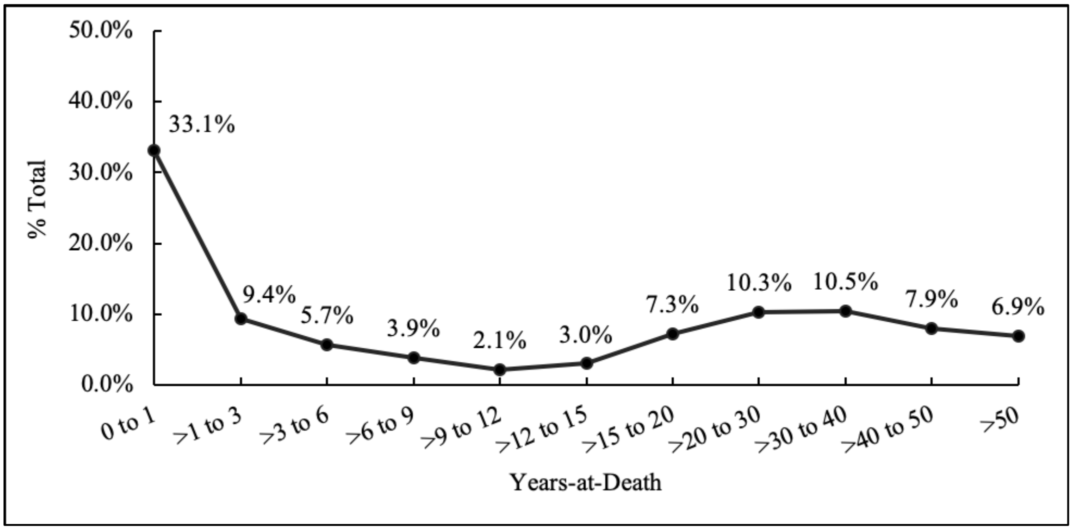


Figure 4.7 Percentage of individuals by age-at-death (Ostojićevo)

Age-at-death and sex were recorded for adults (Table 4.12; Figure 4.8). For all age classes, preservation was the primary factor age-at-death estimation and sex determination. The gracility of skeletal remains at Ostojićevo also contributed to ambiguity in sex determination because of factors such as antemortem tooth loss, which led to extensive remodeling and reduction in muscle scarring in the mandible (*i.e.*, lightweight and gracile body, smooth gonial region, obtuse and rounded gonial angle), mastoid process, and zygomatic process. This ambiguity in sex determination was especially evident among adults >50 years-at-death as twice as many individuals were classified as "probable-female" compared to "probable-male". As illustrated in Figure 4.8, Adult I and Adult II categories had the greatest number of indeterminate-sexed individuals. The relative proportion of males to females was similar for Adult II (*ratio* = 1.14) and Adult III (*ratio* = 1.13) individuals. There was an overrepresentation of Adult I males versus females (*ratio* = 1.50); in contrast, Adult IV males were underrepresented relative to females (*ratio* = 0.28). Across all adult age classes, there was a slight underrepresentation of males (*ratio* = 0.92).

Table 4.12 Ostojićevo adult biological sex and age-at-death

Age Class	Male	Probable Male	Female	Probable Female	Indet.	Total Count
Adult I	12	0	8	2	2	24
Adult II	12	0	11	1	0	24
Adult II/III	1	0	0	0	0	1
Adult III	8	1	7	0	0	16
Adult III/IV	1	0	2	1	0	4
Adult IV	2	2	8	1	1	14
Indeterminate Adult	6	4	9	11	10	40
TOTAL	42	7	45	16	13	123

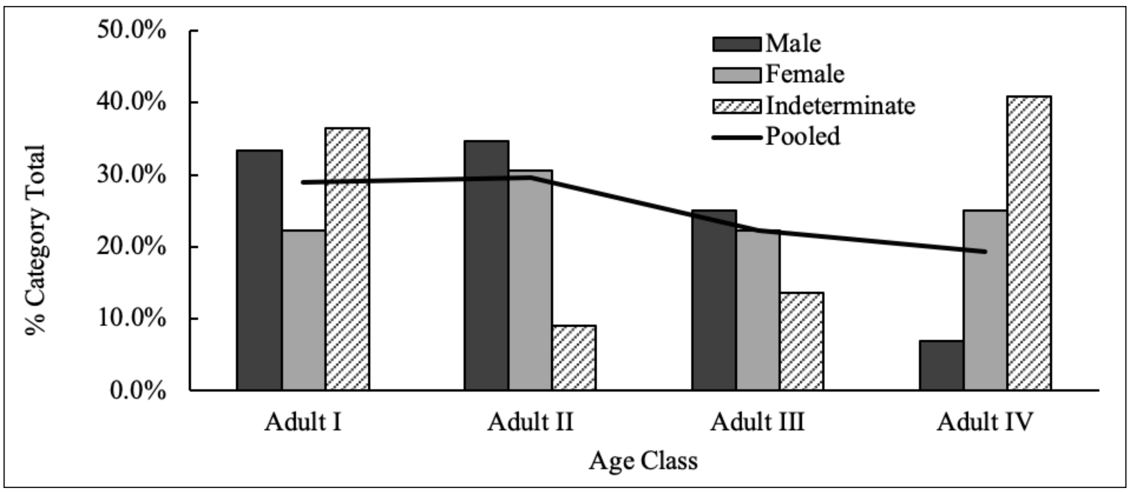


Figure 4.8 Distribution of Ostojićevo adults by age-at-death and sex. Due to uncertainty in sex estimation, probable-males and probable-females re-classified as 'Indeterminate'.

4.6.1 Total Survivorship

Total survivorship was investigated to identify the influence of age-related risks on mortality and longevity. Further analysis was conducted to examine the influence of gender (inferred from body orientation) versus biological sex (estimated from adult skeletal remains) on survivorship.

A life table constructed from the total Ostojićevo skeletal sample is presented in Table 4.13. If this sample is taken to be representative of all deaths, life expectancy at birth was 15.68 years, but increased to 37.23 years for adults (*i.e.*, individuals surviving past 20-years). This reflects the precariousness of infancy and early childhood, with individuals >3 years-at-death representing ~42% of all deaths. Probability of death (qx) decreased after the first year and stabilized until 30 years; qx increased in the fourth and fifth decades, with a sharp increase after 50 years.

Table 4.13 Ostojićevo life table (*n-total* = 233).

x*	Dx	dx	lx	qx	Lx	Tx	e°x	1000lx	Log 1000x
0-.9	77.1**	0.33	1.00	0.33	0.83	15.95	15.95	1000.00	3.00
1-2.9	23.7**	0.09	0.67	0.14	1.25	15.12	22.60	669.10	2.83
3-9.9	26.2**	0.11	0.58	0.20	3.64	13.87	24.09	575.97	2.76
10-19.9	25	0.11	0.46	0.23	4.10	10.24	22.08	463.52	2.67
20-29.9	24	0.10	0.36	0.29	3.05	6.14	17.23	356.22	2.55
30-39.9	24.5	0.11	0.25	0.42	2.01	3.09	12.20	253.22	2.40
40-49.9	18.5	0.08	0.15	0.54	0.74	1.08	7.32	148.07	2.17
50+	16	0.07	0.07	1.00	0.34	0.34	5.00	68.67	1.84

***Note.* * x = age interval (years-at-death); Dx = no. of deaths; dx = % of deaths; lx = survivors entering age interval; qx = probability of death (mortality rate); Lx = total years lived between x and x+1; Tx = total years lived by individuals of age x; e°x = mean life expectance for individuals alive at start of interval x; ** Relative proportion of known neonates, infant I, and infant II urn burials used to estimate age-at-death urn-inhumations for which skeletal remains unavailable.**

Table 4.14 summarizes model life table MT: 20-40, which most closely reflects the population distribution observed at Ostojićevo and is consistent with populations where subadult mortality exceeds that of adults. Populations with *l*(15) values between 30 and 40 require high fertility (Weiss & Wobst, 1973: 56). Comparison of *E*(X), *l*(X), and S values from MT: 20-40 with known human populations demonstrates a fertility rate comparable to proto-agricultural populations (*E*(15) = 19.8, *l*(15) = 50.0, *S* = 19.0, *B*(25) = 0.174), but greater than urban-agricultural Medieval populations (*E*(15) = 26.3, *l*(15) = 50.0, *S* = 34.8, *B*(25) = 0.145) (Weiss & Wobst, 1973:55). Thus, relative to Medieval European populations, prehistoric agriculturalists exhibited both lower life expectancy and higher fertility. The results of a Kolmogorov-

Smirnoff test of normality showed significant non-normality (KS = 0.31, df = 235, α < .001), with the Ostojićevo sample displaying an asymmetrical right-skewed distribution (Figure 4.9). This distribution is characteristic of an attritional sample population, with high fertility and low mean life expectancy.

Table 4.14 Model life table comparison. Values from Ostojićevo (left) and from comparable model table MT: 20-40 (right) (Weiss & Wobst, 1973: 127).

Age	*E'(X)*	*L'(X)*	*T'(X)*
0	19.5	100.0	1945
15	20.2	43.1	872
30	14.1	25.4	358
50	5.0	6.9	35
60	0.0	0.0	0

Age	*E(X)*	*L(X)*	*T(X)*
0	17.3	100.0	1730
15	20.0	45.0	898
30	17.2	23.3	401
50	12.1	8.5	103
60	10.2	4.7	38

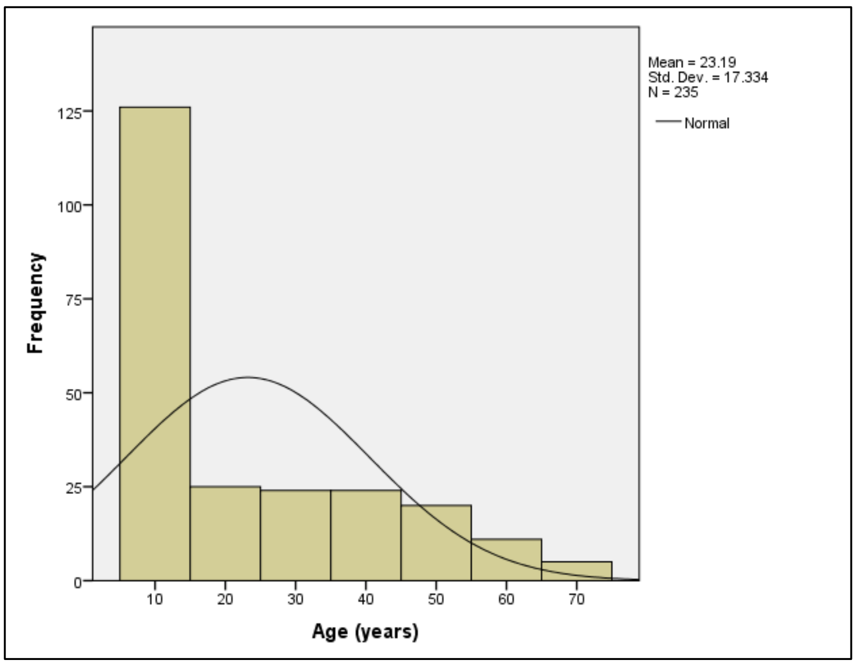


Figure 4.9 Ostojićevo mortality profile with MT: 20-40 correction applied to age intervals >50 years. Line represents normal curve.

4.6.2 Sex-Specific Survivorship

Body orientation based on head location is used here as a proxy for subadult 'sex' based on the correspondence between orientation and biological sex observed for adults (Table 4.15). Among adults ≥20 years-at-death for which sex could be estimated, 86.4% (*n* = 38) of females were buried with their heads to the south or west and 75.6% (*n* = 31) of males with their heads to the north or east (Table 4.16). Exceptions to this pattern include four cremation burials and one symbolic burial. The majority (83.6%, *n-urn* = 97) of individuals less than 6 years-at-death (*n-total* = 116) were interred in a flexed position in ceramic storage urns, with body orientation mirroring that observed for older individuals.

Distribution of age-at-death based on body orientation is summarized in Figure 4.10. The ratio of individuals oriented to the north+east compared to south+west based on head location was 0.83, compared to a ratio of 0.93 for adult biological males versus biological females. Neonates are the most common age category across all head orientations. West-oriented burials included many Juvenile II and Adult II individuals, whereas east-oriented burials included a large number of Infant II, Child I, and Child II age classes. This clustering of ages among east- and west-oriented burials is likely due to the small sample sizes for east- and west-oriented burials, respectively. A log rank (Mantel Cox) test of survival time found no significant difference between north- and east-oriented "male" versus south- and west-oriented "female" burials (χ^2 = 3.64, *df* = 1, *p* = .06) (Figure 4.11). Estimates of mean and median survival time based on body orientation are reported in Table 4.17.

Table 4.15 Ostojićevo body orientation by age-at-death and sex

Orientation	Subadult Inhumation	Subadult Urn	Male	Probable Male	Female	Probable Female	Indet. Adult	Total Count
North	25	32	26	2	6	1	2	94
South	21	44	10	2	35	9	6	127
East	4	7	5	1	0	2	2	21
West	4	5	0	0	3	1	0	13
Vertical	0	4	0	0	0	0	0	4
Indeterminate	5	8	1	2	1	3	3	23
TOTAL	59	100	42	7	45	16	13	282

Table 4.16 Ostojićevo body orientation by age-at-death

Age Category	North	South	East	West	Vertical	Indet.	TOTAL
Neon	1 (25.3)*	1 (29.9)	1 (4.3)	1 (3.3)	0 (3.0)	2 (5.3)	6 (71.1)
Inf. I	5 (5.2)	2 (4.7)	0 (1.4)	0 (1.4)	0 (0.6)	1 (0.4)	8 (13.7)
Inf. II	1 (1.5)	1 (5.4)	0 (1.3)	0 (0.3)	0 (0.4)	2 (0.3)	4 (9.2)
Ch. I	3	4 (1)	1	0	0	0	8 (1)
Ch. II	2	2	1	0	0	0	5
Juv. I	5	1	0	1	0	0	7
Juv. II	8	6	1	2	0	0	17
ISA	0	4 (3)	0 (1)	0	0	0 (1)	4 (5)
Adult I	8	14	1	0	0	1	24
Adult II	9.5	12	1	2	0	0	24.5
Adult III	6.5	9.5	1	1	0	0.5	18.5
Adult IV	5	9.5	0	0	0	1.5	16
IA	8	17	7	1	0	7	40
TOTAL	62 (32)	83 (44)	14 (8)	8 (5)	0 (4)	15 (7)	182 (100)

***Note*. * Relative proportion of known neon., infant I, and infant II urn burials used to estimate age distribution of urn burials for which skeletal remains unavailable for observation. Total observed (*n* = 229); Total observed urn (*n* = 47); Unknown urn (*n* = 53).**

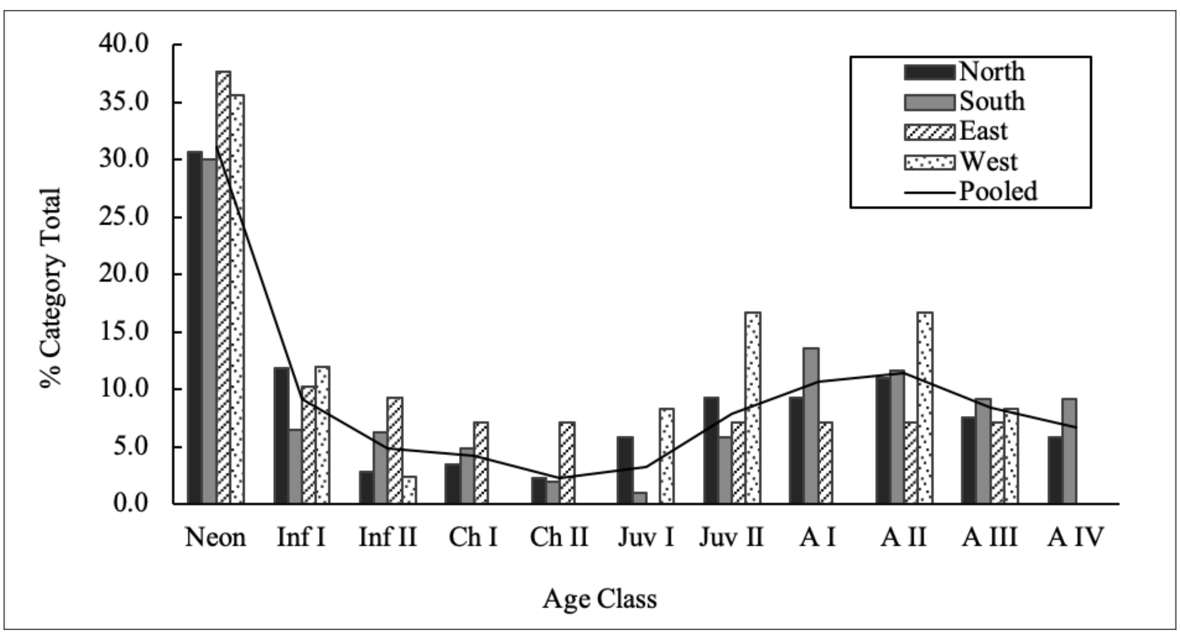


Figure 4.10 Distribution of Ostojićevo individuals by body orientation and age-at-death

Table 4.17 Ostojićevo orientation-specific and total survivorship. All values in years.

Orientation	Mean*				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
North + East	27.01	1.55	23.97	30.04	30.00	3.19	23.76	36.24
South + West	30.88	1.34	28.26	33.50	40.00	3.22	33.69	46.31
Overall	29.22	1.01	27.24	31.21	30.00	1.92	26.25	33.75

***Note*.*Estimation is limited to the largest survival time if it is censored.**

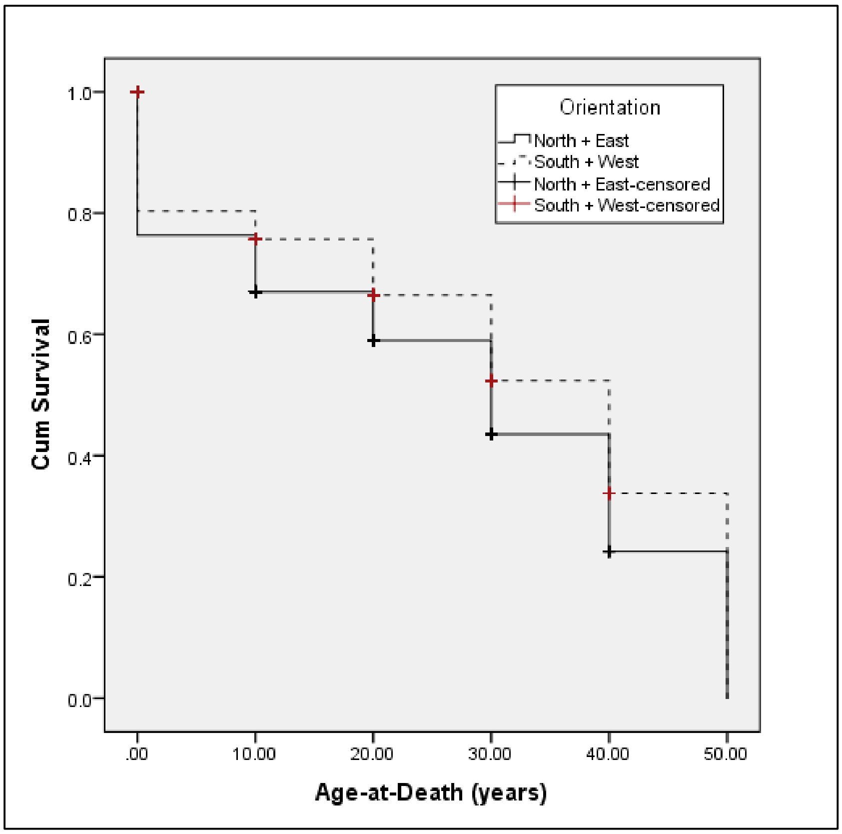


Figure 4.11 Ostojićevo Kaplan-Meier plot of survivorship by body orientation

Sex-specific survivorship included estimation of biological sex from the cranium and pelvis for individuals ≥20 years-at-death and body orientation for individuals <20 years-at-death. Male-specific survivorship is summarized in Table 4.18. Mean male life expectancy at birth was 15.36 years, increasing to 35.21 for adults. Female-specific survivorship is summarized in Table 4.19. Mean female life expectancy at birth was 16.18 years, increasing to 38.75 years for adults.

Comparison of sex-specific probability of death (qx) yielded greater discrepancies in mortality patterns between males and females (Figure 4.12) than that based on body orientation. Probability of death began to diverge around 10 to 20 years, with the greatest difference observed at 40 to 50 years. Male qx showed a series of steep increases throughout the adult period, especially in the third and fourth decades. Female mortality was constant from 3- to 20-years followed by a steep increase in the third decade, a plateau in the fourth decade, and a steep increase in the fifth and sixth decades of life. A log rank (Mantel Cox) test of survival time found no significant difference between males and females ($\chi^2 = 2.19$, $df = 1$, $p = .14$). Estimates of mean and median survival time based on body orientation are reported in Table 4.20.

Table 4.18 Ostojićevo life table, males (*n* = 102). Excludes probable-males.

x	Dx	dx	lx	qx	Lx	Tx	e°x	1000lx	Log 1000x
0-.9	31.5	0.31	1.00	0.31	0.85	15.36	15.36	1000.00	3.00
1-2.9	11.6	0.11	0.69	0.16	1.27	14.51	21.01	690.87	2.84
3-9.9	9.8	0.10	0.58	0.17	3.70	13.25	22.96	577.04	2.76
10-19.9	13	0.13	0.48	0.27	4.17	9.54	19.85	480.86	2.68
20-29.9	12	0.12	0.35	0.33	2.94	5.37	15.21	353.29	2.55
30-39.9	12.5	0.12	0.24	0.52	1.74	2.43	10.31	235.53	2.37
40-49.9	9	0.09	0.11	0.78	0.56	0.69	6.09	112.86	2.05
50+	2.5	0.02	0.02	1.00	0.12	0.12	5.00	24.53	1.39

Table 4.19 Ostojićevo life table, females (*n* = 104). Excludes probable females.

x	Dx	dx	lx	qx	Lx	Tx	e°x	1000lx	Log 1000x
0-.9	35.2	0.34	1.00	0.34	0.83	16.18	16.18	1000.00	3.00
1-2.9	8.1	0.08	0.66	0.12	1.25	15.35	23.20	661.54	2.82
3-9.9	13.7	0.13	0.58	0.23	3.62	14.11	24.17	583.65	2.77
10-19.9	11	0.11	0.45	0.23	3.99	10.48	23.19	451.92	2.66
20-29.9	8	0.08	0.35	0.22	3.08	6.49	18.75	346.15	2.54
30-39.9	11	0.11	0.27	0.39	2.16	3.41	12.68	269.23	2.43
40-49.9	8	0.08	0.16	0.47	0.82	1.25	7.65	163.46	2.21
50+	9	0.09	0.09	1.00	0.43	0.43	5.00	86.54	1.94

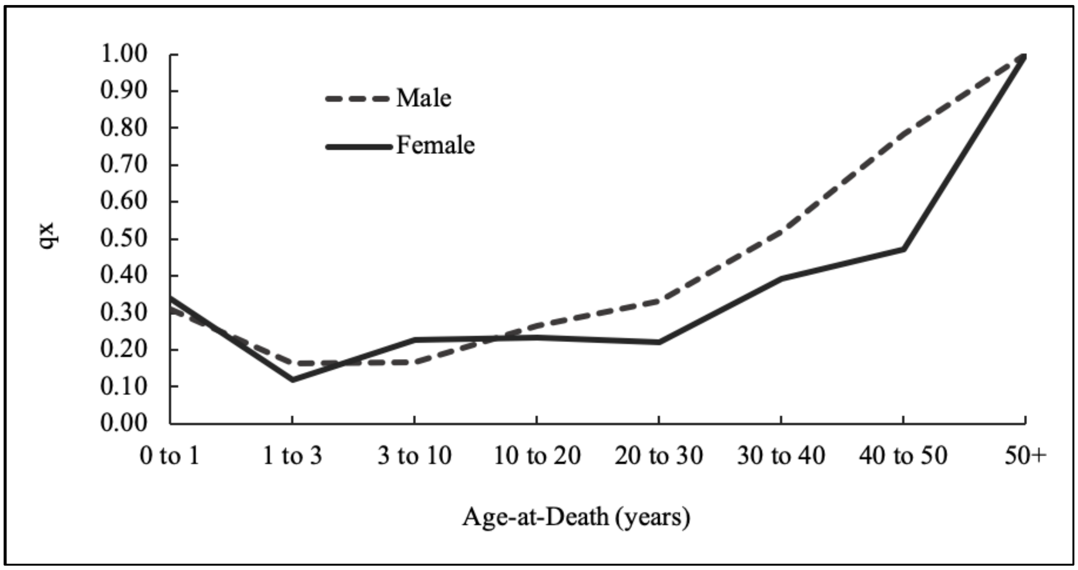


Figure 4.12 Ostojićevo sex-specific (male *n* = 102; female *n* = 104) probability of death (mortality rate). Subadult 'sex' inferred from body orientation (males = head to north or east; females = head to south or west).

Table 4.20 Ostojićevo sex-specific and total survival time.All values in years.

Orientation	Mean*				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Male	25.95	1.46	23.09	28.80	30.00	2.68	24.75	35.25
Female	29.68	1.51	26.72	32.63	40.00	3.87	32.41	47.59
Overall	28.01	1.06	25.92	30.09	30.00	1.96	26.17	33.83

***Note*. *Estimation is limited to the largest survival time if it is censored.**

4.7 Results: Mokrin Paleodemography

A summary of age-at-death categories and number of individuals can be found in Table 4.21; adult age-at-death by sex is summarized in Table 4.22.

The distribution of individuals by age-at-death at Mokrin (Figure 4.13) peaked at 3 to 6-years for subadults, and 18 to 30-years and 50+ years, respectively, for adults. Among individuals >15 years-at-death, mortality peaked for both males and females at 18 to 30-years (Figure 4.14). As Rega (1997) notes, this may be an artifact in underestimation of adult age-at-death, rather than higher under 40-year adult mortality. Similar ratios of males to females are noted for young adults (*ratio* = 1.10) and old adults (*ratio* = 0.90). Males are underrepresented relative to females for prime adults (*ratio* = 0.75) and mature adults (*ratio* = 0.61). Across all adult age classes, there was a slight underrepresentation of males relative to females (*ratio* = 0.88).

Table 4.21 Mokrin total age-at-death. Data modified from Rega, 1995.

Age Category	Abbreviation	Age Range (yrs)	Total Count
Neonate	Neon.	0 to 1	0
Infant I	Inf. I	>1 to 3	15.5
Infant II	Inf. II	>3 to 6	20.5
Child I/II	Ch. I/II	>6 to 12	15
Juvenile I	Juv. I	>12 to 15	4.5
Juvenile II	Juv. II	>15 to 18	7.5
Young Adult	YA	>18 to 30	51.5
Prime Adult	PA	>30 to 40	32.5
Mature Adult	MA	>40 to 50	25
Old Adult	OA	50+	36
Indeterminate Adult	IA	18+	19
TOTAL			227

Table 4.22 Mokrin adult biological sex and age-at-death Data modified from Rega, 1995.

Age Category	Male	Probable Male	Female	Probable Female	Indet.	Total Count
Juvenile II	2	0	1	0	3	6
Juvenile II/Young Adult	1	0	0	0	1	2
Young Adult	20	1	19	3	1	44
Young /Prime Adult	5	2	4	0	0	11
Prime Adult	7	3	10	2	0	22
Prime/Mature Adult	2	2	4	0	0	8
Mature Adult	4	1	6	1	1	13
Mature/Old Adult	4	0	7	2	0	13
Old Adult	11	3	11	2	0	27
Indeterminate Adult	4	3	4	3	4	18
TOTAL	60	15	66	13	10	164

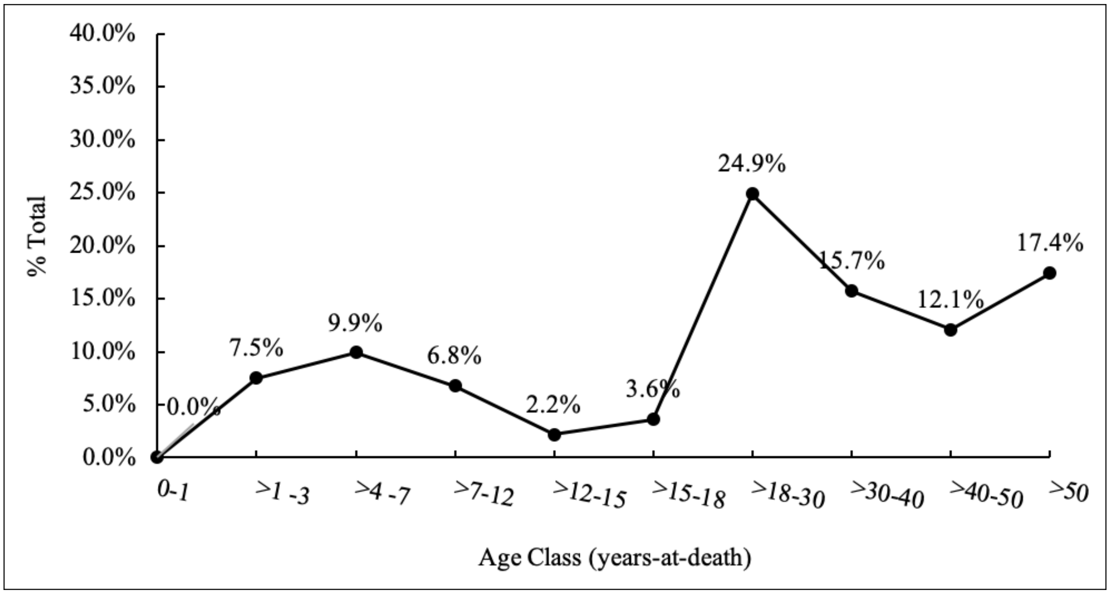


Figure 4.13 Mokrin percentage of individuals by age-at-death

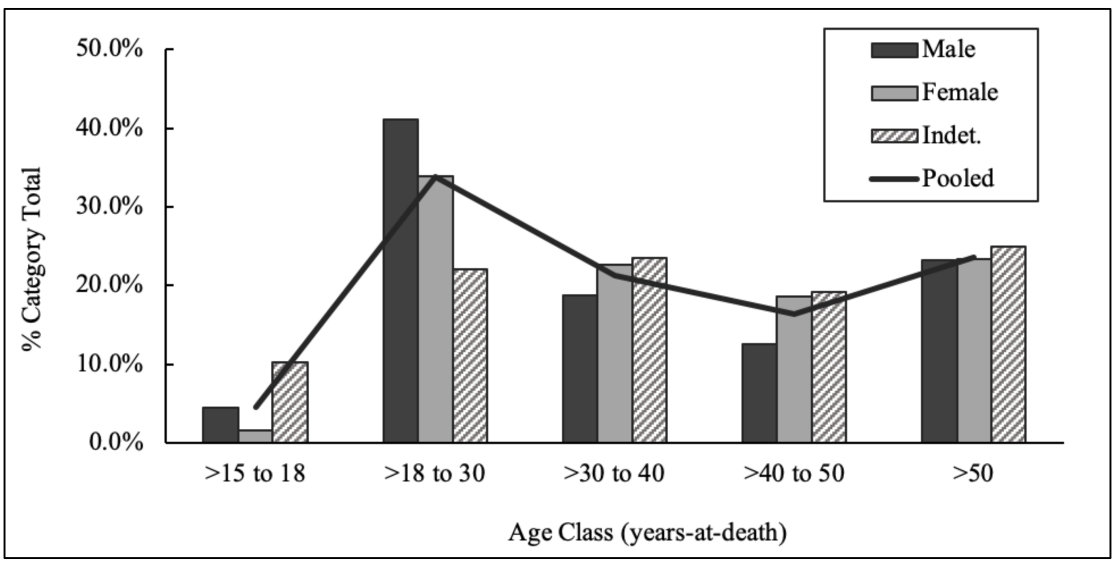


Figure 4.14 Mokrin distribution of individuals by biological sex and age-at-death

4.7.1 Total and Sex-Specific Survivorship

A life table constructed from the total Mokrin skeletal sample is presented in Table 4.23. If this sample is taken to be representative of all deaths, life expectancy at birth was 27.67 years, but increased to 37.53 years for adults (individuals surviving past 20-years). Probability of death (qx) remained low until 20-years, with a gradual increase from the third to fourth decades; qx increased sharply after 40 years.

Table 4.23 Mokrin life table

x	Dx	dx	lx	qx	Lx	Tx	e°x	1000lx	Log 1000x
0-0.9	0	0.00	1.00	0.000	1.00	27.67	27.67	1000.00	3.00
1-2.9	15	0.08	1.00	0.077	1.92	26.67	26.67	1000.00	3.00
3-9.9	27	0.14	0.92	0.150	5.98	24.75	26.81	923.08	2.97
10-19.9	24.5	0.13	0.78	0.160	7.22	18.77	23.92	784.62	2.89
20-29.9	38.5	0.20	0.66	0.300	5.60	11.55	17.53	658.97	2.82
30-39.9	34.5	0.18	0.46	0.383	3.73	5.95	12.89	461.54	2.66
40-49.9	24.5	0.13	0.28	0.441	1.42	2.22	7.79	284.62	2.45
50+	31	0.16	0.16	1.000	0.79	0.79	5.00	158.97	2.20

Table 4.24 Morkin body orientation (head location) by biological sex and age-at-death

Orientation	Subadult Inhumation	Male	Probable Male	Female	Probable Female	Indet. Adult	Total Count
North	22	46	6	6	2	5	87
South	31	8	4	59	9	6	117
East	0	0	0	1	0	0	1
West	1	0	0	0	0	0	1
Indeterminate	4	6	5	0	2	0	17
TOTAL	58	60	15	66	13	11	223

Table 4.25 Mokrin age-at-death by body orientation

Age Class	North	South	East	West	Indet.	TOTAL
Neon	0	0	0	0	0	0
Inf. I	7	6.5	0	1	1	15.5
Inf. II	7	11.5	0	0	2	20.5
Ch. I/II	5	7	0	0	2	14
Juv. I	3	1.5	0	0	0	4.5
Juv. II	2.5	5	0	0	0	7.5
ISA	0	0	0	0	0	0
YA	23.5	24	1	0	3	51.5
PA	11.5	16	0	0	5	32.5
MA	8	16.5	0	0	0.5	25
OA	15.5	20	0	0	0.5	36
IA	5	9	0	0	4	18
TOTAL	88	117	1	1	18	225

Among Mokrin adults >20 years-at-death for which sex could be estimated, 90.8% of females (n = 59) were buried with their heads to the south and 85.2% of males (n = 46) with their heads to the north (Table 4.24). Individuals under 15 years-at-death, which comprised 24.2% (n = 54.5) of burials, were interred in an identical manner and orientation as that observed for adults (Table 4.25).

Distribution of age-at-death by body orientation is summarized in Figure 4.15. The ratio of north versus south burials was 0.75, compared to 0.91 for adult biological males versus biological females. Rega (1997) attributed this discrepancy is due to an overrepresentation of "female" (south-oriented) individuals in the 3 to 9-year age class. Despite the higher relative proportion of north-oriented burials among young adults, and south-oriented burials among mature adults, a log rank (Mantel Cox) test of survival time found no significant difference between north-oriented "male" and south-oriented "female" burials (χ^2 = 0.16, df = 1, p = .69) (Figure 4.16). Estimates of mean and median survival time based on body orientation are reported in Table 4.26.

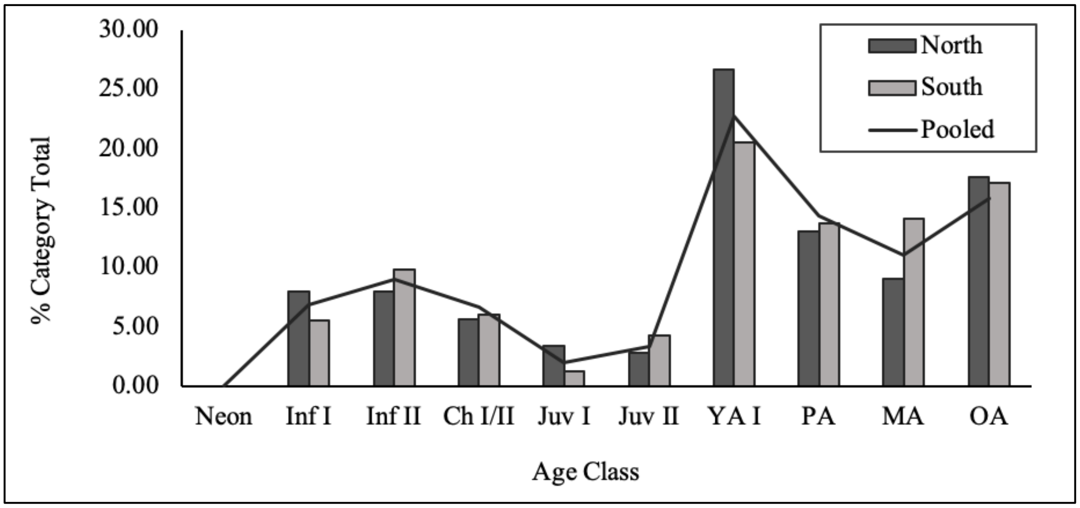


Figure 4.15 Mokrin distribution of individuals by body orientation and age-at-death

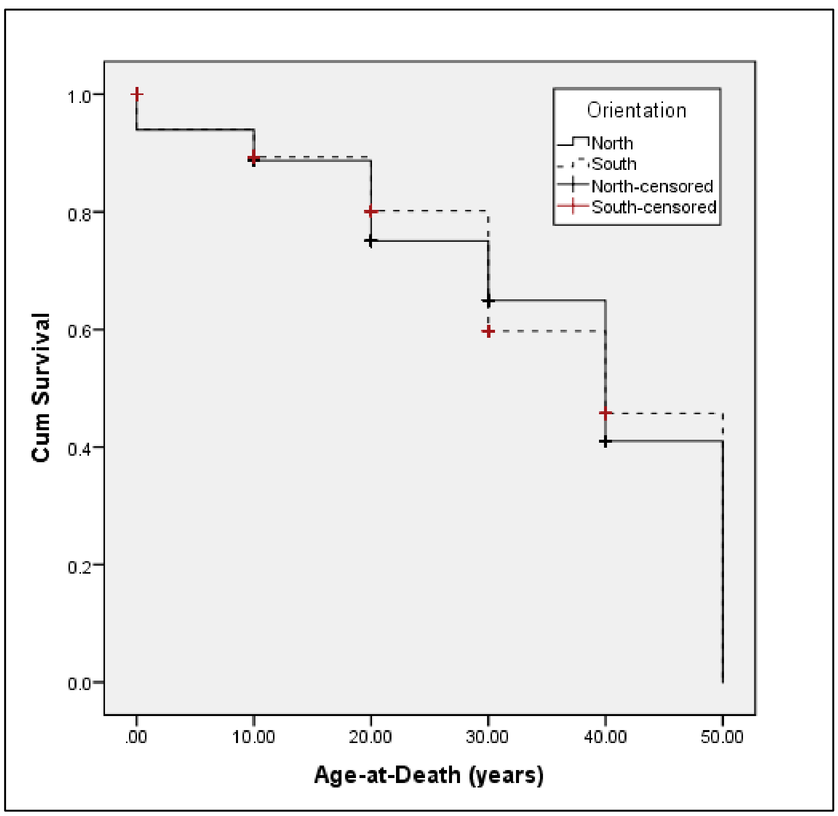


Figure 4.16 Mokrin Kaplan-Meier plot of survivorship by orientation and age-at-death

Table 4.26 Mokrin orientation-specific and total survivorship. All values in years.

Orientation	Mean*				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
North + East	36.36	1.22	33.97	38.76	40.00	2.39	35.32	44.68
South + West	36.90	1.06	34.82	38.99	40.00	1.60	36.87	43.13
Overall	36.69	0.80	35.12	38.25	40.00	2.01	36.05	43.95

***Note*. *Estimation is limited to the largest survival time if it is censored.**

Male-specific survivorship is summarized in Table 4.27. Mean male life expectancy at 1-year was 28.3 years, increasing to ~38.1 years for adults. Female-specific survivorship is summarized in Table 4.28. Mean female life expectancy at 1-year was 27.8 years, increasing to ~39.1 years for adults.

Assuming a stable population structure, males and females exhibited similar mortality profiles (Figure 4.17). Males showed a spike in probability of dying (qx) in the third decade, whereas female qx increased gradually until the fourth decade. A log rank (Mantel Cox) test of survival time found no significant difference in sex-specific survivorship at Mokrin for $\alpha > .05$ ($\chi^2 = .20$, $df = 1$, $\alpha = .65$) (Figure 4.18). Estimates of mean and median survival time based on sex are reported in Table 4.29.

Table 4.27 Mokrin life table males (*n* = 82). Excludes probable-males.

x	Dx	dx	lx	qx	Lx	Tx	e°x	1000lx	Log 1000x
0-0.9	0	0.00	1.00	0.000	1.00	28.29	28.29	1000.00	3.00
1-2.9	8	0.10	1.00	0.098	1.90	27.29	27.29	1000.00	3.00
3-9.9	9	0.11	0.90	0.122	5.93	25.38	28.13	902.44	2.96
10-19.9	10	0.12	0.79	0.154	7.32	19.45	24.54	792.68	2.90
20-29.9	19	0.23	0.67	0.345	5.55	12.13	18.09	670.73	2.83
30-39.9	12.5	0.15	0.44	0.347	3.63	6.59	15.00	439.02	2.64
40-49.9	11	0.13	0.29	0.468	2.20	2.96	10.32	286.59	2.46
50+	12.5	0.15	0.15	1.000	0.76	0.76	5.00	152.44	2.18

Table 4.28 Mokrin life table females (*n* = 94). Excludes probable-females.

x	Dx	dx	lx	qx	Lx	Tx	e°x	1000lx	Log 1000x
0-0.9	0	0.00	1.00	0.000	1.00	27.76	27.76	1000.00	3.00
1-2.9	7.5	0.08	1.00	0.080	1.92	26.76	26.76	1000.00	3.00
3-9.9	14.5	0.15	0.92	0.168	5.90	24.84	26.99	920.21	2.96
10-19.9	13	0.14	0.77	0.181	6.97	18.94	24.72	765.96	2.88
20-29.9	14.5	0.15	0.63	0.246	5.51	11.97	19.07	627.66	2.80
30-39.9	19	0.20	0.47	0.427	3.72	6.46	13.65	473.40	2.68
40-49.9	12.5	0.13	0.27	0.490	2.05	2.74	10.10	271.28	2.43
50+	13	0.14	0.14	1.000	0.69	0.69	5.00	138.30	2.14

Figure 4.17 Mokrin sex-specific probability of death (mortality rate). Subadult ‘sex’ inferred from body orientation. Note spike in p-Male mortality precedes spike in p-Female mortality.

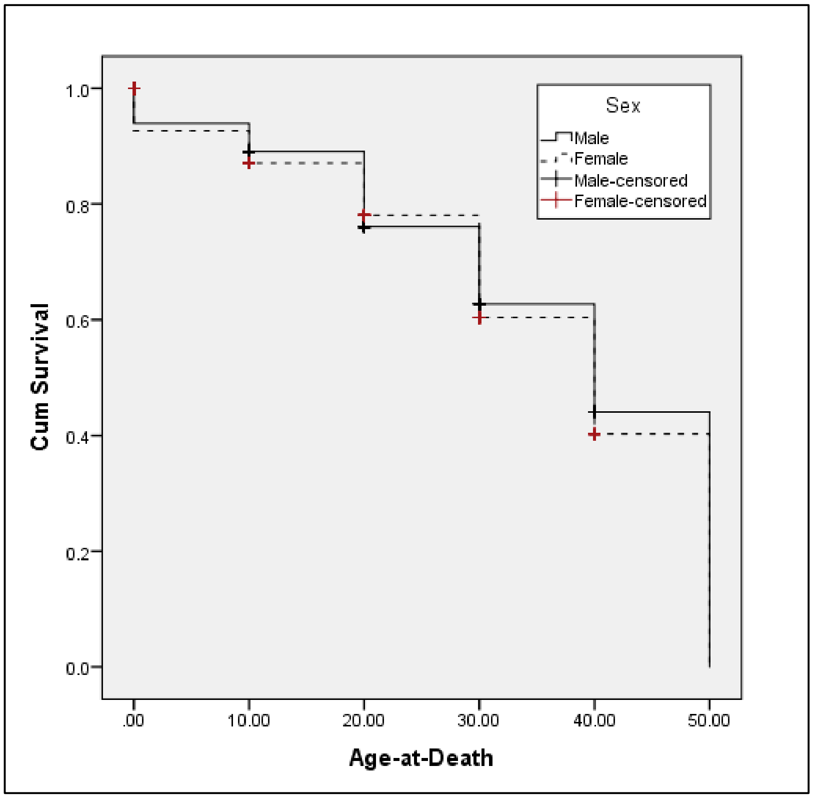


Figure 4.18 Mokrin Kaplan-Meier plot by biological sex and age-at-death

Table 4.29 Mokrin sex-specific and total survival time

Sex	Mean*				Median			
	Estimate	Std. Error	95% CI Lower Bound	95% CI Upper Bound	Estimate	Std. Error	95% CI Lower Bound	95% CI Upper Bound
Male	36.59	1.23	34.17	39.01	40.00	3.00	34.11	45.89
Female	35.84	1.17	33.55	38.13	40.00	2.66	34.79	45.21
Overall	36.20	0.85	34.54	37.86	40.00	1.99	36.09	43.91

***Note*. *Estimation is limited to the largest survival time if it is censored.**

4.8 Results: Comparative Paleodemography

The Mokrin and Ostojićevo samples were normalized to 10-year age classes, with the youngest age class further divided into intervals of 0-1 years, >1-3 years, and >3-10 years (Figure 4.19). At Ostojićevo, 33.1% of individuals were >1 year-at-death and 42.4% >3 years-at-death; only 7.7% of individuals were >3 years-at-death at Mokrin.

To investigate the effect of sample bias on estimation of survivorship, probability of death (qx) was compared across three groups: (1) the entire sample; (2) excluding individuals <1 year-at-death; and (3) excluding individuals <3 years-at-death (Figure 4.20). Between-site difference in survival time was assessed across these three groups (Figure 4.21). A log rank (Mantel Cox) test of survival time showed significant differences in survivorship for the total sample ($\chi^2 = 32.75$, $df = 1$, $\alpha < .000$) and excluding individuals <1 year-at-death ($\chi^2 = 4.24$, $df = 1$, $\alpha = .39$) groups. No significant difference in survivorship was found comparing survivorship among individuals >3 years-at-death ($\chi^2 = 2.83$, $df = 1$, $\alpha = .09$). These results show the effect of cultural differences in burial practices on demographic reconstruction. The absence of neonates and underrepresentation of infants <3 years-at-death at Mokrin results in artificially inflated estimates of mean and median life expectancy relative to Ostojićevo.

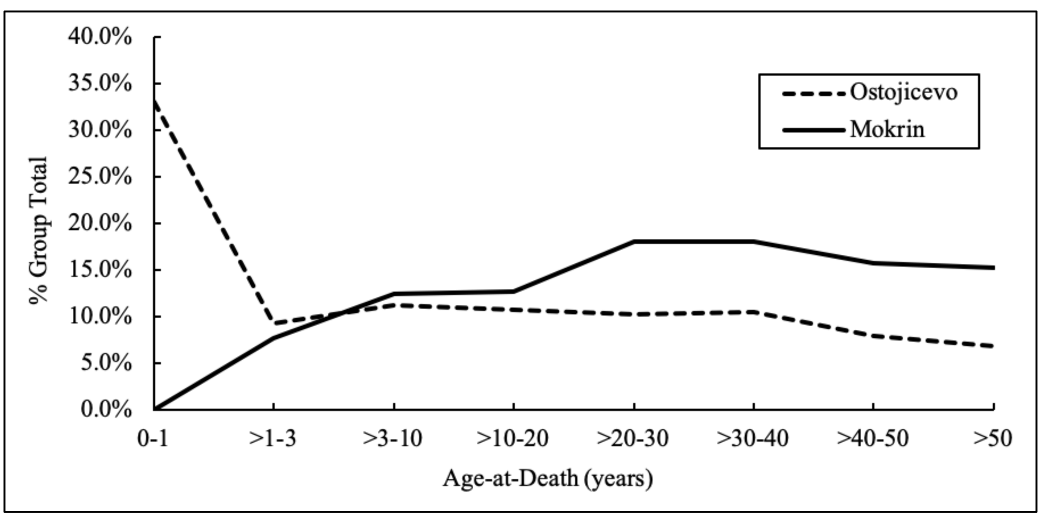


Figure 4.19 Between-site comparison of percentage of total individuals by age-at-death

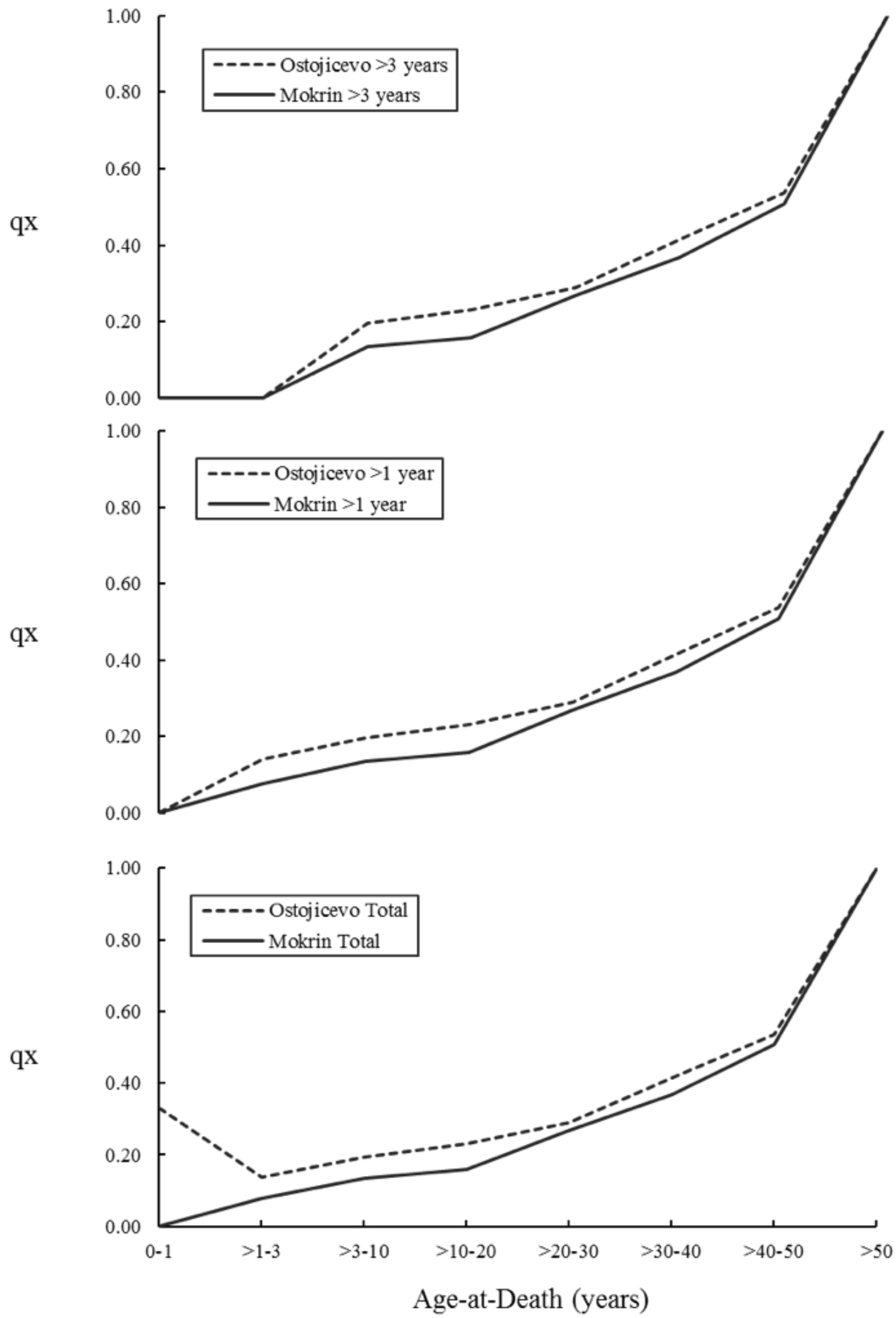
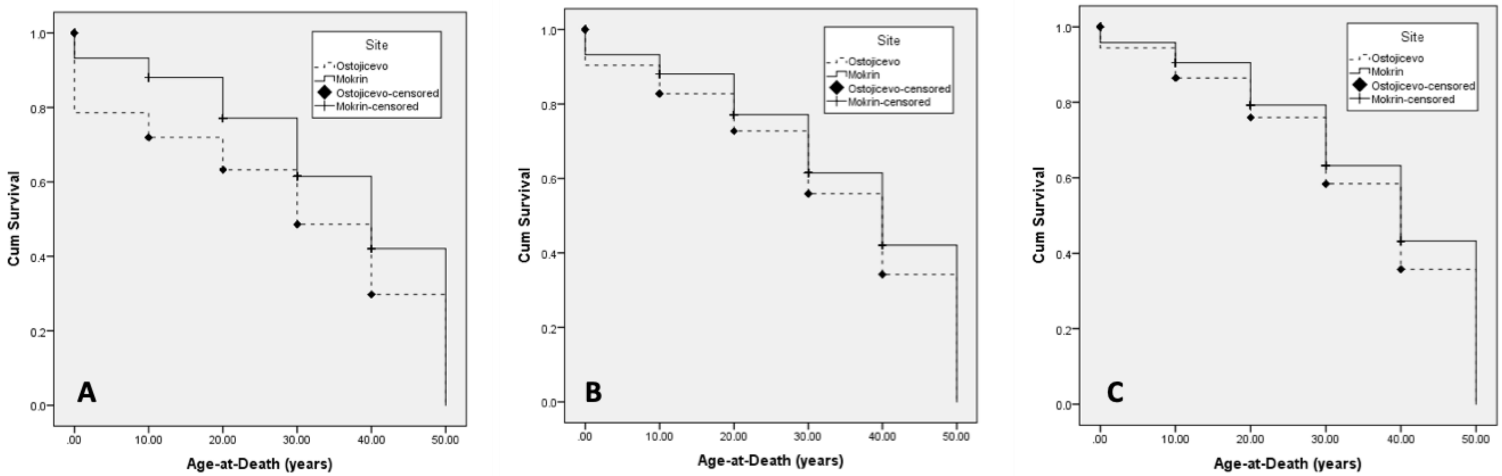


Figure 4.20 Between-site comparison of probability of death (qx). By total sample (A), excluding individuals <1 year-at-death (B), and excluding individuals <3 years-at-death (C).



Site TOTAL	Mean[A]			
	Estimate	Std. Error	95% Confidence Interval	
Ostojićevo	29.22	1.01	27.24	31.21
Mokrin	36.20	0.85	34.54	37.86
Overall	32.97	0.66	31.67	34.27

Site >1 year	Mean[A]			
	Estimate	Std. Error	95% Confidence Interval	
Ostojićevo	33.60	1.02	31.61	35.60
Mokrin	36.20	0.85	34.54	37.86
Overall	35.10	0.65	33.82	36.37

Site >3 years	Mean[C]			
	Estimate	Std. Error	95% Confidence Interval	
Ostojićevo	35.10	1.00	33.13	37.06
Mokrin	37.21	0.83	35.58	38.84
Overall	36.32	0.64	35.06	37.58

Figure 4.21 Between-site comparison of Kaplan-Meier survivorship plots. Total (A), excluding individuals <1 year-at-death (B), and excluding individuals <3 years-at-death (C).

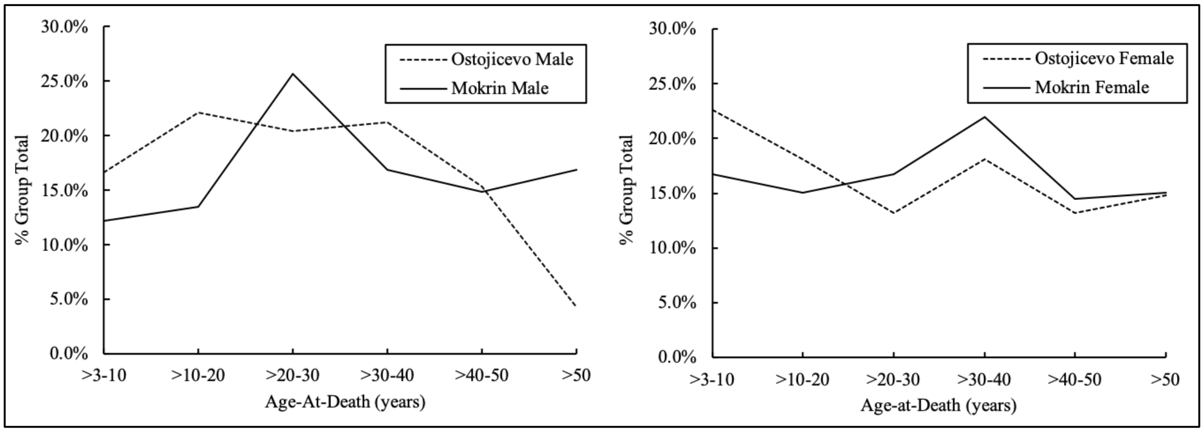


Figure 4.22 Between-site comparison of distribution of individuals by sex and age-at-death. Males (left) and females (right).

Table 4.30 Pairwise comparison of the relative proportion of males and females per age group. Post hoc multiple Z-tests of two relative proportions with a Bonferroni correction, $\chi 2$. Significant results in bold.

	Male			Female		
Age (yrs)	Expected	Residual	p-value	Expected	Residual	p-value
>3 to 10	19	1.6	>.05	29	2.1	>.05
>10 to 20	23	2.8	>.05	24	1.2	>.05
>20 to 30	31	1.8	>.05	23	1.4	>.05
>30 to 40	26	1.4	>.05	30	1.3	>.05
>40 to 50	20	0.1	>.05	21	0.6	>.05
50+	**16**	**4.1**	**<.05**	22	0.0	>.05

Comparison of between-site sex-specific mortality estimates is reported in Figure 4.22. Neonates and infants were excluded due to their underrepresentation at Mokrin. Among males, there is a higher frequency of individuals dying in their 20s and >50-years at Mokrin; among females, there is a lower frequency of child deaths but higher frequency of young adult deaths at Mokrin. A Kruskal-Wallis H test was run to assess between-site differences in the relative proportion of males and females by age-at-death. Median age-at-death was similar across age classes for males (H = 3.06, df =1, p = .080) and females (H = 0.61, df =1, p = .434). Post hoc pairwise comparison of sex (Table 4.30) found no significant differences in the relative proportions of females across age classes. Difference in the relative proportion of males was significant for individuals >50 years-at-death, p > .05.

4.9 Discussion

4.9.1 Ostojićevo Preservation and Taphonomy

Cemetery assemblages represent culturally-created entities, with mortuary practices influencing both demographic representation (*i.e.*, who is buried) and completeness and preservation (*i.e.*, how and where they are buried). Factors such as depositional context, excavation methods, and the history of the skeletal assemblage can further impact the composition and condition of skeletal collections (Cassman & Odegaard, 2007). The assessment of human skeletal remains for completeness and taphonomic alteration can provide important information on the history of pre- and post-depositional processes, including modification by humans and natural agents (*e.g.*, burrowing rodents, water damage, etc.) (Haglund & Sorg, 1997; White & Folkens, 2005). Of 240 unique individuals analyzed for this study, 218 included associated archaeological context and 22 were mislabeled, had no record, or were commingled in storage. The goals of taphonomic and preservational analysis in this study were: (1) assess the impact of intrinsic factors on preservation (*e.g.*, bone size, bone density, etc.); and (2) identify possible extrinsic (environmental) factors affecting preservation at Ostojicevo (*e.g.*, weathering, animal scavenging, thermal alteration, cutmarks, etc.).

Comparisons of measurements of element “presence” (PR) and “completeness” (MPI) showed no preservation bias by sex and a moderate preservation bias by age-at-death in this study. For adults, there was a strong significant positive correlation between male and female PR, and a moderate/strong significant positive correlation between male and female MPI. Adult III and Adult IV individuals had a strong positive association between PR and MPI for cranial elements, indicating that common elements were more likely to be well-preserved. For all age classes, there was a weak association between “presence” and “completeness” for postcranial elements. A correlation matrix was generated to investigate associations of PR (Table 4.31) and MPI (Table 4.32) across adult age classes. Statistically significant correlations were found for all PR age class associations, suggesting age-at-death did not affect postcranial and cranial element frequencies. In contrast, MPI showed greater variation in comparison of relationship strength between age groups. Statistically significant correlations were noted between Adult I and Adult II individuals, and between Adult III and Adult IV individuals. These results have implications for understanding age-specific differences in preservation quality and completeness, with younger adults (Adults I and II) exhibiting less taphonomic changes (*e.g.*, fragmentation, weathering) of skeletal elements than older adults (Adults III and IV).

Table 4.31 Pearson correlations for adult PR at Ostojićevo

	Adult IV	Adult III	Adult II
Adult I	.87*	.92*	.86*
Adult II	.95*	.95*	--
Adult III	.94*	--	--

***Note.* * = statistically significant at *p* < .05 level.**

Table 4.32 Pearson correlations for adult MPI at Ostojićevo

	Adult IV	Adult III	Adult II
Adult I	-.21	.05	.54*
Adult II	.24	.28	--
Adult III	.72*	--	--

***Note.* * = statistically significant at *p* < .05 level.**

Subadults exhibited lower PR and MPI values compared to adults. The strong correlation between postcranial and cranial PR and MPI across subadult age classes indicates that well-preserved major elements (*e.g.*, long bones, braincase) were more likely to be present. In contrast, small bones of the extremities and facial bones had both a low frequency and were often fragmentary when present.

Based on observed taphonomic alterations, there is no evidence of secondary burial at Ostojićevo. Bone presence and completeness followed expected patterns based on bone size and anatomical position (Waldron, 1987). For example, bones of the cranial vault were better-preserved than the thin, delicate, irregular bones of the face and cranial base. Irrespective of adult sex and age-at-death, the five most common cranial elements were parietals, occipital, frontal, temporal, and mandible; the top five most common postcranial elements were tibiae, femora, humeri, ulnae, and fibulae. The most common elements were not, however, the most complete. In terms of highest MPI values, the top five cranial elements were zygoma, nasal bones, lacrimals, ethmoid, and vomer. The reason for this discrepancy is that these elements were only present in exceptionally well-preserved cases. There was less discrepancy between element presence and MPI for postcranial elements.

Variation in MPI by age-at-death provides indirect evidence of a likely effect of bone mineral density on differential preservation. Several authors have noted the relationship between bone mineral density and elemental and individual preservation in an archaeological assemblage (Lam & Pearson, 2005; Willey et al., 1997). Guy et al. (1997) posits that increased bone mineralization after age three contributes to a greater representation of older infants (*i.e.*, infant II) than neonates and younger infants (*i.e.*, infant I).

At Ostojićevo, despite the large numbers of neonates and young infants, age-at-death for individuals under 9 years-at-death was based almost exclusively on dental development. This was largely due to preservation factors, with at least one complete or near-complete long bone present in only 37.3% (n =19) of individuals under 3 years-at-death and 45.5% (n =10) of individuals 3 to 9 years-at-death. Additionally, skeletal remains could only be identified in 47% (n = 47) of non-cremation urn burials. It is unclear if the missing remains were lost or removed from the collection, or if remains were discarded due to poor preservation. Girić (1995) noted poor preservation of the remains of subadult <2 years-at-death compared to older children. Additionally, many urn burials were discovered ca. 20-40 cm (μ = 0.41 m, *+/- 1SD* = 0.17 m, *min* = 0.09 m, *max* = 1.00 m) below the modern surface. In contrast, inhumations were often recovered at depths exceeding ca. 50-70 cm (μ = 0.72 m, *+/- 1SD* = 0.25 m, *min* = 0.06 m, *max* = 1.33 m). The disparity in burial depth between urn burials and inhumations meant that urn burials were more likely to be disturbed or destroyed by agricultural activity (see Dunnell & Simek, 1995; Girić, 2012[1995]).

Age had a greater impact than sex on the preservation and completeness of adult remains. For example, ilia were present in 93.75% of Adult I individuals with an average MPI of 0.75, whereas ilia were present in 84.21% of Adult IV individuals with an average MPI of only 0.54. For the most common element – tibiae - 100% of Adult IV tibiae were present with an MPI of only 0.73 compared to an Adult I MPI of 0.84 with 83.33% present. The often incomplete or fragmentary nature of skeletal elements of older individuals impeded estimation of stature, age-at-death, and sex for these individuals. Insufficient preservation of diagnostic features was the primary limiting factor in determination of adult age-at-death and/or sex. Age-related decreases in bone mineral density combined with pathological conditions affecting bone density and porosity (*e.g.*, age-dependent bone loss, osteopenia, osteoarthritis) have been found to contribute to an underrepresentation of elderly individuals (Nawrocki, 1995; Walker et al., 1988), though other studies found no relationship between age-at-death and element preservation (Stojanowski et al., 2002). The poor skeletal preservation of Adult IV individuals compared to other adult age classes at Ostojićevo is likely due to combined behavioral factors and physiologic processes, such as higher rates of decreased bone mineral density due to reduced muscle mass from inactivity and/or osteoclastic processes contributing to increased bone loss due to dietary deficiency (*e.g.*, calcium) or excess (*e.g.*, hypervitaminosis A). Based on these observations, adults for which age could not be determined due to poor preservation likely represent older individuals.

Taphonomic analysis delineated several post-depositional factors affecting skeletal preservation. These include copper staining, loss of cortical bone, bone distortion and/or fragmentation from soil compression, and rodent gnawing. The site was discovered in 1954 during removal of earth for construction of an embankment along a section of the "Velika Bara" canal (Girić, 1959; Milašinović, 2008). An area of 35x12 meters was excavated and yielded five or six skeletons found in a flexed position associated with Maros ceramics and grave goods. This disturbed area, which was never backfilled, bordered the site to the north and northeast. Subsequent systematic excavations took place from 1981 to 1991 in the undisturbed adjacent flat plain to the south and southwest. This area is known locally as "Stari Vinograd" (Old Vineyard) or "Bašće" (The Gardens), which reflects its historic usage for agriculture and viviculture. As of 2014, the area was still being used to grow corn, wheat, and soy. Excavation records report a range in grave depth ranged from 0.06 m to 1.33 ($\mu = 0.61$ *m)* beneath the modern surface. Plowzone depth was not recorded. The impact of plowing and cultivation on archaeological sites varies depending on farming intensity (frequency of tillage), machinery (*e.g.*, horse- versus tractor-drawn), and variation in surface and sub-plowzone topography and stratigraphy (Dunnell & Simek, 1995). Analysis of plowzone depth and artifact displacement suggests that material within the top 0.3 meters are most vulnerable to disturbance, and that mean lateral displacement is ~3.0 meters (Roper, 1976; Steinberg, 1996). Based on grave depth and pattern of bone fragmentation, postmortem damage is more likely due to soil pressure secondary to mechanical tillage than to direct contact. I visited the site in 2014 and noted ceramic and unburnt bone on the surface, indicating ongoing disturbance of shallow burials.

4.9.2 Paleodemography: Ostojićevo

Although mortality at Ostojićevo follows an attritional mortality pattern, comparison with model life tables derived from historically and ethnographically documented populations indicates that it is marked by high childhood mortality and high fertility (Coale & Demeny, 1983; Margerison & Knüsel, 2002; Weiss & Wobst, 1973; Weiss, 1975). There is a marked drop in the number of deaths from the neonatal period to infancy and childhood, suggesting mortality risks were highest in the first year of life and remained somewhat elevated until ~3-years. For males, probability of death remained low until the mid-to-late-teens, whereas female probability of death remained low into the early-to-mid 20s. Despite no significant difference in male versus female overall survivorship, consideration of sex-specific mortality pattern shows several key differences. There is a high relative proportion of males dying in their 20s and 30s, compared to a modest increase in female deaths in their 30s and relatively similar numbers of females dying in their 20s, 30s, and 50s, respectively. Assuming that women experienced a steep decline in fertility after 40-years and cessation (menopause) by 50-years (see Hayward et al., 2017), then 47.22% (n = 17) of female deaths at Ostojićevo represent post-reproductive individuals. Consideration of sex-specific trends in mortality in the context of infant and child mortality show that high rates of neonate deaths, suggesting high fertility, did not have a strong adverse effect on female mortality. In contrast to adult females, most adult males died in their 20s and 30s, with few (29.49%) surviving past ~40-years.

4.9.3 Paleodemography: Mokrin

The mortality profile at Mokrin demonstrates a complete absence of neonates and a higher number of older infants (>4- to 7-years) than young infants (<1- to 3-years). Mortality rates drop after 7-years and remain low until 18-years. Mortality increases markedly in the late-teens and 20s, with young adults representing ~25% of all deaths. Mortality declines slightly in the fourth decade, but remains elevated across adult age classes. Males and females show no significant difference in age-specific probability of death or mean age-at-death. The percentage of females surviving past their fifth decade (42.6%) is slightly higher than for males (37.4%). This pattern suggests sex-specific differences in the onset and duration of mortality risk. Males displayed elevated mortality levels in their late teens through their twenties and after 50-years; females experienced a slight decrease in mortality from their twenties to thirties but exhibited less variability in mortality rates across adult age classes.

4.9.4 Comparative Paleodemography: Ostojićevo and Mokrin

When corrected for the absence of neonates and underrepresentation of young infants, Mokrin has a similar attritional mortality pattern to Ostojićevo. These results demonstrate the effect of representation bias from cultural practices on demographic profiles. Cultural practices at Mokrin denied group burial rites to all individuals under 1-year-at-death. The underrepresentation of individuals between 1- and 3-years at Mokrin could be in part due to preservation factors. For example, the burial of infants and young children at Ostojićevo in storage urns may have increased the chance of preservation and archaeological recovery of fragile subadult remains compared to the practice of flexed inhumation for all burials at Mokrin. Farkas and Lipták (1971) collected data on age-at-death and sex for 240 individuals at Mokrin, compared to Rega's (1995) analysis of 223 individuals. Comparison of the two studies shows that the "missing" individuals in Rega's study include 10 adults (*n-male* = 5, *n-female* = 5) and 12 subadults, with the subadults classified as either infant I (*n* = 11; birth- to 7-years) or infant II (*n* = 1; 7- to 14-years). Rega (1995: 87-88) reports incorporation in paleodemographic analysis of a subset of 12 individuals analyzed by Farkas and Liptak, but does not include information on grave number, sex, or corrected age. The current study compiled demographic data only from skeletal remains directly analyzed by Rega. Thus, preservation factors combined with missing data and cultural biases contributed to an underrepresentation of neonates and young infants at Mokrin.

A notable difference between the two sites is the low number of males at Ostojićevo surviving past 40-years. Between-site pairwise comparison of sex and age-at-death found a significant difference only in the percentage of males above 50 years-at-death. Interpretation of this demographic difference requires consideration of the three main factors found to influence mortuary profiles at Mokrin and Ostojićevo: (1) preservation bias; (2) representation bias; and/or (3) selective mortality (*i.e.*, fewer males surviving to adulthood). Differential preservation, especially of the remains of the very young and very old, is an important factor in accurately assessing an intrinsic pattern of soft-tissue decomposition and skeletal preservation related to bone size and density (Bello & Andrews, 2009; Duday, 2009; Willey et al., 1997; Von Endt & Ortner, 1984).

Individual data on preservation and taphonomy is not available for Mokrin; however, general patterns can be inferred for both sites by examining the number of 'probable-male' and 'probable-female' adults relative to age-at-death. 'Probable-males' at Ostojićevo for which age-at-death could be estimated correspond to either the Adult III (n = 1) or Adult IV (n = 2) age class. When normalized to number of 'males' plus 'probable-males', this translates to 0.0% of Adults I and II versus 20.7% of Adults III and IV. In contrast, 'probable-females' show a more uniform distribution between Adults I and IIs (*n-probable* = 3; 13.6%) and Adults III and IV (*n-probable* = 2; 10.5%). These results indicate greater uncertainty in sex determination with increased age-at-death for males but not females at Ostojićevo. At Mokrin, similar percentages of 'probable-males' were classified as Adult I or II (*n-probable* = 7; 17.3%) and Adult III or IV (*n-probable* = 5; 20.0%). A similar pattern was observed for Adult I and II (*n-probable* = 5; 12.5%) versus Adult III and IV (*n-probable* = 5; 16.1%) females. The effect of preservation and/or older age on sex determination for males at Ostojićevo, but not Mokrin, accounts for some of the observed underrepresentation of Adult IV males in this sample.

Representation bias has been demonstrated for neonates and possibly young infants at Mokrin. Though it is unclear where the majority of neonates and young infants were buried, they were excluded from formal cemeteries. At Mokrin, O'Shea (1996) reported a deficit of young adult males. He interpreted this as evidence that some young adult males were dying away from settlements, and that their bodies could not be recovered and transported for burial. Reanalysis of sex-specific mortality by Rega (1995: 100) found no evidence for significant differences in the number or relative proportion of adult males and females, a conclusion supported by the current study. Rega (1995; 1997) did, however, find a statistically significant excess of "female-gendered" infants and children. This pattern was interpreted as female-biased parental favoritism contributing to increased survivorship, with the assertion that the greater number of female deaths in this age class reflects a larger pool of living individuals. A similar pattern occurs at Ostojićevo. Several studies have documented an apparent higher mortality risk for male fetuses and infants (Stevenson et al., 2000; Ulizzi & Zonta, 2002). Thus, a greater frequency of male deaths from stillbirths or natural causes would be expected for neonates and young infants. The greater number of females dying between birth and ten years at Ostojićevo and Mokrin could indicate differences in pre- and post-weaning childcare that gave male subadults a survival advantage once they reached a certain age. Based on demographic comparison, this study tentatively interprets differences in subadult mortality patterns as differences in childcare practices which favored survivorship of males at Ostojićevo and Mokrin. Interestingly, while relatively more males "survived" infancy and childhood, these advantages were offset by a more rapid increase in male mortality rates at a younger age (*i.e.*, mid-to-late adolescence for males compared to early-to-mid 20s for females).

Differential sex-specific infant and child mortality can significantly affect adult sex ratios (*e.g.*, Gupta, 1987; Hewlett, 1991; Lee et al., 1994). Additionally, several studies have shown that low socioeconomic status and poor childhood health have a larger effect on adult female than adult male mortality (Gupta, 1995; Kuh et al., 2002), though this effect appears to diminish with increased age (*e.g.*, Bengtsson & Lindstrom, 2000; Crimmins & Finch, 2006; Hayward et al., 2013). Based on trends in female child-mortality between 3 and 6 years, the expected pattern is heterogeneity in adult longevity favoring male survivorship. Paleodemographic analysis of age- and sex-specific probability of death at Mokrin and Ostojićevo show that the reverse is true. Advances in male late-infant and childhood survivorship are offset by greater increases in risk of death in late-adolescence and early-adulthood relative to females.

High young-adult male mortality is well-documented in the clinical and ethnographic literature, with women outliving men an average of 7 years in contemporary societies, though this varies based on factors such as maternal mortality rates and warfare (Kinsella & Suzman, 1992). Among individuals over

60-years, sex ratios of 92 men to 100 women are not unusual in present-day developing countries (Kinsella & Gist, 1998). Research also shows that males have higher rates of perinatal and neonatal mortality (Ulizzi & Zonta, 2002). Increased risk-taking behavior has been implicated in causing increased male vulnerability throughout childhood into young adulthood (see Buhr & Cooke, 1959). Higher male mortality at younger ages due to a behavioral tendency towards risk-taking is typical of pre-industrial human populations. Conversely, a preponderance of young female deaths could provide evidence of cultural practices that expose females to increased risk of death at younger age (*e.g.*, female infanticide, preference for male offspring, lower female social status, and political instability) (Cucina & Tiesler, 2003; Pike et al., 2010; Scott, 2001). The cumulative effect, which is more pronounced at Ostojićevo than Mokrin, is that more males survived childhood, while more females survived the young adult period (*i.e.*, late-teens to early-30s). Thus, the lower male mean life-expectancy at both sites and the small number of males surviving past their sixth decade at Ostojićevo reflect conditions of differential survivorship and mortality, suggesting gender- and age-specific differences in the type and magnitude of occupational, environmental, and/or intrinsic biological influences on morbidity and mortality.

Comparison of mortality patterns between Ostojićevo and Mokrin shows the impact of ever-changing risk factors throughout life on survivorship. For infants, childcare practices can magnify or subvert sex- and specific-differences in intrinsic mortality risk. While implications of differences in childhood health linked to preferential care will be examined in Chapter 5, the evidence presented here suggests that due to cultural childcare practices, females that survived infancy and childhood were on average healthier and lived longer than their male counterparts. In contrast, cultural practices that improved male survival during childhood may have increased individual frailty as adults. Finally, adult mortality is associated with individual vulnerability further compounded by factors such as occupational hazards, reproductive risks, economic or political instability, or socio-economic inequality. Life expectancy at both sites is consistent with that of contemporary horticulturalist and pastoralist groups with limited access to healthcare (Foggin et al., 1997; Hewitt, 2003; Sugiyama, 2004), as well as of preindustrial European populations (Schofield & Wrigley, 1979). Acsádi and Nemeskéri (1970) estimated E(15) values to range from 19.1-years (Neolithic) to 26.9-years (Mesolithic). E(15) at Ostojićevo was 20.2-years, which is slightly below the Bronze Age range of 20.4 to 27.0 years.

4.10 Conclusion

Analysis of preservation, taphonomy, and demography at Ostojićevo and demography at Mokrin illustrate how cultural practices, human biology, and depositional environment influenced the composition of both skeletal samples. At Ostojićevo, consideration of element presence and element completeness shows clear age-specific patterns in preservation, with the very young and very old likely underrepresented in the skeletal sample due to poor preservation. Despite this, the Ostojićevo sample includes a representative cross-section of age- and sex-specific mortality in an EBA/MBA population. Compared to the Early Maros sample from the nearby cemetery at Mokrin, Ostojićevo is demographically unique in the presence of neonates and high frequency of infants. Results presented in this chapter support the interpretation that these demographic differences were due to cultural rather than biological or environmental factors.

Taphonomic analysis provides insight into Maros burial practices. Excavation records (Girić 1981-1991 compiled by Milašinović, 2008) do not suggest secondary burial practices or postmortem manipulation of the body. Almost everyone – from newborns to old adults - were interred in shallow burial pits. Their bodies were flexed at the hips and knees, with legs parallel to one another, feet extended, and the hands crossed in front of the face. There was a progressive infilling of voids as decomposition progressed, resulting in minimal movement of skeletal elements (Duday, 2009). The overwhelming evidence for taphonomic changes can be attributed to accidental disturbance of remains after a period in the ground sufficient for complete soft-tissue decomposition, and excavation and post-excavation damage. A key difference in how the two samples were curated is seen in the recovery and retention of the entire body for all individuals at Ostojićevo, in contrast to the disposal of all but the major long bones from the first 103 graves at Mokrin for (Girić, 1971). Thus, graves from the early phases of excavation at Mokrin are underrepresented in skeletal analysis, with the curation of only selected well-preserved specimens.

One major limitation of demographic reconstruction in this dissertation is an absence of fine-scaled dating of cemetery use at both Ostojićevo and Mokrin. As Milner et al. (2008:581) states: "…in most instances it would seem appropriate to treat skeletal collections as being from stable populations as long as the cemetery was large, had accumulated over lengthy periods of time, and did not otherwise show signs of containing only a select fraction of the original population". Barring major demographic disturbance(s), age-specific incidence and causes of death do not vary widely from year-to-year (Weiss, 1975; Sugiyama, 2004). According to Weiss (1975), it takes populations approximately one decade to recover from a demographic disturbance that lasts one year; and 30-years to recover from a disturbance occurring over five years. Thus, periodic demographic disturbances (*e.g.*, epidemics, migration) are masked by aggregate mortality over the duration of cemetery use, estimated at ca. 280 years at Mokrin (O'Shea, 1996) and 370 years at Ostojićevo (O'Shea et al., 2019). Archaeological evidence for internal phasing is further confounded by a lack of clear temporal relationships between horizontally stratified individual graves, a characteristic which encompasses all known Maros cemeteries (Bóna, 1975; O'Shea, 1996).

5.0 Stature and Paleopathology

5.1 Methods: Ostojićevo Stature

Stature was estimated for Ostojićevo adults ≥20 years for which at least one complete long bone was present. Maximum length was measured for all intact mature long bones (*i.e.*, femur, tibia, fibula, radius, ulna, and humerus). Stature was calculated using the criteria for white males and females outlined in Wilson et al. (2010). For the purpose of stature estimation, male standards were applied to probable-male, and female standards to probable-female. Individuals of indeterminate sex were excluded from stature analysis. Additionally, mean, median, and +/- 1 standard deviation length were calculated for each long bone to document variation within and between males and females.

The differences in "mean stature values" between the upper limbs (humerus + radius) and lower limbs (femur + tibia) were assessed to examine discrepancies in estimated stature from different skeletal elements. To account for the possible impact of preservation on between-element distribution, only individuals with at least one upper limb and one lower limb (excluding ulna and fibula due to small sample sizes) were included.

5.2 Methods: Ostojićevo Non-Specific Stress

5.2.1 Cribra Orbitalia and Porotic Hyperostosis

Cribra orbitalia (CO and porotic hyperostosis (PH) have historically been diagnosed as expansion of the diploë accompanied by cortical thinning in the orbital roofs and cranial vault, respectively, associated with hereditary and/or nutritional anemias (Angel, 1967; Brothwell, 1981; Goodman et al., 1984). More recently, bone changes associated with CO and PH have been recognized as resulting from complex, multifactorial, and potentially unrelated processes (Ortner, 2003; Walker et al., 2009). For example, chronic bleeding in the orbits and/or cranial vault from trauma or underlying factors such as vitamin C deficiency (scurvy) may also produce porosities in these areas. However, whereas anemia leads to widening of the diploë secondary to marrow hypertrophy and cortical thinning, scurvy tends to produce fine porosity and periosteal deposition with vascular imprints (Armelagos et al., 2014; Brickley & Ives, 2006; Ortner, 2003). Skeletal changes associated with scurvy affect only the outer table and lack the "porous labyrinth-like lesions of the skull vault" seen in acquired or hereditary anemia (Ortner, 2003:374). Differential diagnosis of CO or PH must also consider comorbidity of scurvy and anemias arising from nutritional stress and infectious disease (Armelagos et al., 2014; Goodman et al., 1984; Ortner, 2003).

Walker et al. (2009) in their review of CO and PH in the paleopathological and clinical literature, distinguish between the nature of skeletal changes and probable underlying causes of cranial porosities. They argue that PH is characteristic of megaloblastic anemia caused by nutritional deficiencies and/or malabsorption of key nutrients, notably vitamin B_{12} and folic acid. In contrast to inherited hemolytic anemias (*e.g.*, thalassemia, sickle-cell disease) or megaloblastic anemias, iron-deficiency is unlikely to produce marrow hypertrophy as it causes conditions of reduced erythropoiesis. Notably, the incidence of megaloblastic anemia, especially in infants, children, and pregnant or lactating women, is likely to increase in response to nutritional stress from consuming a plant-based diet deficient in vitamin B_{12}, prolonged breastfeeding, premature weaning, and/or exposure to poor sanitation and hygiene, such as found in crowded, unsanitary living conditions (Dagnelie et al., 1989; Lewis, 2006; Walker et al., 2009). Finally, Walker et al. (2009) proposed that CO most likely results from scurvy or comorbidity of scurvy and megaloblastic anemia, citing the susceptibility of the orbital roof in infants and children to periosteal detachment, subperiosteal bleeding, and formation of highly vascularized, porous subperiosteal bone due to vitamin C deficiency. However, computed tomography of cranial vault thickness in the orbits in a sample of archaeological crania from North America by Zuckerman et al. (2014) found considerable overlap in orbital cranial vault thickness and porosity between anemic- versus scorbutic-associated lesions.

Due to uncertainties in differential diagnosis, CO and PH were assessed separately in the context of non-specific indicators of stress arising from scurvy or megaloblastic anemia arising from malabsorption due to infectious disease (bacterial, viral, or parasitic) and/or dietary deficiency, noting that these health stresses are not mutually exclusive. CO was assessed for the right orbit roof (left substituted in cases of absence or poor preservation) and PH for the right ectocranial surfaces (left substituted in cases of absence or poor preservation). Both CO and PH were assessed according to presence or absence, severity (discrete porosity, coalescence of pores), and activity (lesions active, healed, mixed, or indeterminate). Standards for identification and description of CO and PH were adapted from Buikstra & Ubelaker, 1994 (120-1) based on Stuart-Macadam (1985). Scoring criteria can be found in Appendix Figure 2. A series of chi-square tests of homogeneity were used to compare the Crude Prevalence Rate (CPR) of CO, calculated as number of affected divided by total individuals, by sex and age-at-death and CPR of PH by sex and age-at-death.

5.2.2 Linear Enamel Hypoplasia

Systemic disease or malnutrition during periods of enamel formation can disrupt normal development, resulting in permanent defects in the form of pits or grooves. Enamel hypoplasia arises from defects in matrix secretion prior to mineralization (Hillson, 2001). In a review of the clinical and paleopathological literature, Hillson (2001) distinguishes between three types of enamel hypoplasias affecting the tooth crown: (1) furrow-type defects, or linear enamel hypoplasia (LEH) characterized by exaggerated perikymata in the imbricational (cervical) zone; (2) pit-type defects representing disruptions to groups of ameloblasts, appearing as isolated pits or bands of pits on occlusal or incisive surfaces, or around the crown sides; and (3) plane type defects, marked by the exposure of large sections of brown striae of Retzius. Only defects that appeared as a continuous linear horizontal groove or a series of pits were recorded in the current study as these can be readily identified macroscopically under natural light (Wheeler, 2012; Yaussy & DeWitte, 2018).

The timing of enamel formation differs between canines and incisors, males and females. The onset of mineralization of C^1 and C_1 begins around 4-5 postnatal months, with crown completion occurring around 4.1-4.9 years (Ten Cate, 1989 *in* Schwartz, 2007:222-223). For C^1, Moorees et al. (1963) reported 50% crown completion by 1.9 years (1.6-2.4 +/- 1 SD) in females and 2.2 years (1.9-2.5 years, +/- 1 SD) in males, with crown completion occurring around 4.0 years (3.6-4.5 years, +/- 1 SD) in both sexes. The onset of mineralization of permanent incisors begins around 3-4 months (10-12 months for I_2), with crown completion occurring around 3.3-3.7 years for I^1 and I_1 and 3.7-4.0 years for I^2 and I_2 (Ten Cate, 1989 *in* Schwartz, 2007:222-223). According to Goodman and Armelagos (1985a; 1985b), I^1 and C_1 are most susceptible to developing hypoplastic enamel defects among permanent dentition.

LEH were assessed macroscopically according to schema proposed by Buikstra and Ubelaker (1994: 56): 1 = enamel hypoplasia absent; 2 = linear vertical grooves; 3 = linear horizontal grooves (corresponds to Hillson's furrow-type LEH defects); 4 = pits; 5 = other defect. Number of visible defects and crown region (cervical 1/3rd, mid-crown 1/3rd, and incisal or occlusal 1/3rd) were also recorded. Enamel hypoplasia was only recorded for upper and lower canines and incisors as these teeth have been found to be the most sensitive to stress-induced disruptions in enamel formation (Goodman & Armelagos, 1985b). Data analysis included both CPR and total prevalence rate (TPR), with the latter calculated as affected elements divided by total elements. Individuals with no canines or incisors preserved were excluded from calculation of CPR and TPR. A series of chi-square tests of homogeneity were used to compare TPR by sex and age-at-death. CPR was used for statistical analysis to account for individual differences in tooth loss and preservation, and to be broadly comparable with published data on enamel hypoplasia prevalence in prehistoric Copper Age and Bronze Age samples from central Europe (*e.g.*, Hukelova, 2016; Rega, 1995; Ubelaker & Pap, 1996; 2009). The presence of thick calculus deposits on most molars and premolars prohibited direct observation of crown surfaces.

5.3 Methods: Ostojićevo Skeletal Abnormalities

Each adult and subadult were assessed for abnormalities of bone size or shape, abnormal bone loss, and abnormal bone formation (Appendix Figure 2). Joint disease and vertebral pathology were recorded for individuals ≥20 years-at-death (Appendix Figure 2). Differential diagnosis of skeletal pathologies within these categories was based on macroscopic analysis compared to published descriptions of diseases and conditions (Aufderheide & Rodríguez-Martín, 1998; Buikstra & Ubelaker, 1994; Roberts & Manchester, 2008; Ortner, 2003; Schwartz, 2007; Waldron, 2009). A specific diagnosis was avoided in the absence of pathognomonic characteristics.

5.3.1 Abnormalities of Bone Size or Shape

Abnormality of bone size or shape refers to congenital or acquired defects in growth and development (Buikstra & Ubelaker, 1994). These defects may become more pronounced due to factors such as biomechanical stress, trauma, or acquired pathologies (Ortner, 2003). This category includes congenital abnormalities and metabolic dysregulation, as well as those caused by environmental factors (*e.g.*, trauma, infection, malnutrition). Examples include bowing, angulation, abnormal width (*e.g.*, thickening of the cranial vault associated with acromegaly), vertebral deformities (*e.g.*, kyphosis, scoliosis, lordosis), and craniosynostosis (*e.g.*, plagiocephaly, hydrocephaly, etc.). Each individual was assessed for abnormalities of size or shape in the crania and postcrania not associated with trauma.

Skeletal abnormalities of size or shape at Ostojićevo were assessed macroscopically and described on a case-by-case basis. Cases were assigned to one of four categories: hyperostotic, hypostotic, incomplete or non-fusion, and other congenital or acquired anomalies. Briefly, hyperostotic traits refer to increased or extended bone growth of an unknown non-soft tissue origin, whereas hypostotic traits refer to truncated or incomplete bone growth/ossification or coalescence of elements (Aufderheide & Rodríguez-Martín, 1998; Schwartz, 2007). Congenital malformations constitute hereditary or acquired skeletal anomalies occurring during the intrauterine phase of life, whereas acquired deformations indicate abnormal shape arising from postnatal biomechanical, metabolic, and/or infectious causes (Aufderheide & Rodríguez-Martín, 1998; Schwartz, 2007).

5.3.2 Abnormal Bone Loss

Each individual was assessed for abnormal bone loss not associated with trauma in the crania and postcrania. Abnormal bone loss refers to focal (*e.g.*, lytic) or diffuse (*e.g.*, osteoporotic cortical thinning) destruction of bone or mixed bone loss and formation (*e.g.*, granulomatous lesions, nonpyogenic osteomyelitis) (Buikstra & Ubelaker, 1994). Categories of abnormal bone loss or mixed bone loss and formation include granulomatous lesions, nonpyogenic osteomyelitis, lytic lesions, abnormal cortical bone resorption, and other.

The following definitions and criteria were applied in the diagnosis and classification of focal bone destruction:

- Granulomas are associated with nonpyogenic infections such as tuberculosis, syphilis, leprosy, and fungal mycoses (Schwartz, 2007) and appear as lytic-like lesions in the cranium accompanied by cortical bone changes and reactive new bone formation covering or adjacent to destructive areas (Aufderheide & Rodríguez-Martín, 1998). Unlike pyogenic osteomyelitis, nonpyogenic granulomas are rarely associated with large sequestra though sclerotic and hypervascularized bone may be present.
- Nonpyogenic (nonsuppurative) osteomyelitis is characterized by circumscribed cortical bone destruction that may be associated with sequestra formation (Schwartz, 2007).
- Lytic lesions are characterized by circular or ovoid bone cavitation with a “punched-out” appearance (Schwartz, 2007). These lesions may be accompanied by sclerotic reaction and cortical thickening (Buikstra & Ubelaker, 1994).

- Abnormal cortical bone loss or absence consist of focal areas of bone destruction with or without secondary periostitis and/or sclerotic bone formation (Ortner, 2003). This category includes resorptive foci, which consist of cortical destruction and may be surrounded by reactive or remodeled bone (Schwartz, 2007). The margins of resorptive lesions are irregular and not as well-defined as in lytic lesions.

"Other" corresponds to bone loss of an unknown mechanism and/or origin. This category includes "complex lesions" that include a combination of apparent resorptive, erosive, lytic, proliferative, and/or periostitic activity. It also includes large destructive lesions with diffuse margins that have resulted in considerable local or generalized bone destruction. For example, osteonecrosis associated with vascular insufficiency with or without obvious evidence of trauma or infection (see Ortner, 2003; Schwartz, 2007). Aseptic necrosis from a reduction or loss of blood supply to a bone or region of bone disrupts the normal process of cortical remodeling throughout life. The affected bone or region decreases in size and cortical thickness, though the trabecular pattern may be retained. Furthermore, necrosis can lead to the formation of osteon fragments; however, the number and size of these fragments decreases as a larger area becomes affected. Eventually, necrosis can spread to the underlying trabecular bone, resulting in collapse and cavitation (Ortner, 2003).

5.3.3 Abnormal Bone Formation

Abnormal bone formation in this study refers to cases whereby an underlying condition or disease produces an abnormal increase in osteoblast activity (Buikstra & Ubelaker, 1994; Ortner, 2003). Hypertrophy of cortical and/or trabecular bone results from three primary mechanisms: (1) increased bone formation accompanied by increased bone resorption; (2) increased bone formation with normal bone resorption; and (3) normal bone formation and decreased bone resorption (Ortner, 2003: 52). Categories of extravertebral abnormal bone formation included: long bone periostitis, postcranial/extravertebral enthesophytes, postcranial/extravertebral osteophytes, postcranial/extravertebral syndesmophytes, bone tumors and tumor-like growths, and woven bone. Enthesophytes/syndesmophytes and osteophytes were considered "abnormal" if they exceeded 3.0 mm in length (Schultz, 1988 *in* Steckel et al., 2005). Bone-forming lesions on joints associated with primary osteoarthritis (degenerative joint disease) or secondary traumatic arthritis (*e.g.*, myositis ossificans, septic arthritis) are discussed in the section on joint disease (Section 5.11). Vertebral osteophytes are discussed in the section on vertebral pathology (Section 5.12). Finally, woven bone and myositis ossificans associated with trauma are discussed in Chapter 6.

All adult and subadult long bone diaphyses were assessed for periostitis. Long bone diaphyses were divided into three sections: proximal, middle, and distal (Judd, 2002a). Identification and scoring of periostitis in long bones followed the seven-stage schema developed by Steckel et al. (2005:30-31). Scoring ranged from 1 (no periostitis present) to 5 (extensive periosteal reaction affecting ≥1/2 of the diaphyseal surface and accompanied by fusiform swelling).

In addition to periostitis, the following definitions and criteria were applied in the diagnosis and classification of abnormal bone formation not associated with trauma or osteoarthritis:

- Enthesopathy is a complex phenomenon variably associated with trauma, age-related calcification, or hereditary factors or rheumatologic disorders (*e.g.*, seronegative spondyloarthropathy, Diffuse Idiopathic Skeletal Hyperostosis) (Chhem et al., 2008). Briefly, enthesopathy refers to reactive bone formation in the entheses (ligament, tendon, and articular capsule attachment sites on bone) (Ortner, 2003). The age of the individual, location and distribution of entheseal changes, and presence of comorbidities are important in providing a differential diagnosis as to the underlying cause (*e.g.*, trauma, repetitive physical stress, seronegative spondyloarthropathy, etc.).
- Syndesmophytes are osteophyte-like spurs that develop via ossification of soft connective tissue (*e.g.*, ligaments, tendons, etc.) (Schwartz, 2007).
- Osteophytes are a bony strut or spicule at the bone-cartilage interphase at the margins of articular surfaces (White & Folkens, 2005; Schwartz, 2007). Osteophytes are associated with age-related bone formation and their presence often indicates age-progressive (primary) osteoarthritis (degenerative joint disease) due to the breakdown of articular hyaline cartilage (Lieverse et al.,

2016; Rogers & Waldron, 1995). Osteophytes are non-specific indicators of pathology and their presence may be idiopathic (Rogers & Waldron, 1995). Examples of diseases and conditions in which extravertebral osteophytes commonly occur independent of osteoarthritis include secondary arthritis of the glenohumeral joint (rotator cuff arthropathy), neuroarthropathy, fluorosis, reactive arthritis (Reiter's Syndrome), and ochronosis (Aufderheide & Rodríguez-Martín, 1998; Ortner, 2003; Rogers & Waldron, 1995).

- Tumors and tumor-like growths arise from the uncontrolled proliferation of bone (osteoma), cartilage (chondroma), fibrous tissue (fibroma), or blood vessels (hemangioma) (Ortner, 2003). Benign tumors are characterized by undifferentiated dense mature bone, whereas malignancy is indicated by the presence of poorly differentiated immature bone that involves multiple bones (Ortner, 2003). Primary skeletal tumors are specific to bone, with most benign tumors falling in this category. Secondary skeletal tumors are malignant and result from the metastasis of tumors arising in soft tissue (*e.g.*, carcinoma of the lung, kidney, breast, gastrointestinal tract, thyroid, and prostate). (Ortner, 2003). Malignant tumors may be osteolytic, osteoblastic, or a combination, with lytic lesions more often associated with fast growing tumors (Ortner, 2003:533; Schwartz, 2007).
- Woven bone forms beneath the periosteum in response to infection, notably in the floor and sides of the maxillary sinuses, the alveolar sockets of the maxilla and mandible, and in tendon and ligament insertions (Boocock et al., 1995; Ortner, 2003:19). Woven bone appears as bone fiber bundles that resemble cancellous bone. These bone fiber bundles may be random or follow a more regular, linear arrangement (Ortner, 2003). All adult (20+ years) individuals with at least one maxillary sinus with a complete maxillary floor were assessed for the presence of "woven bone lesions" diagnostic of maxillary sinusitis. These diagnostic changes include the presence of "spicules" (subperiosteal bone deposition) interspersed with "pitting" (areas of bone resorption) on the maxillary floor (Boocock et al., 1995; Merrett & Pfeiffer, 2000; Roberts, 2007). Maxillary sinusitis was recorded as present/absent.

5.4 Methods: Ostojićevo Joint Disease

Analysis and diagnosis of joint disease corresponded to four general categories: primary degenerative osteoarthritis (OA), secondary traumatic osteoarthritis, spondyloarthropathy, and osteochondritis dissecans (Ornter, 2003). OA refers to abnormal bone formation proceeding from alterations of the articular cartilage leading to a slow progression of bony changes such as sclerosis, osteophytes, and subchondral eburnation (Ortner, 2003). A further distinction is made between primary OA and secondary OA (Waldron, 2009). As a degenerative "disease", primary OA has no obvious direct cause, Rather, it arises from a combination of mechanical and systemic factors, though it is uncommon in individuals <40 years (Ortner, 2003; Waldron, 2009). Primary OA is associated with age, though it is not an age-related phenomenon *per se*. Genetic predisposition, obesity, and female sex can contribute to an individual's risk of developing OA beyond microtrauma to the joint cartilage and subchondral bone from biomechanical stress (Nelson et al., 2014; Ortner, 2003; Stevens-Lapsely & Kohrt, 2010). Additionally, certain synovial joints show an intrinsic predilection to develop primary OA over others, with a higher prevalence reported for the knee, hip, hand, and acromioclavicular joint (Hutton, 1987). By contrast, secondary OA tends to develop earlier in life due to congenital joint abnormalities (*e.g.*, Leggs-Perthe disease) and/or other systemic diseases affecting joints (*e.g.*, Paget's Disease, osteoporosis, etc.) (Ortner, 2003; Waldron, 2009).

Diarthrodial synovial joints of the upper and lower limbs were systematically assessed for primary osteoarthritis, with osteoarthritis only scored and recorded when present. Scoring corresponded to the five-stage schema developed by Steckel et al. (2005:32-33) for degenerative joint disease in non-vertebral joints, whereby a score of 1 equals no evidence of pathological change, and a score of 5 equals complete joint fusion. Diagnosis of OA was based on criteria outlined in Waldron and Rogers (1991): eburnation and/or presence of at least two structural changes (*i.e.*, marginal lipping, surface porosity, or surface osteophytes). Analysis of OA grouped individual joint surfaces into eight joint regions to calculate TPR: shoulder (glenoid fossa of the scapula and humeral head), elbow (proximal humerus, radial head, and ulna trochlear notch), wrist (distal radius, distal ulna, and carpals), hand (metacarpals and phalanges), hip (femoral head), knee (medial and lateral condyles of the femur and tibia), ankle (distal tibia, distal fibula, and talus), and foot (articular surfaces of the tarsals excluding the talus, metatarsals, and phalanges). TPR was based on individuals with at least one joint surface present for a given region. OA was listed as present in an individual for a given region if diagnostic changes were identified in at least one of the associated joint surfaces. A series of chi-square tests of homogeneity were used to compare TPR of OA in these eight respective regions by sex or age-at-death.

Further distinctions were made between secondary osteoarthritis associated with trauma or spondyloarthropathy associated with autoimmune diseases/disorders such as ankylosing spondylitis, psoriatic arthritis, rheumatoid arthritis, and others (Roberts & Manchester, 2007; Schwartz, 2007; Waldron, 2008). Spondyloarthropathies correspond to underlying pathological conditions that produce bone destruction with minimal reactive bone formation (Ortner, 2003). Identification among subadult and adult individuals at Ostojicevo was on a case-by-case basis, with an emphasis on changes to diarthrodal synovial joints, including ankylosis, not consistent with primary OA. Differential diagnosis can be complicated by the co-occurrence of destructive and proliferative types of arthritis in the same individual. Waldron (2009) and Ortner (2003) identify several subcategories of spondyloarthropathies that may be encountered in the examination of archaeological skeletal assemblages: rheumatoid arthritis, spondyloarthropathy (*e.g.*, ankylosing spondylitis, Reiter's Syndrome, psoriatic arthritis, enteropathic arthropathy, and undifferentiated spondyloarthropathy, and gout.

For the purposes of data collection, osteochondritis dissecans was also included with joint disease. However, whereas osteoarthritis is associated with neuromechanical degeneration, osteochondritis dissecans results from fragmentation of the cartilage due to vascular deficiency and/or trauma (Ortner, 2003). This results in the formation of localized sequestrum (necrotic fragment) in underlying subchondral cortical bone that may extend into cancellous bone. Overtime, the subchondral defect may be partially covered by a thin layer of new bone growth (Ortner, 2003; Roberts & Manchester, 2008). This noninflammatory condition primarily affects adolescents and young adults and is variously attributed to trauma and subchondral defects. OD is more common in males than females, with the knee the most frequent location (Ortner 2003).

5.5 Methods: Ostojićevo Osseous Changes in the Vertebrae

Osseous changes in the vertebrae include both pathological conditions (*e.g.*, ankylosing spondylitis, kyphosis) and age-related degenerative changes (*e.g.*, osteophytes, Schmorl's nodes) (Buikstra & Ubelaker, 1994; Faccia & Williams, 2008; Sofaer Derevenski, 2000). Analysis focused on the presence of osseous changes to vertebral bodies. Fractures to vertebral bodies not associated with an underlying disease or condition, including avulsion fractures, were recorded with other trauma.

Schmorl's nodes result from prolapse of the intervertebral disc into the inferior or superior surface of the vertebral body (Schmorl & Junghanns, 1958), forming a circular or ovoid depression (Aufderheide & Rodríguez-Martín, 1998; Schwartz, 2007). The pathophysiology of Schmorl's nodes begins with extrusion of material from the nucleus pulposus into the vertebral body via a break in the cartilaginous endplate (Faccia & Williams, 2008; Resnick & Niyawama, 1978). Subsequent degeneration of the trabecular bone creates a cavitation in the vertebral body. Bone responds by forming a reactive osseous barrier, preventing further intrusion of the extruded material and creating a smooth-walled defect. Thus, the formation of Schmorl's nodes represents the endpoint of deformation, prolapse, and rupturing of the intervertebral disc. Factors associated with node formation include congenital defects (*e.g.*, Scheuermann's kyphosis), trauma, and degenerative disc disease (Hansson & Roos, 1983; Resnick & Niwayama, 1978; Wagner et al., 2000). Clinical studies have demonstrated that the lower thoracic and lumbar regions are most commonly affected due to experiencing higher axial loads (Chaffin & Park, 1973). Recording of Schmorl's nodes included presence/absence, vertebrae type (cervical, thoracic, or lumbar), and vertebrae number if possible (*i.e.*, C3-C7, T1-T12, L1-L5). A chi-square test of homogeneity was used to compare

Schmorl's node pooled TPR (combined cervical, thoracic, and lumbar) for males versus females and Adult I/II versus Adult III/IV, respectively.

Osteophytes were diagnosed as horizontal outgrowths of bone from the superior and/or inferior margins of a vertebral body (Schwartz, 2007). Osteophyte development is largely age-dependent, associated with spondylosis deformans and/or degenerative disc disease (Adams & Roughley, 2006; Hassett et al., 2003). Though the relationship between physical activity and osteophyte development is unclear (Hassett et al., 2003; Sofaer Derevenski, 2000), factors such as excessive repetitive mechanical stress or obesity are associated with an increased risk of osteophyte development later in life (Klaassen et al., 2011; Schmitt et al., 2004). Adjacent osteophytes may ankylose in advanced cases of spondylosis deformans. Osteophytes were recorded following Brothwell, 1981 as: Grade I large intermittent osteophytes >3mm, Grade II moderate osteophytes >1-3 mm, or Grade III marked osteophytes >3 mm (Brothwell, 1981:150). Classification was based on the use of digital sliding calipers to measure the largest osteophyte on a given vertebrae. Also recorded were vertebrae type (cervical, thoracic, or lumbar) and vertebrae number if possible (*i.e.*, C3-C7, T1-T12, L1-L5). A chi-square test of homogeneity was used to compare pooled TPR (combined cervical, thoracic, and lumbar) for males versus females and Adult I/II versus Adult III/IV, respectively. TPR was based on number of vertebral bodies with osteophytes exceeding 1 mm.

5.6 Results: Ostojićevo Stature

Mean and distribution varied by sex and long bone, with greater estimates obtained from upper limbs compared to lower limbs for both males (Table 5.1; Figure 5.1) and females (Table 5.1; Figure 5.2). Males showed an average difference in stature estimated from upper versus lower limbs of 3.46 cm (μ-*Upper* = 169.60 cm, *SD-Upper* = 6.73; μ-*Lower* = 166.15 cm, *SD-Lower* = 6.93 cm). This difference was significant for $\alpha < .05$ ($df = 62$, $t = 2.02$, $p = .048$).

Females exhibited an average difference in stature estimated from upper versus lower limbs of 4.55 cm (μ*-Upper* = 159.75 cm, *SD-Upper* = 4.29; μ*-Lower* = 155.20 cm, *SD-Lower* = 4.10 cm). This difference was significant for $\alpha < .05$ ($df = 69$, $t = 4.51$, $p < .001$).

The humerus and the femur were used to calculate group stature estimates for males and females, respectively (Table 5.2). Mean male stature was 167.69 cm and mean female stature was 162.04 cm. The ratio of mean male to female height was 1.03. Assuming unequal variance, this difference is significant for $\alpha < .05$ ($df = 26$, $t = 2.32$, $p = .028$).

Table 5.1 Ostojićevo adult stature (cm)

Sex	Bone	N	Range	Min.	Max.	Mean	Std. Dev.	Ratio M:F
MALE	Humerus	21	7.50	159.07	185.87	171.05	6.48	1.06
	Radius	16	5.60	158.51	183.85	170.02	7.45	1.07
	Ulna	6	3.40	171.67	187.08	178.24	5.88	1.1
	Femur	32	11.00	157.49	187.20	168.07	7.13	1.09
	Tibia	20	9.10	152.57	178.88	164.81	7.09	1.06
	Fibula	5	3.80	161.83	172.59	165.74	4.18	1.07
FEMALE	Humerus	26	6.00	153.41	168.62	160.71	5.32	
	Radius	15	4.40	153.89	169.42	159.61	4.81	
	Ulna	8	3.60	157.1	169.15	161.49	4.51	
	Femur	26	6.00	146.35	162.09	154.88	3.58	
	Tibia	22	5.80	147.58	161.22	155.1	4.26	
	Fibula	5	3.00	151.87	159.33	154.6	4.16	

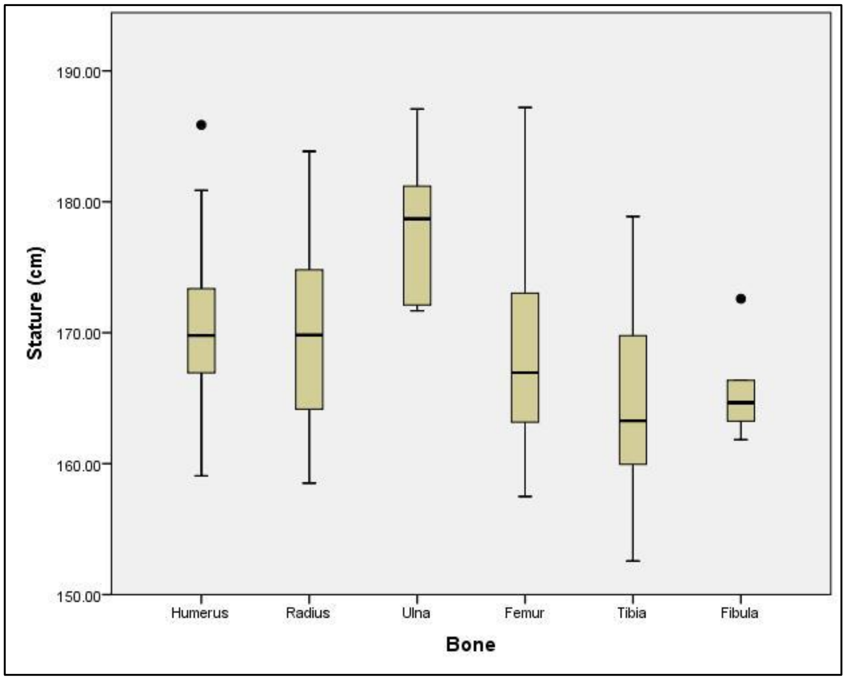


Figure 5.1 Ostojićevo boxplot distributions of male stature

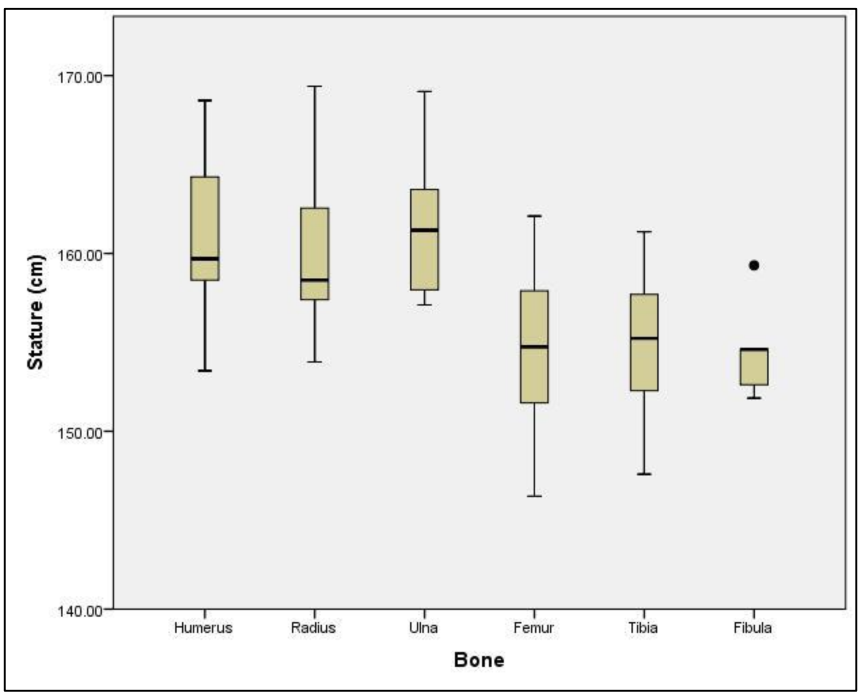


Figure 5.2 Ostojićevo boxplot distributions of female stature

Table 5.2 Ostojićevo adult stature calculated from the combined humerus and femur (cm)

Sex	n	Range	Mean	Min.	25%	50%	75%	100%	Max.	Std. Dev.	Ratio M:F
Male	16	29.38	167.69	158.58	161.00	166.53	169.82	171.98	187.96	8.15	1.03
Female	16	18.05	162.04	152.86	158.32	161.72	165.11	165.28	170.91	5.32	

5.7 Results: Ostojićevo Skeletal Indicators of Stress

5.7.1 Cribra Orbitalia and Porotic Hyperostosis

A total of 47 subadults and 75 adults were assessed for CO "presence", "activity", and "severity". The CPR of individuals affected by CO are reported in Table 5.3. CO prevalence was greater in subadults (*CPR* = 57.4%) than adults (*CPR* = 45.3%), with total CO prevalence ranging from 12.3% for Adult III individuals to 76.9% for Infant I/II individuals. There was no significant difference in total CO prevalence in subadults by age category ($\chi^2 = 5.17$, $df = 1$, $p = .08$) or sex ($\chi^2 = .11$, $df = 1$, $p = .74$). There was a significant difference in total CO prevalence for adults by age category ($\chi^2 = 8.68$, $df = 1$, $p = .01$) but not sex ($\chi^2 = 0.40$, $df = 1$, $p = .53$). A comparison of total CO prevalence showed no significant difference between age-matched males and females (Table 5.4).

Figure 5.3 illustrates differences in the severity and activity of bony changes associated with CO. CPR of CO severity and activity by age-at-death and sex are reported in Table 5.5. Age-at-death was shown to influence CO activity, with 51.1% of subadults displaying active changes compared to only 8.0% of adults (Figure 5.4). In contrast, proportions of discrete porosity versus coalescence of pores were consistent across age categories (Figure 5.5).

Table 5.3 Ostojićevo CPR (%) of CO by sex and age-at-death.Based on Ostojićevo individuals with at least one intact superior orbital surface. Subadult "sex" inferred from body orientation.

	Male			Female			Indeterminate			TOTAL		
	N*	n**	%	N	n	%	N	n	%	N	n	%
Neonate	7	3	42.9	6	2	33.3	3	1	33.3	16	6	37.5
Infant I/II	7	5	71.4	6	5	83.3	-	-	-	13	10	76.9
Child I/II	3	2	66.7	5	4	80.0	-	-	-	8	6	75.0
Juvenile I/II	5	3	60.0	5	2	40.0	-	-	-	10	5	50.0
TOTAL SA	22	13	59.1	22	13	59.1	5	1	20.0	49	27	55.1
Adult I	10	8	80.0	5	3	60.0	3	2	66.7	18	13	72.2
Adult II	9	3	33.3	8	3	37.5	-	-	-	17	6	35.3
Adult III	3	0	0.0	4	0	0.0	1	1	100.0	8	1	12.5
Adult IV	2	0	0.0	8	4	50.0	2	1	50.0	12	5	41.7
Adult ?	3	1	33.3	8	2	25.0	9	6	66.7	20	9	45.0
TOTAL ADULT	27	12	44.4	33	12	36.4	15	10	66.7	75	34	45.3

***Note.* * N = total orbit count (right orbit preferred, left used in cases of absence or poor preservation); ** n = affected orbit count.**

Table 5.4 Statistical analysis of CO CPR at Ostojićevo. Results of chi-square test of homogeneity (df = 1) for CO CPR by age-at-death and sex.

Age	Age Range (years)	n-male	CO - Male	n-female	CO - Female	$\chi^2(1)$	*p*
Neonate	0-1	7	42.9%	6	33.3%	0.12	.73
Infant/Child	>1-12	10	70.0%	11	81.8%	0.40	.53
Juvenile I/II	>12-20	5	60.0%	5	40.0%	--	1.00*
TOTAL Subadult	<20	22	59.1%	22	59.1%	0.00	1.00
Adult I	>20-30	10	80.0%	5	60.0%	--	.56*
Adult II	>30-40	9	33.3%	8	37.5%	0.03	.86
Adult III/IV	>40	5	0.0%	12	33.3%	--	.26*
TOTAL Adult	>20	24	45.8%	25	40.0%	0.17	.68

***Note.* * indicates use of Fisher's Exact when n ≤ 5.**

Figure 5.6 illustrates the distribution of CO severity and activity by age-at-death and sex. Despite similar frequencies of total affected adult individuals, active lesions were about three-fold more prevalent in adult females (*CPR* = 9.1%) than adult males (*CPR* = 3.7%), with the highest frequencies (*CPR* = 20-25%) reported for Adult II females. Frequencies of discrete porosity versus coalescence of pores were similar in adult males and adult females; greater frequencies of coalescence of pores were observed in Adult I males (*T CPR* = 50%) and Adult I females (*CPR* = 40.0%) compared to older individuals.

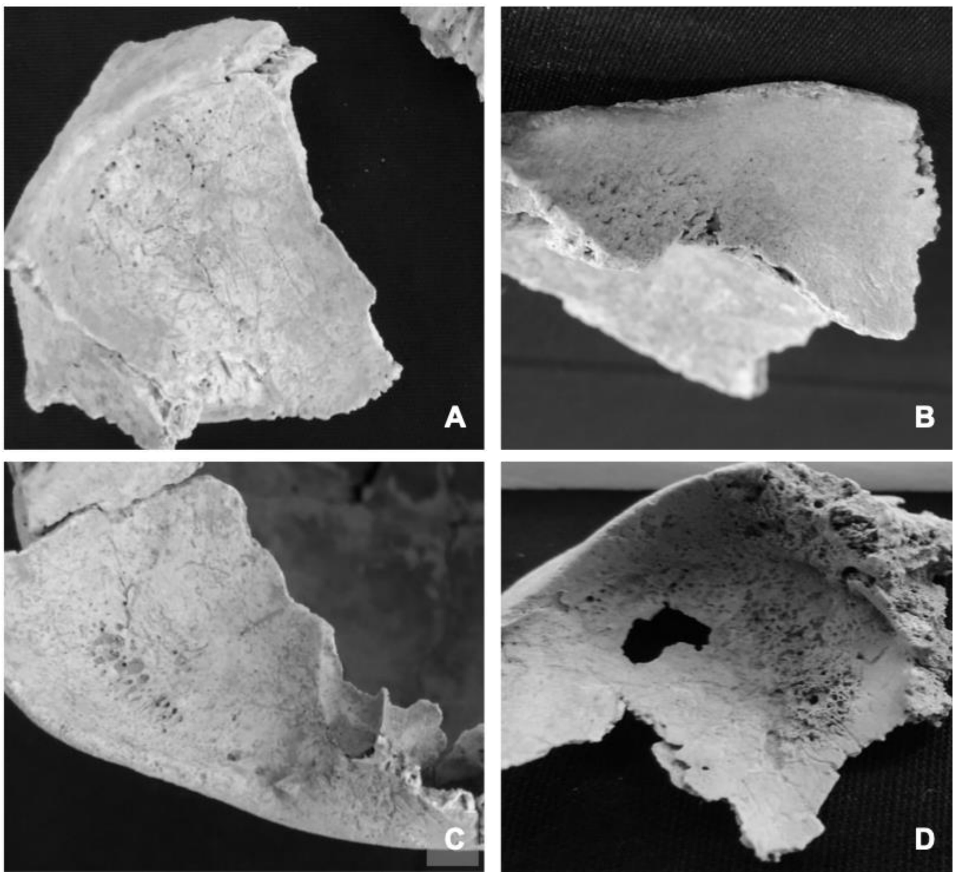


Figure 5.3 Variation in CO severity and activity at Ostojićevo. (A) Slight porosity, active, Grave 217, Child II; (B) Moderate porosity, healed, Grave 158, indeterminate adult; (C) moderate porosity with some coalescence, mix of active and healed, Grave 264, Adult IV female; (D) coalescence of pores with expansion of bone, active, Grave 205, neonate.

Table 5.5 TPR (%) of CO severity and activity by sex and age-at-death at Ostojićevo. Based on individuals with at least one intact superior orbit surface. Subadult "sex" inferred from body orientation.

		Severity Score						Activity Score							
Score	N*	Not affected		Porosity		Coalescence		Active		Healed		Mixed		Indeter.	
		n**	%	n	%	n	%	n	%	n	%	n	%	n	%
Neonate	16	10	62.5	3	18.8	3	18.8	5	31.3	0	0.0	1	6.3	0	0.0
Infant I/II	13	3	23.1	3	23.1	7	53.8	9	69.2	0	0.0	0	0.0	1	7.7
Child I/II	8	2	25.0	5	62.5	1	12.5	6	75.0	0	0.0	0	0.0	0	0.0
Juvenile I/II	10	5	50.0	1	10.0	1	10.0	4	40.0	1	10.0	0	0.0	0	0.0
SUBADULT TOTAL	47	20	42.6	12	25.5	4	8.5	24	51.1	1	2.1	1	2.1	1	2.1
Adult I	10	2	20.0	3	30.0	5	50.0	1	10.0	4	40.0	2	20.0	1	10.0
Adult II	9	6	66.7	1	11.1	2	22.2	0	0.0	2	22.2	1	11.1	0	0.0
Adult III	3	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Adult IV	2	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Adult ?	3	2	66.7	1	33.3	0	0.0	0	0.0	1	33.3	0	0.0	0	0.0
TOTAL Male	27	15	55.6	5	18.5	7	25.9	1	3.7	7	25.9	3	11.1	1	3.7
Adult I	5	2	40.0	1	20.0	2	40.0	1	20.0	1	20.0	1	20.0	0	0.0
Adult II	8	5	62.5	2	25.0	1	12.5	2	25.0	1	12.5	0	0.0	0	0.0
Adult III	4	4	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Adult IV	8	4	50.0	2	25.0	2	25.0	0	0.0	0	0.0	4	50.0	0	0.0
Adult ?	8	6	75.0	0	0.0	2	25.0	0	0.0	1	12.5	1	12.5	0	0.0
TOTAL Female	33	21	63.6	5	15.2	7	21.2	3	9.1	3	9.1	6	18.2	0	0.0
Adult I	15	1	33.3	0	0.0	2	66.7	1	33.3	0	0.0	1	33.3	0	0.0
Adult II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Adult III	3	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0
Adult IV	1	1	50.0	0	0.0	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0
Adult ?	2	3	33.3	2	22.2	4	44.4	1	11.1	2	22.2	3	33.3	0	0.0
TOTAL Adult?	6	5	33.3	3	20.0	7	46.7	2	13.3	3	20.0	4	26.7	1	6.7

***Note.* * N = total orbit count (right orbit preferred, left used in cases of absence or poor preservation); ** n = affected orbit count.**

Table 5.5 (continued).

Score	N*	Severity Score						Activity Score							
		Not affected		Porosity		Coalescence		Active		Healed		Mixed		Indeter.	
		n**	%	n	%	n	%	n	%	n	%	n	%	n	%
Adult I	18	5	27.8	4	22.2	9	50.0	3	16.7	5	27.8	4	22.2	1	5.6
Adult II	17	11	64.7	3	17.6	3	17.6	2	11.8	3	17.6	1	5.9	0	0.0
Adult III	8	7	87.5	1	12.5	0	0.0	0	0.0	0	0.0	0	0.0	1	12.5
Adult IV	12	7	58.3	2	16.7	3	25.0	0	0.0	1	8.3	4	33.3	0	0.0
Adult ?	20	11	55.0	3	15.0	6	30.0	1	5.0	4	20.0	4	20.0	0	0.0
ADULT TOTAL	75	41	54.7	13	17.3	21	28.0	6	8.0	13	17.3	13	17.3	2	2.7

***Note.* * N = total orbit count (right orbit preferred, left used in cases of absence or poor preservation); ** n = affected orbit count.**

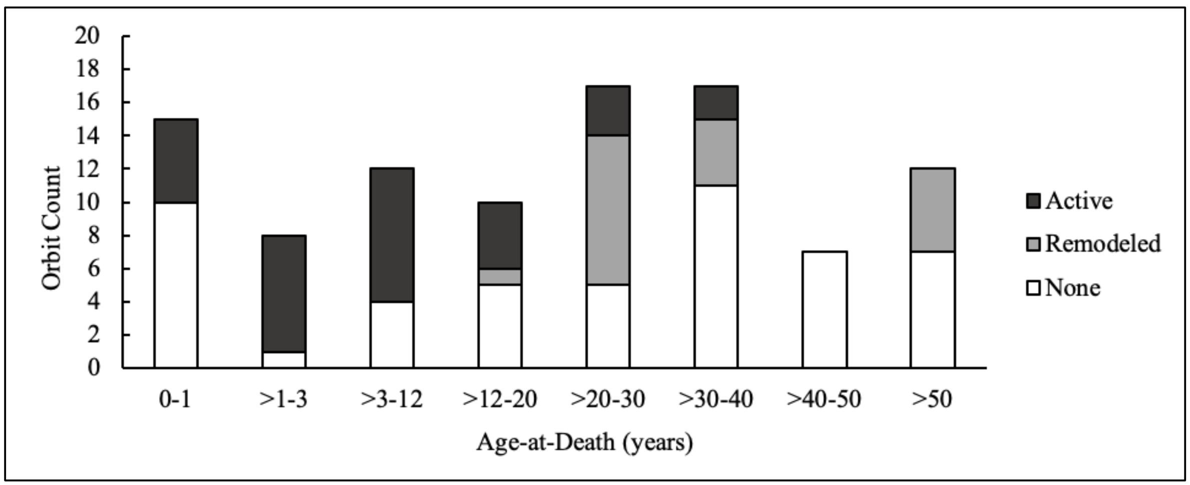


Figure 5.4 Distribution of CO activity by age-at-death at Ostojićevo. Note orbit count based on presence of right orbit. Left side used when right side unavailable.

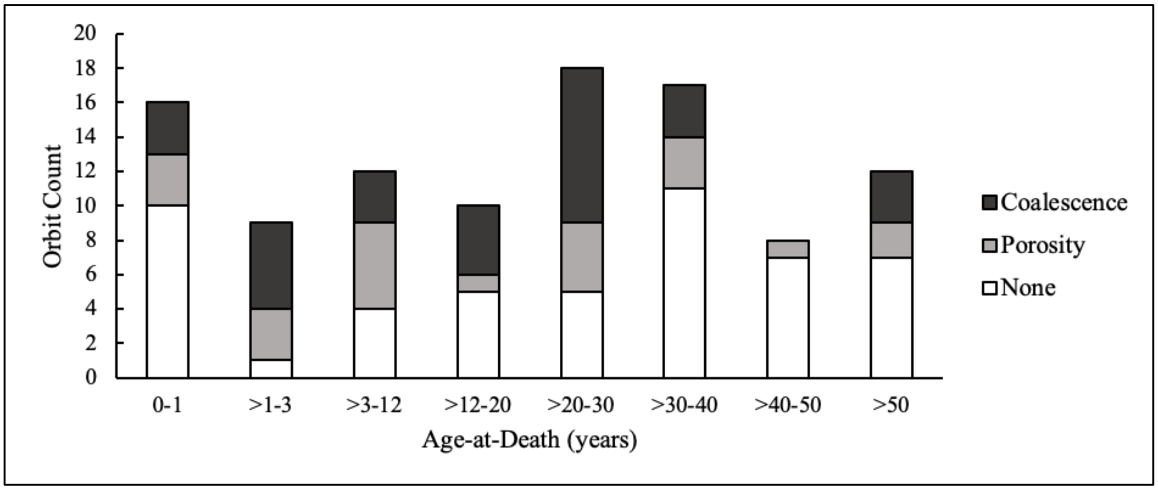


Figure 5.5 Distribution of CO severity by age-at-death at Ostojićevo. Note orbit count based on presence of right orbit. Left side used when right side unavailable.

A total of 55 subadults and 87 adults were assessed for "presence", "activity", and "severity" of PH. The CPR of individuals affected by PH are presented in Table 5.6. Overall PH "presence" was greater in subadults (*CPR* = 25.5%) than adults (*CPR* = 20.7%). PH prevalence ranged from 11.1% for Juvenile I/II to 33.3% for Child I/II. There was no significant difference in total PH prevalence by age for subadults (χ^2 = 1.04, *df* = 1, *p* = .60) or sex (χ^2 = 0.01, *df* = 1, *p* = .93) or adults (χ^2 = 1.08, *df* = 1, *p* = .58) or sex (χ^2 = 2.38, *df* = 1, *p* = .12). A comparison of total PH prevalence showed no significant differences in CPR between age-matched males or females (Table 5.7).

Figure 5.7 illustrates differences in the "activity" and "severity" of bony changes associated with PH. CPR of PH severity and activity by age-at-death and sex are reported in Table 5.8. There was a six-fold difference in the CPR of active PH between subadults and adults with at least one orbit present, with 18.2% of subadults showing active PH compared to only 3.4% of adults (Figure 5.8). CPR of PH severity showed less disparity in between subadults and adults, with 14.5% of subadults compared to 11.5% of adults exhibiting more severe bony changes characterized by coalescence of pores (Figure 5.9).

Figure 5.10 depicts the CPR of PH activity and severity by age-at-death and sex for individuals with at least one half of the cranial surface present. The largest disparity in PH activity was between Adult

I males and females. Among Adult I males, 33.3% demonstrated evidence for healed PH and 8.0% for active PH at time-of-death, compared to no identifiable cases of PH among Adult I females. This pattern contrasts with the high number of Adult I females observed with active CO at time-of-death. While active PH was twice as common among adult females (*CPR* = 5.9%) than adult males (*CPR* = 2.9%), the overall rate of PH was twice that for adult males (*CPR* = 26.5%) as adult females (*CPR* = 11.8%). This difference is not significant.

The highest prevalence of severe lesions, characterized by coalescence of foramina, occurred in Adult I (*CPR* = 41.7%) and Adult II (*CPR* = 18.2%) males. Most adult females and older males with PH demonstrated discrete porosity that was healed at time-of-death. For subadults, similarities in frequencies of discrete porosity versus coalescence of pores were noted between age categories. However, discrete porosity was more common in subadult males (*CPR* = 14.3%) compared to females (*CPR* = 8.7%), and coalescence of pores was more common in subadult females (*CPR* = 17.4%) than males (*CPR* = 7.1%).

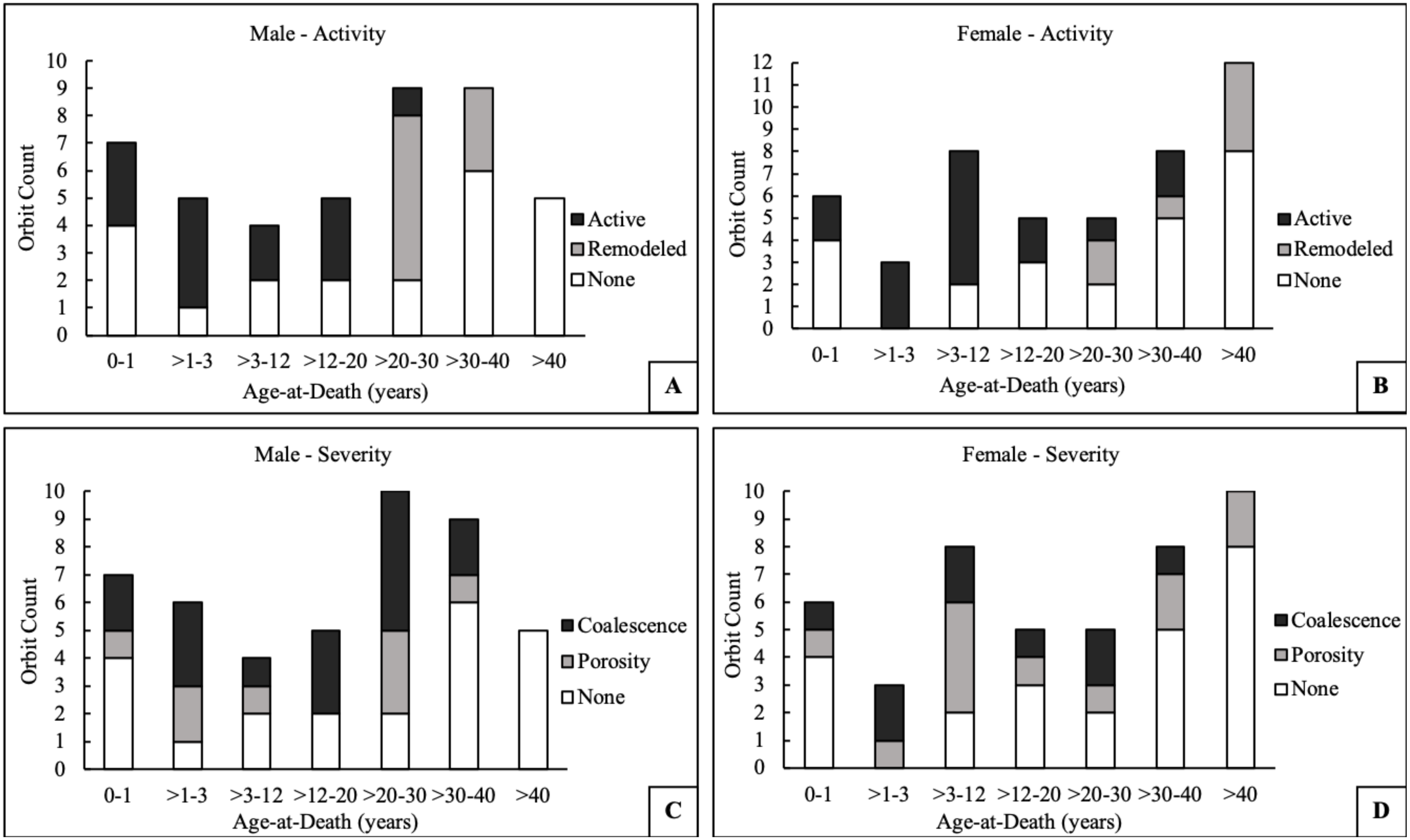


Figure 5.6 Comparison of CO distribution at Ostojićevo by activity and severity. Activity for males (A) and females (B); and severity for males (C) and females (D). Note orbit count based on right orbit, left used when right side unavailable.

Table 5.6 CPR (%) of porotic hyperostosis by sex and age-at-death at Ostojićevo. Based on individuals with at least one intact superior-posterior cranial surface. Subadult "sex" inferred from body orientation.

	Male			Female			Indeterminate			TOTAL		
	N*	n**	%	N	n	%	N	n	%	N	n	%
Neonate	8	2	25.0	5	1	20.0	3	1	33.3	16	4	25.0
Infant I/II	10	2	20.0	7	2	28.6	1	1	100.0	18	5	27.8
Child I/II	5	5	40.0	7	2	28.6	-	-	-	12	4	33.3
Juvenile I/II	5	0	0.0	4	1	25.0	-	-	-	9	1	11.1
TOTAL Subadult	28	6	21.4	23	6	26.1	4	2	50.0	55	14	25.5
Adult I	12	5	41.7	5	0	0.0	4	1	25.0	21	6	28.6
Adult II	11	2	18.2	8	1	12.5	-	-	-	19	3	15.8
Adult III	6	1	16.7	5	0	0.0	1	1	100.0	12	2	16.7
Adult IV	2	1	50.0	8	2	25.0	3	0	0.0	13	3	23.1
Adult ?	3	0	0.0	8	1	12.5	11	3	27.3	22	4	18.2
TOTAL Adult	34	9	26.5	34	4	11.8	19	5	26.3	87	18	20.7

Note. *** N = total cranial surface count (right side preferred, left used in cases of absence or poor preservation); ** n = affected surface count.**

Table 5.7 Statistical analysis of PH CPR at Ostojićevo. Results of chi-square test of homogeneity (df = 1) for PH presence (CPR) by age-at-death and sex.

Age	Age Range (years)	n-male	PH - male	n-female	PH - female	$\chi^2(1)$	*p*
Neonate	0-1	8	2	5	1	--	1.00*
Infant/Child	>1-12	15	4	14	4	0.01	.91
Juvenile I/II	>12-20	5	0	4	1	--	.44*
TOTAL Subadult	<20	28	6	23	6	0.15	.70
Adult I	>20-30	12	5	5	0	--	.25*
Adult II	>30-40	11	2	8	1	0.11	.74
Adult III/IV	>40	8	2	13	2	0.30	.59
TOTAL Adult	>20	31	9	26	3	2.60	.11

Note. *** indicates use of Fisher's Exact when n ≤ 5.**

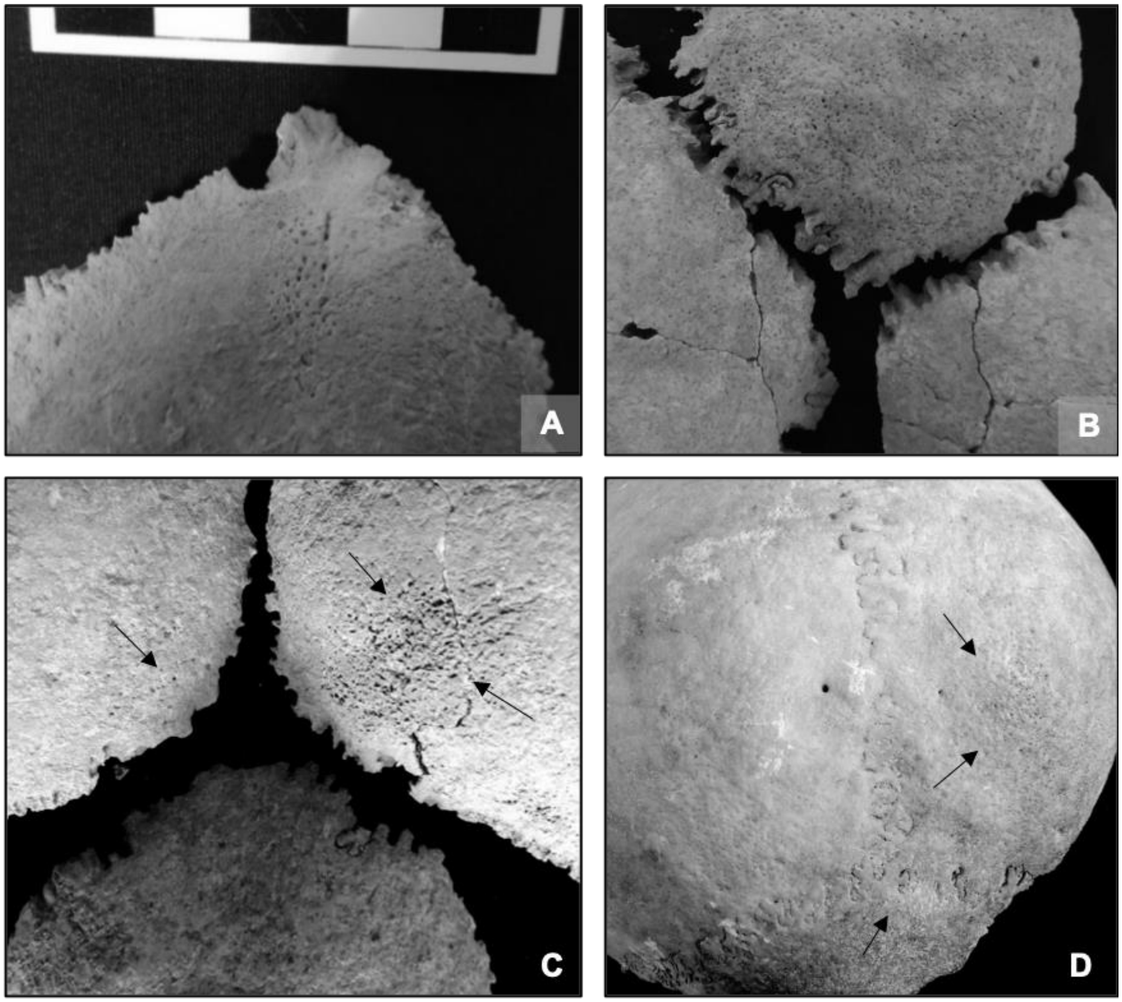


Figure 5.7 Variation in PH severity and activity at Ostojićevo. (A) Slight-to-moderate porosity, active, Grave 5, neonate; (B) Moderate-to-severe porosity, active, Grave 246, Adult IV female; (C) Coalescence of foramina with some expansion of diploë (arrows), active, Grave 111, Child I; (D) Coalescence of foramina without bone expansion (arrows), healed, Grave 186, Adult II male.

Table 5.8 Ostojićevo CPR (%) of PH severity and activity by sex and age-at-death. Based on Ostojićevo individuals with at least one intact superior-posterior cranial surface. Subadult "sex" inferred from body orientation.

		Severity Score						Activity Score							
Score	N*	Not affected		Porosity		Coalescence		Active		Healed		Mixed		Indeter.	
		n**	%	n	%	n	%	n	%	n	%	n	%	n	%
Neonate	16	12	75.0	2	12.5	2	12.5	4	25.0	0	0.0	0	0.0	0	0.0
Infant I/II	18	13	72.2	2	11.1	3	16.7	3	16.7	0	0.0	0	0.0	2	11.1
Child I/II	12	8	66.7	2	16.7	2	16.7	2	16.7	1	8.3	1	8.3	0	0.0
Juvenile I/II	9	8	88.9	0	0.0	1	11.1	1	11.1	0	0.0	0	0.0	0	0.0
SUBADULT TOTAL	55	41	74.5	6	10.9	8	14.5	10	18.2	1	1.8	1	1.8	2	3.6
Adult I	12	7	58.3	0	0.0	5	41.7	1	8.3	4	33.3	0	0.0	0	0.0
Adult II	11	9	81.8	0	0.0	2	18.2	0	0.0	2	18.2	0	0.0	0	0.0
Adult III	6	5	83.3	1	16.7	0	0.0	0	0.0	0	0.0	1	16.7	0	0.0
Adult IV	2	1	50.0	1	50.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0
Adult ?	3	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL Male	34	25	73.5	2	5.9	7	20.6	1	2.9	7	20.6	1	2.9	0	0.0
Adult I	5	5	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Adult II	8	7	87.5	1	12.5	0	0.0	1	12.5	0	0.0	0	0.0	0	0.0
Adult III	5	5	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Adult IV	8	6	75.0	1	12.5	1	12.5	1	12.5	1	12.5	0	0.0	0	0.0
Adult ?	8	7	87.5	0	0.0	1	12.5	0	0.0	0	0.0	1	12.5	0	0.0
TOTAL Female	34	30	88.2	2	5.9	2	5.9	2	5.9	1	2.9	1	2.9	0	0.0
Adult I	4	3	75.0	1	25.0	0	0.0	0	0.0	1	25.0	0	0.0	0	0.0
Adult II	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0
Adult III	1	0	0.0	1	100.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0
Adult IV	3	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Adult ?	11	8	72.7	2	18.2	1	9.1	0	0.0	1	9.1	2	18.2	0	0.0
TOTAL Adult?	19	14	73.7	4	21.1	1	5.3	0	0.0	3	15.8	2	10.5	0	0.0

Note. *** N = total cranial surface count (right side preferred, left used in cases of absence or poor preservation); ** n = affected surface count.**

Table 5.8 (continued).

Score	N*	Severity Score						Activity Score							
		Not affected		Porosity		Coalescence		Active		Healed		Mixed		Indeter.	
		n**	%	n	%	n	%	n	%	n	%	n	%	n	%
Adult I	21	15	71.4	1	4.8	5	23.8	1	4.8	5	23.8	0	0.0	0	0.0
Adult II	19	16	84.2	1	5.3	2	10.5	1	5.3	2	10.5	0	0.0	0	0.0
Adult III	12	10	83.3	2	16.7	0	0.0	0	0.0	1	8.3	1	8.3	0	0.0
Adult IV	13	10	76.9	2	15.4	1	7.7	1	7.7	2	15.4	0	0.0	0	0.0
Adult ?	22	18	81.8	2	9.1	2	9.1	0	0.0	1	4.5	3	13.6	0	0.0
ADULT TOTAL	87	69	79.3	8	9.2	10	11.5	3	3.4	11	12.6	4	4.6	0	0.0

***Note.* * N = total cranial surface count (right side preferred, left used in cases of absence or poor preservation); ** n = affected surface count.**

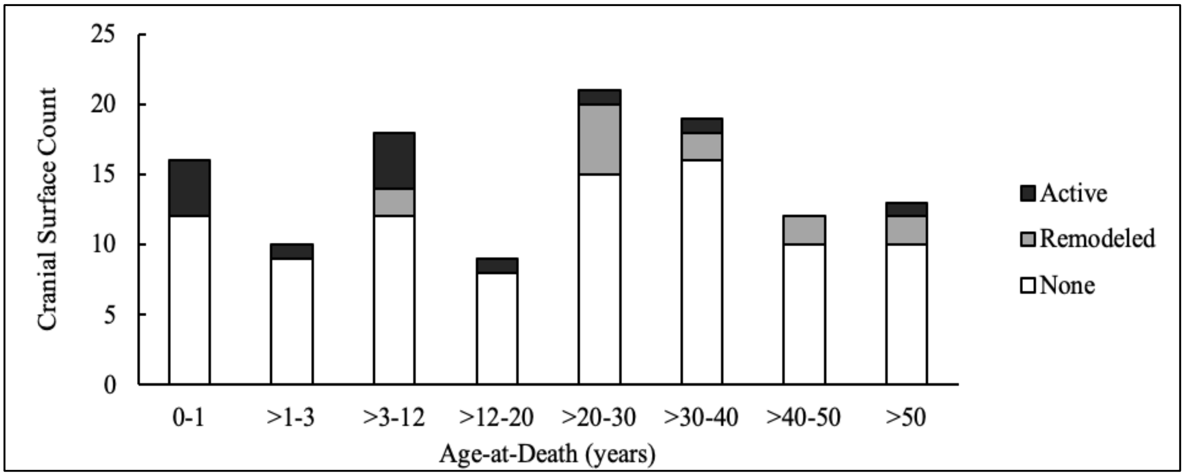


Figure 5.8 Distribution of PH activity by age-at-death at Ostojićevo. ***Note.*** **Cranial surface count based on presence of right half of cranial vault (parietal and superior aspect of occipital). Left side used when right side unavailable.**

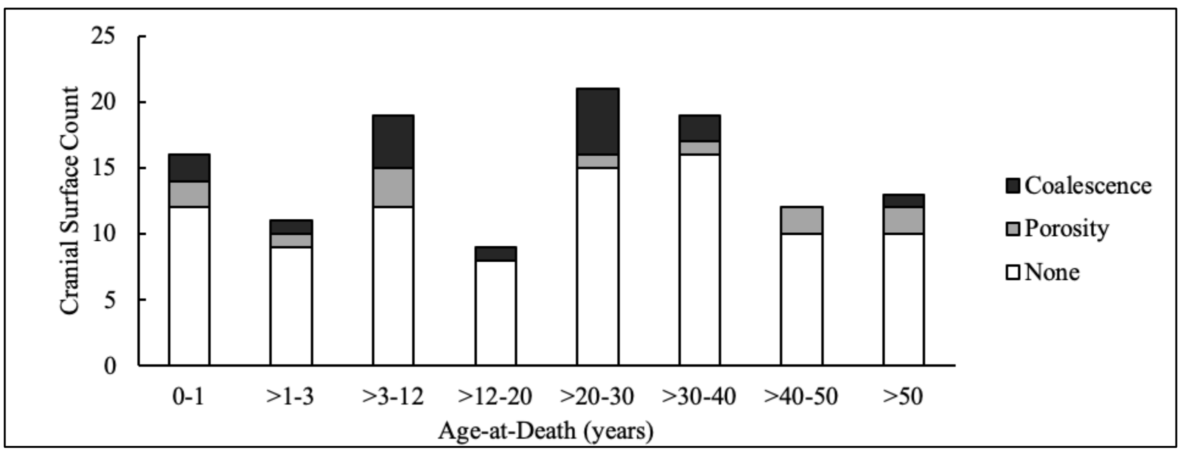


Figure 5.9 Distribution of PH severity by age-at-death at Ostojićevo. ***Note.*** **Cranial surface count based on presence of right half of cranial vault (parietal and superior aspect of occipital). Left side used when right side unavailable.**

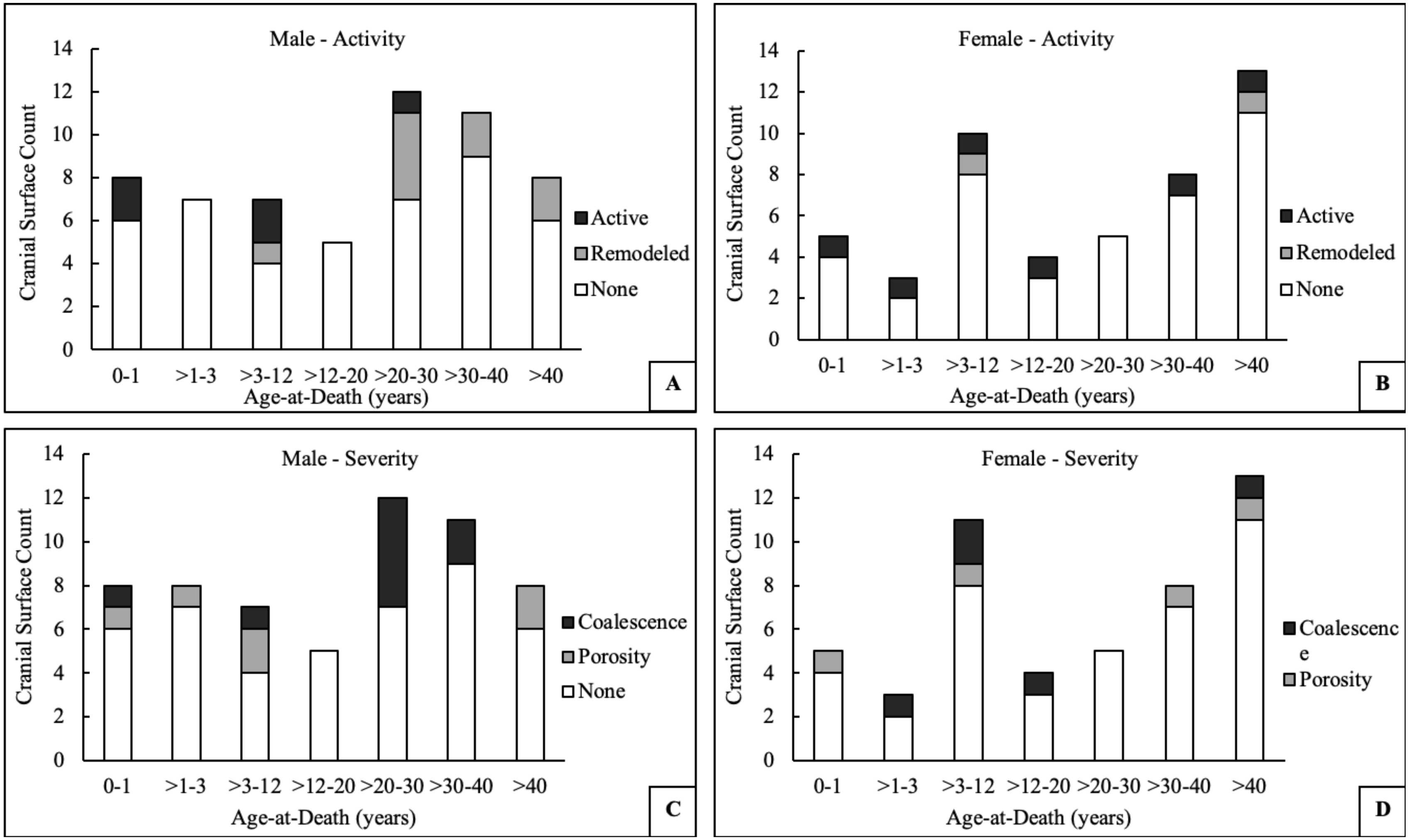


Figure 5.10 Comparison of PH distribution at Ostojićevo by activity and severity. Activity for males (A) and females (B); and "severity" for males (C) and females (D). ***Note.*** **Cranial surface count based on presence of right half of cranial vault (parietal and superior aspect of occipital). Left side used when right side unavailable.**

5.7.2 Linear Enamel Hypoplasia

A total of 175 canines (pooled C^1 and C^1) from 87 individuals were assessed for the presence of Linear Enamel Hypoplasia (LEH-C) in seven age classes (Table 5.9). Thirty-four (*TPR* = 39.1%) and 54 mandibular (*TPR* = 52.4%) canines displayed at least one lesion. Overall, LEH-C were found in 45 canines (*TPR* = 51.7%) representing 31 individuals (*CPR* = 45.6%). Defects were more common in the lower compared to upper teeth for both adult males (*TPR LEH-C^1* = 29.4%; *TPR LEH-C_1* = 33.3%) and adult females (*TPR LEH-C^1* = 41.2%; *TPR LEH-C_1* = 47.8%). For individuals with at least one canine present, LEH-C was more common in females (*CPR* = 52.9%) than males (*CPR* = 44.4%).

Compared to adults, LEH-C was more common in subadults (*TPR* = 58.1%; *CPR* = 73.6%). Defects were present on permanent canines in 6 'subadult-males' (*CPR* = 66.7%) and 7 'subadult-females' (*CPR* = 77.8%). Defects were more common in permanent mandibular versus maxillary canines for subadult 'males' (*TPR LEH-C^1* = 45.5%; *TPR LEH-C_1* = 66.7%) and 'females' (*TPR LEH-C^1* = 44.4%; *TPR LEH-C_1 r* = 66.7%). Analysis by sex and age-at-death revealed that Juvenile I/II individuals, especially 'females', were most likely to be affected. LEH-C was least common in Adult III/IV males (*CPR* = 0.0%) and Adult II females (*CPR* = 25.0%), respectively. Chi-square tests of homogeneity found no significant difference in the CPR of LEH-C between males and females for any age category (Table 5.10). Statistical analysis showed a significant difference in the CPR of LEH-C between adults and subadults ($\chi^2 = 4.68$, $df = 1$, $p = .03$), but no significant difference between males and females for adults ($\chi^2 = 0.42$, $df = 1$, $p = .52$) or for subadults ($\chi^2 = 0.28$, $df = 1$, $p = .59$).

Figure 5.11 illustrates the distribution of LEH-C defects by location within the tooth crown. For males, similar numbers of linear defects were observed in the middle- and lower-thirds of C^1 and C_1 crowns. A greater prevalence of defects in lower-third of C_1 crowns was noted for males 6 to 12 years-at-death and 20 to 30 years-at-death, whereas defects in the middle-third of C_1 crowns were more common in males 12 to 20 years-at-death. Females displayed greater disparities between age classes in the location of defects. For C^1, defects occurred most often in the upper-third of crowns for individuals 6 to 12 and over 40 years-at-death, and the middle-third for individuals 12 to 40 years-at-death; for C_1, defects located in the lower-third were more common in individuals 6 to 12 and over 20 years-at-death. Individuals 12 to 20 years-at-death displayed roughly equal numbers of defects in the lower, middle-, and upper-thirds of C^1 and C_1 crowns. The greater prevalence of LEH at Ostojićevo in the middle-third of C^1 and C_1 crowns in males versus the lower-third C^1 and C_1 crowns in females is due to differences in timing of crown growth between males and females, rather than the onset of stress. Overall, the location of defects relative to the timing of enamel deposition is consistent with development of defects between 2 and 4 years.

Table 5.9 CPR (individual %) and TPR (elemental %) of LEH at Ostojićevo based on pooled C1 and C1 (LEH-C). Subadult 'sex' inferred from body orientation.

	MALE			FEMALE			INDETERMINATE			TOTAL		
INDIVIDUAL	N_1	N_2*	%	N_1	N_2	%	N_1	N_2	%	N_1	N_2	%
Infant/Child	4	2	50.0	5	3	60.0	1	1	100.0	10	6	60.0
Juvenile I/II	5	4	80.0	4	4	100.0	0	0	n/a	9	8	88.9
Adult I	13	6	46.2	6	5	83.3	6	4	66.7	25	15	60.0
Adult II	7	3	42.9	8	2	25.0	1	1	100.0	16	6	37.5
Adult III	4	0	0.0	3	1	33.3	1	0	0.0	8	1	12.5
Adult IV	0	0	n/a	2	1	50.0	1	0	0.0	3	1	33.3
Adult?	3	1	33.3	6	2	33.3	7	5	71.4	16	8	50.0
TOTAL	36	16	44.4	34	18	52.9	17	11	64.7	87	45	51.7
ELEMENTAL	n_1	n_2**	%	n_1	n_2	%	n_1	n_2	%	n_1	n_2	%
Infant/Child	8	3	37.5	11	6	54.5	2	2	100.0	21	11	52.4
Juvenile I/II	12	8	66.7	10	6	60.0	0	0	n/a	22	14	63.6
Adult I	25	9	36.0	15	10	66.7	10	5	50.0	50	24	48.0
Adult II	18	5	27.8	15	5	33.3	3	3	100.0	36	13	36.1
Adult III	1	0	0.0	8	2	25.0	2	0	0.0	11	2	18.2
Adult IV	0	0	n/a	2	1	50.0	1	0	0.0	3	1	33.3
Adult?	8	4	50.0	12	2	16.7	12	7	58.3	32	13	40.6
TOTAL	72	29	40.3	73	32	43.8	30	17	56.7	175	78	44.6

***Note.* *N_2 = individual with at least one affected tooth; **n_2 = total affected teeth**

Table 5.10 Statistical analysis of LEH-C CPR at Ostojićevo. Results of chi-square test of homogeneity (df = 1) for the CPR of LEH-C by age-at-death and sex.

Age	Age Range (years)	n-male	LEH - male	n-female	LEH - female	$\chi^2(1)$	*p*
Infant/Child	>6-12	4	2	5	3	--	1.00*
Juvenile I/II	>12-20	5	4	4	4	--	1.00*
TOTAL Subadult	<20	9	6	9	7	0.28	.599
Adult I	>20-30	13	6	6	5	--	.177*
Adult II	>30-40	7	3	8	2	--	.266*
Adult III/IV	>40	4	0	5	2	--	.515*
TOTAL Adult	>20	24	9	19	9	0.42	.515

***Note.* * indicates use of Fisher's Exact when n ≤ 5.**

A total of 254 incisors (pooled $I^{1\text{-}2}$ and $I_{1\text{-}2}$) from 81 individuals were assessed for the presence of incisor Linear Enamel Hypoplasia (LEH-I) for adults and subadults (Table 5.11). Among adults, 33 incisors (*TPR* = 20.2%) displayed at least one lesion and 37 individuals had at least one affected incisor (*CPR* = 45.7%). LEH-I prevalence was greater in $I^{1\text{-}2}$ (*TPR* = 24.4%) compared to $I_{1\text{-}2}$ (*TRP* = 17.6%) for both adult males (*TPR LEH-*$I^{1\text{-}2}$ = 24.3%; *TPR LEH-*$I_{1\text{-}2}$ = 15.0%) and females (*TPR LEH-*$I^{1\text{-}2}$ = 31.6%; *TPR LEH-*$I_{1\text{-}2}$ = 21.7%). Of the adult 70 individuals for which sex could be determined, 15 males (*CPR* = 41.7%) and 19 females (*CPR* = 55.9%) had a defect on at least one incisor.

Subadults exhibited greater prevalence of LEH-I (*TPR* = 45.1%; *CPR* = 61.5%) compared to adults, with defects present on permanent incisors in 6 'subadult-males' (*CPR* = 60.0%) and 9 'subadult-females' (*CPR* = 60.0%). Similar numbers of defects were noted for $I^{1\text{-}2}$ (*TPR* = 47.5%) and $I_{1\text{-}2}$ (*TPR* = 43.1%), although frequencies differed for subadult 'males' (*TPR LEH-*$I^{1\text{-}2}$ = 53.3%; *TPR LEH-*$I_{1\text{-}2}$ = 60.0%) and 'females' (*TPR LEH-*$I^{1\text{-}2}$ = 45.8%; *TPR LEH-*$I_{1\text{-}2}$ = 22.2%). Analysis by sex and age-at-death revealed that Juvenile I/IIs, especially females, were the individuals most likely to be affected. The lowest LEH-I prevalence was observed for Adult III/IV males (*CPR* = 0.0%) and Adult II females (*CPR* = 40.0%), respectively. Chi-square tests of homogeneity showed no significant difference in LEH-I CPR between males and females for any age class (Table 5.12). Statistical analysis found a significant difference in LEH-

I CPR between adults and subadults (χ^2 = 3.88, df = 1, p = .05), but no significant difference between males and females for adults (χ^2 = 1.77, df = 1, p = .18) or for subadults (χ^2 = 0.00, df = 1, p = 1.00).

Figure 5.12 illustrates the distribution of LEH-I defects by location on the tooth crown. For males, the highest prevalence of defects was found on the middle-third of I^{1-2} crowns, and middle- and lower-thirds of I_{1-2} crowns. Defects in the middle-third of I^{I-2} and I_{1-2} crowns were slightly more common in infant/child and adolescent males, with defects in the upper-third (near the occlusal surface) present in I^{1-2} crowns of individuals 12 to 20 and 30 to 40 years-at-death, and I_{1-2} crowns of individuals 6 to 12 years-at-death. Among females, the highest prevalence of defects occurred on the middle-third of I^{1-2} crowns. Roughly equal numbers of defects were observed on the middle- and lower-thirds of I_{1-2}. Except for the occurrence of defects in the upper-third of I^{1-2} crowns of females 6 to 12 and over 40 years-at-death, there was little discrepancy in defect location between adult age categories. The greater prevalence of LEH in the middle-third of I^{1-2} and I_{1-2} suggests most individuals experienced episodes of stress around 2 years-of-age, with a range of 1.5-2.9 years. The lower-third of I^{1-2} and I_{1-2} crowns was the second most common location for hypoplastic defects in the permanent incisors, corresponding to an onset of stress around ca. 3.0-4.0 years. These approximations of age-of-onset of stress events corresponds generally to the defect pattern observed in the permanent canines. There is little disparity in the location of defects on incisor crowns between males and females or adults and subadults. However, subadults did display greater overall frequencies of defects. This suggests that childhood health influenced longevity, with those experiencing period of stress early in life dying at earlier ages.

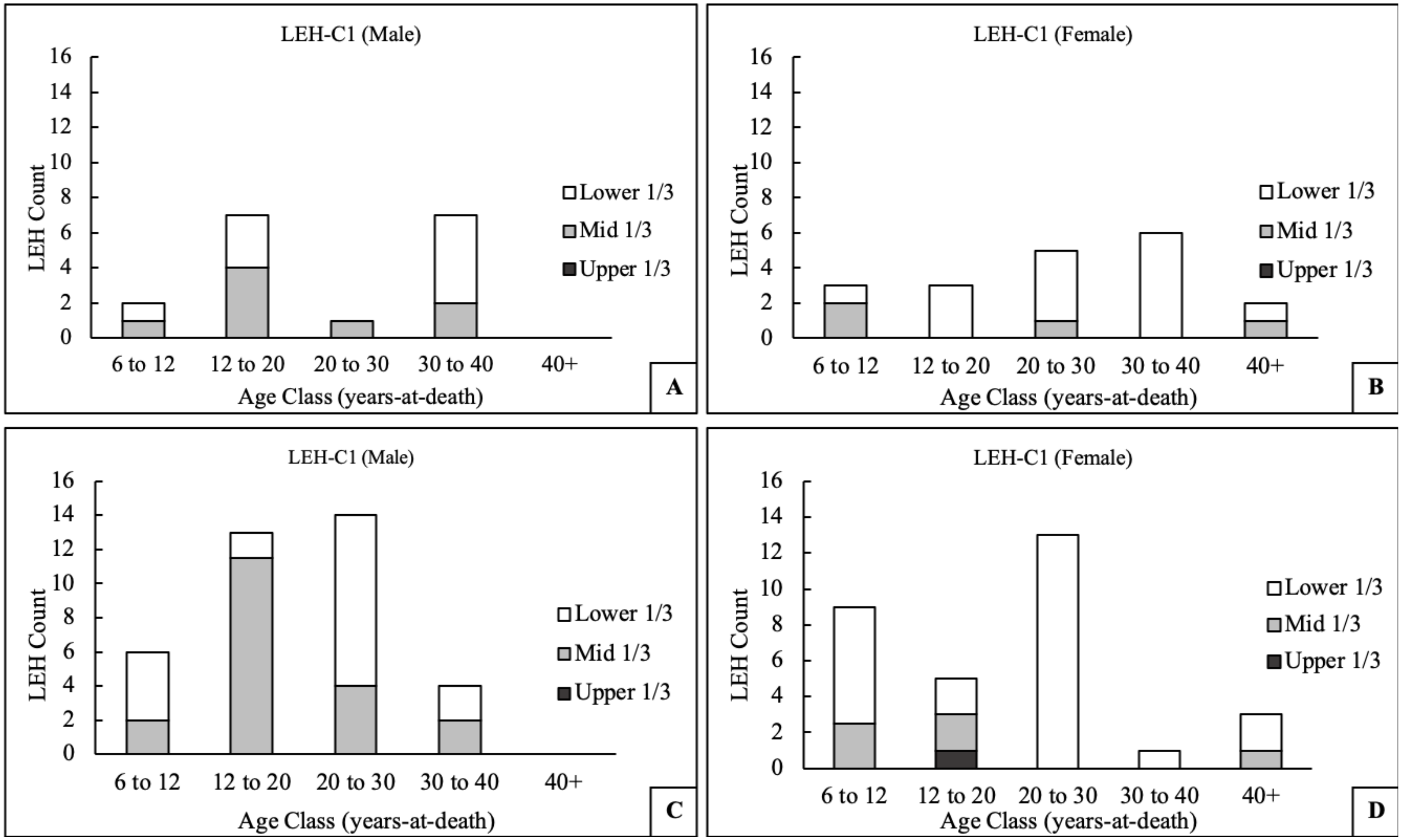


Figure 5.11 Comparison of LEH-C defect location by age-at-death at Ostojićevo. Males C^1 (A); Females C^1 (B); Males C_1 (C); and Females C_1 (D). Location refers to position on crown, divided into upper (occlusal third), middle (body), and lower (basal-third above cemento-enamel junction). LEH count refers to number of defects.

Table 5.11 CPR (individual %) and TPR (elemental %) of LEH-I at Ostojićevo. Pooled I^{1-2} and I_{1-2} incisors (LEH-I). Subadult 'sex' inferred from body orientation.

	MALE			FEMALE			INDETERMINATE			TOTAL		
INDIVIDUAL	N_1	N_2*	%	N_1	N_2	%	N_1	N_2	%	N_1	N_2	%
Infant/Child	6	3	50.0	10	5	50.0	1	1	100.0	17	9	52.9
Juvenile I/II	4	3	75.0	5	4	80.0	0	0	n/a	9	7	77.8
Adult I	12	6	50.0	5	3	60.0	5	1	20.0	22	10	45.5
Adult II	7	2	28.6	5	2	40.0	0	0	n/a	12	4	33.3
Adult III	4	0	0.0	2	2	100.0	0	0	n/a	6	2	33.3
Adult IV	0	0	n/a	2	1	50.0	0	0	n/a	2	1	50.0
Adult?	3	1	33.3	5	2	40.0	5	1	20.0	13	4	30.8
TOTAL	36	15	41.7	34	19	55.9	11	3	27.3	81	37	45.7
ELEMENTAL	n_1	n_2**	%	n_1	n_2	%	n_1	n_2	%	n_1	n_2	%
Infant/Child	20	10	50.0	31	13	41.9	5	4	80.0	56	27	48.2
Juvenile I/II	15	10	66.7	20	4	20.0	0	0	n/a	35	14	40.0
Adult I	47	10	21.3	16	6	37.5	10	1	10.0	73	17	23.3
Adult II	26	5	19.2	11	2	18.2	0	0	n/a	37	7	18.9
Adult III	4	0	0.0	12	2	16.7	0	0	n/a	16	2	12.5
Adult IV	0	0	n/a	3	1	33.3	0	0	n/a	3	1	33.3
Adult?	8	1	12.5	18	4	22.2	8	1	12.5	34	6	17.6
TOTAL	120	36	30.0	111	32	28.8	23	6	26.1	254	74	29.1

***Note.* *N_2 = individuals with at least one affected tooth; **n_2 = total affected teeth.**

Table 5.12 Statistical analysis of LEH-I CPR at Ostojićevo. Results of chi-square test of homogeneity (*df* = 1) for the CPR of LEH-I by age-at-death and sex.

Age	Age Range (years)	n-male	LEH - male	n-female	LEH - female	$\chi^2(1)$	*p*
Infant/Child	>6-12	6	3	10	5	--	1.00*
Juvenile I/II	>12-20	4	3	5	4	--	1.00*
TOTAL Subadult	<20	10	6	15	9	.00	1.00
Adult I	>20-30	12	6	5	3	--	1.00*
Adult II	>30-40	7	2	5	2	--	.588*
Adult III/IV	>40	4	0	4	3	--	.143*
TOTAL Adult	>20	23	8	14	8	1.77	.183

***Note.* * indicates use of Fisher's Exact when n ≤ 5.**

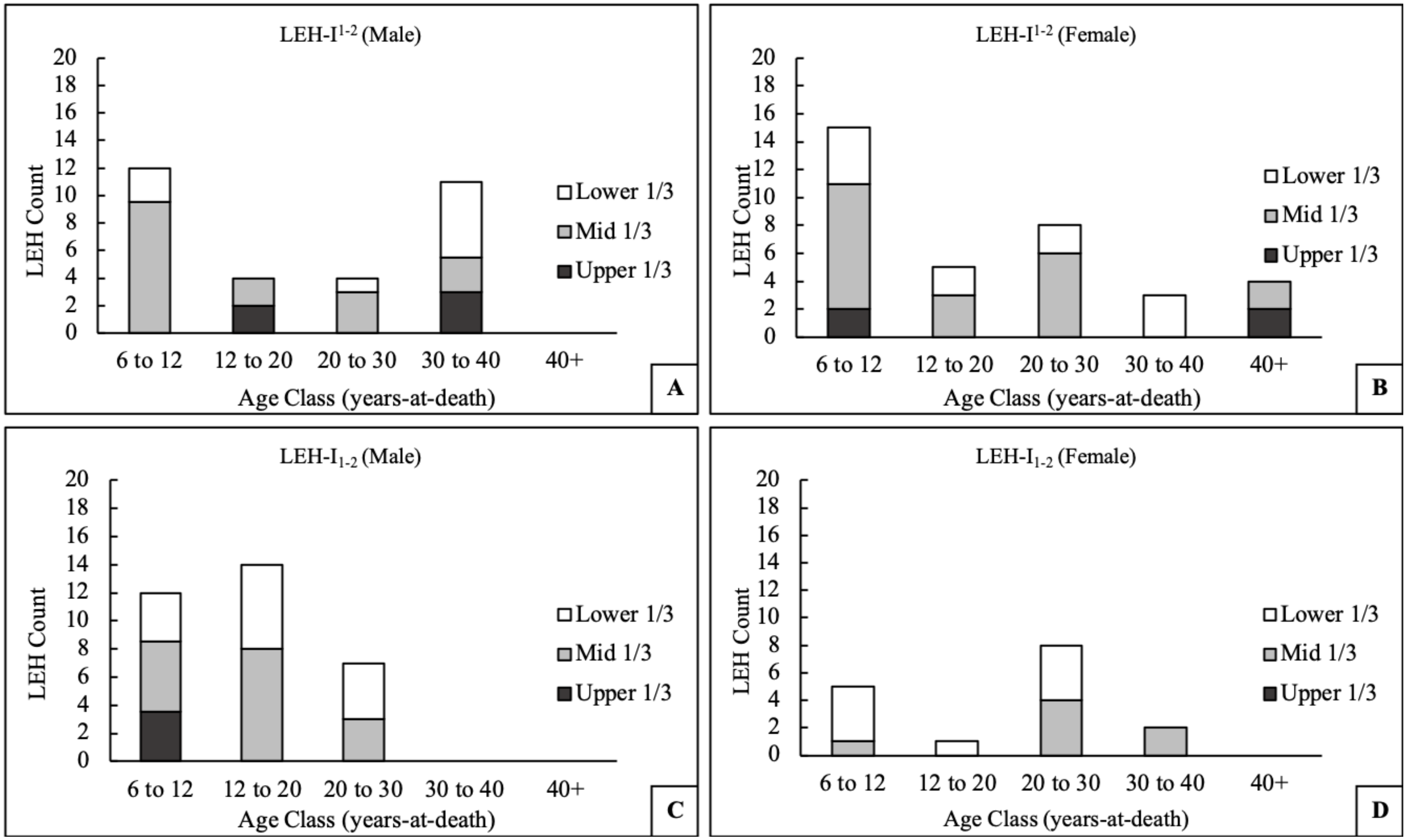


Figure 5.12 Comparison of LEH-I defect location by age-at-death at Ostojićevo. Males I^{1-2} (A); Females I^{1-2} (B); Males I_{1-2} (C); and Females I_{1-2} (D). Location refers to position on crown, divided into upper (occlusal third), middle (body), and lower (basal-third above cemento-enamel junction). LEH count refers to number of defects.

5.8 Results: Ostojićevo Abnormalities of Size or Shape

Seventeen individuals displayed 19 cases of abnormalities in bone size or shape (Appendix Table 9). Major abnormalities in bone size and shape observed in the Ostojićevo sample can be divided into four general categories: hyperostotic traits (*n-individual* = 5), hypostotic traits (*n-individual* = 6), incomplete union or nonfusion (*n-individual* = 6), and other hereditary or acquired skeletal anomalies (*n-individual* = 2).

5.8.1 Hyperostotic Traits

Three individuals displayed some form of anterior or posterior iliac buttressing: an Adult I female (Grave 29), an Adult II female (Grave 96), and an Adult III female (Grave 170) (Figure 5.13). Anterior (acetabulocristal) or posterior (acetabulosacral) buttressing of the iliac are developmental variants that allow for increased load bearing and greater weight transfer across the iliac body (Rader & Peters, 1993; Kibii et al., 2011). In contrast to a single case of hypertrophy of the acetabulocristal buttress in a robust adult male described by Rader and Peters (1993), all three individuals from Ostojićevo were gracile females. Although the stature of the Grave 23 individual could not be determined, the Grave 96 (μ-*humerus* = 158.4 cm) and Grave 170 (μ-*radius* = 157.4 cm) individuals were near or below the boundary between the third- and fourth-lowest quartiles for female stature (<158.3 cm). All three individuals exhibited additional skeletal abnormalities and pathologies. The Grave 29 individual displayed abnormal exostoses, or "horns", on the central aspect of the posterior left ilium.

Two individuals exhibited an enlarged and distally projecting anterior process of the calcaneus. This presented bilaterally in the Grave 280 individual, an Adult II female. The left calcaneus was not preserved in the Grave 234 individual, an adult of indeterminate sex. As this trait presented bilaterally in the case in which the left and right calcanei were preserved, CPR was calculated based on skeletally mature

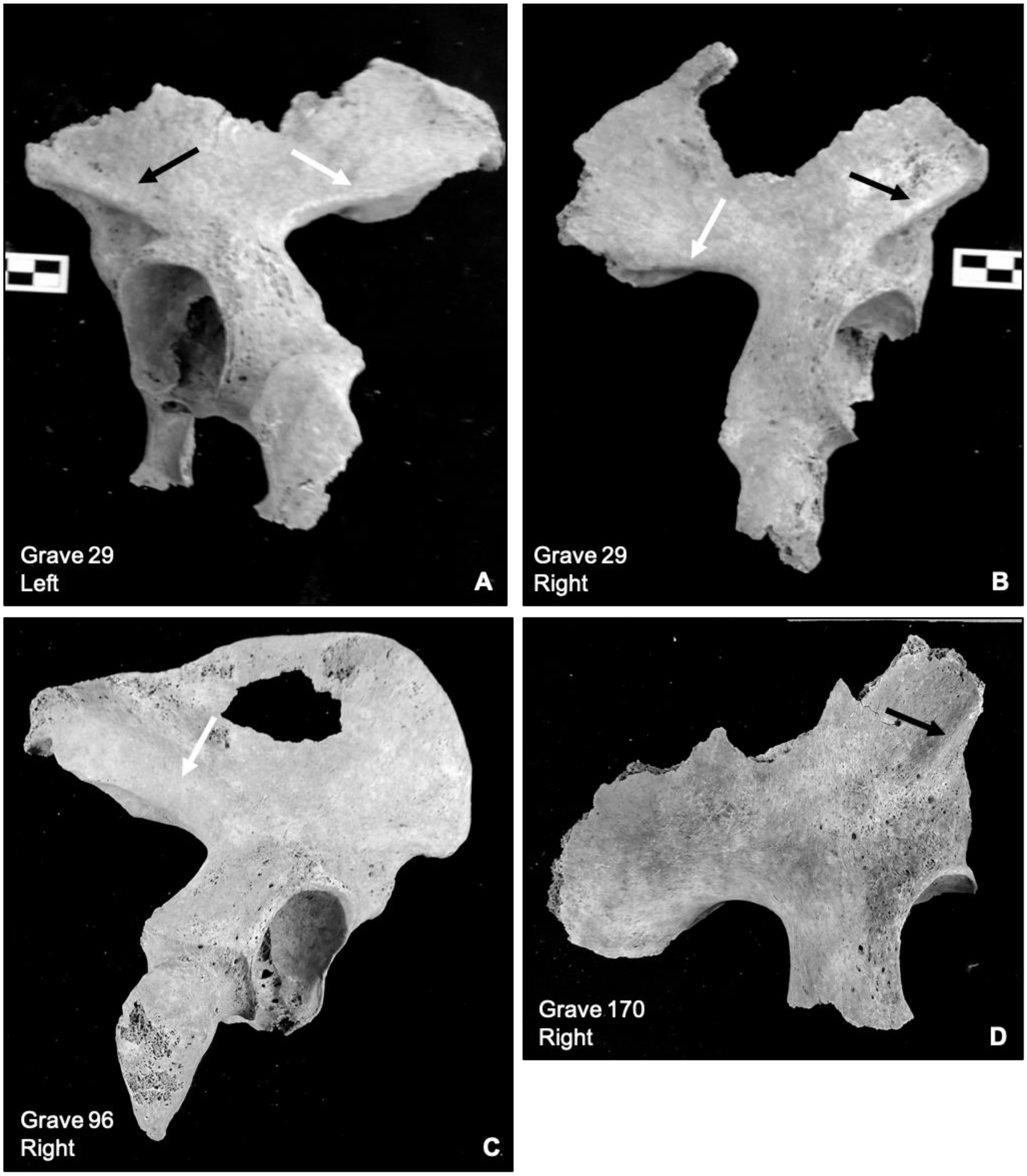


Figure 5.13 Iliac buttressing in three adult females at Ostojićevo. Hypertrophy of the acetabulo-cristal buttress (white arrows) and acetabulo-sacral buttress (black arrows). (A and B) Grave 29, Adult I female; (C) Grave 96, Adult II female; (D) Grave 170, Adult II female (D).

individuals >20 years-at-death with at least one calcaneus presented and rated as “good”, very good”, or “excellent” preservation. Total CPR was 2.1%. Male CPR was 0.0%; female CPR was 2.8%.

5.8.2 Hypostotic Traits

Six individuals exhibited traits consistent with truncated or incomplete ossification. Septal aperture of the proximal humerus was present in two individuals, an Adult II male (Grave 66B, assymetrical right-side only) and an Adult I female (Grave 69, bilateral). This non-metric variant is more prevalent in females than males and is characterized by incomplete mineralization resulting in the persistence of an opening or perforation in the olecranon fossa of the humerus (Schwartz, 2007).

An Adult II female (Grave 155) exhibited an aplastic hook of hamate in the right hamate. The left side was not preserved. A hypoplastic or aplastic hook of hamate is a rare anatomical variant that affects ~1.6-3.1% of hamates (Chow et al., 2005; Huang et al., 2019). The hook of hamate separates the ulnar aspect of the carpal tunnel from Guyon’s canal, a semi-rigid structure that supports the passage of the ulnar nerve and artery from the wrist into the hand. Deficiencies in the hook of hamate, including bipartite, hypoplastic, or aplastic anatomical variants, have been associated with development of carpal tunnel syndrome (Chow et al., 2005). CPR was calculated based on skeletally mature individuals >20 years-at-death with at least one calcaneus presented and rated as “good”, very good”, or “excellent” preservation. Total CPR was 2.4%. Male CPR was 0.0%; female CPR was 5.9%.

An Adult II male (Grave 71), an Adult III male (Grave 266), and an Adult II female (Grave 92) displayed hypoplastic defects in the greater wing of the sphenoid. The lateral pterygoid plate was also affected in the Grave 71 individual (Figure 5.14). These defects presented as irregular fenestrations in the cortical bone due to a disequilibrium in the osteoid-bone interface of an unknown origin. Consistent coloration along the margins suggests a developmental rather than taphonomic source. Pinprick porosity on the greater wing of the sphenoid, anterior aspect of the squamous portion of the temporal bone, and active porotic hyperostosis characterized by fine pitting on the occipital bone (Grave 266) and frontal bone

(Grave 71) indicate possible co-occurrence of a metabolic disorder such as scurvy in two of the three affected individuals (Armelagos et al., 2014; Ortner et al., 2001). CPR was calculated for skeletally mature individuals >20 years-at-death with at least one greater wing of the sphenoid preserved, as hypoplastic defects presented bilaterally in cases in which both the right and left sphenoid were present. Total CPR was 7.0%. Male CPR was 11.1%; female CPR was 4.8%.

Figure 5.14 Hypoplastic defects of the sphenoid (arrows). (A) Grave 71, Adult I probable male, fenestrations in the lateral pterygoid plate. Note also fine porosity on lateral pterygoid plate extending onto the greater wing of the sphenoid and anterior aspect of temporal bone. (B) Grave 266, Adult IV probable male, fenestratations on the greater wing of the sphenoid. Note also fine porosity on greater wing extending onto the anterior aspect of the temporal bone.

5.8.3 Incomplete Union or Non-fusion

Six individuals exhibited incomplete union or non-fusion of skeletal elements, including os acromiale (Grave 30), sternal aperture (Grave 147), spondylolysis (Graves 34, 98, and 153), and incomplete union of a vertebral spinous process (Grave 216).

Os acromiale of the right scapula was present in an Adult I female. The corresponding region of the left scapula was not preserved. *Os acromiale* is associated with incomplete ossification of the acromion process resulting in non-union of the epiphysis (Miles, 1994). However, *os acromiale* prevalence greater than 1% of adult individuals has been taken to indicate a pattern of heavy strain on the shoulder prior to and during growth from repetitive overhead movements associated with overhand throwing or habitual use of a long bow (Knüsel, 2007; Miles, 1994). The comparative rarity of this case at Ostojićevo and absence of osseous signs of hypertrophy of the rotator cuff muscles support a diagnosis of a non-metric hypostotic variant.

A small perforation in the sternal body consistent with a sternal aperture was present in an Adult I probable-female. Unlike a septal aperture, which arises via incomplete or arrested ossification, a sternal aperture occurs due to a disturbance in preossification development (Schwartz, 2007). An accurate estimation of TPR and/or CPR for this trait in the Ostojićevo sample is not possible due to poor preservation of the sternal body. Only 21 out of a total possible 140 individuals >15 years-at-death had an intact sternal body rated as having "very good" or "excellent" preservation.

Four individuals, two Adult III males, one Adult IV female, and one Juvenile II/Adult I probable-female, exhibited spondylolysis characterized by bilateral nonunion of the pars interarticularis affecting lumbar vertebra(e) (Figure 5.15). Only the L5 was affected in three of the four individuals. The neural arch was absent in all cases. As only lumbar vertebrae below the level of L3 were affected, CPR was calculated for individuals >15 years-at-death with lumbar vertebrae 3/4/5 present. Total CPR was 7.3%. Male CPR was 8.7% and Female CPR was 8.0%. Spondylolysis prevalence at Ostojićevo corresponds to those reported in clinical settings (D'Orazio, 1999) and are less than or equal to those reported for historic and prehistoric skeletal samples corresponding to agricultural populations from England (Fibiger & Knüsel, 2005).

Finally, non-union of the spinous process in a lower thoracic vertebra (T10) was noted in an Adult female (Grave 216). The T9 and T10 spinous processes were normal.

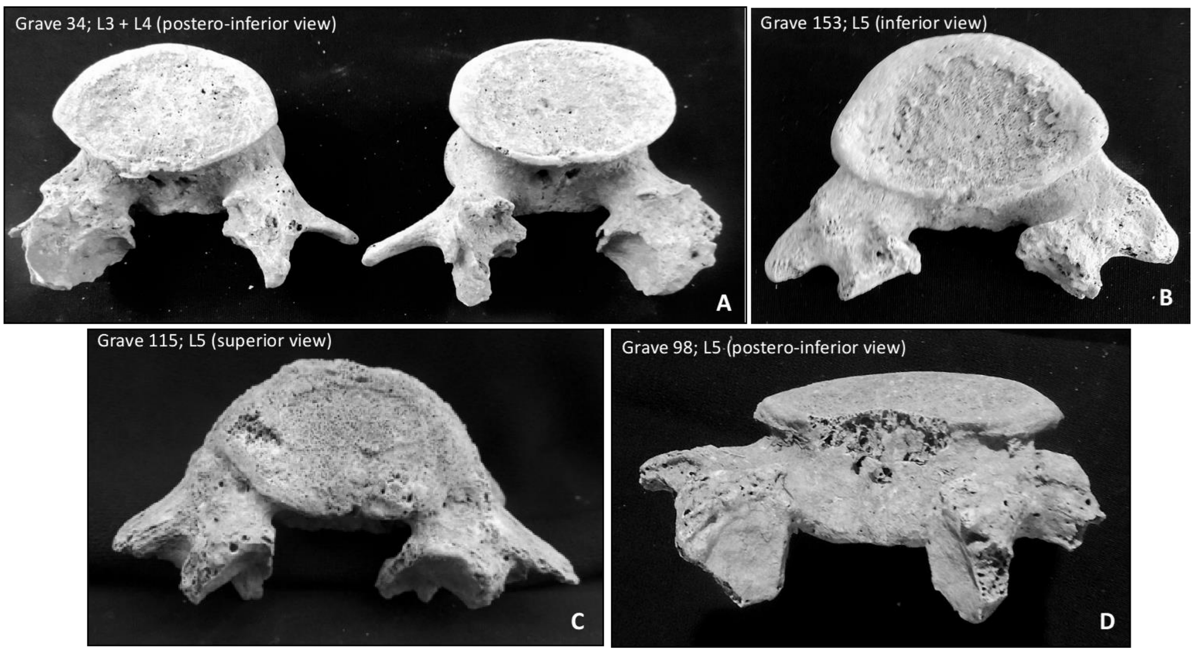


Figure 5.15 Bilateral ununited spondylolysis. (A) Grave 34, Adult III Male; (B) Grave 153, Juvenile II/Adult I probable female; (C) Grave 115, Adult IV female; (D) Grave 98, Adult III Male.

5.8.4 Other Hereditary or Acquired Anomalies

The Grave 96 individual also displayed ipsilateral (left-side) forehead flattening, posterior parietal bossing, and inferior displacement of the supraorbital margin and contralateral bulging of the right forehead (Figure 5.16). No deviation in the nasal root or mental eminence was observed. A differential diagnosis of deformational frontal plagiocephaly is proposed based on modern clinical comparisons (Bruneteau & Mulliken, 1992; Di Rocco et al., 2012). The superior cranial vault was largely intact, with some reconstruction of the posterior vault and damage to the basicranium. The abnormalities described were not due to taphonomic distortion or modification as postmortem damage did not extend to the affected areas. However, preservation precluded assessment of the position of the malar eminence or position of the external auditory meatus. Ipsilateral posterior projection of the malar eminence and posterioinferior ear displacement have been reported in cases of deformational frontal plagiocephaly (Bruneteau & Mulliken, 1992). Deformational plagiocephaly is more common than synostotic types, and often self-corrects in infancy or childhood (Di Rocco et al., 2012; Hansen & Mulliken, 1994). Permanent deformity occurs in ~10% of affected infants (Miller & Claren, 2000). While synostotic plagiocephaly represents a true malformation resulting from abnormal cranial development in utero, deformational plagiocephaly occurs secondary to external compression of the head in utero (Miller & Claren, 2000). An increased incidence of deformation has been reported for multiple fetuses, premature pelvic descent, and breech births (Bruneteau & Mulliken, 1992; Miller & Claren, 2000). Abnormalities associated with deformational frontal plagiocephaly include torticollis, congenital hip dislocation, shortening of the sternocleidomastoid muscle, and scoliosis (Bruneteau & Mulliken, 1992; Miller & Claren, 2000). The shape of the cervical and thoracic vertebral bodies in the Grave 100 individual were normal. Further analysis is needed to assess differences in sternocleidomastoid robusticity by comparing right and left mastoid process length and breadth as well as document the degree of muscle scarring on the medial clavicle. Lateral bowing of the femora, and medial bowing of the tibiae and fibulae were also present.

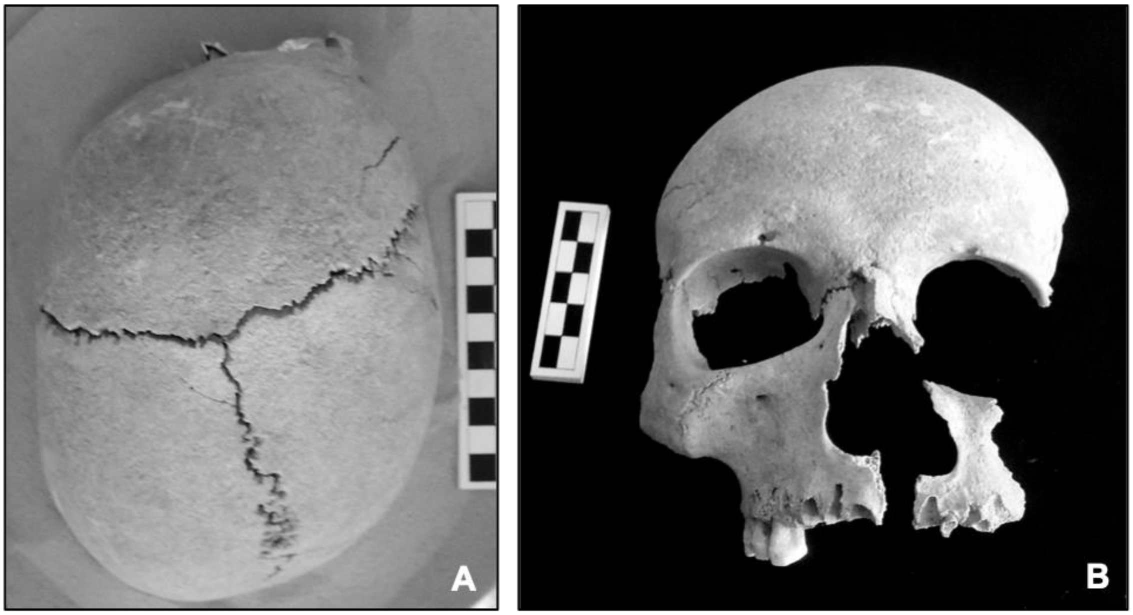


Figure 5.16 Deformational frontal plagiocephaly in an Adult II female (Grave 96). (A) Superior view, note left-frontal bossing and right-frontal flattening; (B) Anterior view, note slight inferior displacement of the left supraorbital margin.

Chronic subluxation of the right and left hip was identified in the Grave 100 individual, an Adult I male (Figure 6.17). Bony changes included anterior and superior expansion of the superior lunate surfaces, shallow acetabular fossae, and erosive lesions on the right femoral head (Ortner, 2003:472). The lack of secondary joint formation suggests a congenital rather than traumatic origin (Ortner, 2003). Hypertrophy of the quadratus femoris origin and the presence marginal osteophytes and surface porosity on the bodies of L4 and L5 indicate biomechanical strain on the hip and lower back secondary to congenital hip subluxation. This individual also exhibited moderately robust upper limbs and short stature (μ-*humerus+femur* = 158.6 cm), falling within the fourth-lowest quartile for males (<161.0 cm).

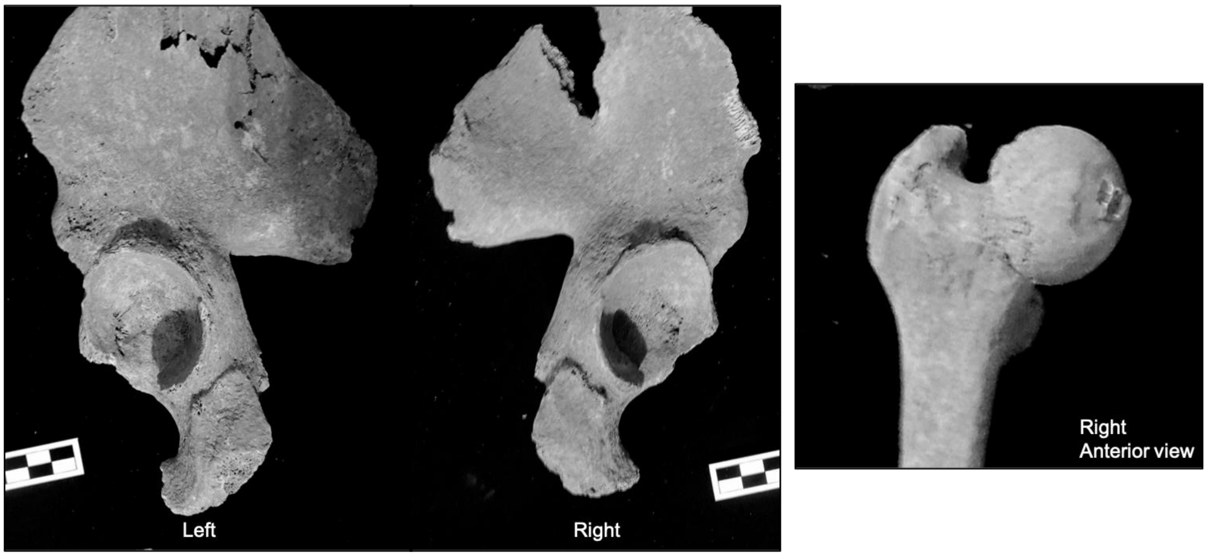


Figure 5.17 Chronic subluxation of the right and left hip in an Adult I male (Grave 100). Posterior os coxae (left) illustrating enlarged, flattened acetabula characteristic of chronic (congenital) subluxation of the right and left hip; (right) detail of proximal right femur with enthesopathy of the teres ligament insertion and depressed area surrounding the fovea capitis.

5.9 Results: Ostojićevo Abnormal Bone Loss

Sixteen cases of cranial and/or postcranial abnormal bone loss were observed in nine individuals (Appendix Table 10). Observed categories of abnormal cranial bone loss include: ectocranial granulomatous lesions (*n-individual* = 1), abnormal cortical bone loss or absence (*n-individual* = 3), osteomyelitis (*n-individual* = 2), mycotic lesions (*n-individual* = 3), and other (*n-individual* = 3). Cases of abnormal bone loss associated with degenerative osteoarthritis or osteoarthrosis are discussed in the sections on joint disease and vertebral pathologies.

5.9.1 Granulomatous Lesions

One individual, an Adult female (Grave 216), displayed granulomatous and osteolytic lesions on the ectocranial surface of the right parietal bone and superior-right aspect of the occipital bone, respectively (Figure 5.18). At least two granulomas, characterized by areas of focal cortical destruction with adjacent deposition of irregular sclerotic bone, were present on the posterior aspect of the right on the ectocranial surface of the right parietal. Additionally, two lytic lesions were identified on the anterior aspect of the right parietal bone. The presence of irregular sclerotic bone formation on the right parietal indicates a mixture of healed and active lesions at the time of death. The endocranial surface was unaffected. No additional cranial or postcranial pathologies or abnormalities were identified. The “worm-eaten” appearance of the bone is characteristic of tertiary treponemal disease; however, fusiform enlargement through periosteal layering in hands and feet, tibia, clavicle, or ulna, which would be expected in cases of advanced endemic syphilis, is absent (Buckley & Dias, 2002; Ortner, 2003).

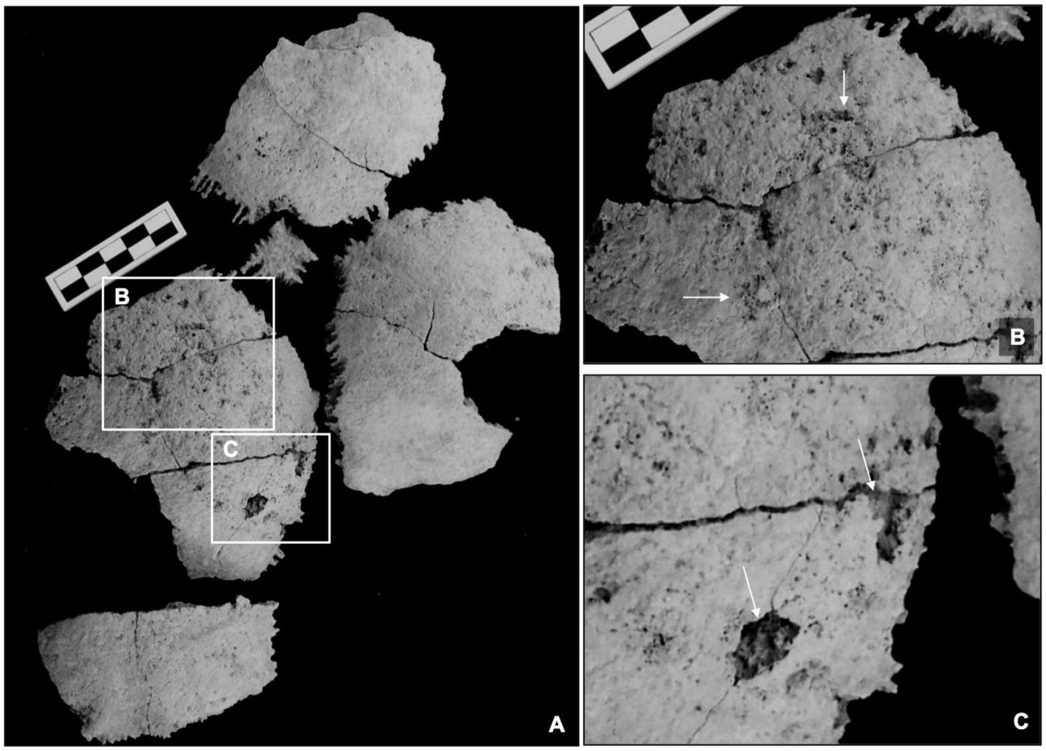


Figure 5.18 Granulomatous lesions on the cranial vault in an Adult female (Grave 216): (A) detail of at least two granulomas (arrows) showing focal cortical bone destruction by the granulation tissue mixed with a sclerotic response that creates a mottled appearance of healed and new lesions; (B) two osteolytic foci (arrows) with focal destruction of the cortical bone and diploë. Crisp margins indicate lesions active at time of death.

5.9.2 Abnormal Cortical Bone Resorption

Three individuals exhibited abnormal focal cortical bone resorption: a Juvenile II probable-female (Grave 104), an Adult IV female (Grave 264), and an Adult III probable-male (Grave 266).

The Juvenile II probable-female (Grave 104) exhibited a single circumscribed area of bone resorption extending into the diploë in the upper-right corner of the frontal bone near the coronal suture (Figure 5.19). There is some taphonomic damage to the margin, but sclerotic bone is present both within the lesion and along the margins. The Grave 104 individual also displayed periosteal bone formation with focal cortical bone loss accompanied by sclerotic bone formation on the posterior aspect of the right and left distal femora. Periosteal bone formation (secondary periostitis) was noted on the lateral margin of the right and left distal femora and medial aspect of the right proximal tibia, just inferior to the medial condyle (Figure 5.19). The bone loss, sclerotic bone, and secondary periostitis on the right femur and tibia and left femur have an uncertain etiology. Differential diagnosis includes bacterial of fungal infection (hematogenous or contiguous spread) or reaction to an unknown systemic disorder. The affected areas lack sequestra or cloaca, which precludes a diagnosis of pyogenic osteomyelitis or tuberculosis (Schwartz, 2007). Leprosy, sarcoidosis, and treponematosis can be excluded based on the absence of clear granulomas, cortical lytic foci, and/or cortical thickening (Lefort & Bennike, 2007; Ortner, 2003; Schwartz, 2007). Mycotic infections such as cryptococcosis (see Medaris et. al, 2016; Jain et al., 2011) or sporotrichosis (see Chang et al., 1984; Lurie, 1963) could account for the postcranial joint lesions observed in the Grave 104 individuals. However, the single cranial lesion is restricted to the ectocranial surface, whereas calvarial granulomatous lesions associated with cryptococcosis or sporotrichosis frequently erodes through the calvarium into the endocranial, extradural space (Amit et al.., 2008; Lurie, 1963). Further research is needed to compare histologic bone cross-sections with known cases of cryptococcosis or sporotrichosis. Finally, a large round cyst with smooth margins is present in the plantar aspect of the tarsometatarsal joint surface of the left 3rd metatarsal. All other tubular bones of the hand and feet appear normal.

An Adult IV female (Grave 264) displayed abnormal cortical bone loss in the area of the inguinal ligament attachment on the ventral aspect of the left pubis (right pubis not preserved) (Figure 5.20). Differential diagnosis is disequilibrium at the inguinal ligament attachment due to a resorptive lesion of unknown etiology seems to have resulted in destruction of the pubic tubercle.

An Adult III probable-male (Grave 266) exhibited erosive lesions anterior to the articular fossa on the right and left temporal bones. The differential diagnosis is artificially induced anterior displacement of the mandible due to activity.

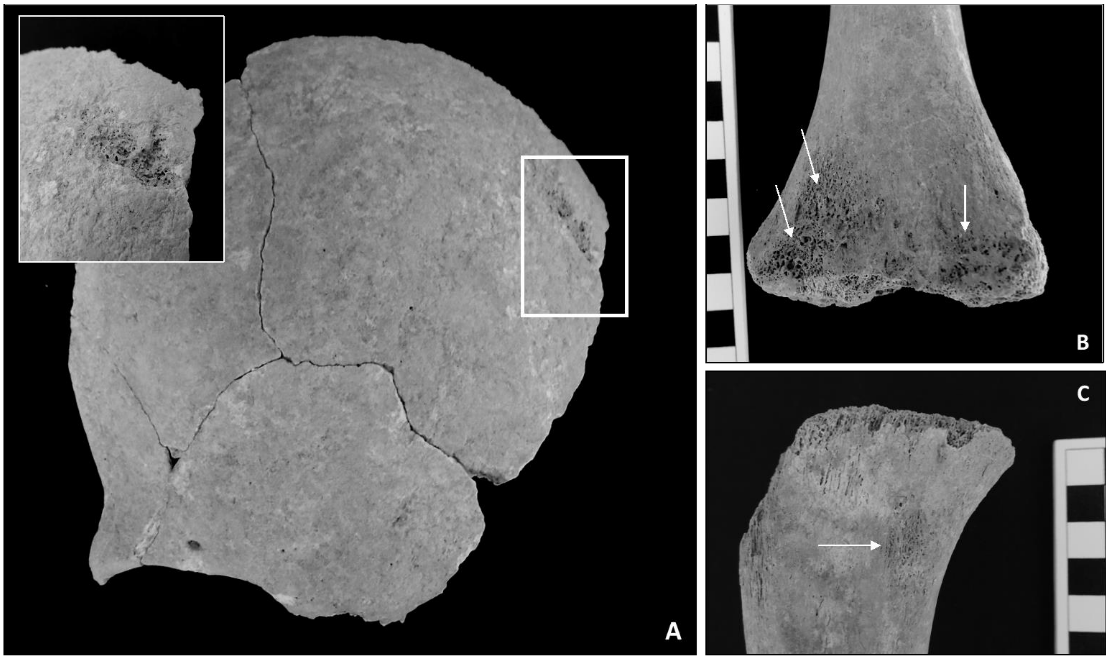


Figure 5.19 Multiple loci of cortical bone resporption in a Juv. II probable-female (Grave 104). (A) Oblong area of focal bone resorption on left-lateral ectocranial surface of frontal bone (inset show detail); (B) periosteal bone formation with focal resorption of cortical bone (arrows) on posterior aspect of distal right femur; and (C) area of slight periosteal bone formation (arrow) on medial aspect of right proximal tibia.

Figure 5.20 Resorptive lesion on the ventral aspect of the left pubis in an Adult IV female (Grave 264).

5.9.3 Osteomyelitis

Grave 121, an Adult II male, displayed a small circular abscess on the spinous process (inferior aspect) of an upper thoracic vertebra (Figure 5.21). No additional vertebral or extravertebral infectious or inflammatory lesions were identified in this individual. The involvement of the spinal process rather than the body indicates a differential diagnosis of vertebral osteomyelitis rather than tuberculosis, despite the absence of bone regeneration (Ortner, 2003; Schwartz, 2007). Clinically-documented cases of pyogenic vertebral osteomyelitis note hematogenous spread or contiguous spread from an adjacent soft tissue infection (Torda et al., 1995; Zimmerli, 2010). The most common microorganisms associated with pyogenic vertebral osteomyelitis are *Staphylococcus aureus* and *Escherichia coli* (Torda et al., 1995).

Grave 266, an Adult III probable-male, exhibited an abscess on the inferior aspect of the right clavicle just medial to the sternal end (Figure 5.21). Postmortem damage to the sternal face has exposed abnormally enlarged air cells, which indicates the presence of an active infection at the time of death. Radiographic or CT imaging is needed to confirm the diagnoses, however macroscopic assessment indicates osteomyelitis due to a bacterial infection of unknown etiology. Acute osteoarticular bone infections (*i.e.*, osteitis, osteomyelitis, and septic arthritis) reported in children (Moumile et al., 2005) and adults (Gottlieb et al., 2002) have been variously attributed to *Staphylococcus aureus*, *Kingella kingae*, *Streptococcus pyogenes*, and *Streptococcus pneumoniae*. Bone infection occurs through either haematogenous spread of microorganisms or contiguous-focus infection, especially in adults with peripheral vascular disease (Mader et al., 1997). This presence of at least one large abscess, or cloaca, supports a differential diagnosis of haematogenous infection by a bacterium such as *Staphylococcus* or *Streptococcus* as these cause septic (pyogenic) arthritis in the hips, lower extremities, and clavicles (Gutierrez, 2005; Moumile et al., 2005). Clinical diagnosis of acute pyogenic osteomyelitis depends on serological analysis as bone changes often cannot be detected by radiograph until 10 to 21 days after the onset of symptoms (Gutierrez, 2005). Skeletal scintigraphy and radionucleotide bone scans, however, are often sensitive enough to detect compromised vascular supply to the bone in the early stages of osteomyelitis, within 48 to 72 hours after the onset of symptoms (Gutierrez, 2005). It is possible that the cases described here represent the early stages of bacterial infection to which the individuals succumbed prior to the spread to other skeletal elements.

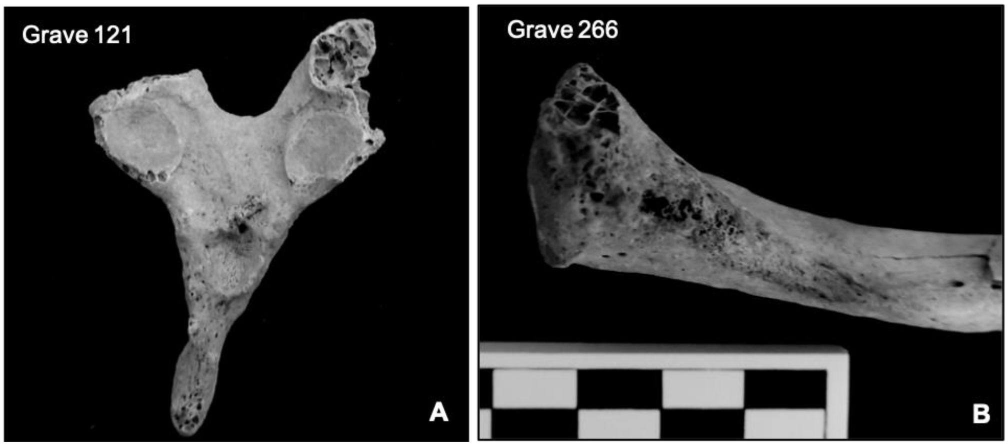


Figure 5.21 Osteomyelitis in (A) the spinous process of a lower thoracic vertebrae in an Adult II male (Grave 121), and (B) inferior aspect of the sternal end of the right clavicle in an Adult III probable male (Grave 266). Both cases are not associated with trauma and show no evidence of healing.

5.9.4 Mycotic Lesions

Three individuals displayed circular mycotic lesions on one or more joint surfaces: an Adult IV female (Grave 258), an Adult III probable-male (Grave 266), and an Adult IV male (Grave 269) (Figure 5.22). The Grave 258 individual had circular lytic lesions on the posterior articular surface of the right and left navicular with an ovoid fistula also present on the diaphysis of the left 1st metatarsal (right 1st metatarsal unaffected). The Grave 266 individual displayed circular lytic lesions on the right distal tibia and the medial talar facet of the right calcaneus. A circular lesion was also present in the Grave 269 individual, affecting the capitate facet of the left hamate. A differential diagnosis of osteochondritis dissecans for lesions affecting joint surfaces was considered as the margins are smooth and well-defined, with a crater-like indentation marked by exposure of trabeculae. This was rejected based on the absence of similar lesions in

Juvenile and Adult I individuals, absence of a layer of new bone formation lining the “crater” as would be expected if the bone defect had occurred earlier in life, and non-involvement of the femoral condyle, talus, and elbow (Aufderheide & Rodríguez-Martín, 1998; Vikatou et al., 2017). Finally, both the Grave 258 and Grave 266 individuals contain lesions or osteomyelitis in non-synovial joint locations.

The postcranial lesions described here can collectively be characterized as having a circular or oval shape with a well-defined perimeter and no evidence of healing. The physical characteristics, locations, and random multifocal presentation of the lesions are consistent with a general diagnosis of a fungal infection (Ortner, 2003; Schwartz, 2007). The geographic location of the burials on the border between central and southeast Europe and the specific sites of skeletal lesions strongly suggest a more specific diagnosis of *Sporotrichosis schenkii* or *Cryptococcosis neoformans* infection.

Sporotrichosis schenkii is introduced into the body through skin lacerations, usually puncture wounds from thorns or contaminated wood, and subsequently spreads to the bone via a contiguous-focus infection and/or regional lymphatics (Chang et al., 1984; Corr et al., 2011; Ortner, 2003). The most common sites for skeletal lesions are the tibia, the cranium, and the bones of the hands and feet, as well as the joints of the knee, elbow, wrist, and the sternoclavicular joint (Ortner, 2003). Clinical studies have found that osseous sporotrichosis most commonly occurs in older and immunocompromised individuals, especially those suffering from diabetes mellitus, sarcoidosis, or alcoholism (Chang et al., 1984; Lurie, 1963). One important occupational correlation is gardening (Chang et al., 1984; Lurie, 1963), which is consistent with the subsistence activities inferred for Early Bronze Age peoples in the study region (Bogaard, 2005; Nicodemus, 2014).

Cryptococcosis neoformans, also known as tulorosis, European blastomycosis, or Busse-Buschke disease, is a dimorphic yeast spread through inhalation of fungal propagules (Corr et al., 2011; Zhou et al., 2015). Clinical research has found no association with sex or age in *Cryptococcosis* patients, though immunocompromised individuals exhibit more extreme symptoms (Geller et al., 2009). In cases of osseous involvement, the knee is the most frequently affected joint, followed by the hip, acromioclavicular joint, the joints of the wrist, the sternoclavicular joint, the elbow, the shoulder, the ankle, and the sacroiliac joint

(Geller et al., 2009). Septic arthritis may occur in rare cases, but symptoms generally present as joint swelling and pain, with radiological examinations of affected joints revealing sclerosis, subperiosteal new bone formation, irregular cortical destruction, and osteomyelitis (Zhou et al., 2015). Occupational and behavioral correlates include farming (contact with soil), trauma, and exposure to bird droppings (Zhou, 2015).

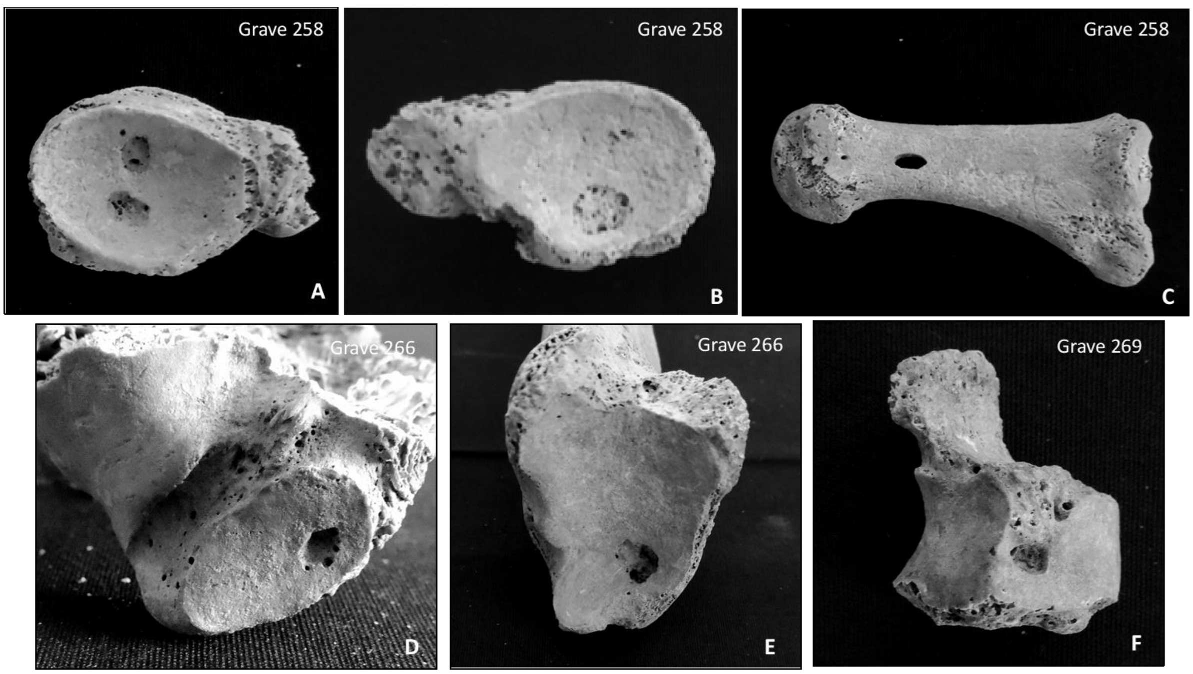


Figure 5.22 Postcranial mycotic lesions: (A) right and (B) left navicular, proximal surface; (C) Ovoid fistula on left 1st metatarsal; (D) Right calcaneus, talar facet; (E) Right tibia, distal surface; (F) Left hamate, capitate facet. All affected individuals ca. >45 years-at-death.

5.9.5 Other

Three individuals displayed cranial or postcranial bone loss that did not “fit” into the three categories described above: a Juvenile II probable-female (Grave 104), an Adult of indeterminate sex (Grave 210), and an Adult II female (Grave 280).

The Grave 104 individual displayed an abnormal circular cavitation with smooth, rounded margins on the distal surface of the left 3rd metatarsal (plantar side) (Figure 5.23). Slight plantar expansion was noted. The right side was unaffected. The location of the cavity outside the diaphyseal or diaphyseal-metaphyseal region, opening of the cavity onto the joint surface, and absence of a thin “bony shell” excludes possible diagnosis as a unicameral bone cyst, Brodie’s cyst, or aneurysmal bone cyst, and is inconsistent with clinical presentations of enchondromas (Chun et al., 2015; Ortner, 2003). Radiographic analysis of the small bones of the hands and feet is needed to identify intramedullary involvement, though no obvious trauma or metaphyseal-diaphyseal expansion was visible macroscopically.

The Grave 280 individual exhibited a possible bone cyst on the inferior aspect of the left sternoclavicular joint. Like the Grave 104 individual, this lesion was characterized by a circular cavitation with smooth, rounded margins. The right side was unaffected. The manubrium was not preserved. The lesion is non-proliferative and appears to erode into the bone. The floor of the lesion consisted of a sclerotic lining that separated it from the medullary cavity A differential diagnosis of primary benign tumor or cyst is proposed (Ortner, 2003).

Finally, the Grave 210 individual displayed destruction and resorption of the area surrounding the external acoustic meatus with involvement of the tympanic tube and the mastoid process (Figure 5.24). Differential diagnosis includes bone destruction from an osteolytic tumor (Ortner, 2003), or lytic destruction due to a soft tissue lesion (*e.g.,* dermatosis infection, benign tumor, etc.) (Aufderheide & Rodríguez-Martín, 1998). Postcranial preservation was poor; no additional pathologies or abnormalities were identified.

Figure 5.23 Probable bone cyst on the plantar surface of the left 3rd metatarsal in a Juvenile II probable female (Grave 104). Lateral view (top), proximal view (bottom).

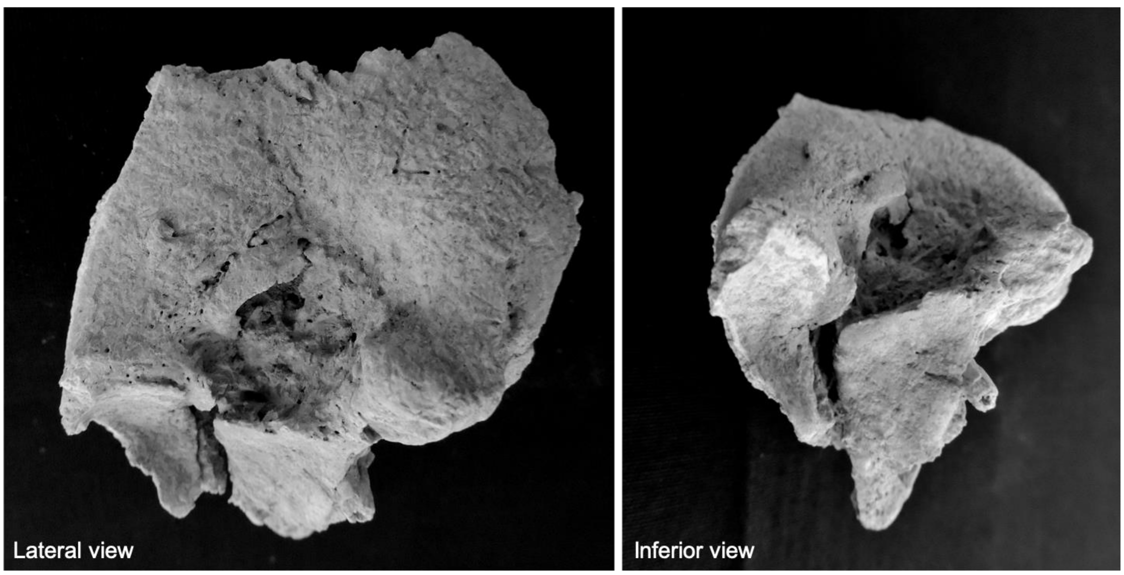


Figure 5.24 Destruction and resorption of the left external acoustic meatus, also affecting the tympanic tube and surrounding bone in an Adult (Grave 210).

5.10 Results: Ostojićevo Abnormal Bone Formation

Thirty-four cases of cranial and/or postcranial abnormal bone formation were observed in 20 individuals (Appendix Tables 11 and 12). Observed categories of abnormal cranial bone loss include: periostitis (*n-individual* = 9) (Appendix Table 11), enthesopathy/syndesmophytes (*n-individual* = 10) (Appendix Table 12), woven bone (*n-individual* = 1) (Appendix Table 12), and tumor-like growths (*n-individual* = 3) (Appendix Table 12). Cases of abnormal bone formation associated with degenerative osteoarthritis or osteoarthrosis are discussed in the sections on joint disease and vertebral pathologies. Cases of abnormal bone formation secondary to trauma (*e.g.*, myositis ossificans) are discussed in Chapter 6.

5.10.1 Periostitis

Nine individuals displayed periostitis on at least one long bone diaphysis. Periostitis was more common and more severe in subadults (*n-individual* =5) compared to adults (*n-individual* = 3) (Figures 5.25 and 5.26). Among subadults, four individuals displayed bony changes to multiple elements, with the tibia being the most affected element. Periosteal inflammation was isolated to the distal tibiae in all adult cases. Periostitis presented bilaterally in long bones in adults and subadults for whom both the respective right and left elements were present. The distal third of the tibial diaphysis adjacent to the anterior crest was the most common location for bony changes, with bone formation marked by the deposition of new bone layers parallel to the long axis of the shaft.

The somewhat diffuse pattern of periostitis observed at Ostojićevo indicates systemic inflammation associated with generalized lymphadenopathy, rather than localized trauma and inflammation to the underlying bone (Buckley & Dias, 2002). Historically, non-venereal syphilis was present in parts of the eastern Mediterranean, including the Balkans, in areas characterized by poor hygiene (*e.g.*, sharing of drinking vessels and eating implements) and low socioeconomic status (Aufderheide & Rodríguez-Martín, 1998; Grin, 1953). Infection in early infancy often occurred through skin-to-skin contact with primary lesions on the nipples of breastfeeding women. Differential diagnose of secondary nonvenereal treponemal infection explains the presence and distribution of osteoperiostitis in subadults at Ostojićevo (Antal et al., 2002; Grin, 1953).

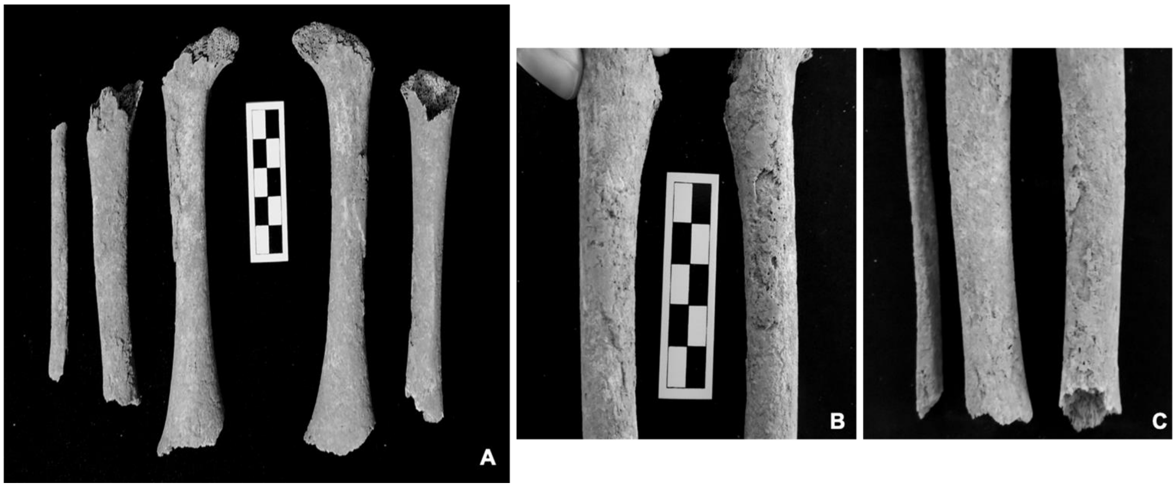


Figure 5.25 Periostitis in the lower limbs of an Infant IA 'female' (Grave 87) (A). (B) Detail of stage 3-4 periosteal reaction on the posterior femora; (C) Detail of stage 4 periosteal reaction on the distal half of the medial tibiae.

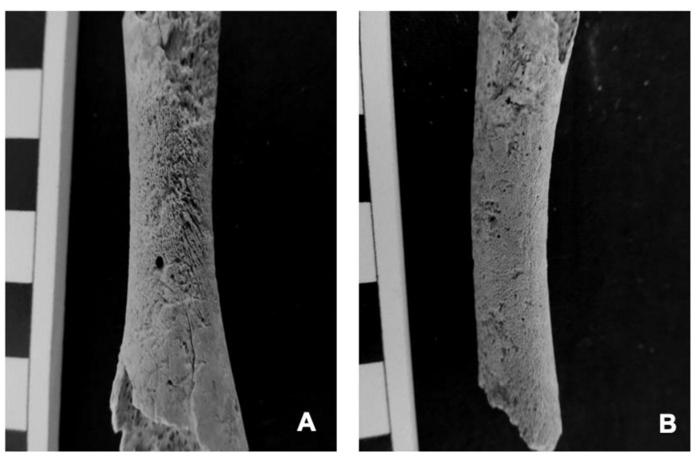


Figure 5.26 Periostitis in the lower limbs of a Neonate 'male' (Grave 177). Stage 4 periosteal reaction on the right posterior femur (A) and fusiform swelling of the right tibia (B, medial view).

5.10.2 Syndesmophytes (Enthesopathy)

Nine adult individuals displayed sixteen cases of postcranial extravertebral syndesmophytes >3.0 mm. This included four males, two females, one probable-female, and two indeterminate adults. Large postcranial extravertebral syndesmophytes were primarily identified in older individuals, especially those >50 years-at-death.

The most common type of extravertebral sydesmophytes >3 mm was ossification of the entheseal cartilage at the insertion site of the Achilles tendon on the postero-superior tuberosity of the calcaneus (retrocalcaneal enthesopathy) (Figure 5.27). Clinically, new bone formation and abnormal calcification at this insertion site is associated with insertional Achilles tendinopathy (van Dijk et al., 2011). Symptoms include pain, stiffness, and swelling in the tendon at or near the insertion site. Three individuals, two Adult IV males and one Adult IV female, displayed enthesophyte formation at the point of insertion of the distal triceps tendon into the olecranon process (Figure 5.27). Also known as “olecranon traction spurs”, or triceps enthesopathy, these “ossifications” often occur in association with posterior elbow pain, triceps tendinopathy, and olecranon bursitis from repetitive mechanical loading, such as done in weight lifting exercises (Alvi et al., 2014).

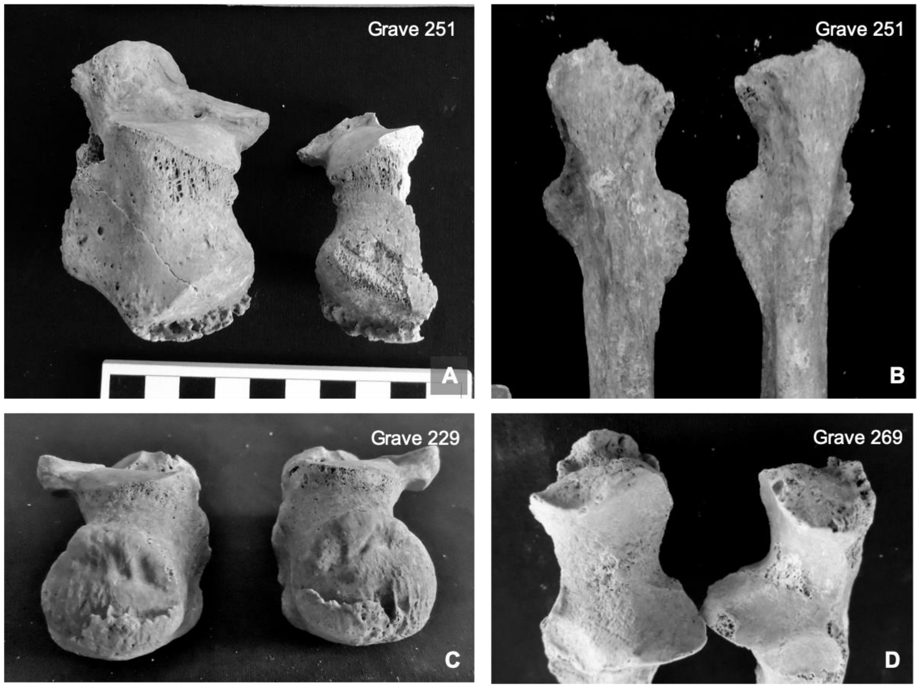


Figure 5.27 Retrocalcaneal enthesopathy and olecranon traction spurs. Syndesmophytes associated with the Achilles tendon insertion (retrocalcaneal enthesopathy) (A and C) and distal triceps tendon insertion (olecranon traction spurs) (B and D).

5.10.3 Exostosis/Osteochondroma

An Adult III female (Grave 170) displayed a solitary, abnormal solid bone mass on the anterolateral aspect of the left distal ulna near the metaphysis (Figure 6.28). The left radius and right radius and ulna appeared normal. A differential diagnosis of osteochondroma is suggested based on its location at the metaphysis, the presence of a proliferative well-defined cortical mass arising uninterrupted from the adjacent cortex, and the orientation of the tip away from the metaphysis (Aufderheide and Rodríguez-Martín, 1998; Cchem et al., 2008). Macroscopic analysis revealed similarities with "Bizarre parosteal osteochondromatous proliferation" (BPOP), also known as a Nora lesion (Dhondt et al., 2006).

Unlike osteochondromas, which form via outgrowth and subsequent ossification of epiphyseal plate cartilage, Nora lesions consist of an exophytic mixture of bone, cartilage, and fibrous tissue emerging from an intact cortex with a normal medulla (Dhondt et al., 2006; Gruber et al., 2008). Pathogenesis in clinical cases diagnosed via radiographs or MRIs follows a three-stage progression from localized florid reactive periostitis with soft-tissue swelling (Stage 1), to osteocartilaginous proliferation and initial parosteal calcification (Stage 2), and finally complete ossification of the lesion (Stage 3) (Dhondt et al., 2006). This process takes ca. six months from the onset of symptoms (Dhondt et al., 2006). The surface of the lesion in life would be covered by a cartilage cap of reactive fibrocartilage (Matsui et al., 2016). Like osteochondromas, Nora's lesions are a benign type of bone tumor. Patients often report the presence of a tender, painful, palpable mass that develop spontaneously, without any prior history of trauma in the affected area (Gruber et al., 2008; Matsui et al., 2016). Left untreated, a Nora lesion on the distal ulna will result in persistent pain and reduced range of motion in both forearm supination/pronation and wrist extension/flexion (Matsui et al., 2016).

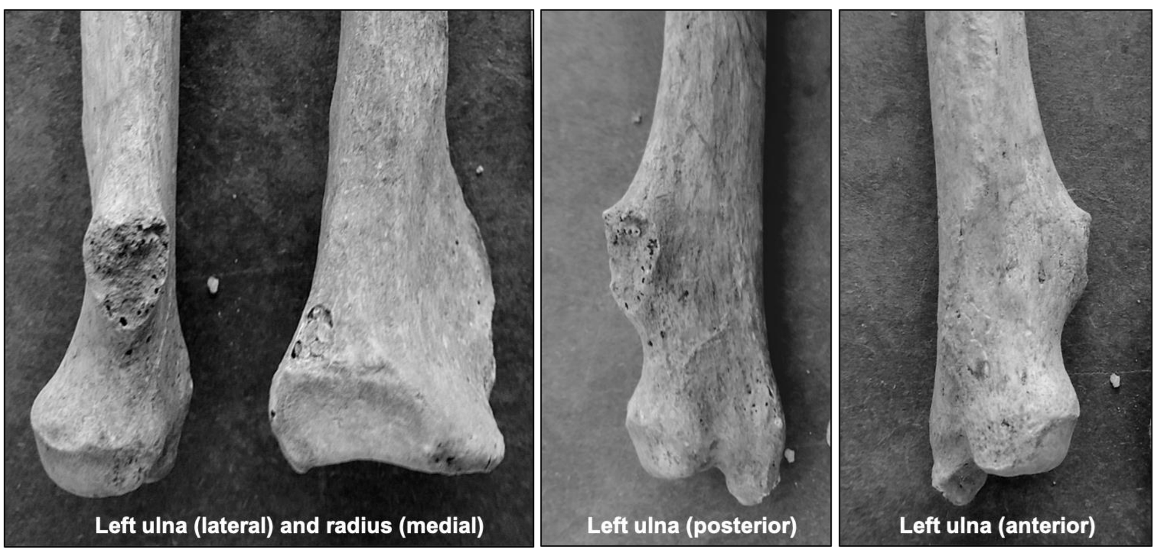


Figure 5.28 Osteochondroma (Nora's Lesion). Abnormal solid bone mass consistent with an osteochondroma or Nora's lesion in an Adult III female (Grave 170).

5.10.4 Woven Bone

One case of maxillary sinusitis marked by bilateral periosteal new bone formation was documented in an indeterminate adult probable-female (Grave 202). Total adult CPR based on individuals with at least one maxilla present with preservation classified as “good”, “very good”, or “excellent” was 1.6%; CPR based on combined left and right maxillae with “good” or better preservation was 1.1%. Bony changes in the affected sinuses conformed to a pattern of partially overlapping layers of “spicules” interspersed with “pits”, (*i.e.*, holes in the periosteal surface) on the walls and floor of the maxillary sinuses (Merrett & Pfeiffer, 2000). A periapical abscess was associated with the left-M^3. This abscess formed a sinus along the buccal aspect of the mesial surface of the tooth, which penetrated the alveolar margin and ostensibly caused the draining of exudate into the oral cavity. The absence of a sinus or fistula penetrating the maxillary sinus lumen is indicative of a rhinogenous rather than dental origin. The presence of woven bone associated with rhinogenous inflammation is consistent with chronic inflammation of the upper respiratory tract (Merrett & Pfeiffer, 2000; Roberts, 2007).

5.11 Results: Ostojićevo Joint Disease

5.11.1 Primary Osteoarthritis (Degenerative Joint Disease)

A total of 134 adult individuals were assessed for primary OA. Individuals with ≤ 25% of a given joint surface present were excluded from analysis as preservation was inadequate for an accurate and complete assessment. Primary OA was monoarticular in 21 individuals, and polyarticular (*i.e.*, affected multiple joints in different locations) in 16 individuals. A summary of individual counts and frequencies are reported for the upper limbs (Table 5.13), upper extremities (Table 5.14), lower limbs (Table 5.15), and lower extremities (Table 5.16). Eight individuals (38.1%) exhibited OA in the upper limb only, six individuals (28.6%) in the lower limb only, and seven individuals (33.3%) in both the upper and lower limbs. The most commonly affected regions were: (1) the glenoid process of the scapula (*CPR* = 10.8% (Figure 5.29); (2) the humeral head (*CPR* = 10.3%); (3) foot phalanges (*CPR* = 6.3%); and (4) metatarsals, (*CPR* = 4.6%).

Statistical analysis of OA by joint location is reported in Table 5.17. All joint regions showed a significant difference between age classes except for the hand, hip, ankle, and foot. There was no significant relationship between the prevalence of primary OA and sex. Comparison between males and females, however, found differences in the sequence of most to least affected joint regions (Figure 5.30). This is interesting as females lived on average longer than males, suggesting a slightly earlier onset of primary OA in males (see section 6.3.4.1). The shoulder (glenoid fossa of the scapula + proximal humerus) was the most commonly affected region in both males and females. Males exhibited a greater prevalence of primary OA in the foot, knee, and ankle, whereas the wrist and elbow, foot, and hand were more commonly affected in females. Overall, the prevalence of primary OA was higher in joints of the upper limbs compared to the lower limbs. Total adult prevalence of primary OA ranged from 10.6% in the shoulder (combined glenoid fossa and proximal humerus) to 1.6% in the hand (combined metacarpals and phalanges).

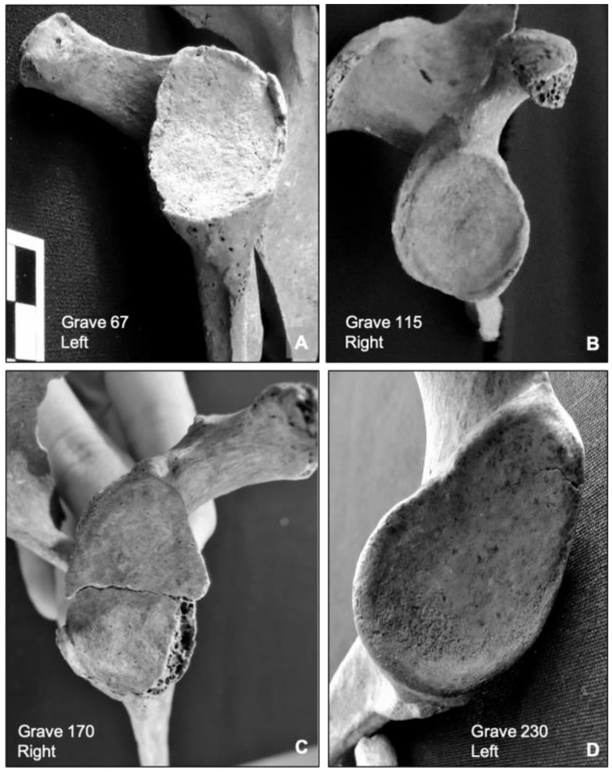


Figure 5.29 Degenerative OA of the glenoid fossa. (A) Severe marginal lipping and osteophytes (Stage 3/4), Adult IV Female (Grave 67); (B) Severe marginal lipping and osteophytes with eburnation (Stage 3/4), Adult IV female (Grave 115); (C) Marginal lipping and osteophytes with surface porosity (Stage 3), Adult III female (Grave 170); (D) Slight marginal lipping with surface porosity (Stage 2), Adult II Male (Grave 230).

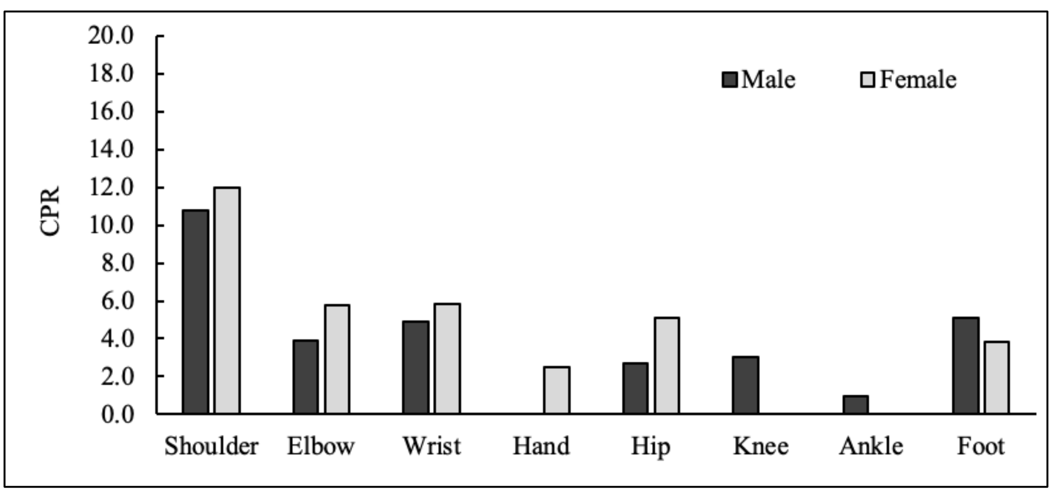


Figure 5.30 CPR (%) and distribution of primary OA at Ostojićevo in adult (>20 years) males and females.

Table 5.13 OA individual count and CPR (%) at Ostojićevo, upper limbs

		Scapula (Glenoid)			Prox. Humerus			Dist. Humerus			Prox. Radius			Dist. Radius			Prox. Ulna			Dist. Ulna		
	N*	n1**	n2***	%	n1	n2	%	n1	n2	%	n1	n2	%	n1	n2	%	n1	n2	%	n1	n2	%
Adult I	12	9	0	0.0	9	0	0.0	11	0	0.0	9	0	0.0	8	0	0.0	9	0	0.0	7	0	0.0
Adult II	12	10	2	20.0	9	1	11.1	11	1	9.1	10	0	0.0	10	0	0.0	11	0	0.0	10	1	10.0
Adult III	9	8	0	0.0	6	0	0.0	8	0	0.0	7	0	0.0	6	0	0.0	7	0	0.0	6	0	0.0
Adult IV	3	2	2	100.0	3	2	66.7	3	1	33.3	2	1	50.0	2	2	100.0	3	1	33.3	1	1	100.0
Adult ?	7	5	0	0.0	4	0	0.0	4	0	0.0	4	0	0.0	4	0	0.0	3	0	0.0	3	0	0.0
TOTAL Male	43	34	4	11.8	31	3	9.7	37	2	5.4	32	1	3.1	30	2	6.7	33	1	3.0	27	2	7.4
Adult I	8	8	0	0.0	8	0	0.0	8	0	0.0	7	0	0.0	7	0	0.0	7	0	0.0	7	0	0.0
Adult II	11	11	0	0.0	9	0	0.0	10	0	0.0	11	0	0.0	11	0	0.0	11	1	9.1	9	0	0.0
Adult III	8	6	1	16.7	5	0	0.0	4	0	0.0	7	0	0.0	5	0	0.0	8	0	0.0	8	0	0.0
Adult IV	11	9	4	44.4	9	4	44.4	11	2	18.2	9	1	11.1	10	2	20.0	10	3	30.0	6	2	33.3
Adult ?	7	5	0	0.0	5	0	0.0	6	0	0.0	6	0	0.0	5	0	0.0	6	0	0.0	4	0	0.0
TOTAL Female	45	39	5	12.8	36	4	11.1	39	2	5.1	40	1	2.5	38	2	5.3	42	4	9.5	34	2	5.9
Adult I	4	1	1	100.0	2	0	0.0	2	0	0.0	1	0	0.0	2	0	0.0	2	0	0.0	2	0	0.0
Adult II	1	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0
Adult III	1	1	0	0.0	-	-	-	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0
Adult IV	5	3	0	0.0	3	0	0.0	4	0	0.0	3	0	0.0	3	0	0.0	4	0	0.0	2	0	0.0
Adult ?	26	14	0	0.0	14	2	14.3	17	0	0.0	15	0	0.0	17	0	0.0	17	0	0.0	13	0	0.0
TOTAL Indeter.	37	20	1	5.0	20	2	10.0	25	0	0.0	21	0	0.0	24	0	0.0	25	0	0.0	19	0	0.0
Adult I	24	18	1	5.6	19	0	0.0	21	0	0.0	17	0	0.0	17	0	0.0	18	0	0.0	16	0	0.0
Adult II	24	22	2	9.1	19	1	5.3	22	1	4.5	22	0	0.0	22	0	0.0	23	1	4.3	20	1	5.0
Adult III	18	15	1	6.7	11	0	0.0	13	0	0.0	15	0	0.0	12	0	0.0	16	0	0.0	15	0	0.0
Adult IV	19	14	6	42.9	15	6	40.0	18	3	16.7	14	2	14.3	15	4	26.7	17	4	23.5	9	3	33.3
Adult ?	40	24	0	0.0	23	2	8.7	27	0	0.0	25	0	0.0	26	0	0.0	26	0	0.0	20	0	0.0
TOTAL	125	93	10	10.8	87	9	10.3	101	4	4.0	93	2	2.2	92	4	4.3	100	5	5.5	80	4	5.0

***Note.* * N = individual count; ** n1 = individual with joint surface present; *** n2 = affected individual**

Table 5.14 OA individual count and CPR (%) at Ostojićevo, upper extremities

		Carpals			Metacarpals			Phalanges		
	N*	n1**	n2***	%	n1	n2	%	n1	n2	%
Adult I	12	6	0	0.0	7	0	0.0	8	0	0.0
Adult II	12	11	0	0.0	11	0	0.0	12	0	0.0
Adult III	9	4	0	0.0	7	0	0.0	7	0	0.0
Adult IV	3	2	0	0.0	2	0	0.0	3	0	0.0
Adult ?	7	2	0	0.0	2	0	0.0	3	0	0.0
TOTAL Male	43	25	0	0.0	29	0	0.0	33	0	0.0
Adult I	8	5	0	0.0	7	0	0.0	7	0	0.0
Adult II	11	8	0	0.0	10	0	0.0	9	0	0.0
Adult III	8	5	0	0.0	7	0	0.0	7	0	0.0
Adult IV	11	8	2	25.0	11	1	9.1	11	1	9.1
Adult ?	7	5	0	0.0	6	0	0.0	5	0	0.0
TOTAL Female	45	31	2	6.5	41	1	2.4	39	1	2.6
Adult I	4	2	0	0.0	4	0	0.0	4	0	0.0
Adult II	1	1	0	0.0	1	0	0.0	1	0	0.0
Adult III	1	-	-	-	1	0	0.0	1	0	0.0
Adult IV	5	3	0	0.0	2	0	0.0	2	0	0.0
Adult ?	26	11	0	0.0	14	1	7.1	16	0	0.0
TOTAL Indeterminate	37	17	0	0.0	22	1	4.6	24	0	0.0
Adult I	24	13	0	0.0	18	0	0.0	19	0	0.0
Adult II	24	20	0	0.0	22	0	0.0	22	0	0.0
Adult III	18	9	0	0.0	15	0	0.0	15	0	0.0
Adult IV	19	13	2	15.4	15	1	6.7	16	1	6.3
Adult ?	40	18	0	0.0	22	1	4.6	24	0	0.0
TOTAL	125	73	2	2.7	92	2	2.2	96	1	1.0

***Note.* * N = individual count; ** n1 = individual with joint surface present; *** n2 = affected individual**

Table 5.15 OA individual count and CPR (%) at Ostojićevo, lower limbs

		Prox. Femur			Dist. Femur			Patella			Prox. Tibia			Dist. Tibia			Prox. Fibula			Dist. Fibula		
	N*	n1**	n2***	%	n1	n2	%	n1	n2	%	n1	n2	%	n1	n2	%	n1	n2	%	n1	n2	%
Adult I	12	12	0	0.0	12	0	0.0	9	0	0.0	10	0	0.0	10	0	0.0	11	0	0.0	11	0	0.0
Adult II	12	11	1	9.1	12	0	0.0	6	0	0.0	11	0	0.0	12	0	0.0	8	0	0.0	12	0	0.0
Adult III	9	8	0	0.0	8	0	0.0	7	0	0.0	8	0	0.0	8	0	0.0	7	0	0.0	8	0	0.0
Adult IV	3	3	0	0.0	3	1	33.3	2	1	50.0	3	1	33.3	3	1	33.3	2	0	0.0	3	0	0.0
Adult ?	7	3	0	0.0	3	0	0.0	2	0	0.0	4	0	0.0	3	0	0.0	1	0	0.0	2	0	0.0
TOTAL Male	43	37	1	2.7	38	1	2.6	26	1	3.8	36	1	2.8	36	1	2.8	29	0	0.0	36	1	2.8
Adult I	8	7	0	0.0	7	0	0.0	7	0	0.0	7	0	0.0	5	0	0.0	8	0	0.0	8	0	0.0
Adult II	11	11	0	0.0	11	0	0.0	5	0	0.0	10	0	0.0	11	0	0.0	9	0	0.0	9	0	0.0
Adult III	8	5	0	0.0	7	0	0.0	7	0	0.0	6	0	0.0	6	0	0.0	2	0	0.0	3	0	0.0
Adult IV	11	10	2	20.0	9	0	0.0	7	0	0.0	8	0	0.0	9	0	0.0	6	0	0.0	8	0	0.0
Adult ?	7	6	0	0.0	5	0	0.0	4	0	0.0	4	0	0.0	4	0	0.0	2	0	0.0	4	0	0.0
TOTAL Female	45	39	2	5.1	39	0	0.0	30	0	0.0	35	0	0.0	35	0	0.0	27	0	0.0	32	0	0.0
Adult I	4	2	0	0.0	2	0	0.0	2	0	0.0	3	0	0.0	3	0	0.0	3	0	0.0	4	0	0.0
Adult II	1	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0
Adult III	1	1	0	0.0	1	0	0.0	1	0	0.0	1	1	100.0	1	0	0.0	1	0	0.0	1	0	0.0
Adult IV	5	3	0	0.0	3	0	0.0	2	0	0.0	4	0	0.0	4	0	0.0	1	0	0.0	3	0	0.0
Adult ?	26	15	0	0.0	13	1	7.7	9	1	11.1	10	0	0.0	13	1	7.7	10	0	0.0	10	1	10.0
TOTAL Indeter.	37	22	0	0.0	20	1	5.0	15	1	6.7	19	1	5.3	22	1	4.5	16	0	0.0	19	1	5.3
Adult I	24	21	0	0.0	21	0	0.0	18	0	0.0	20	0	0.0	18	0	0.0	22	0	0.0	23	0	0.0
Adult II	24	23	1	4.3	24	0	0.0	12	0	0.0	22	0	0.0	24	0	0.0	18	0	0.0	22	0	0.0
Adult III	18	14	0	0.0	16	0	0.0	15	0	0.0	15	1	6.7	15	0	0.0	10	0	0.0	12	0	0.0
Adult IV	19	16	2	12.5	15	1	6.7	11	1	9.1	15	1	6.7	16	1	6.3	9	0	0.0	14	0	0.0
Adult ?	40	24	0	0.0	21	1	4.8	15	1	6.7	18	0	0.0	20	1	5.0	13	0	0.0	16	1	6.3
TOTAL	125	98	3	3.1	97	2	2.1	71	2	2.8	90	2	2.2	93	2	2.2	72	0	0.0	87	1	1.1

***Note.* * N = individual count; ** n1 = individual with joint surface present; *** n2 = affected individual**

Table 5.16 OA individual count and CPR (%) at Ostojićevo, lower extremities

		Tarsals			Metatarsals			Phalanges		
	N*	n1**	n2***	%	n1	n2	%	n1	n2	%
Adult I	12	10	0	0.0	10	0	0.0	8	0	0.0
Adult II	12	12	0	0.0	10	0	0.0	8	1	12.5
Adult III	9	9	1	11.1	7	1	14.3	7	1	14.3
Adult IV	3	3	0	0.0	3	0	0.0	3	0	0.0
Adult ?	7	2	0	0.0	2	0	0.0	1	0	0.0
TOTAL Male	43	36	1	2.8	32	1	3.1	27	2	7.4
Adult I	8	6	0	0.0	6	0	0.0	4	0	0.0
Adult II	11	11	0	0.0	10	0	0.0	5	0	0.0
Adult III	8	6	0	0.0	3	0	0.0	1	1	100.0
Adult IV	11	11	0	0.0	9	1	11.1	6	0	0.0
Adult ?	7	5	0	0.0	5	0	0.0	3	0	0.0
TOTAL Female	45	6	0	0.0	6	0	0.0	4	0	0.0
Adult I	4	39	0	0.0	33	1	3.0	19	1	5.3
Adult II	1	4	0	0.0	3	0	0.0	3	0	0.0
Adult III	1	1	0	0.0	1	0	0.0	1	0	0.0
Adult IV	5	1	1	100.0	1	1	100.0	1	1	100.0
Adult ?	26	5	0	0.0	2	0	0.0	2	0	0.0
TOTAL Indeterminate	37	28	2	7.1	22	2	9.1	17	1	5.9
Adult I	24	20	0	0.0	19	0	0.0	15	0	0.0
Adult II	24	24	0	0.0	21	0	0.0	14	1	7.1
Adult III	18	16	2	12.5	11	2	18.2	9	3	33.3
Adult IV	19	19	0	0.0	14	1	7.1	11	0	0.0
Adult ?	40	24	1	4.2	22	1	4.5	14	0	0.0
TOTAL	125	103	3	2.9	87	4	4.6	63	4	6.3

***Note*. * N = individual count; ** n1 = individual with joint surface present; *** n2 = affected individual**

Table 5.17 Statistical analysis of CPR for postcranial OA at Ostojićevo. Results of chi-square tests of homogeneity for CPR (%) by age-at-death (*df* = 3) and sex (*df* = 1). Bold indicate statistical significance

Region	Age-at-Death		Sex	
	χ^2	*p*	χ^2	*p*
Shoulder*	**27.61**	**<.01**	0.05	.82
Elbow	**23.88**	**<.01**	0.41	.52
Wrist	**31.66**	**<.01**	0.08	.77
Hand	7.26	.06	1.57	.21
Hip	4.42	.22	0.30	.59
Knee	**8.47**	**.04**	3.17	.08
Ankle	3.09	.38	0.99	.32
Foot	6.13	.11	0.10	.75

***Note*. * Analysis based on joint location. Included individuals with at least one joint surface present for each region. Corresponding articular surfaces and/or elements include: Shoulder = glenoid fossa + proximal humerus; Elbow = distal humerus + proximal radius and ulna; Wrist = distal radius and ulna + carpals; Hand = metacarpals + phalanges; Hip = proximal femur; Knee = patella + distal humerus + proximal tibia; Ankle = distal tibia and fibula + tarsals; Foot = metatarsals + phalanges.**

Seven individuals exhibited nine cases of OA in adults ≤ 40 years-at-death: one female (Grave 280), five males (Graves 100, 186, 212, 230, and 232), and one indeterminate adult (Grave 176). The age distribution of affected individuals was 18-20 years (n = 1, 14.3%), 20-30 years (n = 1, 14.3%), and 30-40 years (n = 5, 71.4%). Of the nine cases, the left shoulder was the most affected (n = 4, 77.8%; Graves 176, 212, 230, and 280), followed by the right and left hips (Graves 100 and 223), and one case each of the right elbow (Grave 186), right wrist (Grave 212), and right and left proximal first pedal digits (Grave 232). While these cases were classified as primary OA, a differential diagnosis of primary OA secondary to minor trauma cannot be discounted due to the relatively young age of these individuals.

Two individuals, an Adult I male (Grave 100) and an Adult II male (Grave 223), displayed premature primary OA of the right and left hip. Chronic subluxation of the right and left hip in the Grave 100 individual is described in Section 6.3.1.3. Briefly, both acetabula had a shallow and anteriorly- and superiorly-enlarged diameter with Stage II OA. The femoral heads appear small, with a large central depression with irregular margins present on the right head surrounding the attachment for the ligamentum teres. These abnormalities are consistent with congenital dislocation producing repeated, partial anterosuperior subluxation causing abnormal abrasion to the femoral head coupled with elongation and instability of the ligamentum teres (Ortner, 2003). In contrast, the Grave 223 individual did not exhibit any obvious congenital abnormalities (*e.g.*, shallow acetabulum) of the hip. Rather, subluxation in this individual is due to traumatic femoroacetabulur impingement (FAI) (Figure 5.31).

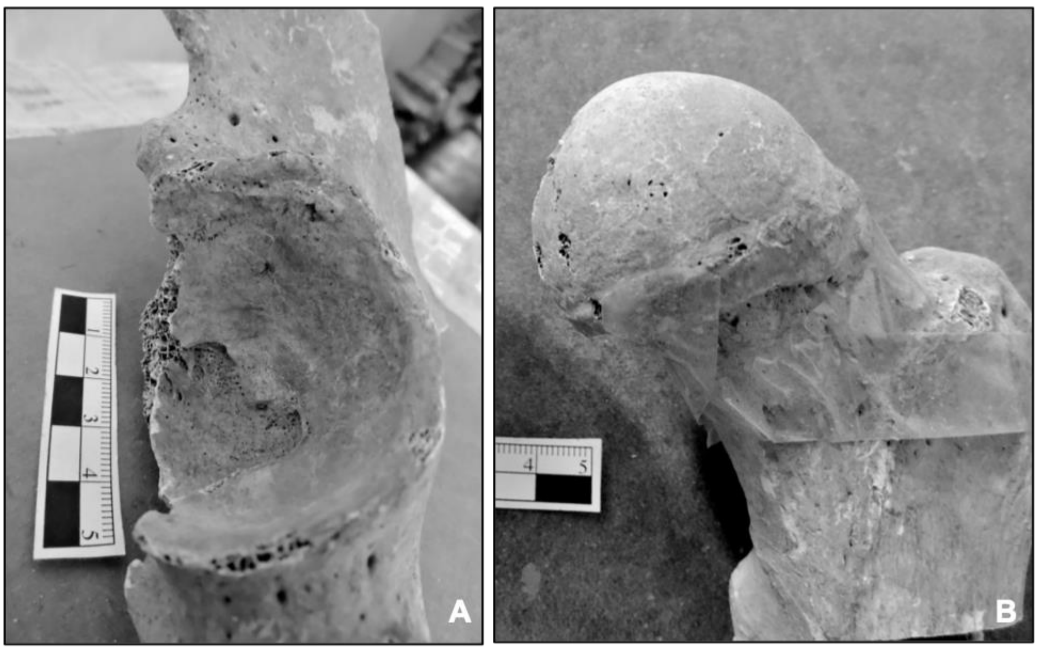


Figure 5.31 Degenerative OA associated with traumatic femoroacetabular impingement in an Adult II male (Grave 223). Bony changes present bilaterally (only right side pictured). Note expansion of the femoral head onto the neck and macroporosity and surface osteophytes on the lunate surface of the acetabulum near the superoposterior rim.

Bony changes included minor flattening of the right and left femoral head, with expansion of the joint surface onto the neck. The fovea capiti were normal, indicating no disruption of the ligamentum teres. Stage II/III OA of the right and left acetabula was concentrated on the superoposterior rim and consisted of surface and marginal osteophytes and macroporosity. FAI results from abnormal contact between the acetabular rim and femoral neck that produces labral and chondral lesions (Parvizi et al., 2007). In the absence of predisposing factors such as Legg-Calvé-Perthes disease, coxa profunda deformity, and femoral neck fractures, repeated microtrauma from activities that subject the hip to an increased range of motion is the most common cause of FAI (Beck et al., 2005). A clinical study of patients with no clear predisposing factors found FAI to affect physically active males and females, with an average age-at-diagnosis of 32 years (Beck et al., 2005). Left untreated, FAI can lead to primary OA in the hip joint via separation of the labrum and cartilage during movement causing damage to the acetabular cartilage (Beck et al., 2005; Parvizi et al., 2007).

5.11.2 Secondary Traumatic Osteoarthritis

Osteoarthritis was a common complication of postcranial blunt-force trauma (BFT) occurring at or near joint surfaces. Details on specific injuries are presented in Chapter 7, Section 7.2.1. Five individuals exhibited seven cases of OA secondary to BFT: one female (Grave 64), three males (Graves 66B, 226, and 251), and one subadult (Grave 185).

Injury location followed by injury type were the most important factors influencing the severity of bony changes associated with traumatic OA. Excluding trauma to ribs and vertebrae, there were 12 cases of postcranial trauma affecting nine individuals (Appendix Table 14). Of these, traumatic OA was present in seven cases (77.8%), including all cases of trauma in the shoulder and forearm/wrist. Traumatic OA was present in only one of the two individuals with a healed injury to the distal fibula, affecting the Adult III male (Grave 251) but not the Adult I female (Grave 41). Finally, joint damage was not associated with a fracture to the left superior pubic ramus in an Adult II male (Grave 156) or an oblique fracture to the midshaft of the left 2nd metacarpal in an adult female (Grave 113).

5.11.3 Spondyloarthropathy

Two individuals displayed bony changes consistent with an undifferentiated spondyloarthropathy. Diagnosis was based primarily on partial or complete fusion of one or both sacroiliac joints. Affected individuals include an Adult II/III male (Grave 101) and an Adult I male (Grave 107).

Fusion of the right sacroiliac joint was observed in an Adult II/III male (Grave 101) (Figure 5.32). Postmortem damage to this area revealed that ankylosis occurred along the joint margins rather than across the joint surface. The left sacroiliac joint was normal. No ankylosis was seen in the diarthrodial or amphiarthrodial joints of extant vertebrae. Abnormal bone formation in the vertebral column was restricted to hyperostosis of the ligamentum flavum in T11 and T12, a large horizontal osteophyte on the superior right margin of T11, and small (>1.0 mm) horizontal osteophytes on the anterior margins of L5, T9, and T6. Preservation of the cervical vertebrae was poor. Bony changes associated with Stage III/IV OA were documented in the T11 and T12 left costovertebral joints and in the right knee, with Stage II/III OA seen in both glenoid fossae and acromioclavicular joints. Joint instability/posteromedial dislocation of the right knee was indicated by the formation of a new joint surface on the medial condyle of the right tibia. Despite degenerative changes in and medial displacement of the right tibiofemoral joint, the left tibiofemoral joint and both patellae were unaffected. Differential diagnosis of degeneration of the right tibiofemoral sacroiliac joints includes sacroiliitis and joint instability secondary to chronic traumatic posteromedial dislocation of the right knee (Robertson et al., 2006). This same individual also displayed a healed wedge-impaction injury resulting in permanent left-lateral angulation in the L2 and L3 vertebral bodies.

The right sacroiliac joint was fused in an Adult I male (Grave 107), with two circumscribed areas of bone destruction bordered by bone proliferation in the left retroauricular area (Figure 5.33). Hyperostosisof the ligamentum flavum (OLF) was noted in the lower and middle thoracic vertebrae (T12-

T5). No marginal syndesmophytes were identified on any of the extant vertebral bodies. Additional skeletal abnormalities in this individual included hyper-robusticity of the distal clavicles and proximal ulnae. All appendicular synovial joints appeared normal. A longitudinal study by McEwen et al. (1971) of bony changes associated with ankylosing spondylitis and reactive spondylitis found that, while rare, bilateral asymmetric involvement of sacroiliac joints does occur in cases of reactive spondylitis associated with ulcerative colitis or psoriasis. Furthermore, additional bony changes such as pelvic whiskering, “squaring” of the anterior surface of vertebral bodies, and marginal or paravertebral ligamentous ossification are often absent in the early stages of the disease (*i.e.*, <6 years onset of spondylitis). Hyperostosis of the ligamentum flavum but not the capsular ligaments or interspinous ligaments was an atypical presentation, as the latter two are commonly associated with ankylosing spondylitis and reactive spondylitis whereas the former is a common finding in Diffuse Idiopathic Skeletal Hyperostosis (DISH) (McEwen et al., 1971; Olivieri et al., 2009; Ono et al., 1999). The etiology and pathophysiology of OLF is poorly understood. This condition results from a complex of mechanical, degenerative, metabolic, dietary, and genetic factors, and is more common in males (Kim et al., 2018; Wang et al., 2008). The young age of the Grave 107 individual coupled with location of OLF in the midthoracic and lower thoracic vertebrae suggest an underlying association with microtrauma from repetitive mechanical stress (Li et al., 2013).

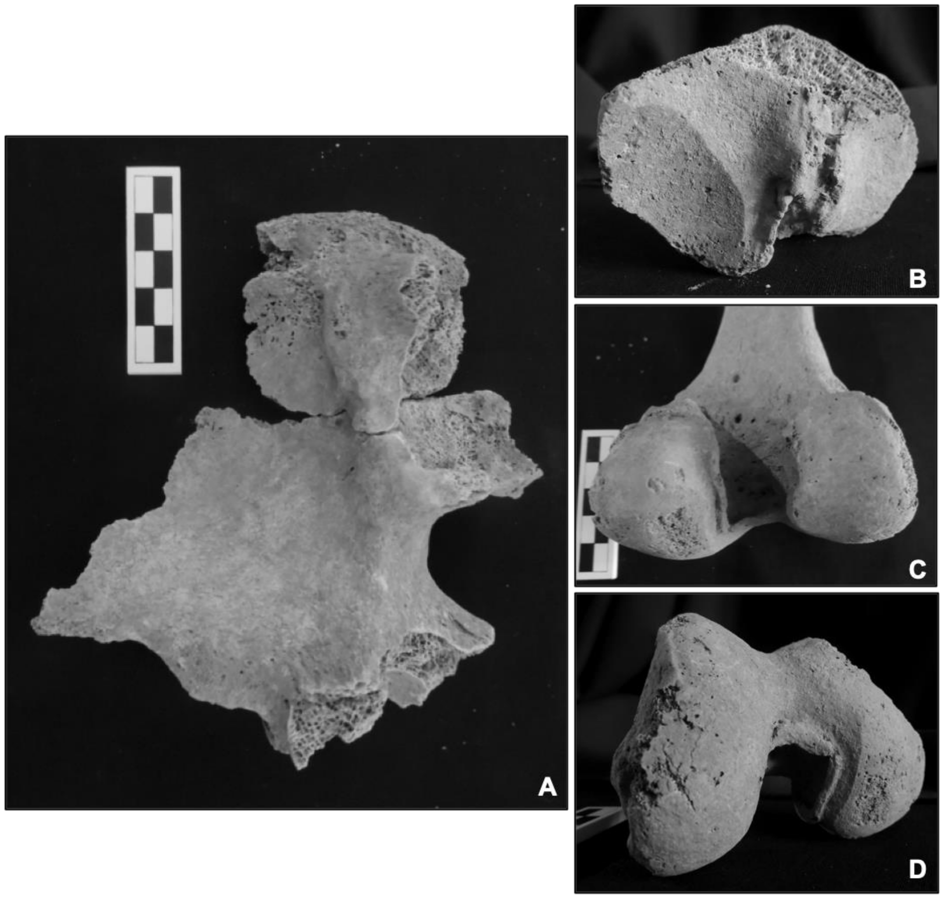


Figure 5.32 Joint ankylosis and Stage 4 OA in an Adult III/IV male (Grave 101). (A) Right sacroiliac joint fusion (arrows) with postmortem damage to retroauricular region (circle); (B and C) Stage 4 osteoarthritic changes to right distal femur including erosion and eburnation (circle) to medial condyle and extensive marginal lipping and osteophytes; (D) Stage 3/4 osteoarthritic changes to right proximal tibia including expansion of joint surface (arrow).

Figure 5.33 Joint ankylosis and partial ossification of the ligamentum flavum (OLF) in an Adult I male (Grave 107). (A) Ankylosis of right SI joint (arrows); (B) Detail of right SI joint; (C) Detail of left SI joint with circumscribed areas of bone destruction and proliferation (circles); (D) T12 to T5 OLF (arrows).

5.11.4 Septic Arthritis

Septic arthritis of the hands not associated with skeletal trauma was documented in an Adult IV female (Grave 246) (Figure 5.34). Bony changes were characterized by irregular articular margins, bone loss, and sequestra with cloacae on or near the articular surfaces. Affected joints included the left and right first metacarpophalangeal joint and the left first distal interphalangeal joint (right side not preserved). Differential diagnosis is osteomyelitis from bacteremia due to hematogenous or contiguous spread from a local infection (Horowitz et al., 2011; Shirtliff & Mader, 2002). Symptoms of septic arthritis as marked by acute swelling, pain, warmth, and mobility at the joint(s). Patients may also experience systemic symptoms such as fever and chills (Horowitz et al., 2011). Individuals older than 65 years with a preexisting medical condition such as diabetes mellitus, OA, or rheumatoid arthritis are at highest risk for septic arthritis (Weston et al., 1999). The majority (c. 80-85%) of clinical cases are monoarticular (Horowitz et al., 2011; Weston et al., 1999). The knee is the most commonly affected joint, followed by the hip, elbow, and interphalangeal or metacarpophalangeal joints (Weston et al., 1999). In their comprehensive review of the etiology, pathogenesis, risk factors, and treatment of acute septic arthritis, Shirtliff and Mader (2002) found that *Staphyloccous aureus* is the most common infectious agent in nongonococcal cases of septic arthritis in Europe and the United States. *S. aureus* is especially common in individuals with rheumatoid arthritis and/or diabetes, whereas *Streptoccocus pyogenes* is associated with acute septic arthritis from chronic skin infections or trauma. A study of British patients diagnoses with septic arthritis from 1982 to 1991 found that the mortality rate after hospitalization was 32% in patients >65 years (Weston et al., 1999). The Grave 246 individual exhibited several comorbidities, which in addition to their age, likely placed them at a higher risk for experiencing complications such as permanent joint disfigurement, and even death. Marginal lipping, marginal osteophytes, and slight surface porosity indicative of Stage II OA was present in the left humeral head, left distal radius, and the left carpals. More extreme changes consistent with Stage III/IV OA were present in the left glenoid fossa (right absent) and left sacroiliac joint (right absent).

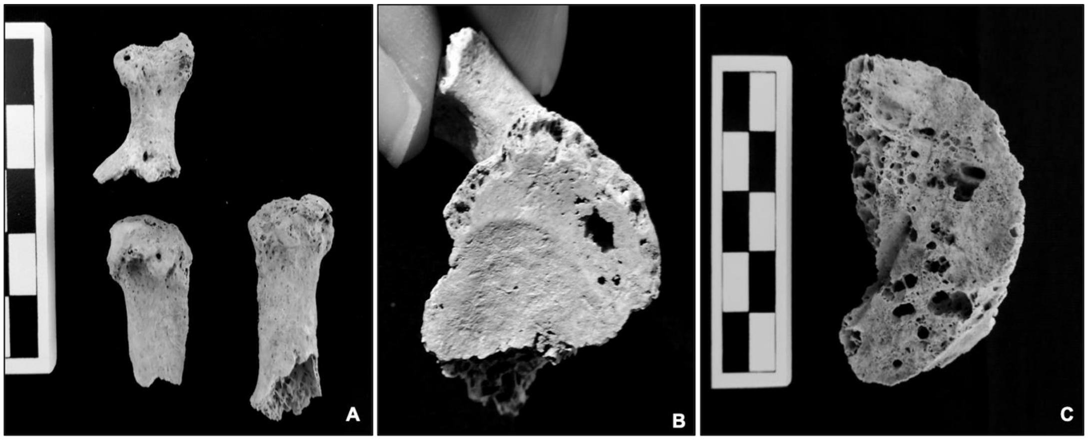


Figure 5.34 Septic OA. (A) Polyarticular erosive OA in an Adult IV female (Grave 246) affecting the right and left first metacarpophalangeal and proximal interphalangeal joints; (B) Stage III/IV OA with eburnation in the left glenoid fossa; and (C) Stage III/IV OA with extensive macroporosity in the left SI joint.

5.11.5 Osteochondritis Dissecans

Differential diagnosis of mycotic lesions described in Section 5.9.4 affecting synovial joint surfaces in the distal tibia, feet, and hands of three Adult III and Adult IV individuals includes osteochondritis dissecans. A diagnosis of mycotic lesion was favored due to location of the lesions/defects, age of the individuals, absence of new bone formation, and the presence of co-morbidities consistent with fungal infection.

5.12 Results: Ostojićevo Osseous Changes in the Vertebrae

TPR (%) of osseous changes in the vertebrae (*i.e.*, Schmorl's nodes and marginal osteophytes) are listed in Table 5.18 by sex and age-at-death. Figures 5.35 and 5.36 illustrate the distribution of vertebral pathology by sex and vertebral region, excluding C1 and C2. Marginal osteophytes represent the most common category of vertebral pathology, affecting 7.4% of adult vertebrae. TPR increased significantly with age. Chi-square analysis of pathology presence and adult age-at-death found significant differences for osteophytes and but not for Schmorl's nodes (Table 5.19). TPR for Schmorl's nodes was similar in males and females. However, there was a significantly greater prevalence of marginal osteophytes in females (*TPR* = 11.0%) compared to males (*TPR* = 6.9%) ($\chi^2 = 7.99$, $df = 1$, $p < .01$).

Table 5.18 Vertebral Pathology TPR (%) by sex and age-at-death at Ostojićevo

	N*	Schmorl's nodes			Marginal Osteophytes		
		n1**	n2***	%	n1	n2	%
Adult I	12	157	2	1.3	176	2	1.1
Adult II	11	141	5	3.5	154	0	0.0
Adult III	8	66	3	4.5	75	9	12.0
Adult IV	3	32	2	6.3	36	19	52.8
Adult ?	6	20	0	0.0	25	2	8.0
TOTAL Male	40	416	12	2.9	466	32	6.9
Adult I	9	145	3	2.1	156	4	2.6
Adult II	11	133	5	3.8	141	6	4.3
Adult III	6	70	0	0.0	80	11	13.8
Adult IV	9	95	4	4.2	102	38	37.3
Adult ?	9	69	0	0.0	83	3	3.6
TOTAL Female	49	512	12	2.3	562	62	11.0
Adult I	10	74	5	6.8	82	0	0.0
Adult II	1	12	0	0.0	13	0	0.0
Adult III	1	19	7	36.8	20	7	35.0
Adult IV	5	48	0	0.0	54	0	0.0
Adult ?	25	86	8	9.3	101	2	2.0
TOTAL Indeterminate	42	239	20	8.4	270	9	3.3
Adult I	31	376	10	2.7	414	6	1.4
Adult II	23	286	10	3.5	308	6	1.9
Adult III	15	155	10	6.5	175	27	15.4
Adult IV	17	175	6	3.4	192	57	29.7
Adult ?	40	175	8	4.6	209	7	3.3
TOTAL	126	1167	44	3.8	1298	103	7.9

***Note.* * N = individual count; ** n1 = pooled element count; *** n2 = pooled affected element count**

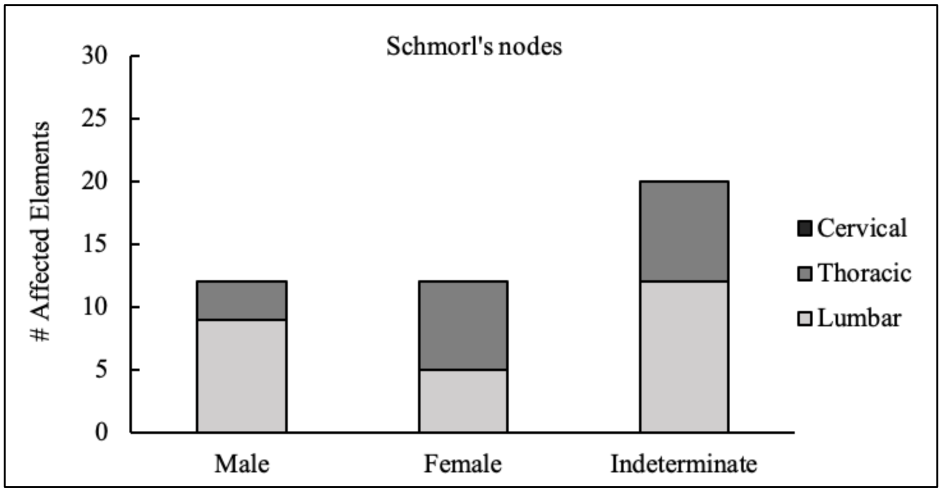


Figure 5.35 Schmorl’s nodes by vertebral region and biological sex at Ostojićevo

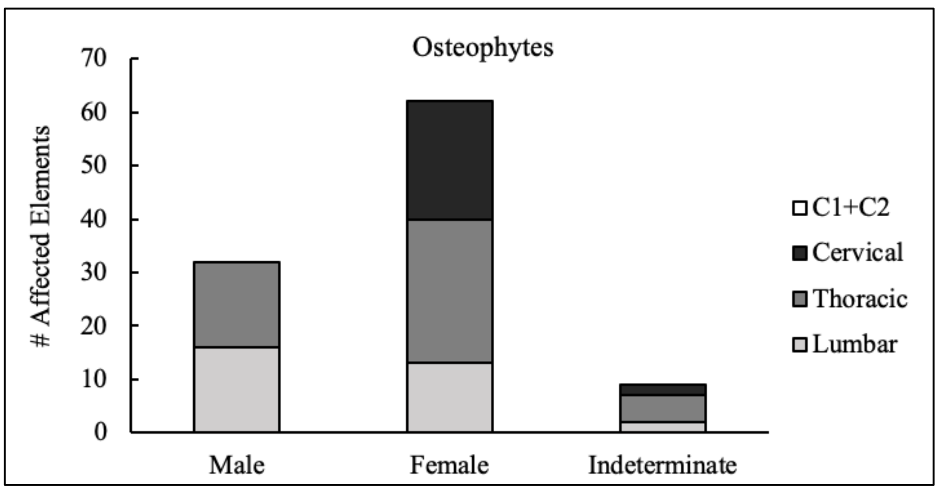


Figure 5.36 Marginal osteophytes by vertebral region and biological sex at Ostojićevo

Table 5.19 Statistical analysis of TPR for vertebral pathology at Ostojićevo. Results of chi-square tests of homogeneity of TPR (%) for age-at-death (*df* = 3) and sex (*df* = 1). Bold indicates statistical significance.

Pathology	Age-at-Death		Sex	
	χ^2	*p*	χ^2	*p*
Schmorl’s nodes	3.99	.26	0.08	.78
Osteophytes	**203.08**	**<.01**	**7.99**	**<.01**

***Note.* * indicates use of Fisher’s Exact when n ≤ 5.**

5.12.1 Schmorl's Nodes

Total adult TPR of Schmorl's nodes ranged from 2.7% (Adult I) to 6.5% (Adult III) of combined cervical (excluding C1 and C2), thoracic, and lumbar vertebrae. There was no significant difference in Schmorl's node presence by age-at-death; however, the greatest prevalence was seen in Adult IV males (*TPR* = 6.3%). The lumbar region was the most commonly affected (*TPR* = 9.4%) followed by the thoracic vertebrae (*TPR* = 2.9%). No cervical vertebral lesions were observed. For males, Schmorl's nodes were six times more common in lumbar (*TPR* = 8.5%) compared to thoracic (*TPR* = 1.4%) vertebrae. There was less discrepancy between vertebral regions in females, with defects observed on 4.5% of lumbar vertebrae versus 2.5% of thoracic vertebrae.

The pattern observed at Ostojićevo demonstrated sex-specific differences in the relationship between Schmorl's node presence, location within the vertebral column, and age. No Schmorl's nodes were identified in thoracic vertebrae for males <40 years-at-death; Schmorl's node prevalence in the thoracic (*TPR* = 6.4%) and lumbar (*TPR* = 6.7%) vertebrae were almost equal among males >40 years-at-death (Figure 5.37). Among females <40 years-at-death, Schmorl's nodes were slightly more prevalent in the lumbar vertebrae (*TPR* = 3.2%) compared to the thoracic vertebrae (*TPR* = 2.6%); among females >40 years-at-death, Schmorl's nodes were more prevalent in the thoracic vertebrae (*TPR* = 5.8%) compared to the lumbar vertebrae (*TPR* = 2.9%).

Figure 5.37 Schmorl's nodes in a Juv. II probable-male (Grave 181). L1 (right) and L3 (left). Postmortem damage to L2 centrum (center).

5.12.2 Osteophytes

Total adult CPR of marginal osteophytes ranged from 1.4% (Adult I) to 29.7% (Adult IV) of combined cervical (including C1 and C2), thoracic, and lumbar vertebrae. Although females had a significantly greater overall prevalence than males, though Adult IV males (*TPR* = 52.8%) were the most affected. Adult II males had the lowest prevalence with no affected vertebrae. Lumbar vertebrae had the prevalence of osteophytes (*TPR* = 11.2%) followed by cervical vertebrae (*TPR* = 9.1%) and thoracic vertebrae (*TPR* = 7.7%). The distribution of osteophytes between vertebral regions differed between males and females. Osteophyte prevalence was greatest in males for lumbar vertebrae (*TPR* = 15.1%), with osteophytes also present on 7.3% (of thoracic vertebrae. In contrast, cervical vertebrae (*TPR* = 18.3%) were more commonly affected in females followed by lumbar vertebrae (*TPR* = 11.6%) and thoracic vertebrae (*TPR* = 9.6%.

Studies have shown that vertebral osteophytosis is strongly correlated with age, with osteophytes most commonly occurring in the lumbar and dorsal (thoracic) spine (Klaassen et al., 2011; Zukowski et al., 2012). While osteophyte presence is correlated with age (Hassett et al., 2003; Novak & Šlaus, 2011), biomechanical factors such as strenuous physical activity associated with throwing and heavy lifting can influence the pattern and severity of osteophyte development in the vertebral column (Van der Merwe et al., 2006; Schmitt et al., 2004). Sex- and age-specific differences in marginal osteophyte prevalence and distribution at Ostojićevo suggests their utility as indicators of activity-related stress. For example, osteophytes occurred most often in the cervical vertebrae across all female age classes (except for Adult III females) (Figure 5.38). Older females were disproportionately affected (Figure 5.39). For Adult IV females, osteophytes were present on 60% of cervical vertebrae, 40% of thoracic vertebrae, and 43.8% of lumbar vertebrae. Among males, marginal osteophytes occurred most often in the lumbar vertebrae in Adult I (*TPR* = 5.6%) and Adult III (*TPR* = 33.3%) individuals (vertebral osteophytes were absent in Adult II males). For adult IV males, marginal osteophytes were present on 92.9% of thoracic vertebrae and 50.0% of lumbar vertebrae (Figure 5.40). Notably, marginal osteophytes were absent from thoracic vertebrae in males and females <40 years-at-death, and mostly absent from lumbar vertebrae in males <40 years-at-death.

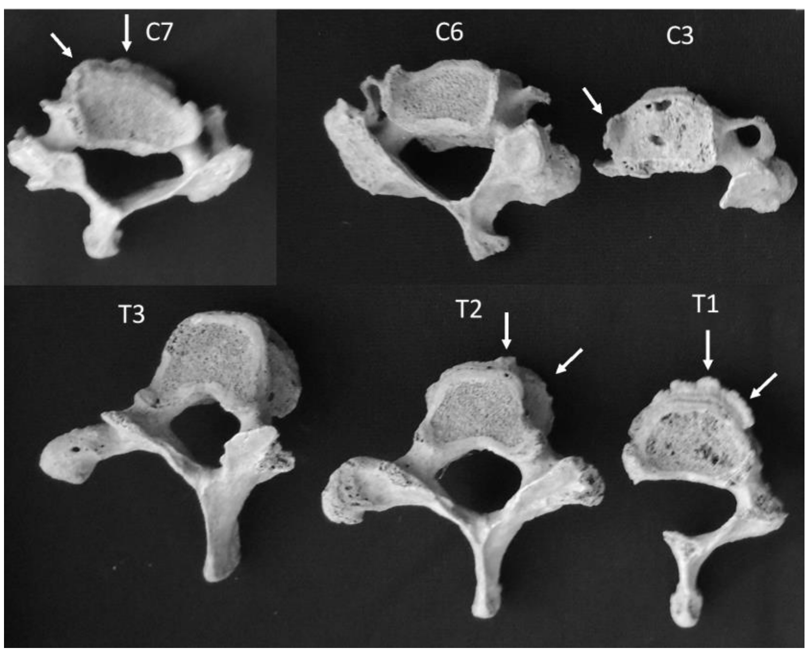


Figure 5.38 Anterior marginal osteophytes (arrows) on vertebral bodies C3, C7, T1, and T2 (superior view) in an Adult II female (Grave 78). Mid- and lower-thoracic and lumbar vertebrae unaffected.

Figure 5.39 Spondylosis deformans in an Adult III female (Grave 170). Large anterior superior and inferior marginal osteophytes on L1 to L5 (pictured, arrows). Note large claw-like paravertebral osteophytes on superior aspect of L1 and L4.

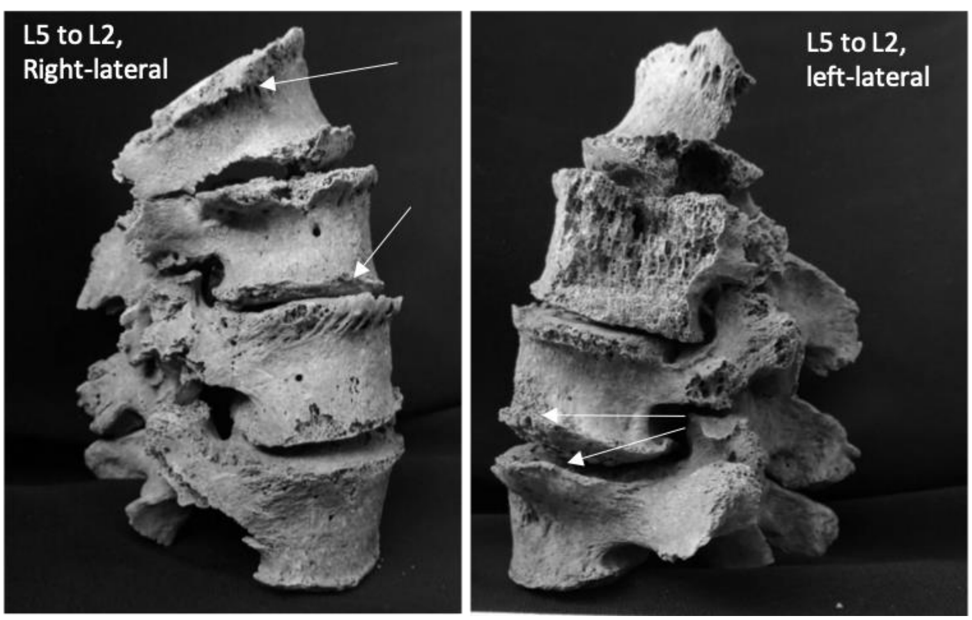


Figure 5.40 Spondylosis deformans in an Adult IV male (Grave 209). Paravertebral osteophytosis (arrows), L5 to T10 (L1 to T 10 not pictured).

5.12.3 Multiple Pathologies

Abnormal anterior curvature of the thoracic spine indicative of senile kyphosis secondary to decreased mechanical resiliency was observed in a single individual (Ortner, 2003). The Grave 81 individual, an Adult IV female, exhibited anterior compression and vertebral body collapse in five consecutive thoracic vertebrae (T2 to T6) (Figure 5.41). Additional pathological changes in the vertebrae included osteophytes on the superior and inferior margins of the L5 body and porosity and sclerotic bone formation on the superior aspect of three consecutive cervical bodies (C5 to C7). The lower thoracic vertebrae and L1 to L4 appeared normal. The proximal end of the left femur had been bisected, revealing thinning of the trabeculae in the neck and greater trochanter and expansion of the medullary cavity above the lesser trochanter (Acsádi & Nemeskéri, 1970 *in* Schwartz, 2007: 252-256). A differential diagnosis of osteoporosis resulting from hormonal changes (*i.e.*, cessation of estrogen production) associated with aging is proposed based on the pattern of vertebral collapse, cortical and trabecular thinning in the proximal femur, and the age and sex of the individual (Ortner, 2003). Cross-section imaging of the femora and radiographs of articulated vertebrae are needed to investigate underlying structural changes in these regions not visible through macroscopic analysis.

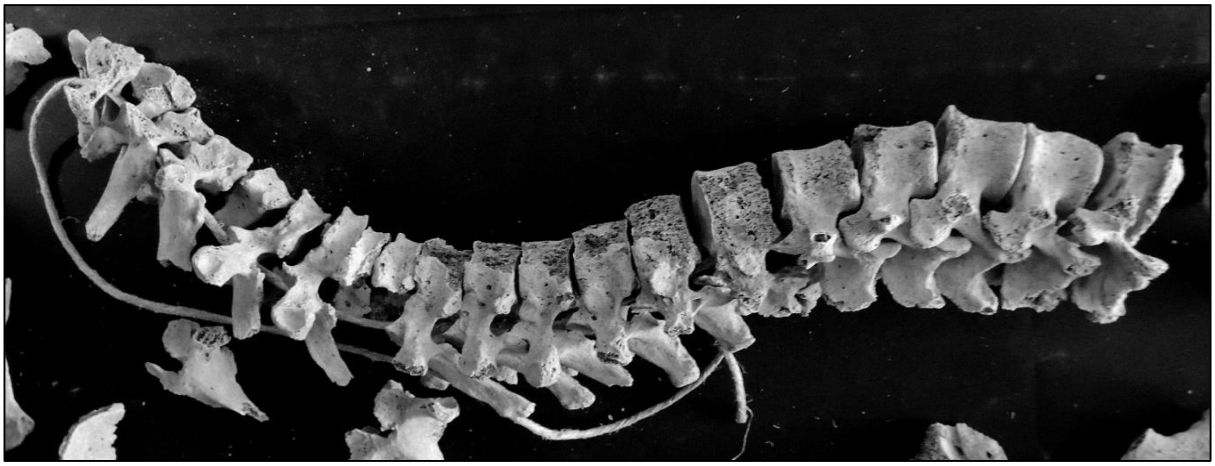


Figure 5.41 Senile kyphosis in an Adult IV female (Grave 81). Anterior compression and collapse of bodies of T2 to T6. Degeneration and attrition of intervertebral discs, C5-C7. Note osteophytes extending from superior and inferior margins of the body of L5.

5.13 Discussion: Stature

5.13.1 Ostojićevo Stature and Health

Stature is related to health (Norgan et al., 2012; Lejarraga, 2012) and sexual dimorphism (Gray & Wolfe, 1980; Holden & Mace, 1999). Cross-cultural variation in stature sexual dimorphism has been attributed to factors such as sexual division of labor (Holden & Mace, 1999), marriage systems (Gaulin & Boster, 1992), and subsistence practices (Wolfe & Gray, 1982). Gray and Wolfe (1982) in their study of stature in 216 human societies found an average difference ratio of 1.08 (range 1.04 to 1.12). Similarly, Holden and Mace (1999) noted mean differences in male and female stature of 4% to 10%, which is equivalent to a difference ratio of ca. 1.06 to 1.11. Mean living stature estimates at Ostojićevo derived from the femur showed a mean difference of 3.37% (mean difference ratio 1.03, range 1.01 to 1.10) between males and females. Based on cross-cultural studies of stature dimorphism, differences in stature at Ostojićevo fall within the expected mean differences for preindustrial human populations.

5.13.2 Comparative Stature and Health

Hukelova (2016) assessed the stature of 148 individuals spanning the Neolithic, CA, and EBA in Slovakia and the Czech Republic (Moravia and Bohemia) and found that Copper and Bronze Age individuals were on average ~5 cm taller than their Neolithic counterparts. Bronze Age individuals, however, showed the greatest variation in mean stature. Based on combined mean living stature estimates from femora, males at Ostojićevo were ca. 4.8 cm shorter and females ca. 6.9 cm shorter than EBA groups from Slovakia and Moravia. Stature dimorphism at Ostojićevo (mean difference ratio 1.09) was slightly greater than Neolithic, CA, EBA, and MBA samples from the Carpathian Basin and to the north in Slovakia and Moravia. Interestingly, maximum male stature at Ostojićevo was 5.0 cm greater than the Early Bronze Age male maximum reported by Hukelova (2016). These results are similar to those reported by Macintosh et al. (2015), who found that Bronze and IA populations from Moravia and Hungary increased in stature over time (particularly females), while stature remained relatively constant in northern Serbian populations during the same period. They attributed this difference to regional differences in early childhood health associated with diet and sanitation between the two populations, which led to impaired growth rates and smaller body size in EBA/MBA groups in northern Serbia compared to contemporaneous groups in Moravia and in the northern Carpathian Basin region. Among groups from northeastern Hungary, mean male and female stature remained relatively consistent overtime (Table 5.20). Despite archaeological evidence for migration into the Carpathian Basin during the LCA and IA (Gerling et al., 2012; Kemenczei, 2003; Parkinson, 2006), the consistency in stature over time suggests the influence of environmental factors beyond changes in genetic composition and/or health.

Table 5.20 Regional and temporal variation in living stature from the lower limbs, primarily the femur and tibia.

Period	Date	Location	Citation	Male Stature (cm)				Female Stature (cm)				Ratio (M:F)
				n	Mean (SD)	Max.	Min.	n	Mean (SD)	Max.	Min.	
MN; LN	4970-4380 BC	NE Hungary	Ubelaker et al. (2006)	15	168.3 (5.9)	183.0	157.0	12	157.2 (5.7)	169.0	145.0	1.07
LN	4800-4100 BC	W Slovakia	Hukelova (2016)	14	167.9 (5.7)	180.3	156.4	19	156.0 (6.1)	165.0	147.3	1.08
ECA; MCA	4400-3500 BC	NE Hungary	Ubelaker & Pap (2009)	35	168.2 (4.6)	178.0	159.7	32	156.7 (5.6)	167.0	149.7	1.07
LCA	2400-2000 BC	Czech Rep.	Hukelova (2016)	24	173.2 (5.0)	182.5	166.2	17	160.8 (4.3)	167.6	152.6	1.08
EBA	2200-1600 BC	Czech Rep.; W Slovakia	Hukelova (2016)	42	172.9 (4.7)	182.2	157.0	32	161.8 (5.3)	170.6	149.3	1.07
EBA/MBA (Ostojićevo)	1800-1500 BC	NE Serbia	This study	32	168.1 (7.1)	187.2	157.5	26	154.9 (3.6)	162.1	146.4	1.09
MBA	1400-1100 BC	NE Hungary	Ubelaker & Pap (1996)	123	168.3 (5.9)	183.0	157.0	130	157.2 (5.7)	169.0	145.0	1.07
EIA; IA	800-600 BC BC; 400 BC - AD 100	NE Hungary	Ubelaker & Pap (1998)	29	168.9 (4.8)	178.0	158.0	44	154.3 (4.0)	160.0	141.0	1.09

Previous research on skeletal growth and biomechanics in prehistoric central European populations has shown considerable intra-sample variation in infant and childhood growth trajectories (Pinhasi et al., 2011), physical activity (Stefanović & Porčić, 2009), and change over time in lower limb cross-sectional geometry (Macintosh et al., 2014; Macintosh et al., 2015). In their analysis of regional variation and change overtime in lower limb bone robusticity in prehistoric and medieval groups in central Europe (including Ostojićevo), Macintosh et al. (2014) found a decrease in compressional strength, bending, and torsional rigidity in the femur and tibia of males, and a shift toward more circular cross-sectional geometry in both males and females. Compared to Neolithic and Bronze Age males, IA and Medieval males exhibited progressive gracilization of the femur and tibia over time, with the most marked changes seen in a reduction in tibial midshaft bending and torsional rigidity. The two northern Serbian groups in the study – the sample from the Neolithic Vinča site of Hrtkovci-Gomolava and the Early/Middle Bronze Age Maros sample from Ostojićevo – were exceptions to this general pattern. Males at both sites had especially low tibial midshaft bending and rotational scores relative to contemporaneous groups, suggesting they were less mobile. In contrast, females showed a progressive trend toward increased circular cross-sectional tibial geometry overtime with no evidence for regional variation in degree of mobility. These findings are noteworthy in that prehistoric groups in northern Serbia diverged from the pattern of greater male lower limb bone strength characteristic of other central European Neolithic and Bronze Age populations.

Comparative studies examining growth velocity and changes in bone shape and robusticity provide evidence for the effects of environmental and technological factors on limb morphology. Specifically, morphological change is associated with functional adaptative responses to change in subsistence economy, mobility, and transportation technology (*e.g.*, horses, watercraft). Taken together, biomechanical adaptations and stature in adults from Ostojićevo suggest conditions of lower mobility and greater developmental stress compared to contemporary groups in central Europe.

5.14 Discussion: Ostojićevo Morbidity and Mortality

Morbidity and mortality in this study were assessed according to the impact of age- and sex-specific biological and behavioral differences on health at Ostojićevo. Briefly, subadults are defined as individuals <20 years at death and adults ≥20 years-at-death, unless otherwise stated. This distinction was based on developmental criteria, outlined in Chapter 4. However, it is likely that sociocultural aspects of age patterns differed from chronologically- or biologically-defined age categories among the EBA Maros (*e.g.*, Elder, 1975; Halcrow & Tayles, 2011). The theoretical and analytic framework employed in this study focused on a "life course epidemiology" approach (Kuh et al., 2002). This approach seeks to identify population-level effects of prenatal, early childhood, and adolescent exposure to physical, environmental, and/or psychosocial stress on adult health and longevity (Agarwal, 2016; Halfon et al., 2014; Kuh et al., 2002). The purpose of adopting this approach was threefold: (1) to test the hypothesis that survival of childhood life-stresses had a negative effect on adult health, including longevity; (2) to provide a general framework in which to situate specific intragroup (age and/or sex) variation in the context of social and/or behavioral factors; and (3) develop a general health profile of subadults and adults, males and females at Ostojićevo that could be compared with datasets from Hungary, northern Serbia, Slovakia, and the Czech Republic.

The purpose of this discussion is not to suggest specific cause(s) of mortality, but to identify possible mechanisms by which early childhood lifestyle factors (*e.g.*, nutrition, environment) and diseases affect differential morbidity and mortality during key stages of human growth and development. A consideration of the skeletal evidence in the context of published archaeological and clinical data provides a means of investigating possible environmental and behavioral factors that contributed to the presence and transmission of infectious disease. For example, the cause and effect of metabolic disorders, such as vitamin B_{12} deficiency megaloblastic anemia, can offer insight into the complex relationship between health and diet. Specifically, how co-factors such as age, age-at-exposure, and prior infection impact heterogeneous frailty in otherwise "healthy" individuals. The presence/absence of skeletal lesions and general mortality patterns present a hypothesis for future research into specific intrinsic (*e.g.*, paleoparasitology, aDNA of infectious pathogens) and extrinsic causes of differential adult mortality in the Bronze Age. As such, an evaluation of morbidity and mortality must consider the age-dependent changes in individual susceptibility and the interplay between nutrition, diet, infectious disease, and the environment on individual and population health.

This study found no evidence of sex differences in skeletal indicators of non-specific stress (*i.e.*, CO, PH, or linear hypoplastic enamel defects (LEH)) in adults or subadults at Ostojićevo (Table 5.21). In contrast to adults, subadults consistently displayed higher frequencies of CO, PH, and LEH as indicators of non-specific childhood stress (Table 5.21). Notably, differences in CO and PH prevalence between adults and subadults were only statistically significant for "active" lesions, not total lesions (combined "active" and "remodeled"). These findings support the hypothesis of increased subadult susceptibility to and mortality from infectious diseases and malnutrition. The implications of these findings for reconstructing health at Ostojićevo are twofold: (1) infant and childhood morbidity influenced mortality, with children experiencing episodic stress (*e.g.*, infectious disease, malnutrition, etc.) less likely to survive to adulthood (higher rates of skeletal indicators of non-specific stress such as CO and PH were also present in adult males and females dying in their early to late 20s); and (2) age - not sex - is the most important demographic predictor of susceptibility to disease and selective mortality.

The high prevalence of CO, PH, and LEH in subadults indicates an increased individual susceptibility to death in children and adolescents that experienced episodic stress at keys points in infancy and early childhood. Notably, the higher prevalence of LEH-C in the upper to mid-third of canine crowns in both males and females dying c. 12-20 years supports an earlier onset of stress contributing to adolescent mortality. However, this pattern is not supported by the distribution of LEH in upper canines or the upper or lower incisors. Among subadults, CO prevalence peaks in individuals (male and female) dying between 1 and 12 years, and PH prevalence peaks in males dying between 6 and 12 years, and in females dying between 1 and 12 years. Among adults, stress (*e.g.*, dietary, behavioral, environmental, pathogenic, etc.) during childhood contributed to increased morbidity and selective mortality in individuals ca. 20 to 40 years-at-death. In males, the prevalence of CO and PH in Adult I individuals was equal to or greater than that for all male subadult age classes. The effect of childhood health on increased risk of adult mortality <40 years was less pronounced in females than in males. Females lived on average three years longer than males, with ~22% of adult females surviving past 50+ years compared to only ~7% of adult males. Differences in the age distribution of skeletal indicators of non-specific stress in adult males versus females may be due to more males dying at a younger age of other factors (*e.g.*, accidents, violence) irrespective of childhood health. Thus, as per the osteological paradox, adult female morbidity and mortality risk was not necessarily less affected by early childhood health, but rather young adult males were disproportionately affected by social or behavioral factors during their 20s and 30s that increased their risk of death independent of earlier exposure to nutritional and/or disease stress (Wood et al., 1992).

Older individuals were susceptible to exhibiting skeletal changes from soil-born fungal infections (mycotic diseases), as indicated by characteristic ovoid or circular mycotic lesions in three adults >40 years-at-death, including one female, one male, and one probable-male. Furthermore, an Adult IV female displayed abnormal cortical bone resorption consistent with hematogenous spread following exposure to pathogenic fungi such as *Sporotrichosis* or *Cryptococcosis neoformans* bacterium (Ortner, 2002). The age of the affected individuals and presence of co-morbidities such as OA indicates the appearance of skeletal lesions is likely due to these individuals being immunocompromised thus increasing their risk of becoming symptomatic rather than a higher incidence of exposure (see Corr et al., 2011). There was also a positive correlation between age and a significant increase in the prevalence of osteophyte formation on vertebral bodies and primary osteoarthritis (degenerative joint disease) in the upper limb (*i.e.*, shoulder, elbow, and wrist). Additionally, primary osteoarthritis was found to exclusively affect Adult IV individuals (>50 years) in the proximal radius, distal radius, carpals, metacarpals, hand phalanges, distal femur, patella, and distal tibia.

Table 5.21 Ostojićevo non-specific stress by sex, age, and statistical significance (yes/no). SA = subadults, A = adults. Parentheses indicate group with significantly higher rate.

	SA %	A %	Age	SA Male %	SA Female %	SA Sex	A Male %	A Female %	A Sex
CO Total	55.1	45.3	No	59.1	59.1	No	44.4	36.4	No
CO Active	51.1	8.0	Yes (SA)	54.5	59.1	No	3.7	9.1	No
PH Total	25.5	20.7	No	21.4	26.1	No	26.5	11.8	No
PH Active	18.2	3.4	Yes (SA)	14.3	17.4	No	2.9	5.9	No
LEH-C	73.7	45.6	Yes (SA)	66.7	77.8	No	37.0	44.0	No
LEH-I	61.5	38.2	Yes (SA)	60.0	60.0	No	34.6	52.6	No

5.15 Conclusion

The Maros lived in small one- or two-roomed single-family houses, often separated by a small corridor. Thus, settlements were characterized by individuals and families living close together with little difference in household layout and size. Settlements were almost always placed adjacent to or near running water in the form of either a river or stream. As well as providing a source of drinking water for humans and livestock, rivers and streams also functioned as key transportation routes that linked villages with the Maros region as well as to neighboring areas to the north in the Great Hungarian Plain (O'Shea, 2011). While far from an urban metropolis, this environment would have contributed to the spread of infectious diseases such as dysentery, gastroenteritis, and parasitic intestinal infections, among others due to poor sanitation and contamination of drinking water by human and domestic animal fecal matter (Esrey et al., 1991). Despite small population size, high population density in many Maros villages coupled with open defecation would have led to the spread of diarrheal diseases, despite the rural setting (see Hathi et al., 2017). Contemporary metanalyses of the interaction between water quality, sanitation, and childhood health have found a strong association between poor sanitation and high under five-year-old diarrhea mortality, all-cause mortality, and all-cause neonatal mortality (Esrey et al., 1991). Short-term diarrheal morbidity includes frequent loose and/or bloody stools and dehydration, whereas more long-term effects include wasting and stunting (Kosek et al., 2003; Lampl & Johnston, 1996). Several studies have identified confounding factors that prolong the duration of diarrheal disease episodes and/or increase risk of diarrheal death, notably undernutrition, associated major infection (*e.g.*, pneumonia, meningitis), severe wasting, severe stunting, and illness lasting longer than 14 days (Black et al., 2008; Richard et al., 2013). While dehydration is the most common cause of infant death from diarrheal disease, general health status cannot be discounted in understanding why neonates, infants, and young children may be at a higher risk of infectious and diarrheal disease mortality. Interestingly, periostitis was not widespread at Ostojićevo, indicating that individuals succumbed to infectious diseases before it could affect the skeleton. Alternatively, infection rates from diseases known to involve the skeleton and that have been identified at other prehistoric sites in the Carpathian Basin, such as tuberculosis, were low to non-existent at Ostojićevo (Masson et al., 2007; Spekker et al., 2012). Furthermore, a single individual with granulomatous and lytic lesions on the ectocranial surface of the cranial vault provides tentative evidence of treponemal infection in the Ostojićevo population; however, if this is a case of advanced treponematosis, the absence of postcranial involvement indicates an atypical presentation (see Buckley & Dias, 2002).

Further research at Ostojićevo is necessary to examine the influence of confounders, such as weaning age and stunting, on early childhood morbidity and mortality. For example, LEH suggests breastfeeding may have continued until two years of age, with two to four years being the most common period for developing LEHs. Early cessation of breastfeeding could be responsible for neonatal deaths and early onset of skeletal indicators of non-specific stress in some individuals (Agarwal, 2016; Lewis, 2007). Furthermore, supplemental foods may have been nutritionally insufficient and also a source of contamination due to unsanitary food preparation and feeding practices (Black et al., 2008; Ochoa et al., 2009). There is a tentative link between childhood health and morbidity and mortality later in life at Ostojićevo, especially among males c. 20-40 years. This link is further supported by the relatively low prevalence of CO, PH, and LEH in adults >40 years. The occurrence of healed CO and PH in Adult IV females represents a statistical of more women living to older ages rather than older adult females being healthier than older adult males (see Wood et al., 1992).

6.0 Trauma

6.1 Methods: Ostojićevo Trauma

Skeletal trauma may include a broad range of lesions, including abnormal displacement or dislocation, pathological fractures, “weapon” injuries, artificial manipulation of shape and/or contour, amputation, and trepanation (Judd & Redfern, 2012; Roberts & Manchester, 2005). Skeletal trauma was classified according to mechanism: sharp force trauma (SFT), blunt force trauma (BFT), or projectile (Appendix Figure 2) (Komar & Buikstra, 2008). To ensure consistency in describing and evaluating possible trauma, each case was further assessed for: timing and healing (antemortem, perimortem, or postmortem), fracture type (simple or open, partial/greenstick, partial/avulsion, partial/longitudinal, complete/transverse, complete/spiral, complete/comminuted, or compression), and complications (*e.g.*, secondary infection, persistent disability or deformation, joint disease, pseudoarthrosis or re-injury, etc.) (SWGANTH, 2011). Finally, evidence of underlying disease or conditions that may have contributed to or exacerbated the injury were also noted.

When possible, depending on preservation, healing, and visibility, certain measurements were recorded for BFT, SFT, and projectile trauma. For BFT, these included: configuration (difference in affected bone length compared to corresponding bone length; distance from distal end in long bones; and maximum supero-inferior, medio-lateral, and antero-posterior dimensions); apposition (proximo-distal and antero-posterior overlap); rotation (proximal relative to distal compared to normal); and angulation defined as displacement from midline (Byers, 2017; Lovell, 1997). For SFT and projectile trauma, these included: length, width, and depth of the puncture, incision, or cleft. SFT and projectile trauma were also systematically assessed for shape, associated fracture(s), and unilateral or bilateral flaking, and/or feathering/hinging (Byers, 2017; Lewis, 2008; Lynn & Fairgrieve, 2009).

Trauma affecting vertebral bodies was considered separately. Avulsion and crush (wedge) fractures were diagnosed and described according to criteria outlined in Maat and Mastwijk (2000). Diagnosis and description of vertebral compression fractures followed Buikstra and Ubelaker (1994: 116) and Ortner (2003:121-122). Fractures were classified according to type, location (*i.e.*, vertebrae type and number if possible and region as cervical, thoracic, and lumbar), timing (evidence of healing), force (*i.e.*, flexion, extension, rotation, or compression). As spondylolysis and Schmorl's nodes have an uncertain etiology as associated with trauma, development defects, or biomechanical stress, they were considered separately in Chapter 5 (see D'Orazio, 1999; Faccia & Williams, 2008; Ortner, 2003).

CPR was only calculated for skeletal elements with at least one example of BFT or SFT. Elements were separate by side, unless otherwise noted. Only cranial and postcranial elements with sufficient preservation, generally "good" or better, were included in calculating CPR. CPR for vertebral body trauma was calculated by region: cervical (excluding C1 and C2), thoracic, and lumbar.

6.2 Methods: Mokrin Trauma

Mokrin crania were not available for analysis. Lidija Milašinović, the director of the Narodni Muzej Kikinda, reported that crania had been moved to Belgrade or Novi Sad prior to her tenure at the museum. At least two crania from Mokrin exhibiting likely trepanations are on display as of August 2014 at the Muzej Vojvodine, Novi Sad, Serbia. There are no published descriptions of postcranial trauma from Mokrin. Cranial trauma from Mokrin has been described, but has not been studied systematically. Comparative analysis of cranial trauma relied on published descriptions by Farkas & Lipták, 1971 and Rega, 1995. Rega (1995) briefly reviews trauma at Mokrin. She notes that the Grave 208 individual, who was buried with an axe placed so the cutting edge faced inwards towards the chin, may have died from traumatic injuries to the skull. Farkas & Lipták (1971) provide a slightly more detailed analysis, with an emphasis on differential diagnosis of traumatic cranial lesions as trepanation, possible trepanation, BFT, or unknown.

6.3 Results: Ostojićevo Craniofacial Trauma

6.3.1 Blunt Force Trauma

Craniofacial blunt force trauma (BFT) was uncommon at Ostojićevo. Individual cases are presented in Appendix Table 13 and CPR for BFT by sex are listed in Table 6.1. Three males under 40 years-at-death and one female 40-50 years-at-death exhibited BFT to the cranial vault. Of these four cases, two exhibited antemortem injuries (Figure 6.1 and 6.2) and two suffered perimortem injuries (Figure 6.3 and 6.4). There were no examples of mixed antemortem and perimortem wounds.

Excavation reports include descriptions of two additional individuals with BFT to the cranial vault. The excavation record for Grave 180 describes the remains of an adult male with a ca. 2.0 cm opening on the top of the skull that was interpreted as the result of a trepanation. Neither the cranial nor postcranial remains associated with Grave 180 could be located. The museum record for Grave 185 describes a ca. 1.8 cm circular fracture on the occipital resulting from a blow to the back of the head. While the cranial remains could not be located, the postcranial skeleton was available for analysis and had bilateral antemortem BFT to the shoulder and upper arms (described in section 7.2.1). Both cases were excluded from analysis of trauma frequency at Ostojićevo due to uncertainties about injury diagnosis, location, and timing.

Table 6.1 CPR (%) of craniofacial elements with BFT and/or SFT at Ostojićevo by biological sex.

Element + Side	Male (n_1*)	Male (n_2**)	Male %	Fem. (n_1)	Fem. (n_2)	Fem. %	Juv. I/II (n_1)	Juv. I/II (n_2)	Juv. I/II %
Frontal (Right)	33	2	6.1	38	1	2.6	12	0	0.0
Parietal (Right or Left)	37	3	8.1	37	0	0.0	17	1	5.9
Occipital	36	0	0.0	44	0	0.0	17	1	5.9
Zygoma (Left)	27	1	3.7	31	0	0.0	16	0	0.0

***Note*. * n_1 = total element count; ** n_2 = affected element count**

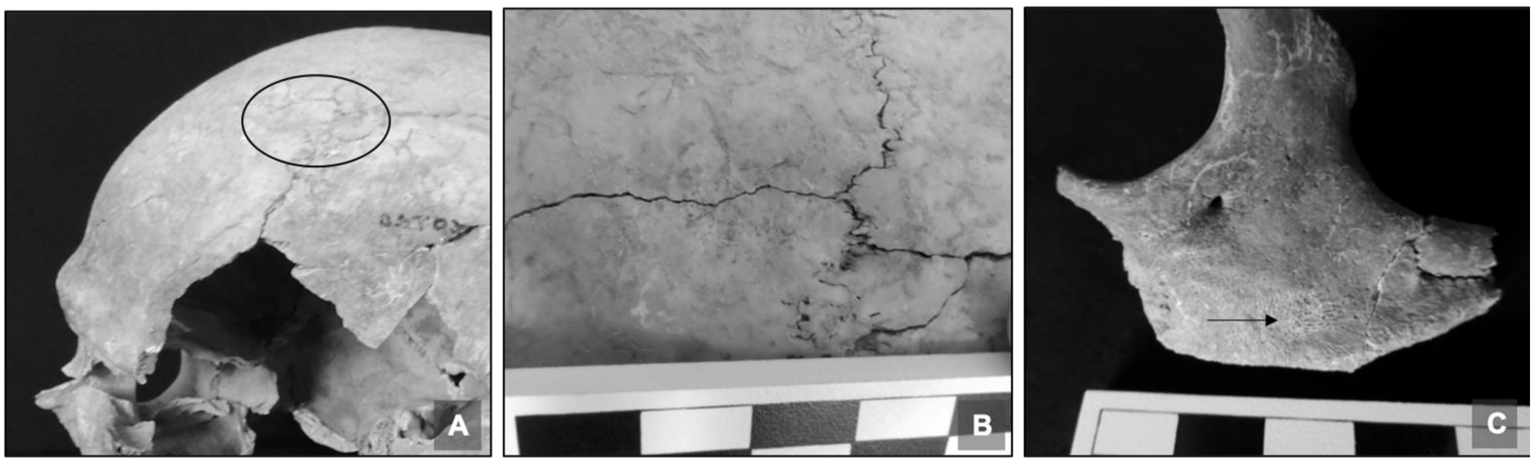


Figure 6.1 Antemortem craniofacial trauma to the left frontal and zygoma in an Adult II male (Grave 223). Left frontal BFT (circle, A; detail, B) and periostitis from possible facial laceration on left zygoma (arrow, C).

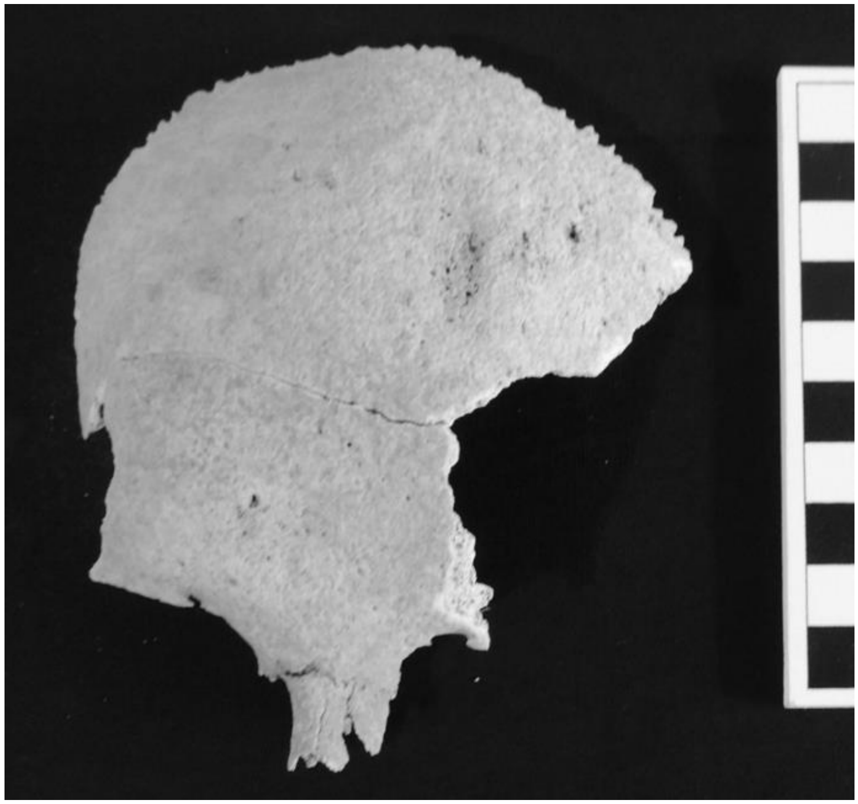


Figure 6.2 Antemortem BFT to left frontal in an Adult III female (Grave 191).

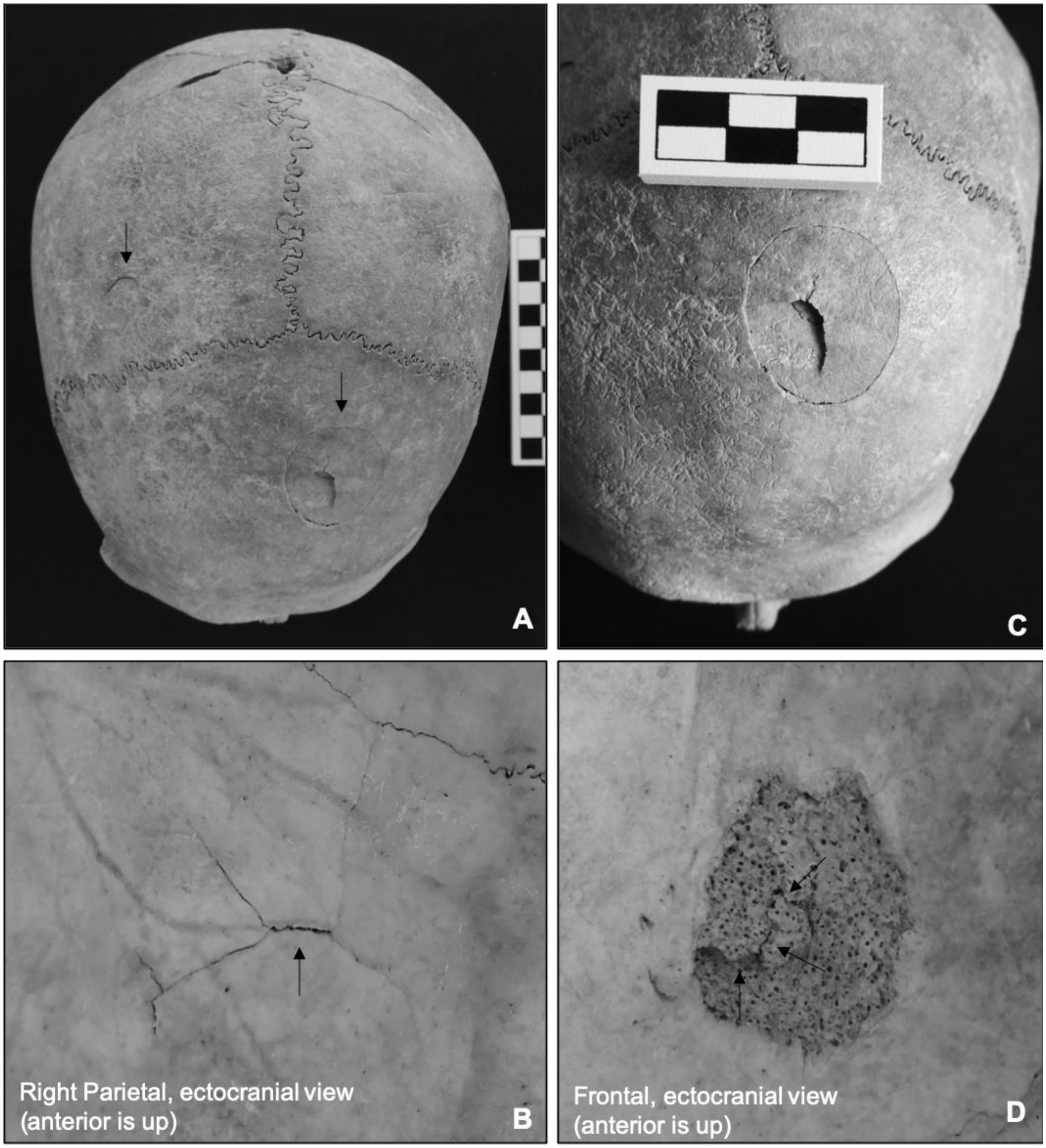


Figure 6.3 Perimortem cranial trauma in an Adult I male (Grave 230). (A) Superior view of cranial vault showing fractures (arrows) to right parietal and left frontal; (B) endocranial view of semicircular fracture (arrow) of right parietal, note radiating terminal fracture lines; (C) detail of concentric circular and semicircular fractures to left frontal; (D) endocranial detail of left frontal showing displacement of cortical bone plug, note taphonomic damage to fracture margins.

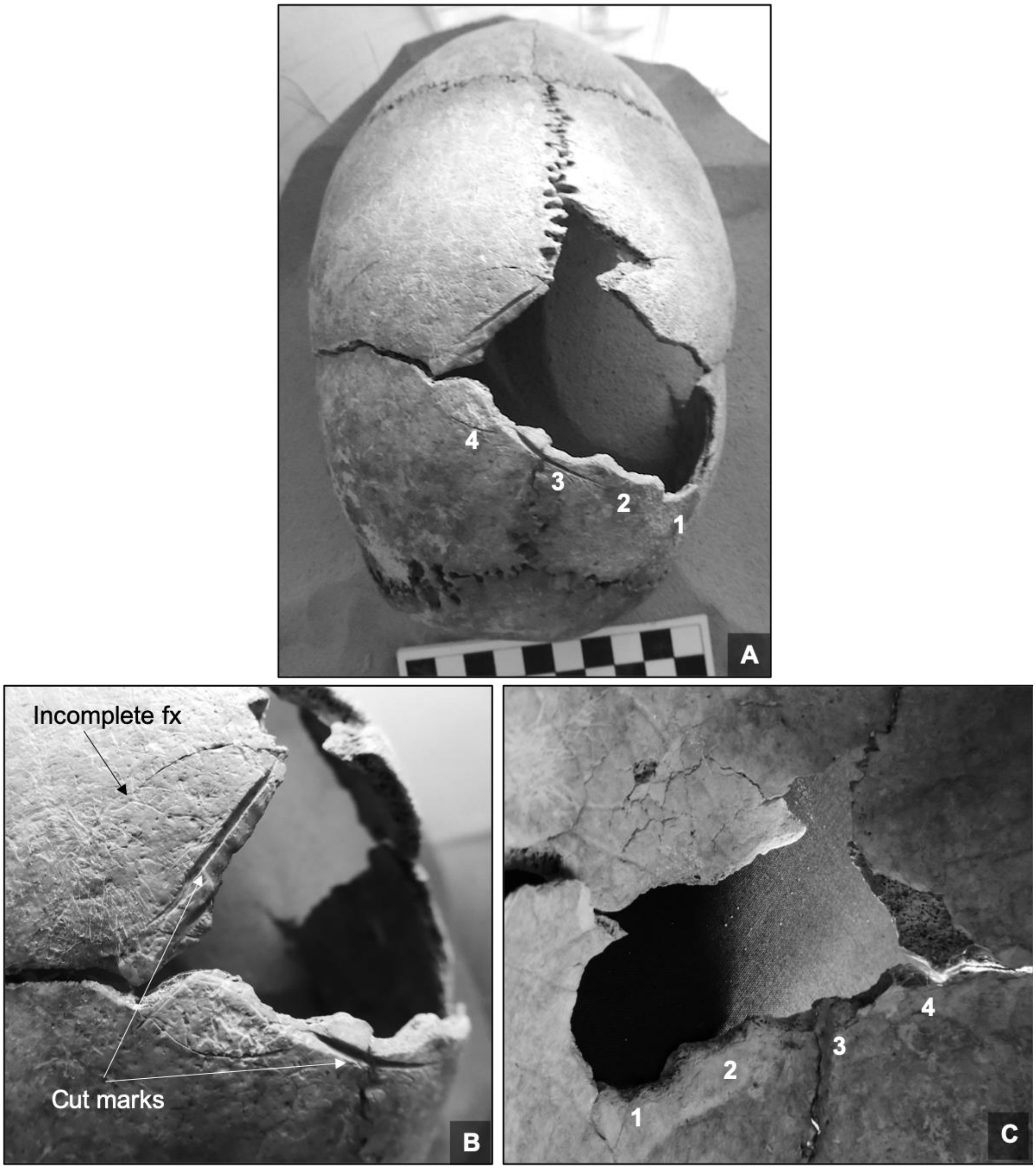


Figure 6.4 Perimortem BFT and SFT in a Juv. II probable-male (Grave 268). (A) Four overlapping circular fractures to posterior parietals crossing sagittal suture; (B) detail of left-lateral circular fracture with cutmarks (arrows) along inferior margin and superior margins of areas of perimortem bone loss/removal (B); (C) endocranial view, note thin fracture line radiating anteriorly from superior margin.

6.3.2 Sharp Force Trauma

Two cases of SFT not associated with BFT or trepanation (*i.e.*, Grave 268) were observed (Appendix Table 13). An Adult II male (Grave 274) displayed a single perimortem cutmark to the right parietal (Figure 6.5). The cut extended ca. 9.2 mm anterior-posterior and had unilateral flaking on the medial border and a V-shaped kerf. No additional evidence of antemortem or perimortem trauma was identified in this individual. An Indeterminate Adult Male (Grave 131) displayed two perimortem sharp-force weapon injuries to the right parietal (Figure 6.6). The more anteriorly placed injury measured ca. 15.5 mm mediolaterally by 5.9 mm anteroposteriorly; the smaller injury measured ca. 8.0 mm mediolaterally by ca. 3.0 mm anteroposteriorly. Both were less than 1.0 mm deep with a V-shaped kerf. These injuries are consistent with trauma from a straight edged weapon (Waldron, 2009:156). This individual also displayed a small perimortem cutmark on the anterior margin of the left superior articular facet and lateral margin of the right superior articular facet. The remains were discovered in a disturbed burial adjacent to the partially disturbed burial of an Adult II Male (Grave 129) (Girić *in* Milašinović, 2008). Only the cranium and several elements from the upper extremities were recovered from Grave 131.

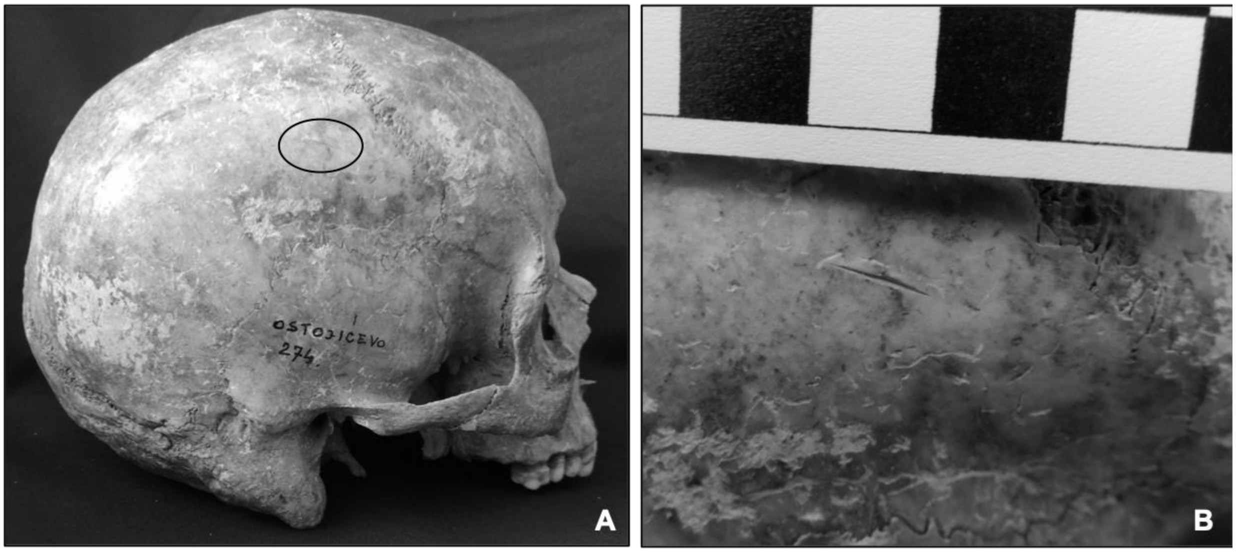


Figure 6.5 Perimoterm cranial SFT in an Adult II male (Grave 274). (A) Right-lateral view of cranium with cutmark (circle); (B) Detail of cutmark.

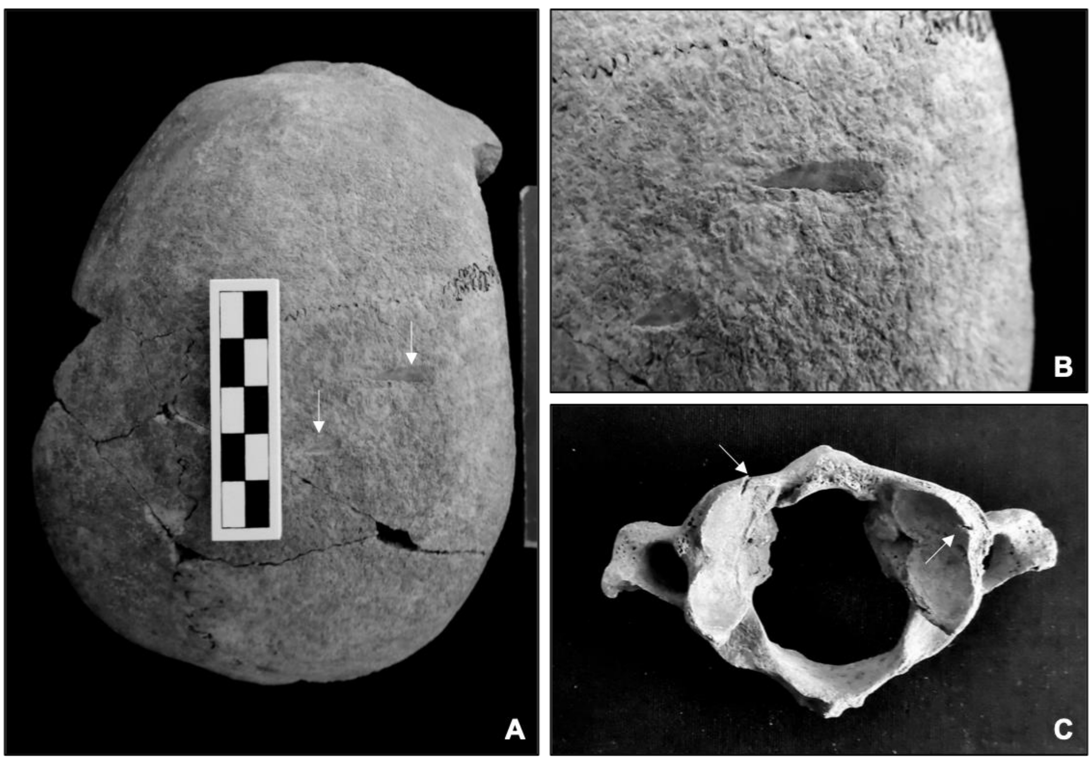


Figure 6.6 Perimortem cranial and vertebral SFT in an Adult male (Grave 131). (A) Perimortem injuries to right parietal (arrows) made with a straight edged weapon; (B) Detail of injuries; (C) Cut marks (arrows) to atlas vertebra.

6.4 Results: Ostojićevo Postcranial Trauma

6.4.1 Blunt Force Trauma

CPR of BFT by sex are listed in Table 6.2; individual cases of BFT are presented in Appendix Table 14. Frequencies of BFT to rib bodies were not calculated due to inter- and intra-individual variation in rib completeness. All BFT was antemortem. CPR was greater for males than for females for all elements except the sternal body, metacarpals, and fibula (Table 6.2). Of the 11 individuals with evidence of BFT, 0.9% (*n* = 1) were between 12 and 20 years-at-death, 54.5% (*n* = 6) 20 to 40 years-at-death, 1.8% (*n* =2) older than 40 years-at-death, and 1.8% (*n* =2) were adults of indeterminate age-at-death.

The body regions most affected by trauma were the shoulder girdle (*n* = 7), (radius and/or ulna, *n* = 4) (Figure 6.7 and 6.8), rib cage (*n* = 3) (Figure 6.9), forearm and distal fibula (*n* = 2) (Figure 6.10 and 6.11). Of the 11 individuals with healed postcranial BFT, eight displayed trauma to a single element or region (*e.g.*, shoulder, ankle). Complications such as apposition, angulation, and/or rotation of affected elements were nonexistent or slight. Only one individual, Grave 226, showed evidence of osteomyelitis consistent with bacterial infection from an open wound (Figure 6.12). The preponderance of acute low-impact type injuries consistent with closed complete fractures further supports a differential diagnosis of accidental causes, such as falls from a short height, physically strenuous habitual activities targeting the upper extremities, and working with domestic animals (Eshed et al., 2010; Moini et al., 2011).

Interpersonal violence was suggested as the cause of the unique injury pattern observed in two individuals: Grave 226 and Grave 185. Of the three individuals with forearm fractures, one Adult II male (Grave 226) displayed multiple injuries: a parry fracture of the distal third of the left ulnar diaphysis, a Smith’s fracture of the left radius, transverse fracture of the left clavicle, and dislocation of the left glenohumeral joint (Figure 6.12 and 6.13). It is hypothesized that the injuries resulted from a single traumatic event involving a direct blow or series of blows to the left-side of the body, as only the left-side was affected and all injuries were at a similar stage of healing at time of death (Judd, 2002b; 2006). A similar trauma pattern was observed in a Juvenile I probable-male (Grave 185). This individual experienced bilateral dislocation of the glenohumeral joint resulting in Hill-Sachs lesion and Bankart deformity (Figure 6.14). The presence of a Hill-Sachs lesion, characterized by a bony defect to the posterolateral aspect of the humeral head, is consistent with anterior shoulder dislocation and compression of the humeral head into the anterior glenoid rim, typically when the shoulder is abducted and externally rotated as it would be when throwing or setting down a heavy weight (Cresswell & Smith, 1998; Fox et al., 2017; Hill & Sachs, 1940). Additional possible mechanisms of injury include assault, seizure, falls from a height >2 m, and participation in contact sports. Bankart deformities were identified on the corresponding anteroinferior glenoid surface. Often found in conjunction with Hill-Sachs lesions (Provencher et al., 2012), Bankart deformities form via avulsion of a bone fragment from the anterior glenoid surface due to injury to the joint capsule and labrum (Woertler & Waldt, 2006). The unique constellation of multiple upper extremity injuries associated with extreme joint positions and dislocation are seen clinically in association with combat-type sports such as wrestling (Agel et al., 2007; Pappas, 2007). These patterns are consistent with injuries likely sustained during interpersonal combat.

Table 6.2 CPR (%) of postcranial elements with BFT and/or SFT by biological sex at Ostojićevo

Element* + Side	Male (n_1**)	Male (n_2***)	Male %	Female (n_1)	Female (n_2)	Female %	Juv. I/II (n_1)	Juv. I/II (n_2)	Juv. I/II %	Tota l (n_1)	Total (n_2)	Total %
Sternum (body)	13	0	0.0	8	1	12.5	7	0	0.0	28	1	3.6
Clavicle (right or left)	38	2	5.3	39	0	0.0	20	1	5.0	97	3	3.1
Scapula (glenoid, right or left)	33	2	6.1	38	0	0.0	11	1	9.1	82	3	3.7
Humerus (prox., right or left)	27	0	0.0	35	0	0.0	17	1	5.9	79	1	1.3
Radius (distal, right or left)	30	2	6.7	38	1	2.6	14	0	0.0	82	3	3.7
Ulna (distal, left only)	19	1	5.3	27	0	0.0	16	0	0.0	62	1	1.6
Metacarpals (left only)	16	0	0.0	19	1	5.3	9	0	0.0	44	1	2.3
Pubis (left only)	14	1	7.1	23	0	0.0	15	0	0.0	52	1	1.9
Fibula (distal, right only)	25	1	4.0	23	1	4.3	10	0	0.0	58	2	3.4

***Note*. * includes only elements or regions of elements with MPI > 0.25, at least 3 metacarpals; **n_1 = total element count; *n_2 = affected element count.**

Figure 6.7 Healed Smith's fracture in an Adult II male (Grave 66B). (A) Right radius anterior view; (B) posterior view.

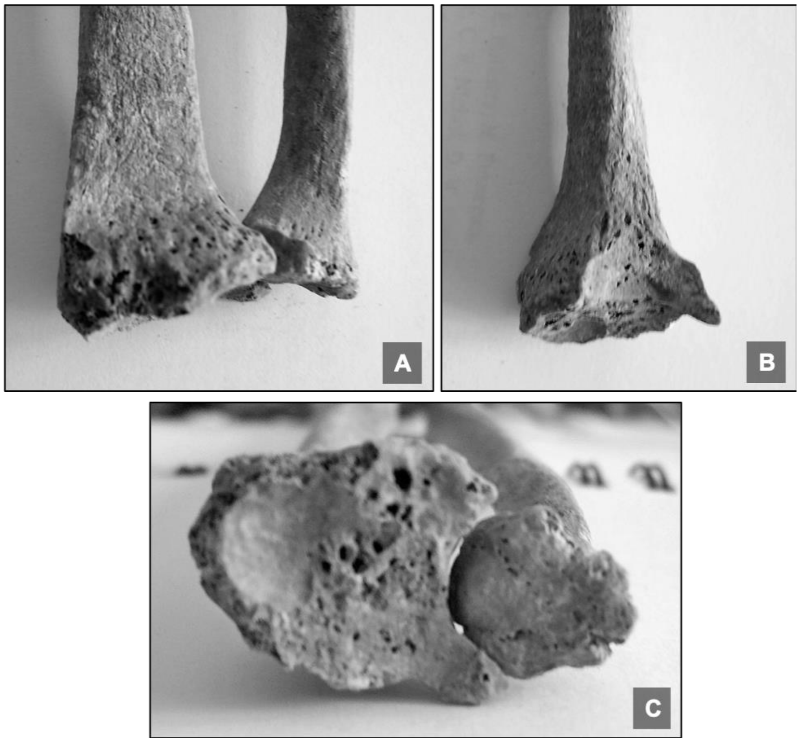


Figure 6.8 Well-healed Colles' fracture in an Adult III female (Grave 64). (A) Right radius and ulna, anterior view; (B) medial view; (C) distal view (note OA on distal articular surfaces and anterior and posterior expansion of distal radius).

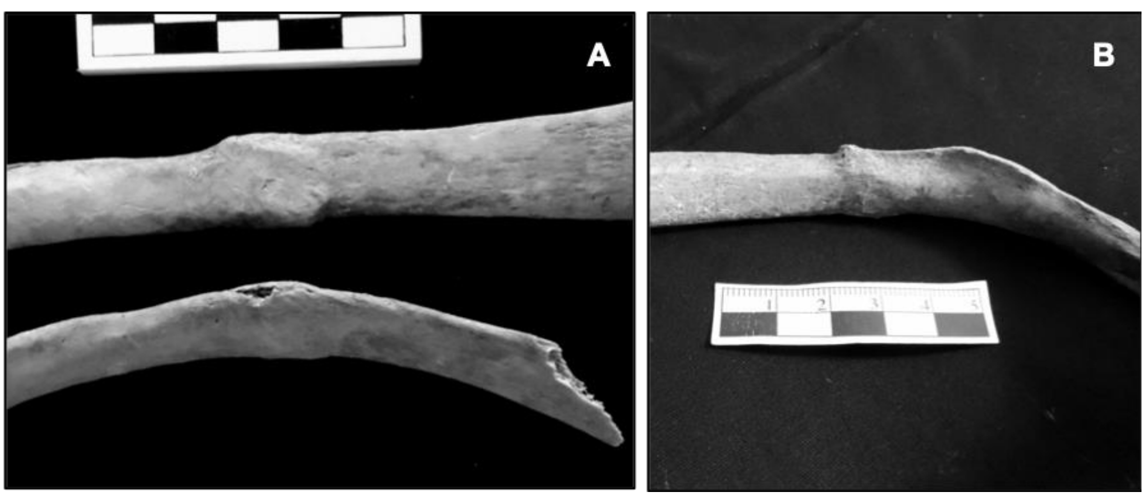


Figure 6.9 Antemortem transverse rib fractures. (A) Right ribs 4 & 5, ventral view, Adult II male (Grave 156); and (B) Right rib 7, dorsal viewAdult I female (Grave 147).

Figure 6.10 Right distal fibula, well-healed oblique fracture in an Adult I female (Grave 41). (A) Anterior view; (B) posterior view.

Figure 6.11 Right distal fibula, well-healed oblique fracture of the lateral malleolus in an Adult III male (Grave 251). (A) Medial view; (B) lateral view.

Figure 6.12 Antemortem trauma to the left shoulder in an Adult II male (Grave 226). (A) Superior view of left clavicle; (B) Transverse open fracture of left clavicle, inferior view (note cloacae, arrows); (C) Inferolateral expansion of glenoid fossa due to dislocation of left shoulder.

Figure 6.13 Healed Parry fracture and Colles' fracture in an Adult II male (Grave 226). (A) Left radius and ulna, anterior view; (B) anterior view (ulna) and lateral view (radius); (C) posterior view (ulna) and medial view (radius); (D) Distal view, note osteoarthritis and myositis ossificans.

Figure 6.14 Healed bilateral shoulder injuries in a Juv. I probable-male (Grave 185). (A) Recurrent bilateral anterior shoulder dislocation; (B) Detail of right proximal humerus with Hill Sachs deformity (arrows); (C) Detail of right glenoid fossa with Bankart lesion (arrow).

6.4.2 Sharp Force and Penetrating Trauma

A single case of sharp force or penetrating trauma was observed (Appendix Table 14). An Adult IV female (Grave 115) displayed a perimortem circular injury to the inferior portion of the sternal body (Figure 6.15). The dorsal surface was unaffected. The injury, which was ca. 9.6 mm mediolaterally by 6.2 mm superior inferiorly, had a "punched-in" appearance in the center with hinging along the margins. A hairline fracture extended inferiorly ca. 9.2 mm. This individual had several pathological changes associated with advanced age and/or heavy labor, including spondylolysis (L5), vertebral osteophytosis, triceps tendinopathy, and stage 2-3 OA in the right acromioclavicular and glenohumeral jojnts (left side absent), right and left proximal ulnae, right distal ulna (left side normal), right trapezium (left side absent), and left distal fibula (right side normal).

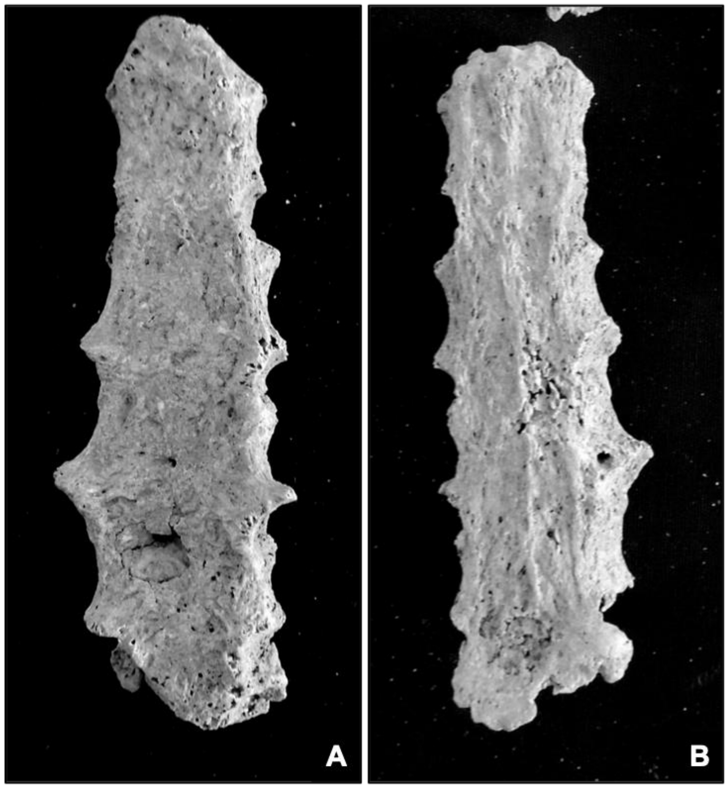


Figure 6.15 Perimortem puncture wound to the inferior sternal body in an Adult IV female (Grave 115). (A) Ventral view; (B) Dorsal view.

6.4.3 Vertebral Trauma

Vertebral trauma was identified in twelve individuals (Appendix Table 15). No subadults exhibited vertebral trauma. Total TPR was 2.1%; male TPR was 1.9% and female TPR was 2.1% (Table 6.3; Figure 6.16). Cervical (*TPR* = 3.3%) were most affected in males, whereas the thoracic vertebrae (*TPR* = 3.6%) were the most affected in females. There was a single case of trauma in a cervical vertebra and no trauma in lumbar vertebrae in females. Overall, trauma was uncommon in Adult I (<1.0%) and Adult II (<1.0%), with prevalence increasing for Adult III (*TPR* = 3.2%) and Adult IV (*TPR* = 5.7%) individuals. The highest prevalence was seen in Adult IV females (8.4%).

Endplate avulsion was more common in males (*n-individual* = 5) than females (*n-individual* = 1) and affected the thoracolumbar and cervical vertebrae. There was no relationship between endplate avulsion and age-at-death. Compression with cavitation of the anterior corner of the vertebral body with "step-off" deformity occurred in four of the individuals with endplate avulsion, which is consistent with injury resulting from hyperflexion after fusion of the annular epiphysis (Maat & Mastwijk, 2000). Most cases involved a single vertebra, with only one individual (Grave 251) displaying endplate avulsion in multiple vertebral regions.

Compression-type fractures were identified in four individuals, including two females, one probable-female, and one male. Adults 50+ years-at-death were affected in three of the four cases. This pattern suggests that compression fractures were associated with age-related bone loss and attrition linked to osteoporosis and/or spinal osteoarthrosis. Thoracic vertebrae, especially in the upper and mid-thoracic regions, were the most affected. Spinal kyphosis was identified in two individuals, one (Figure 5.41) with a likely senile onset and the other (Figure 6.17) consistent with mild Scheuermann's Kyphosis (Ortner, 2003).

Two cases of rotational trauma were associated with Adult IV females (Figure 6.18). Both involved the mid- to lower thoracic vertebrae and were healed at time-of-death. Poor preservation of associated neural arches precluded assessment of evidence of posterior disruption (*i.e.*, displacement of the body posteriorly into the vertebral foramen). Despite the risk of spinal instability and/or retropulsion of vertebral fragments into the vertebral foramen, neither individual exhibited evidence of chronic physical impairment.

Table 6.3 Vertebral trauma TPR (%) by biological sex, age-at-death, and vertebral region at Ostojićevo. No trauma observed for C1 or C2.

Sex + Age	N*	Cervical (C3 to C7)			Thoracic			Lumbar			TOTAL		
		n1**	n2***	%	n1	n2	%	n1	n2	%	n1	n2	%
Adult I	12	34	1	2.9	87	0	0.0	36	0	0.0	157	1	0.6
Adult II	11	31	0	0.0	74	0	0.0	36	0	0.0	141	0	0.0
Adult III	8	15	2	13.3	33	2	6.1	18	0	0.0	66	4	6.1
Adult IV	3	6	0	0.0	14	0	0.0	12	2	16.7	32	2	6.3
Adult ?	6	6	0	0.0	10	0	0.0	4	1	25.0	20	1	5.0
TOTAL Male	40	92	3	3.3	218	2	0.9	106	3	2.8	416	8	1.9
Adult I	9	31	0	0.0	78	1	1.3	36	0	0.0	145	1	0.7
Adult II	11	26	0	0.0	74	1	1.4	33	0	0.0	133	1	0.8
Adult III	6	17	0	0.0	37	1	2.7	16	0	0.0	70	1	1.4
Adult IV	9	20	1	5.0	57	7	12.3	18	0	0.0	95	8	8.4
Adult ?	9	26	0	0.0	34	0	0.0	9	0	0.0	69	0	0.0
TOTAL Female	44	120	1	0.8	280	10	3.6	112	0	0.0	512	11	2.1
Adult I	10	15	0	0.0	32	0	0.0	27	0	0.0	74	0	0.0
Adult II	1	1	0	0.0	9	0	0.0	2	0	0.0	12	0	0.0
Adult III	1	4	0	0.0	11	0	0.0	4	0	0.0	19	0	0.0
Adult IV	5	7	0	0.0	28	0	0.0	13	0	0.0	48	0	0.0
Adult ?	25	26	0	0.0	47	3	6.4	13	2	15.4	86	5	5.8
TOTAL Indeterminate	42	53	0	0.0	127	3	2.4	59	2	3.4	239	5	2.1
Adult I	31	80	1	1.3	197	1	0.5	99	0	0.0	376	2	0.5
Adult II	23	58	0	0.0	157	1	0.6	71	0	0.0	286	1	0.3
Adult III	15	36	2	5.6	81	3	3.7	38	0	0.0	155	5	3.2
Adult IV	17	33	1	3.0	99	7	7.1	43	2	4.7	175	10	5.7
Adult ?	40	58	0	0.0	91	3	3.3	26	3	11.5	175	6	3.4
TOTAL	126	265	4	1.5	625	15	2.4	277	5	1.8	1167	24	2.1

***Note.* * N = individual count; ** n1 = pooled element count; *** n2 = pooled affected element count**

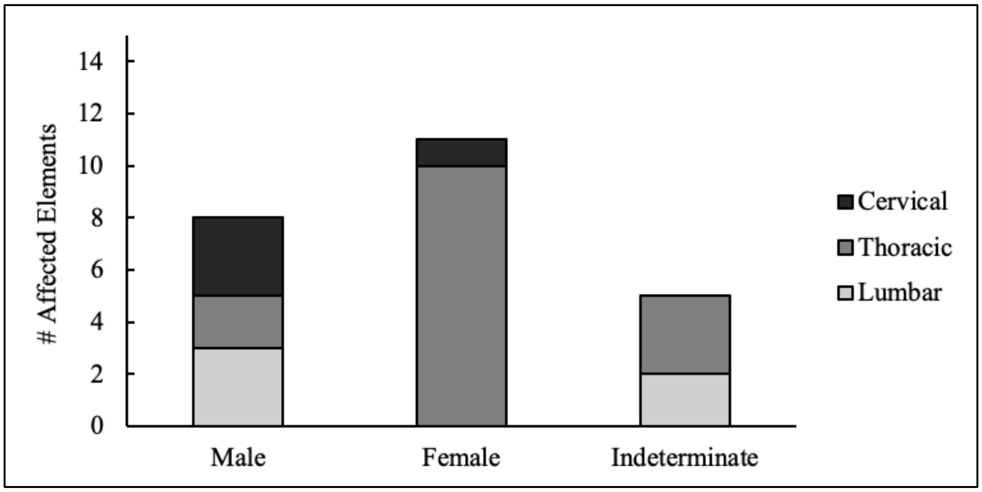


Figure 6.16 Distribution of vertebral trauma by biological sex and vertebral region at Ostojićevo

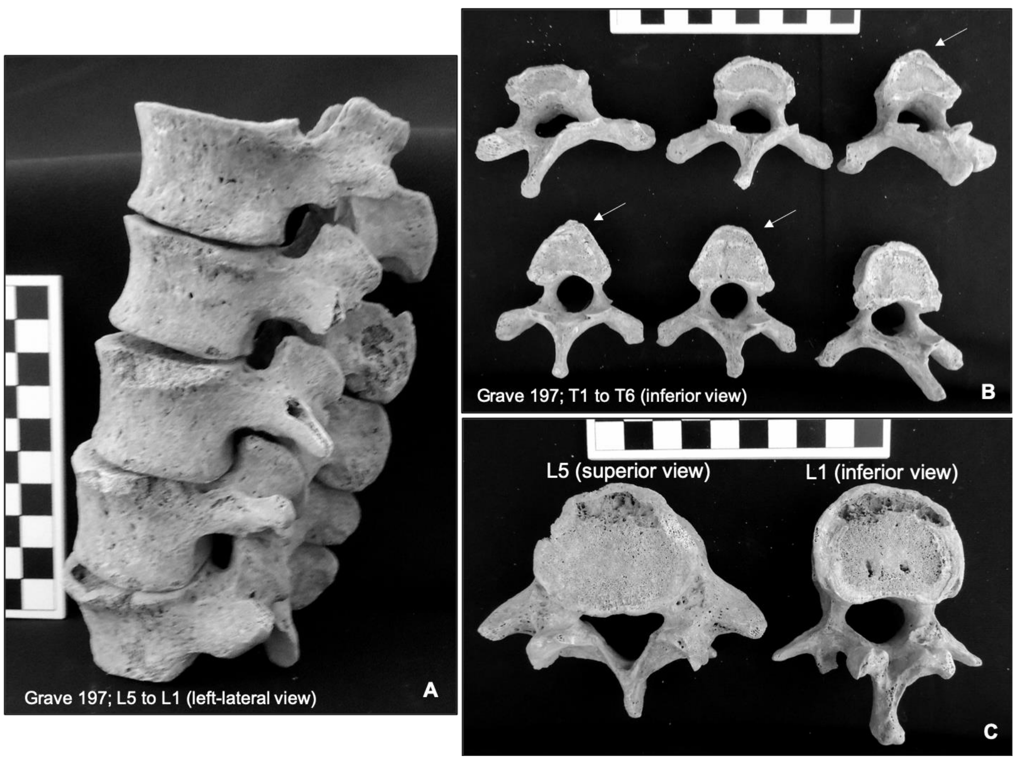


Figure 6.17 Multiple vertebral trauma in an Adult (Grave 197) (A) L5 superior endplate avulsion with anterior displacement associated with hyperflexion and L1 inferior endplate avulsion without displacement associated with hyperextension; (B) Possible Scheuermann's Kyphosis, note extension of body beyond annular rings (T3 to T5, arrows); (C) Detail of L1 and L5 endplate avulsion.

Figure 6.18 T10 burst fracture with lateral subluxation in an Adult III female (Grave 170).

6.5 Results: Statistical Analysis of Trauma at Ostojićevo

Analysis of trauma by isolated versus multiple traumas demonstrated differences between adult males (Table 6.4), adult females (Table 6.5), and subadults (Table 6.6). Inter-individual variation in preservation meant that more cases of trauma existed than were observed, especially in the vertebral column. Despite this, the crude prevalence (CPR) of total trauma (individuals with at least one injury) was 26.2% of adult males (n = 11), 26.7% of adult females (n = 12), 6.3% of probable-females (n = 1), and no probable-males. There was no significant difference in total trauma CPR between males and females (χ^2 = 0.003, df = 1, p = .96). CPR for total trauma by age-at-death included 8.3% of juveniles I and II (n = 2), 25.0% of Adult Is (n = 6), 25.0% of Adult IIs (n = 6), 29.4% of Adult IIIs (n = 5), 27.8% of combined Adult III/IVs and Adult IVs (n = 5), and 5.0% of indeterminate-Adults (n = 2). There was no significant relationship between total trauma CPR in Adult I/II versus Adult III/IV individuals (χ^2 = .133, df = 1, p = .716). When sex and age-at-death were combined, prevalence of sex-specific trauma was similar for Adult III and Adult IV individuals, but higher for Adult I females and Adult II males (Figure 6.19).

Table 6.4 Age-at-death, timing of injury, and affected elements among adult males at Ostojićevo

Grave	Age-at-Death	Element(s)	Timing	Complications
106	Adult I	3rd Cervical	Ante.	Endplate avulsion & secondary compression
230	Adult I	Parietal (right) + Frontal (left)	Peri.	Death
66B	Adult II	Radius (right)	Ante.	Slight angulation & OA
156	Adult II	Pubis; Ribs #4 + 5	Ante.	Slight rotation & periostitis; callus formation
223	Adult II	Frontal (left)	Ante.	Well-healed depression; periostitis
226	Adult II	Clavicle (left); Scapula (left); Radius (left); Ulna (left); Carpals (left)	Ante.	Osteomyelitis and angulation; Dislocation, OA, joint instability; Slight angulation, OA, & myositis ossificans; OA; OA & myositis ossificans.
274	Adult II	Parietal (right)	Peri.	Death
192	Adult III	Thoracic (upper)	Ante.	Endplate avulsion, hematoma, & secondary compression
251	Adult III	Fibula (right); 3rd + 4th Cervical; 1st Thoracic	Ante.	Well-healed; endplate avulsion, hematoma, & secondary compression
101	Adult III/IV	2nd + 3rd Lumbar	Ante.	Wedging
52	Adult ?	Clavicle + Scapula (right); 4th Lumbar	Ante.	Joint instability; endplate avulsion & secondary compression

Table 6.5 Age-at-death, timing of injury, and affected elements among adult females at Ostojićevo

Grave	Age-at-Death	Element(s)	Timing	Complications
41	Adult I	Fibula (right)	Ante.	Slight angulation
69	Adult I	Ribs #11 + 12	Ante.	Bony callus
147	Adult I	Rib #7	Ante.	Bony callus
176*	Adult I	9th Thoracic	Ante.	Wedging/compression, marginal sclerosis & porosity
21	Adult II	8th Thoracic	Ante.	Endplate avulsion
64	Adult III	Radius (right)	Ante.	Slight angulation & slight OA
170	Adult III	10th Thoracic	Ante.	Lateral subluxation
191	Adult III	Frontal (left)	Ante.	Well-healed depression
67	Adult IV	6th + 7th Thoracic	Ante.	Well-healed split fracture
81	Adult IV	2nd to 6th Thoracic	Ante.	Senile kyphosis
115	Adult IV	Sternum	Peri.	Death
258	Adult IV	6th Cervical	Ante.	Body collapse
113	Adult ?	2nd Metacarpal (left)	Ante.	Slight apposition and angulation, slight OA

Table 6.6 Age-at-death, timing of injury, and affected elements among subadults at Ostojićevo

Grave	Age-at-Death	Element(s)	Timing	Complications
185	Juv. I	Occipital; Shoulder + Elbow	Ante.	Unknown; limb deformation, damage to growth plate, joint instability, & OA
268	Juv. II	Parietal + Occipital	Peri.	Surgical intervention & death

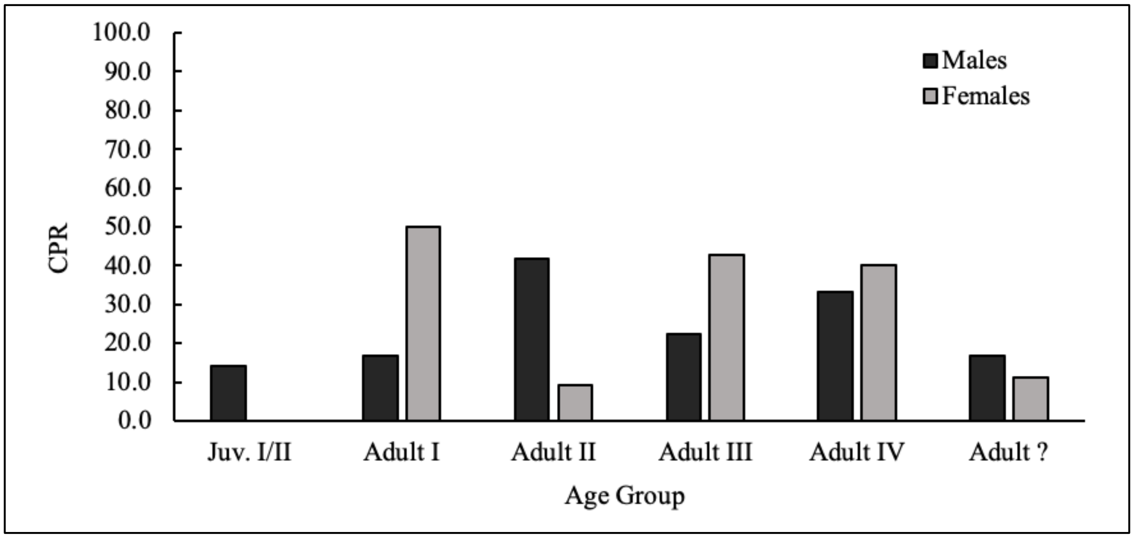


Figure 6.19 CPR (%) of trauma by age-at-death and biological sex at Ostojićevo

6.6 Results: Mokrin Trauma

Eleven individuals at Mokrin exhibited 21 cases of cranial trauma, including seven adult males, two probable-males, one adult female, and one subadult, based on descriptions and images provided by Farkas & Lipták (1971) (Table 6.7). Cranial trauma was classified as trepanation (*n-trauma* = 13, 61.9%), possible trepanation (*n-trauma* = 3, 14.3%), BFT (*n-trauma* = 2, 9.5%), possible BFT (*n-trauma* = 1, 4.8%), or unknown (*n-trauma* = 2, 9.5%). Trepanations were characterized as either depressions, often referred to as symbolic trepanations (Bereczki et al., 2015; Erdal & Erdal, 2011), or as single or overlapping lesions that penetrated the cranial vault.

The width of complete trepanations in individuals at Mokrin varied from ca. 2.6 cm to 7.1 cm, whereas the height was remarkably consistent and ranged from 2.1 cm to 3.3 cm. Of the nine individuals with complete, symbolic, or possible trepanations, 44.4% displayed multiple lesions. Additionally, 55.6% of individuals survived the procedure.

Table 6.7 Summary of cranial trauma at Mokrin (summarized from Farkas & Lipták, 1971).

Grave	Sex	Age-at-Death (yrs)	Element(s)	Timing	Differential Diagnosis*	Description
85	M	20-30	Frontal (left); Parietals	Peri.	BFT?; Trepanation	Oval lesion near coronal suture (ca. 1.7 cm x 0.9 cm); Oval lesion above lambda (ca. 3.3 cm x 4.6 cm)
180	M?	30-50	Frontal (left)	Peri.	Trepanation	Oval lesion (ca. 4.0 cm x 2.6 mm)
196	M?	20-30	Frontal (left); Frontal (right)	Peri.	BFT	Incomplete circular lesion above left orbit (ca. 2.5 cm x 2.1 cm); Semicircular fracture of right-frontal
218	M	20-30	Parietal (left)	Peri.	Trepanation	Incomplete circular lesion with cutmarks along anterior margin (ca. 2.6 cm x 2.7 cm)
230	M	40-60	Frontal (left)	Ante.	Trepanation	Circular depression (ca. 1.4 cm x 3.0 cm)
264	M	40-50	Frontal (bregma); Frontal	Peri.	Trepanation	Pear-shaped lesion (ca. 2.7 cm x 2.3 cm); Two overlapping pear-shaped lesions (total ca. 4.7 mm x 2.1 mm)
273	M	50+	Frontal + Parietal (left); Left-Parietal	Ante.	Trepanation	Three overlapping pear-shaped and circular lesions, crosses coronal suture and extends from left-frontal just posterior to orbital margin to left-parietal near squamosal suture (ca. 7.1 cm x 2.2 cm); Pear-shaped lesion near sagittal and coronal sutures (ca. 3.1 cm x 2.6 cm)
281	M	20-40	Occipital (left); Frontal+Parietal (left)	Ante.	Trepanation	Circular lesion beneath left-lambdoid suture (ca. 3.0 cm x 3.2 cm); Circular lesion extending from left-frontal to left-parietal across coronal suture (ca. 4.1 cm x 3.5 cm)
282	SA	9-12	Parietal (right)	Ante.	Unknown	Two lesions (depressions?), near coronal suture
284	M	50+	Parietal (right)	Ante.	Possible Trepanation	Two depressions, near coronal suture
293	F	20-30	Frontal (left)	Ante.	Possible trepanation	Circular depression

***Note*. * Based on analysis of images in Farkas & Lipták (1971: Plates III, IV, V, XV, & XV)**

6.7 Discussion: Ostojićevo Trauma

6.7.1 Violent Trauma

Differential diagnosis of injury mechanism depends on consideration of the cultural context in proposing a causative agent (Judd & Redfern, 2012). Characterizations of political power and social status in the European Bronze Age often focus on high-status warrior males (Harding, 1999; Treherne, 1995). For example, Vandkilde (2003:138) describes scholarship on warfare and its connections to social structure and relations of power in prehistoric Europe as an archaeological tradition focused on "warriors and peasants" that aims to "pacify the past and populate it with idealized figures of male identity." Evidence of interpersonal violence has primarily been inferred from non-skeletal evidence, principally fortifications, grave goods, and artifacts such as weaponry and defensive armor (Armit et al., 2007; Hanks, 2008; Harding, 2000). The appearance of 'weapons', such as bronze or copper objects identified as daggers, knives, and/or stone axes, as grave offerings in the EBA lend credence to the significance of these items as symbolic markers of special status (Harding, 2007). However, the functional significance of these items as either symbolic markers of prestige and power, their use as effective weapons, or both is unclear. Few studies have investigated associations between skeletal indicators of violent trauma, the sex and age of the deceased, and the presence of weapons or other funerary markers indicative of special status (see Aranda-Jiménez et al., 2009; Knüsel, 2005). The nature and scale of violence among EBA/MBA groups, such as the Maros, remains unexplored.

The types of injuries most often associated with interpersonal violence are blows to the head (Martin et al., 2010; Redfern, 2008; Tung, 2007), forearm fractures (*e.g.*, Colles' fracture and parry fracture) (Judd, 2002; 2008), and injuries to the hand (Hershkovitz et al., 1996; Smith et al., 1985). Injury recidivism or co-occurrence of trauma can also indicate interpersonal violence, especially when paired with cranial trauma (Judd, 2002b; Martin et al., 2010). Judd (2002b) reviewed clinical evidence of injury recidivism associated with violent versus accidental or occupational causes and presented a bioarchaeological analysis of the Kerma group of Nubia. Repeat trauma was most often observed in young adult males, with trauma resulting from assault and overexertion the most common and accidental causes such as falls less frequent. Identification of mechanism of injury in forearm fractures depends on fracture type and location. For example, injuries caused by a direct blow to the forearm produces a transverse or comminuted fracture of the distal (*i.e.*, parry fracture) or proximal (*i.e.*, Monteggia fracture) third of the ulna, whereas indirect forces associated with falling onto the back of the hand (*i.e.*, Smith) or onto an outstretched hand (*i.e.*, Colles' fracture) produces ventral or dorsal displacement of the distal radius (Apley & Solomon, 2000; Judd, 2008). The occurrence of an isolated transverse fracture in the mid-third of the ulnar diaphysis with pronounced callus formation may indicate an ulnar stress fracture associated with repetitive supination in conjunction with elbow flexion and extension while holding or lifting a heavy weight (Evans, 1955; Hsu et al., 2005).

There was no unequivocal evidence of extra-vertebral injury recidivism at Ostojićevo. Several individuals, however, exhibited multiple co-incident injuries consistent with interpersonal violence (Table 6.8; Figure 6.20). The only parry fracture observed was in a male ca. 30-35 years-at-death with multiple antemortem injuries resulting from repeated blows to the left-side of the body, possibly during hand-to-hand combat (Grave 226). Close-quarter combat is also proposed as causing repeated antemortem anterior shoulder dislocation and cranial trauma in an early juvenile probable-male (Grave 185). Intentional violence is also suggested for a perimortem penetrating injury to the sternum in an elderly female (Grave 115). Indirect evidence of an association between the injury patterns observed in the Grave 185 and 226 individuals and interpersonal violence comes from these being the only burials with a stone axe grave offering at Ostojićevo.

Table 6.8 Suggested fracture injury mechanism observed in Juv. I/II and Adults at Ostojićevo. Includes individuals with one or more injuries (includes vertebral trauma). Numbers indicate grave.

Injury Mechanism	Single Injury	Multiple Injuries
Violence	115, 191*, 274	131, 185, 223, 226, 230, 268*
Accident/Occupational	21, 34**, 41, 64, 66B, 67**, 81**, 98, 106, 147, 153, 170, 176, 192, 222A	52, 156, 251
Unknown	69**, 113	101, 258

***Note*. * Multiple injuries to single element; ** Single injury affecting multiple elements.**

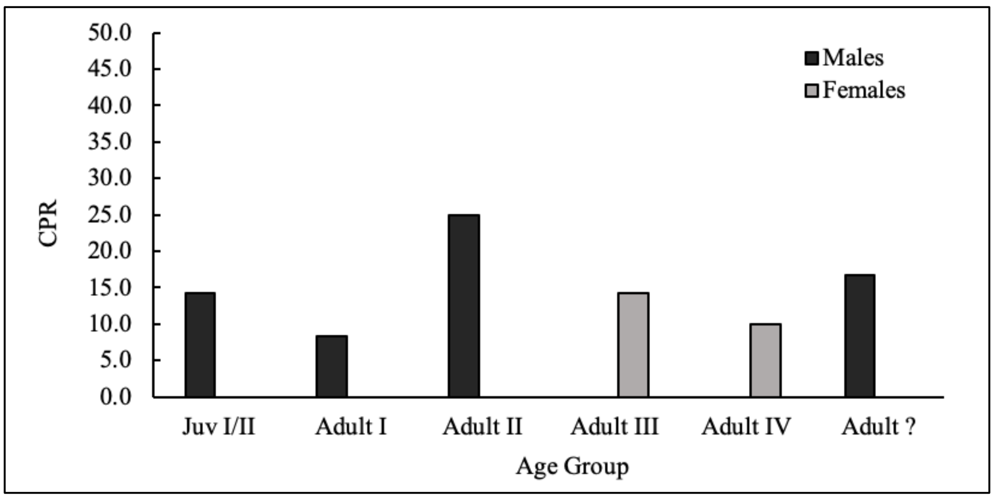


Figure 6.20 CPR (%) by biological sex and age-at-death of individuals with injuries consistent with violent trauma at Ostojićevo

Sharp-force and blunt-force weapon injuries to the cranial vault present the most unequivocal evidence of interpersonal violence. Circular- or linear-patterned blunt-force injuries were likely produced by stone axes, of which several forms have been recovered from Maros cemeteries and settlements (Figure 6.21). Stone axes correspond to Chapman's (1999) concept of tool-weapons: implements with a predominantly mundane function in everyday use that could be, and ostensibly were, also used as weapons. Bronze blades and stone and copper axes were used in violent encounters, resulting in both non-lethal and lethal injuries at Ostijćevo. Males in their 20s and 30s, who were buried with prestige offerings suggestive of their high-status, were more likely to display signs of violent trauma than males with few or no grave goods or females. By the end of the EBA/early MBA, the increased hardness and durability of metal implements such as daggers and axes made them effective weapons. Compositional analysis of metal objects, including axes, from Maros sites in northeastern Serbia suggests a shift from copper obtained from near-surface oxide ores at Mokrin to the manufacture of bronze (tin-copper) via copper from sulphide ores at Ostojićevo (Powell et al., 2017). Possible evidence of the use of bronze blades as weapons comes from cut marks observed on crania from Grave 268 and Grave 274. Cut marks on human remains have smooth, even sides with a deep, narrow broad/flat floor consistent with the use of a metal blade (Greenfield, 1999). Microscopic analyses of cut-marks by Greenfield (1999) on faunal remains at Neolithic, Copper Age, and Early to MBA settlements in central Serbia found that tin-bronze knives came into regular use as tools for butchering animals by the EBA. Further research is needed to compare cut-marks on human remains from Ostojićevo with those on animal remains from Late Maros sites in Hungary and Romania.

The injury profile for the Ostojićevo population is broadly consistent with other prehistoric groups from the Carpathian Basin. The prevalence of violent trauma was higher at Ostojićevo compared to CA, MBA, and IA groups in the Carpathian Basin, but comparable to EBA groups from western Slovakia and the Czech Republic. Within Hårde's (2006:364) three-part classification of cranial trauma, most head injuries at Ostojićevo corresponded to crush-type or hack-and-slash injuries. The major difference among prehistoric groups within the Carpathian Basin, including Ostojićevo, compared to those to the north, was the complete absence of projectile injuries. Based on the current study, projectiles were not used as weapons. Rather, stone and copper axes were preferred.

Despite the appearance of improved metallurgical technology during the EBA-MBA transition and the occasional use of metal tools as weapons, there was no evidence of changes in the nature or frequency of violence. Interpersonal violence was present in less than half of all cases of skeletal trauma at Ostojićevo, and in LCA, MBA, and IA groups from northeastern Hungary (Ubekaler & Pap, 1996; 1998; 2009). However, the majority of individuals with violent injuries were males between 16 and 40 years. The injury prevalence reported here and in published data from northeastern Hungary almost certainly underestimates true trauma-related morbidity and mortality (Croft & Ferllini, 2012). Nevertheless, there is no evidence of indiscriminate mass violence. Fighting involved the use of tool-weapons in close-quarter, hand-to-hand combat. Furthermore, there is no evidence of systematic socially sanctioned domestic or gender-based violence (see Martin et al., 2010) at Ostojićevo or in any of the groups discussed here.

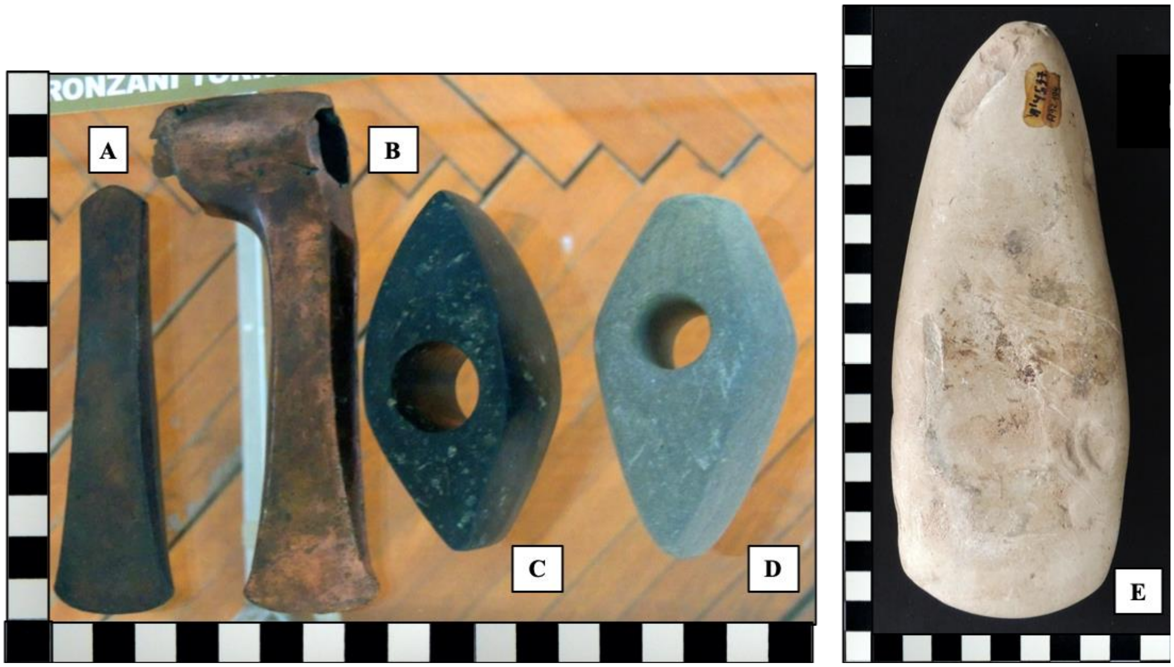


Figure 6.21 Maros bronze and stone axe grave offerings: (A) Mokrin, Grave 16; (B) Mokrin, Grave 208; (C) Mokrin, Grave 153; (D) Mokrin, Grave 57; (E) Ostojićevo, Grave 226.

6.7.2 Sex-specific and Life Course Trauma

There was no clear pattern for males or females in location of injuries, though males were more likely to have multiple injuries. There was no correlation between number of injuries and age-at-death, though there was some evidence that age was a factor in injury location. For example, healed rib fractures were observed in younger adult individuals under 35-years-at-death. The wrist and ankle were the two most common areas for accidental trauma, with injuries occurring in males and females between 20 and 50 years-at-death. Falls or missteps are the most common causes of injury to the wrists and ankles; however, being pushed during an altercation cannot be excluded as a proximate cause (Judd, 2002b; 2008). In the current study, isolated ankle and wrist injuries were well healed with few complications (*e.g.*, osteoarthritis, periostitis, angulation, displacement) at time-of-death. Finally, the vertebrae present the strongest evidence of occupation-related trauma. Vertebral body avulsion and compression in the upper thoracic and cervical vertebrae were common injuries in males older than 40 years-at-death; fractures to the vertebral body were most common in the lower thoracic vertebrae in females as young as 20 to 30 years-at-death. Several females >50-years-at-death exhibited compression fractures to the middle and upper thoracic vertebrae and cervical vertebrae, corresponding to areas of peak biomechanical strain.

Consideration of sex- and age-specific patterns of trauma demonstrated that females experienced minor injuries that were well-healed with minimal complications and no evidence of secondary infection. While the exact cause cannot be definitively known, insight into the environmental and social context of trauma patterns from ethnographic and clinical analysis can narrow down the range of possible injury mechanisms. For example, rib fractures, Colles' fractures, and injuries to the hands and/or feet can indicate actions such as being taken captive or physical abuse (Gowland, 2016a; 2016b; Martin et al., 2010). However, the low prevalence of lethal trauma and/or disfiguring trauma, or injury recidivism in females at Ostojićevo suggests they were infrequently targeted in violent encounters. Furthermore, most injuries were well-healed at death, thus indicating that women received adequate care and had access to the time and resources needed to recover. Finally, the occurrence of trauma affecting the thoracic vertebrae (*i.e.*, endplate avulsion, split fracture, burst fracture, wedge fracture, single vertebral body collapse, and multiple vertebral body collapse with kyphosis) in females suggests: (1) disproportionate biomechanical stress placed on the thoracic vertebrae, especially below T7; and (2) trauma secondary to age-related degenerative changes of the vertebral bodies. Load-bearing stress from a tumpline or creel could account for abnormal posture leading to proportionately less strain on the lower back at the expense of the thoracic vertebrae (Bridges, 1994; Sofaer Derevenski, 2000).

The low prevalence of sex-specific injuries to the shoulder, trunk, pelvis, limbs, and extremities was striking in light of the risks associated with pre-industrial agropastoral lifeways (Judd, 2002; Judd & Roberts, 1999; Moini et al., 2011). Skeletal evidence from Late Medieval populations in Serbia that farming supports farming in this region as a “low-risk” occupation (Djurić et al., 2006). The introduction of horses and wheeled vehicles into the Carpathian during the Terminal Copper Age were not associated with an increase in severe high-impact trauma. Several cases of crush fractures affecting thoracic vertebrae in females at Ostojićevo may have occurred as a result of being thrown or falling from a horse (Norwood et al., 2000; Silver, 2002). Silver et al. (2002) found that thoracolumbar fractures were associated with horseback riding, which they attributed to an individual falling on their buttocks or being thrown against an obstacle while on horseback. Several crush or split fractures of the thoracic vertebrae were found in females at Ostojićevo, with individuals ranging in age-at-death from 20 to 30 years to >50 years. Additional research examining vertebral trauma in the context of detailed sex-specific assessments of muscle use, especially in the shoulders, lower back, and neck, is needed to test the hypothesis that some people at Ostojićevo, in particular women, were regularly riding horses (see Löfqvist et al., 2009; Norwood et al., 2000).

Males deviated from females in mechanism of injury and age-related trends in trauma location and type. Violent trauma to the head, shoulder, and wrist was concentrated among adult males less than 40 years, whereas vertebral trauma primarily affected males older than 40 years. Males also differed from females in about half of individuals with skeletal trauma exhibited trauma to multiple body regions. For example, three males (Graves 52, 101, and 251) displayed trauma to at least one cranial or postcranial element in additional to vertebral injury (*e.g.*, endplate avulsion and compression, wedge impaction). Males were also more likely to experience more serious complications, such as infection, traumatic osteoarthritis, and/or dislocation. Trauma was more likely to be lethal in males than females. Notably, the Grave 226 Adult II male developed an infection secondary to their injuries that may have contributed to their premature death. The only male to survive a craniofacial injury was Grave 223, though this individual also died prematurely from unknown causes.

The most common types of trauma among males older than 40 years-at-death included endplate avulsion with secondary compression and minor trauma (*i.e.*, well-healed fracture of the lateral malleolus of the distal fibula). These vertebral injuries are consistent with repetitive trauma that was initiated in childhood prior to fusion of neural arches or vertebral endplates (Maat & Mastwijk, 2000). Heavy physical labor that placed added strain on the lumbar vertebrae from habitual hyperflexion and hyperextension (*e.g.*, bending at the waist) began at early age and continued into the fifth decade of life and beyond. The absence of vertebral trauma in individuals with evidence of violent injuries suggest a possible gendered-division of labor beginning in late childhood/adolescence, with the formation of male social status associated with engaging in certain types of activities. Notably, "warrior-males" were not only distinguished based on grave goods (*e.g.*, stone axes) (Pompeani, 2018), but also major and minor trauma. In contrast, "laborers and farmers" were more likely to live past their fourth-decade and display types of trauma associated with physically strenuous and repetitive labor affecting the lower back.

Ultimately, true trauma prevalence may be underestimated due to the absence of soft-tissue injuries such as bruises, cuts, and lacerations and the incomplete or poor preservation of skeletal remains, especially in Adult IV individuals. In their analysis of macroscopic and microscopic characteristics of knife stab wounds (punctures and cuts) to fleshed and clothed pig torsos, Ferllini (2012) found that 41.2% of intentional downward thrusts and 30.6% of straight thrusts failed to strike a rib. A study of injury patterns related to interpersonal violence in Denmark reported to medical personnel and legal authorities found that the majority of injuries were to soft tissue only (*e.g.*, abrasions, contusions, lacerations, incised wounds, bite wound, etc.), with fractures representing only 13.0% of injuries in men and 7.5% of injuries in women (Brink et al., 1998). The most common injury sites were to the left side on the head, neck, and face in both males and females. Females were more likely than males to exhibit neck abrasions from strangulation and to experience thoracic or abdominal injuries (Brink et al., 1998). Finally, the well-preserved body of the Similuan Iceman, also called "Ötzi", exhibited several perimortem and antemortem soft tissue and skeletal injuries. These include a healed stab wound to his right hand, a fresh laceration to his right hand, an arrow head embedded in soft tissue in the left shoulder, and healed fractures on the left fifth through ninth ribs (Murphy et al., 2003; Nerlich et al., 2009). Of these, only the healed rib fractures would be visible in dry bone. Despite its proximity to the scapula and clavicle, the potentially fatal projectile injury did not impact bone. Thus, this type injury would not be visible if the projectile had been removed prior to burial - or discovery. These examples serve to demonstrate that individuals with healed trauma or no evidence of skeletal trauma may have been affected by fatal soft tissue injury through accidental or violent mechanisms. It is possible that "trauma-free" skeletons of individuals dying in their teens, 20s, or 30s may have succumbed to soft tissue injuries (Wood et al., 1992). Nevertheless, the pattern presented at Ostojićevo indicates that trauma contributed to increased mortality risk in males <40 years. Trauma in females is generally more common in women >40 years-at-death. However, Adult I females had the highest trauma CPR, including two women with healed rib fractures. Studies of fractures associated with interpersonal violence in contemporary (Brink et al., 1998; Porter et al., 2019) and archaeological (Martin et al., 2010) case studies have found that rib fractures are the most common injury site after fractures to the face and cranial vault, especially in reproductive-aged women. However, in the absence of evidence of injury recidivism in these two young females (see Judd, 2002b; Tung, 2007), diagnosis of injuries due to violent or accidental causes remains speculative.

6.8 Discussion: Trepanation

Among CA, MBA, and IA groups from northeast Hungary, the Maros are unique in their practice of cranial trepanation. The seven (possibly nine) cases described for Mokrin and two cases (one analyzed and described here, the second described in excavation reports) from Ostojićevo demonstrate that trepanation was practiced in the Maros region between ca. 2100-1500 BCE. A case of healed trepanation was reported by Hukelova (2016) in an EBA male from the Czech Republic (Praha Malá Ohrada). Trepanation in the Carpathian Basin does not reappear in the human skeletal record until the 5th/6th century AD (Bereczki et al., 2015). The presence of cutmarks on at least three crania at Ostojićevo suggests the use of sharp-edged weapons, such as copper or bronze knives. A single case each of cranial SFT was described for the MBA and IA samples from northeastern Hungary, one EBA cranium from Slovakia (Nižná Myšľa), and one EBA proximal humerus from the Czech Republic (Praha Malá Ohrada). Sharp tool trauma has been documented for CA groups in Slovakia and the Czech Republic (Hukelova, 2016). Greenfield (1999) identified the use of metal (copper) tools on animal remains from sites in central Serbia as early as the Late Neolithic (Vinča D, 3800-3300 BCE). The use of metal implements in butchering increased dramatically during the Early-MBA (Vatin Culture, 2500-1500 BCE) with the production of tin-bronze tools.

According to Bereczki and Marcsik (2005) and Bereczki et al. (2015), complete and symbolic trepanations in Hungary date to after the 5th century AD and are associated with the conquest of the Carpathian Basin by semi-nomadic horse-riding peoples from the east. The presence of multiple individuals with trepanation at Mokrin and at least one case at Ostojićevo thus have little to no precedent among contemporaneous prehistoric groups in the region. A single trepanation was reported for an EBA adult male (ca. 36-50 years-at-death) from the site of Praha Mala Ohrada, who displayed a large complete healed oval lesion to the left side of the cranium in addition to a healed depression associated with BFT to the top of the skull (Hukelova, 2016:336). The survival rate of purported trepanations at Mokrin is consistent with prehistoric evidence from Anatolia (Erdal & Erdal, 2011). It is unclear whether the single case of trepanation (Grave 180) at Ostojićevo, known only from excavation records, exhibited healing at time of death. However, the six overlapping circular fractures coupled with deep cutmarks along the perimeter of the only incomplete fracture in the Grave 268 individual at Ostojićevo may indicate a potential trepanation in response to cranial BFT. Similarities in shape and size of the circular fractures with those observed in the Grave 191 and Grave 230 individuals support the same type of implement being used in all three cases, most likely a stone axe or wooden club. However, at present, there are no other cases that present as a combination of BFT and “surgical” SFT for Bronze Age populations from the Carpathian Basin.

6.9 Conclusion

Skeletal trauma is often underutilized in reconstructions of behavior associated with social complexity, warfare, and violence in Bronze Age societies in central and southeastern Europe. This is primarily due to the incomplete and haphazard ways in which data on skeletal trauma have been compiled and reported. Several authors have undertaken systematic studies of BFT, SFT, and projectile trauma in human skeletal remains, notably Ubelaker and Pap (1996; 1998; 2006; 2009) for prehistoric and medieval populations from northeastern Hungary and Hårde (2005; 2006) and Hukelova (2016) for Neolithic, CA, and BA groups from western Slovakia and the Czech Republic. However, reporting of data varies between studies, making direct comparisons difficult. For example, Hukelova (2016) includes several cases of "postmortem" trauma from taphonomic processes rather than human action. Additionally, minor trauma affecting the vertebrae (*e.g.*, vertebral endplate avulsion, spondylolysis, etc.) are often excluded from analyses of BFT, SFT, and projectile trauma.

My dissertation study has sought to address these shortcomings by focusing on trauma type, location on the body, and timing, as well as to identify the mechanism of injury. The purpose of the current analysis was to illustrate the types and incidence of trauma experienced by people living in the southeastern corner of the Carpathian Basin at the end of the EBA. The accumulation of traumatic events with age, and higher prevalence of trauma in males, have been documented clinically and ethnographically (see Brukner et al., 1996; Buhr, 1959; Judd, 2002b; Legood et al., 2002; Sugiyama, 2004). By examining trauma in the context of human biology, technology, and culturally mediated behavior, my dissertation research contributes to a more nuanced reconstruction of the social correlates and physical causes of injury.

Adolescent and young adult males at Ostojićevo were the most likely to experience lethal and non-lethal interpersonal violence, irrespective of age. Perimortem trauma to the right anterior, right lateral, and/or posterior regions of the skull was observed in at least four, and possibly as many as six individuals based on excavation records. Of these six confirmed or tentative cases, only one was observed in a female. There were no cases of perimortem postcranial trauma in males; however, males were more likely to display multiple injuries and experience complications, including postcranial disfigurement and disability. Most males with violent injuries died young, whereas females tended to be older. Among females, there was a single case of non-lethal cranial trauma, which was the result of a blow from a blunt instrument to the right frontal. BFT to the right frontal bone is consistent with face-to-face encounter with a right-handed attacker.

This individual, who was between 40 and 50 years-at-death, did not exhibit any defensive wounds. This individual had survived long enough after the injury for the wound to heal. The only other female with a violent injury was an older adult >50 years-at-death with an apparent lethal puncture to the sternum, likely made by a sharp pointed instrument.

This association between sex, age-at-death, and injury mechanism indicates a pattern of male-combatants (Judd, 2002b; Martin et al., 2010). It would be premature to use these isolated cases to argue for the existence of endemic warfare and raiding during the Late and Terminal Maros culture sequence. While the true circumstances surrounding these injuries – and occasional deaths – will never be definitively known, it should be noted that participation in hand-to-hand combat was more common among males. In contrast, females were rarely victims or combatants. The low frequency of violent injury, especially in females, suggests that violence in the form of surprise attacks on villages was uncommon.

7.0 Dental Disease and Diet

This chapter includes a slight modification to age categories. Individuals classified as Juvenile II/Adult I (ca. 18-21 years-at-death) were grouped with Adult I for dental analysis as these represent dentally mature persons.

7.1 Methods: Ostojićevo Dental Inventory and Coding

A customized dental recording form following standardized criteria was developed and used to record data on intact and isolated permanent teeth (Appendix Figure 3) and deciduous or mixed dentition (Appendix Figure 4). Teeth and associated alveolar bone were assessed separately. Data collection distinguished between permanent and deciduous teeth, tooth type (incisor, canine, premolar, molar), and location (left or right, upper or lower). Individual permanent and deciduous teeth were scored using the following criteria: 0 = absent unknown, 1= tooth present, 2 = antemortem loss, 3 = postmortem loss, 4 = present but damaged, 5 = present but partial eruption, 6 = present but unerrupted, and 6 = congenital absence. Alveolar bone was scored according to corresponding tooth type and location: 0 = bone absent, 1 = bone present and intact, 2 = bone present with some resorption or remodeling, 3 = bone present with complete resorption, and 4 = bone present but damaged. Descriptions used the following abbreviations:

- Location: UR = upper right, UL = upper left, LR = lower right, LL = lower left
- Type: I = incisor, C = canine, P = premolar, M = molar, di = deciduous incisor, dc = deciduous canine, and dm = deciduous molar
- Aspect: B = buccal/labial, L = lingual, M = mesial, D = distal, and O = occlusal
- Region: C = crown, CEJ = cementoenamel junction, R = root, and AC = alveolar crest

7.2 Methods: Ostojićevo Dental Disease

7.2.1 Antemortem Tooth Loss

Antemortem tooth loss (AMTL) results from an infectious (*e.g.*, caries-induced AMTL) and/or degenerative (*e.g.*, attrition-induced AMTL) cause (Hillson, 1996; 2008). Pregnancy, parity, and preexisting periodontal infection can increase the risk of tooth loss in reproductive-age females (Lieff et al., 2004; Morelli et al., 2018). Total prevalence rate (TPR) for AMTL was calculated based on # of resorbed / total alveolar margin. Damaged or missing alveolar margin sections were excluded from analysis. "Present" equals alveolar bone and teeth present, alveolar bone present but teeth lost postmortem, and alveolar bone present but teeth damaged. AMTL was only assessed for permanent dentition in individuals >18 years. To address issues with small sample sizes, especially for Adult IV males, Adult I and II individuals and Adult III and IV individuals, respectively, were pooled for statistical analysis.

7.2.2 Periodontal Disease

Periodontal disease or "periodontitis" has a complex and non-specific etiology and refers broadly to inflammation of the tissues surrounding the teeth (*i.e.*, alveolar bone, the periodontal ligament, cement, gingiva, and mucosa) (Hillson, 1996). Diagnostic criteria depend on the exposure of porous trabecular bone due to loss of overlying cortical bone height and contour (Clarke & Hirsch, 1991; Schwartz, 2007). The relationship between bone loss (*i.e.*, decrease in alveolar height) and inflammation and infection of the gingiva and mucosa is poorly understood (see Albandar, 2000; Clarke et al., 1986; Clarke & Hirsche, 1991). Furthermore, periodontal disease often progresses through periodic bursts of activity separated by quiescent periods (Clarke et al., 1986). Left untreated, periodontal disease can lead to extensive loss of periodontal attachments and tooth loss (Morris et al., 2001) and has been found to increase the risk of pre-term birth <37 gestational weeks in pregnant women (Wimmer & Pihlstrom, 2008).

Bone loss associated with periodontal disease involves the outer cortical bone on the buccal and lingual surfaces, the tooth socket alveolus, and the underlying medullary bone (Hillson, 1996). Bone loss proceeds via two routes: ‘horizontal bone loss’, which manifests as a loss in height of the buccal, lingual, and proximal alveolar crest surrounding tooth roots; or ‘vertical bone loss’, which is the formation of localized pockets of rarified bone around individual teeth (Larsen, 2015). These two patterns of bone loss do not necessarily need to co-occur in the same tooth or the same individual. Lukacs (1989) classified ‘horizontal bone loss’ based on root exposure: slight (<1/2 root), moderate (>1/2 root), severe (evulsion), and complete (alveolus resorbed). To address difficulties in distinguishing between root exposure from compensatory continuous eruption due to tooth wear and mechanical loading versus periodontal disease, I implemented additional criteria from Clarke and Hirsche (1991) and Ogden (2007) relating to the appearance of the alveolar margin as dense, irregular, and porotic in periodontal disease. I only diagnosed periodontal disease in cases in which both criteria were met: (1) root exposure >1/2; and (2) an irregular and porotic alveolar margin.

TPR (%) was calculated based on # affected alveolus / total alveolar margin. Damaged or missing alveolar margin sections were excluded from analysis. Periodontitis was only assessed for permanent dentition in individuals >18 years. To address issues with small sample sizes, especially for Adult IV males, Adult I and II individuals and Adult III and IV individuals, respectively, were pooled for statistical analysis.

7.2.3 Dental Caries

Dental caries is a slowly progressive and chronic disease (Hillson, 2001). The breakdown of fermentable carbohydrates, especially sucrose, by bacteria that thrive in dental plaque and dental fissures and pits produce organic acids that destroy dental hard tissues (*i.e.*, enamel, dentine, and cementum) (Bradshaw & Lynch, 2013; Hillson, 1996). Localized demineralization initiated on the crown or root surface occurs when pH values fall below a critical point of pH 5.5; this process is characterized by periods of rapid demineralization interspersed with quiescent or remineralizing phases (Hillson, 1996; Lingström et al., 2000). Initial crown surface changes are characterized as “spot lesions” or “incipient lesions” defined by a white or brown (“arrested caries”) spot of opacity that appears as a radiolucency in dental x-rays. These early lesions are often not visible macroscopically. Further enamel destruction creates a clear indentation in the crown surface, which can be identified through macroscopic examination. The progression of a cavitated lesion into the dentine produces a “dentine dead zone” capped by reparative secondary dentine on the pulpal end. Active dentine lesions arise when micro-organisms (*e.g.*, *Streptococcus mutans*, *Streptococcus oralis*, *Lactobacillus* spp., etc.) from the oral cavity form successive zones of destruction, bacterial invasion, demineralization, and sclerosis. Caries progression at this stage is marked by the spread of zones of bacterial invasion and demineralization through the dentine and into the pulp. Continuity via the zone of destruction with the oral cavity allows for the spread of bacteria into the pulp resulting in pulp inflammation (pulpitis), infection, and pulp death. Dental caries has been found to be associated with rapid tooth wear, age, female sex, and diets high in sucrose (Larsen, 2015; Lukacs, 2011a; 2011b; Turner, 1979). Proteins from saliva, dietary fats and proteins, and uptake of calcium, phosphorous, and fluoride have a protective effect against caries and may even reverse early stages of demineralization (Lingström et al., 2000).

Identification and recording of dental caries follow standards outlined in Hillson (2001). Caries were assessed macroscopically for all permanent and erupted deciduous teeth (unerupted and partial-erupted deciduous and permanent teeth excluded) and scored based on presence/severity and location (region):

- Severity was recorded for all teeth: 0 = tooth absent, 1 = tooth unaffected, 2 = incipient (can only be recorded microscopically or radiographically), 3 = slight (rough or slight destruction, no dentine exposure), 4 = small (small cavity with evidence of penetration into underlying dentine), 5 = large (clearly penetrates into outer half of dentine), 6 = larger (exposed pulp chamber or shallow cavity following line of CEJ), 7 = gross cavity (involves neighboring teeth and/or involves CEJ or root with pulp chamber exposed), and 8 = gross cavity/complete destruction (almost complete destruction of outer hard tissues, exposure of pulp chamber and open root canals).

- Location (region) was only recorded if lesion present: 1 = crown, 2 = CEJ only, 3 = CEJ + root, 4 = CEJ + crown, and 5 = crown + CEJ + root.

For data analysis, several changes were made to severity criteria to reflect ambiguities in caries classification based on macroscopic analysis. These include the exclusion of incipient caries and combination of several categories: Score 1/2 = no caries/incipient; Score 3 = slight (primarily enamel, possible slight dentine exposure), Score 4 = small (penetrates to outer half of dentine, no pulp exposure), Score 5/6 = large/larger (penetrates to inner half of dentine, pulp exposure), and Score 7/8 = gross/gross-complete destruction (pulp fully exposed, substantial or complete destruction of crown). TPR (%) was calculated based on # teeth with at least one carious lesion / total teeth. To address issues with small sample sizes, especially for Adult IV males, Adult I and II individuals and Adult III and IV individuals, respectively, were pooled for statistical analysis.

7.2.4 Dental Abscesses

Bacterial infection in teeth, if left untreated, can cause necrosis of living tissue and the production of pus (Schwartz, 2007). In dry bone, the spread of infection from the tooth through the root apex into the surrounding alveolar bone creates a balloon-like pus-filled abscess. In early stages, bone necrosis is only visible radiographically or through identification of rough-walled cavity around the apex of a root by removing the tooth in a dry bone specimen (see Dias & Tayles, 1997; Hillson, 2008). Enlargement of the pus-filled cavity may lead to the eruption of a drainage hole through the facial or lingual alveolar surface. “Periapical abscess” is used to refer to the formation of a circular or ovoid periapical balloon-like cavity with or without a drainage hole. Continued enlargement of the pus-filled abscess may result in further tissue necrosis, including expansion of the drainage sinus or fistula to include the alveolar crest. The category “continuous abscess” reflects this more advanced stage in which most or all hard-tissue support surrounding a tooth have been destroyed on the facial or lingual surface. A “continuous abscess” may also result from the combined effects of periapical bone loss from a chronic abscess and reduction in the height of the alveolar process from periodontal disease (Hillson, 2008). Finally, the classification "other" refers to a "complex-periapical abscess", in which the infection has spread beyond the alveolar bone (*e.g.*, one or more fistula extending into the maxillary sinus), or a "complex-continuous" abscess, in which the apex of the tooth root(s) is exposed on both the facial and lingual surfaces. Nonapical periodontal abscesses of pulpal origin must be considered as a differential diagnosis of "continuous" or "complex-continuous" abscesses. Infection may develop from inflammation due to exposure of pulp cavities from several attrition or tooth fracture. Like periapical abscesses arising from the proliferation of a carious lesion, periodontal abscesses can lead to internal and external bone destruction of dental supporting structures (*i.e.*, periodontal ligaments and alveolar bone) both toward and away from the alveolar margin (Schwartz, 2007).

For this study, abscesses were defined as cavitation and bone resorption associated with formation and progression of a granuloma or cyst originating in the periapical region and progressing towards the alveolar margin. Abscesses were recorded and scored according to criteria adapted from Hillson (2001:279-280). Parentheses indicate to which broader category abscesses were assigned based on appearance and wall shape:

- Appearance: 0 = alveolar bone absent; 1 = alveolar bone present, unaffected; 2 = periapical buccal/labial lesion or perforation (periapical abscess); 3 = periapical lingual lesion or perforation (periapical abscess); 4 = expansion of lesion, continuous with buccal/labial alveolar margin (continuous abscess); 5 = expansion of lesion, continuous with lingual alveolar margin (continuous abscess); 6 = lesion or perforation other (complex-periapical abscess or complex-continuous abscess).
- Wall shape: 0 = alveolar bone absent; 1 = alveolar bone intact, unaffected; 2 = dehiscence or fenestration, antemortem opening in buccal/labial or lingual wall of alveolar process that is confined to periapical region (periapical abscess); 3= fenestration and cavity, initiated at root apex with formation of lateral canal (periapical abscess); 4 = sinus formation, opening through buccal/labial or lingual surface (continuous or complex-continuous abscess); 5 = sinus formation, opening through palatine process into nasal floor (complex-periapical abscess); 6 = sinus

formation, opening into maxillary cavity (complex-periapical abscess); 7 = unable to determine extent of sinus due to damage or preservation.

TPR (%) was calculated based on # affected alveolus / total alveolar margin. Damaged or missing alveolar margin sections were excluded from analysis. To address issues with small sample sizes, especially for Adult IV males, Adult I and II individuals and Adult III and IV individuals, respectively, were pooled for statistical analysis.

7.2.5 Calculus

Dental plaque results from the accumulation of microorganisms on dental surfaces, whereas calculus is the mineralization of dental plaque (Hillson, 1996). The exact mechanism by which plaque becomes mineralized is poorly understood (Hillson, 2008; Lieverse, 1999). Dental calculus includes both organic and inorganic constituents that vary widely between supra-gingival and sub-gingival calculus (Lieverse, 1999). Briefly, the organic component or matrix consists of carbohydrates, proteins, and lipids. Saliva is the source of the inorganic or mineralized component, which primarily consists of calcium phosphate mineral salts, with carbonate, sodium, magnesium, fluoride also present (Hillson, 1996; Lieverse, 1999). Supragingival calculus located on dental enamel is more heavily mineralized (46-83% by volume) than subgingival calculus (16-80% by volume), which forms on root surfaces subsequent to the recession of gingival tissues associated with periodontal disease (Hillson, 1996; 2008). Dental plaque and calculus can affect any part of the tooth, including coronal crevices and grooves, smooth coronal surfaces, dentine, and root surfaces (Schwartz, 2007). However, supragingival calculus deposits tend to be most abundant in areas adjacent to the submandibular and parotic salivary glands (Lieverse, 1999). These include the lingual surfaces of mandibular incisors and buccal surfaces of the maxillary first molars. Supragingival calculus development has been linked to an alkaline oral environment, poor oral hygiene, and carbohydrate consumption, especially sucrose (Hillson, 1996; Lieverse, 1999; Scheie, 1996). However, endogenous factors such as salivary flow rate, salivary mineral ion levels, and the lipid and protein composition of saliva seem to have a greater effect on calculus formation than exogenous factors such as diet (Lieverse, 1999; White, 1997). It has been suggested that high protein intake leads to increased calculus production (Hillson, 1979). Rather than affecting oral pH directly (*i.e.*, food passing through the oral cavity), high protein diets facilitate an alkaline oral environment by increasing urea levels in body fluids, including blood and saliva (Lieverse, 1999). Finally, several studies have suggested a link between dietary silicon, found in plant cells, beer, and drinking water, and calculus formation (Rølla et al., 1989; see Lieverse, 1999; White, 1997). Supragingival calculus can begin forming soon after dental eruption and often reaches a maximum around 30 years in populations without access to professional dental care (White, 1997).

I used a four-point scoring system adapted from Dobney and Brothwell (1987) to record and score supragingival calculus on permanent and deciduous dentition. This four-point system reflects the percent of the crown surface obscured by dental calculus: none = 0% of crown, slight = <25% of crown (thin, flat band), moderate = >25-50% of crown (thick flat band, distinct bumps), heavy = >50-75% of crown (three-dimensional wedges), and gross = >75-100% (three-dimensional chunks, overhangs gingival margin). TPR (%) was calculated based on # of teeth with at least one affected surface / total teeth. To address issues with small sample sizes, especially for Adult IV males, Adult I and II individuals and Adult III and IV individuals, respectively, were pooled for statistical analysis.

7.3 Methods: Ostojićevo and Mokrin Comparative Dental Disease

The data set for dental caries and AMTL in permanent dentition (*n-individual* = 209) at Mokrin was based on Rega (1995: 134-142). I calculated alveolus count by dividing # of AMTL by AMTL rate. Composite data was presented for males and females by jaw and tooth type; however, there was no information on differences in dental pathology prevalence by age-at-death. It is also unclear whether Rega (1995) included permanent teeth from individuals <18 years. No data is available on dental abscesses, periodontitis, calculus, or carious lesion type/severity from Mokrin. My analysis of caries and AMTL prevalence is based on my reanalysis of raw data for males and females, as count data was not available for individuals of indeterminate sex.

Both individual and elemental sample size was smaller at Ostojićevo compared to Mokrin (see section 7.7, Table 7.22). This discrepancy in sample size might contribute to extreme cases (*i.e.*, most teeth affected in one individual or an individual exhibiting multiple pathologies) having a disproportionate influence on dental disease averages calculated for the Ostojićevo samples. Nevertheless, all four sex-site groups had large elemental sample sizes and this effect is likely negligible (though see section 7.7 for discussion of a possible age-effect on AMTL prevalence in Ostojićevo females). Comparative data on caries prevalence at Ostojićevo is based on my analysis of male and female individuals >18 years and includes upper teeth in 60 individuals and lower teeth in 65 individuals; AMTL prevalence is based on my examination of the alveolar margin in the maxillae of 58 individuals and the mandible of 72 individuals. To match the demographic composition of the Mokrin sample, only data from adult males and females from Ostojićevo were included in comparative analyses.

7.4 Methods: Stable Isotope Sampling and Analysis

Stable isotope analysis of animal and human bone collagen was conducted to examine dietary patterns at Ostojićevo (ca. 2000-1500 BCE) and Mokrin (ca. 2100-1800 BCE). Stable isotope analysis included $\delta^{15}N_{collagen}$ and $\delta^{13}C_{collagen}$ from faunal (*n-total* = 24) and human (*n-total* = 118) remains from four Maros sites in Hungary and Serbia, two cemeteries and two settlements (Figure 7.1). Human remains sampled included a cross-section of individuals by age-at-death and sex from Ostojićevo (*n* = 89) and Mokrin (*n* = 29). Samples were collected at the Narodni Muzej Kikinda, Serbia. To examine the potential impact of age and sex on individual differences in isotope values, individuals from Ostojićevo and Mokrin were separated into two age groups: Adult I/II (>18-40 years) and Adult III/IV (>40 years). Individuals were also categorized as "high" or "low" status based on association with prestige grave goods

(Milašinović, 2009; O’Shea, 1995; Pompeani, 2018). Grave goods classified as “prestige” items at include: bronze/copper beads or coils, bronze coil bracelet, beaded necklace, beaded belt, baroque pot, presence of three or more pots, and/or stone axe.

Faunal remains included specimens of several taxa included as grave offerings at Ostojićevo, Serbia (*n* = 8) as well as faunal specimens uncovered during settlement excavations at Kiszombor-Új-Élet, an Early Maros (2600-2000 BCE) site in southeastern Hungary (*n* = 9), and Klárafalva-Hajdova, a Late Maros (2000-1700 BCE) fortified tell site in southeastern Hungary (*n* = 7) (Michelaki, 2008; Nicodemus, 2014; O’Shea, 1996). Briefly, Klárafalva is a tell site that includes three occupation phases, including two corresponding to the Early Maros (2300-2000 BCE) period and one Late Maros (1800-1500 BCE) phase. The site is located within a wooded floodplain ca. 350 m from the Maros River. Despite its strategic location on a major regional waterway, the inhabitants would have had limited access to year-round dry, arable land (O’Shea, 1996; 2010). Kiszombor is a stratified open site located ca. 9 km southeast of Klárafalva and occupied during two phases in the Early Maros period (2500-2400 BCE and 2000-1700 BCE). The settlement was situated within a 1-1.5 km strip of dry steppe-forest areas adjacent to the Porgány Creek. This land, which is bounded by marshes and wet meadows, is characterized by highly productive loess soils that are well-suited to agriculture and herding. Faunal specimens from Hungary were collected at the Móra Ferenc Museum, Szeged, Hungary. Funding for isotope analyses was provided by Graduate School ‘Human Development in Landscapes’ as part of postdoctoral funds provided to Dr. A. R. Ventresca Miller. Permission for sampling was granted by the director of the Narodni Muzej Kikinda, Lidija Milašinović, and the director of the Móra Ferenc Museum, Ottó Fogas. No permits were required.

Human (rib where possible, and femur, tibia, or fibula) and animal bone were sampled in the field with a Dremel® Micro 8050 drill sampled using a 545-diamond cutting wheel attachment. Ribs were preferred as they have a faster cortical turnover rate (ca. 4% per year) than other skeletal elements (*i.e.*, 1.5-3.0% per year after age 20 for the femur) and thus reflect diet during a shorter period prior to death (Cox & Sealy, 1997; Fahy et al., 2017; Frost, 1969; Hedges et al., 2007). Collagen turnover is much higher during adolescence (age 10-15 years) at ca. 10-30% per year, with males exhibiting a higher turnover rate than females (Hedges et al., 2007). Higher bone turnover rate may account for rib specimens from young adult males producing higher values of $\delta^{15}N$ independent of diet (Fahy et al., 2017; Pollard et al., 2012).

Laboratory analysis was carried out at the Archaeological Stable Isotope Laboratory (ASIL) at the University of Kiel. Samples with a carbon-to-nitrogen (C/N) ratio outside the range of 2.9 to 3.6 were excluded for potential contamination and/or insufficient preservation of biogenic carbon or nitrogen (DeNiro, 1985). Additionally, samples displaying wt % C below 30% and/or wt % N below 11% were also excluded, even if the associated C:N value was "normal" (Van Klinken, 1999).

Figure 7.1 Maros sites sampled for stable isotope analysis (circles).

7.5 Results: Ostojićevo Inventory

7.5.1 Permanent Dentition

The inventory of permanent "dentition" included erupted, partial-erupted, unerupted, and damaged teeth. Teeth lost antemortem (AMTL), teeth lost postmortem (PMTL), teeth damaged postmortem, and congenital absence were only recorded when the associated alveolar bone was present. Congenital absence was only marked for third molars. A complete inventory of permanent dentition by age-at-death and sex can be found in Appendix Table 16 (upper jaw, male), Appendix Table 17 (upper jaw, female), Appendix Table 18 (upper jaw, indeterminate), Appendix Table 19 (lower jaw, male), Appendix Table 20 (lower jaw, female), and Appendix Table 21 (lower jaw, indeterminate). Table 7.1 includes tooth count data for permanent dentition for the upper and lower jaw by age-at-death; Table 7.2 includes elemental prevalence for upper and lower permanent teeth by age-at-death. Sex-specific count data are listed in Tables 7.3 and 7.4 for male upper and lower permanent teeth, respectively, and Tables 7.5 and 7.6 for female upper and lower permanent teeth, respectively. Sex- and age-specific trends in antemortem tooth loss are summarized in Section 7.6.1. True PMTL is likely higher than reported since absent teeth with no corresponding alveolus were not counted. Finally, M^3 agenesis prevalence in Juvenile I individuals may be inflated due to individual variation in the timing of M^3 development (see Moorrees et al., 1963). All % refers to TPR unless otherwise stated.

A total of 1292 permanent upper (maxillary) "teeth" were recorded for 123 individuals. Of these, 55.5% were present/erupted, 6.1% were lost antemortem, 23.9% were lost postmortem), 15 1.2% were present but damaged, 1.5% were partial-erupted, 10.1% were unerupted. There was an average of 7.3 teeth out of a possible maximum of 18 teeth present (present + damaged) per individual >18 years-at-death. Adults >40 years had almost half the number of teeth present per individual (*average* = 4.5) than adults <40 years (*average* = 8.8).

A total of 1594 permanent lower (mandibular) “teeth” were recorded for 149 individuals. Of these, 51.4% were present/erupted, 11.9% were lost antemortem, 22.1% were lost postmortem, 1.1% were present but damaged, 1.4% were partial-erupted, and 10.5% were unerupted. There was an average of 7.3 teeth out of a possible maximum of 18 teeth present (present + damaged) per individual >18 years-at-death. Adults >40 years had fewer teeth present per individual (*average* = 4.3) than adults <40 years (*average* = 9.1).

A total of 531 upper and 623 lower permanent “teeth” were recorded for males. There was an average of 8.7 upper teeth out of a possible maximum of 18 teeth present (present + damaged) per individual >18 years-at-death. Adults >40 years had fewer upper teeth present per individual (*average* = 4.3) than adults <40 years (*average* = 9.8). There was an average of 9.0 lower teeth out of a possible maximum of 18 teeth present (present + damaged) per individual >18 years-at-death. Adults >40 years had fewer lower teeth present per individual (*average* = 5.4) than adults <40 years (*average* = 10.8, *range* = 4.0-11.5). Among adult males, total PMTL (excluding AMTL and congenital absence) was 25.6% for upper permanent “teeth” and 26.4% for lower permanent “teeth”.

A total of 568 upper and 691 lower permanent “teeth” were recorded for females. There was an average of 7.2 upper teeth out of a possible maximum of 18 teeth present (present + damaged) per individual >18 years-at-death. On average, adults >40 years had fewer upper teeth present per individual (*average* = 5.4) than adults <40 years (*average* = 7.7). There was an average of 6.6 lower teeth out of a possible maximum of 18 teeth present (present + damaged) per individual >18 years-at-death. Adults >40 years had fewer lower teeth present per individual (*average* = 4.1) than adults <40 years (*average* = 7.4). Among adult females, total PMTL (excluding AMTL and congenital absence) was 33.8% for upper permanent “teeth” and 33.5% for lower permanent “teeth”.

Table 7.1 Ostojićevo pooled male, female, and indeterminate TOTAL permanent dentition

Jaw	Category	SA ?	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult?	Total
Upper	n-individual	2	4	7	6	9	4	5	6	26	18	8	9	19	123
	n-teeth	2	8	20	50	65	44	55	85	381	191	76	90	225	1292
	1 - Present	0	0	0	1	19	16	34	58	246	127	48	29	139	717
	2 - AMTL	0	0	0	0	0	0	0	0	5	12	5	44	13	79
	3 - PMTL	0	0	0	0	1	1	16	22	119	43	23	16	68	309
	4 - Damaged	1	0	0	0	0	1	0	0	2	7	0	0	4	15
	5 - Partial	0	0	0	7	0	8	0	4	1	0	0	0	0	20
	6 - Unerupted	1	8	20	42	45	18	3	1	3	0	0	0	0	141
	7 – Congenital**	0	0	0	0	0	0	2	0	5	2	0	1	1	11
Lower	n-individual	1	10	12	7	9	4	5	6	25	22	11	12	25	149
	n-teeth	1	26	34	49	72	40	68	84	328	294	143	156	299	1594
	1 - Present	1	0	0	2	26	19	44	59	245	169	58	40	157	820
	2 - AMTL	0	0	0	0	0	0	0	0	3	27	31	78	50	189
	3 - PMTL	0	0	0	0	0	0	17	16	72	80	49	36	82	352
	4 - Damaged	0	0	0	0	4	0	0	0	0	9	1	0	4	18
	5 - Partial	0	0	0	8	0	7	3	5	0	0	0	0	0	23
	6 - Unerupted	0	26	34	39	42	14	3	3	3	0	0	0	3	167
	7 – Congenital**	0	0	0	0	0	0	1	1	5	9	4	2	3	25

***Note*. *Adult I = 18-30 years; **Congenital absence = M^3 only.**

Table 7.2 Ostojićevo pooled male, female, and indeterminate TOTAL permanent dentition TPR (% age group total).

Jaw	Category	SA ?	Neon.	Inf. I	Inf. II	Ch. I	Ch. II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult ?	Total
Upper % Total	**n-individual**	2	4	7	6	9	4	5	6	26	18	8	9	19	123
	n-teeth	2	8	20	50	65	44	55	85	381	191	76	90	225	1292
	avg. teeth/person**	1.0	2.0	2.9	8.3	7.1	10.8	7.4	10.5	9.7	7.4	6.0	3.2	7.5	7.3
	1 - Present	0.0	0.0	0.0	2.0	29.2	36.4	61.8	68.2	64.6	66.5	63.2	32.2	61.8	55.5
	2 - AMTL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	6.3	6.6	48.9	5.8	6.1
	3 – PMTL***	0.0	0.0	0.0	0.0	1.5	2.3	30.2	25.9	32.1	24.3	32.4	35.6	32.2	25.7
	4 - Damaged	50.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.5	3.7	0.0	0.0	1.8	1.2
	5 - Partial	0.0	0.0	0.0	14.0	0.0	18.2	0.0	4.7	0.3	0.0	0.0	0.0	0.0	1.5
	6 - Unerupted	50.0	100.0	100.0	84.0	69.2	40.9	5.5	1.2	0.8	0.0	0.0	0.0	0.0	10.9
	7 – Congenital***	--	--	--	--	--	--	33.3	0.0	11.6	11.1	0.0	14.3	4.0	9.5
Lower % Total	**n-individual**	1	10	12	7	9	4	5	6	24	22	9	7	21	137
	n-teeth	1	26	34	49	72	40	68	84	328	294	143	156	299	1594
	avg. teeth/person**	1.0	2.6	2.8	7.0	8.0	10.0	10.0	11.2	9.9	8.1	5.4	3.3	6.6	6.9
	1 - Present	100.0	0.0	0.0	4.1	36.1	47.5	64.7	70.2	74.7	57.5	40.6	25.6	52.5	51.4
	2 - AMTL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	9.2	21.7	50.0	16.7	11.9
	3 – PMTL***	0.0	0.0	0.0	0.0	0.0	25.4	19.3	22.5	31.0	45.4	47.4	33.3	25.5	25.5
	4 - Damaged	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	3.1	0.7	0.0	1.3	1.1
	5 - Partial	0.0	0.0	0.0	16.3	0.0	17.5	4.4	6.0	0.0	0.0	0.0	0.0	0.0	1.4
	6 - Unerupted	0.0	100.0	100.0	79.6	58.3	35.0	4.4	3.6	0.9	0.0	0.0	0.0	1.0	10.5
	7 – Congenital***	--	--	--	--	--	--	12.5	8.3	12.5	24.3	25.0	10.0	8.1	14.7

Note. ***Adult I = 18-30 years; **teeth = present + damaged + partial + unerupted; *** Excludes AMTL and congenital absence; ****Congenital absence = % M^3 only.**

Table 7.3 Ostojićevo male permanent dentition (upper) count by tooth category and age-at-death. SA = subadult, A = adult.

Type	Category	SA?	Neo.	Inf I	Inf II	Ch I	Ch II	Juv I	Juv II	AI*	AII	AIII	AIV	A?	TOTAL
	n-individual	0	3	3	2	4	2	4	2	12	10	4	2	3	51
	n-teeth	0	4	4	16	35	17	47	25	182	110	34	24	33	531
	avg. teeth/person**	--	1.3	1.3	8.0	8.5	8.0	8.3	8.5	10.5	9.0	5.0	3.0	9.3	7.7
Molars	**1 - Present**	--	0	0	0	6	3	11	9	54	32	10	2	11	138
	2 - AMTL	--	0	0	0	0	0	0	0	1	0	1	3	0	5
	3 - PMTL	--	0	0	0	0	0	1	0	6	6	0	2	1	16
	4 - Damaged	--	0	0	0	0	0	0	0	0	1	0	0	0	1
	5 - Partial	--	0	0	2	0	0	0	2	0	0	0	0	0	4
	6 - Unerupted	--	3	3	3	4	4	2	0	0	0	0	0	0	19
	7 – Congenital***	--	--	--	--	--	--	2	0	4	0	0	0	0	6
Premolars	**1 - Present**	--	--	--	0	0	1	10	4	37	24	6	2	7	91
	2 - AMTL	--	--	--	0	0	0	0	0	1	1	0	0	0	2
	3 - PMTL	--	--	--	0	0	0	2	2	9	0	2	5	1	21
	4 - Damaged	--	--	--	0	0	0	0	0	0	3	0	0	0	3
	5 - Partial	--	--	--	0	0	2	0	0	0	0	0	0	0	2
	6 - Unerupted	--	--	--	4	13	2	0	0	0	0	0	0	0	19
Canines	**1 - Present**	--	--	--	0	0	0	5	1	10	10	3	2	4	35
	2 - AMTL	--	--	--	0	0	0	0	0	0	2	0	0	0	2
	3 - PMTL	--	--	--	0	1	0	2	2	12	1	2	2	0	22
	4 - Damaged	--	--	--	0	0	1	0	0	1	2	0	0	0	4
	5 - Partial	--	--	--	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	--	--	--	3	4	1	0	0	0	0	0	0	0	8
Incisors	**1 - Present**	--	0	0	0	3	2	5	1	24	18	1	0	6	60
	2 - AMTL	--	0	0	0	0	0	0	0	0	4	0	3	0	7
	3 - PMTL	--	0	0	0	0	1	7	4	23	6	9	3	3	56
	4 - Damaged	--	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	--	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	--	1	1	4	4	0	0	0	0	0	0	0	0	10
TOTAL	**1 - Present**	--	0	0	0	9	6	31	15	125	84	20	6	28	324
	2 - AMTL	--	0	0	0	0	0	0	0	2	7	1	6	0	16
	3 - PMTL	--	0	0	0	1	1	12	8	50	13	13	12	5	115
	4 - Damaged	--	0	0	0	0	1	0	0	1	6	0	0	0	8
	5 - Partial	--	0	0	2	0	2	0	2	0	0	0	0	0	6
	6 - Unerupted	--	4	4	14	25	7	2	0	0	0	0	0	0	56
	7 – Congenital***	--	--	--	--	--	--	2	0	4	0	0	0	0	6

***Note*. * Adult I = 18-30 years; **teeth = present + damaged + partial +unerupted; ***Congenital absence = M^3 only.**

Table 7.4 Ostojićevo male permanent dentition (lower) count by tooth category and age-at-death. SA = subadult, A = adult.

Type	Category	SA?	Neo.	Inf I	Inf II	Ch I	Ch II	Juv I	Juv II	AI*	AII	AIII	AIV	A?	TOTAL
	n-individual	0	5	7	2	4	2	4	2	12	10	5	2	5	60
	n-teeth	0	9	13	14	33	14	63	27	173	145	57	32	43	623
	avg. teeth/person**	--	1.8	1.9	7.0	8.3	7.0	12.0	9.0	11.5	9.9	6.0	4.0	6.2	7.6
Molars	**1 - Present**	--	0	0	0	8	4	16	10	55	41	8	4	12	158
	2 - AMTL	--	0	0	0	0	0	0	0	1	8	5	4	0	18
	3 - PMTL	--	0	0	0	0	0	1	0	4	4	5	4	2	20
	4 - Damaged	--	0	0	0	0	0	0	0	0	0	0	0	2	2
	5 - Partial	--	0	0	1	0	2	2	2	0	0	0	0	0	7
	6 - Unerupted	--	3	7	3	7	0	3	0	0	0	0	0	0	23
	7 – Congenital***	--	--	--	--	--	--	1	0	2	3	2	0	0	8
Premolars	**1 - Present**	--	--	--	0	0	0	12	3	37	28	10	3	6	99
	2 - AMTL	--	--	--	0	0	0	0	0	0	3	1	1	0	5
	3 - PMTL	--	--	--	0	0	0	4	3	8	3	4	4	2	28
	4 - Damaged	--	--	--	0	0	0	0	0	0	2	0	0	2	4
	5 - Partial	--	--	--	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	--	--	--	4	5	4	0	0	0	0	0	0	0	13
Canines	**1 - Present**	--	--	--	0	0	0	5	1	19	10	6	0	4	45
	2 - AMTL	--	--	--	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	--	--	--	0	0	0	3	2	4	5	1	4	2	21
	4 - Damaged	--	--	--	0	0	0	0	0	0	3	0	0	0	3
	5 - Partial	--	--	--	0	0	2	0	0	0	0	0	0	0	2
	6 - Unerupted	--	--	--	2	5	0	0	0	0	0	0	0	0	7
Incisors	**1 - Present**	--	0	0	0	6	2	10	2	27	14	6	1	2	70
	2 - AMTL	--	0	0	0	0	0	0	0	0	2	0	0	2	4
	3 - PMTL	--	0	0	0	0	0	6	4	16	18	9	7	4	64
	4 - Damaged	--	0	0	0	0	0	0	0	0	1	0	0	0	1
	5 - Partial	--	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	--	6	6	4	2	0	0	0	0	0	0	0	3	21
TOTAL	**1 - Present**	--	0	0	0	14	6	43	16	138	93	30	8	24	372
	2 - AMTL	--	0	0	0	0	0	0	0	1	13	6	5	2	27
	3 - PMTL	--	0	0	0	0	0	14	9	32	30	19	19	10	133
	4 - Damaged	--	0	0	0	0	0	0	0	0	6	0	0	4	10
	5 - Partial	--	0	0	1	0	4	2	2	0	0	0	0	0	9
	6 - Unerupted	--	9	13	13	19	4	3	0	0	0	0	0	3	64
	7 – Congenital***	--	--	--	--	--	--	1	0	2	3	2	0	0	8

***Note*. * Adult I = 18-30 years; **teeth = present + damaged + partial +unerupted; ***Congenital absence = M^3 only.**

Table 7.5 Ostojićevo female permanent dentition (upper) count by tooth category and age-at-death. SA = subadult, A = adult.

Type	Category	SA?	Neo.	Inf I	Inf II	Ch I	Ch II	Juv I	Juv II	AI*	AII	AIII	AIV	A?	TOTAL
	n-individual	2	0	3	3	5	2	1	4	8	7	3	6	7	51
	n-teeth	2	0	15	25	30	27	8	60	115	78	41	65	102	568
	avg. teeth/person**	1.0	--	5.0	8.3	6.0	13.5	4.0	11.5	9.3	5.9	9.0	3.7	8.4	7.3
Molars	**1 - Present**	0	--	0	0	9	4	1	16	28	18	9	9	23	117
	2 - AMTL	0	--	0	0	0	0	0	0	0	0	2	13	3	18
	3 - PMTL	0	--	0	0	0	0	1	2	12	5	1	0	7	28
	4 - Damaged	0	--	0	0	0	0	0	0	1	0	0	0	0	1
	5 - Partial	0	--	0	4	0	4	0	2	0	0	0	0	0	10
	6 - Unerupted	1	--	4	2	6	1	1	1	0	0	0	0	0	16
	7 – Congenital***	--	--	--	--	--	--	1	2	0	1	0	4	1	2
Premolars	**1 - Present**	--	--	0	0	0	0	0	12	22	13	7	5	18	77
	2 - AMTL	--	--	0	0	0	0	0	0	1	2	1	10	3	17
	3 - PMTL	--	--	0	0	0	0	2	4	7	7	4	1	6	31
	4 - Damaged	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	--	--	2	7	7	8	0	0	0	0	0	0	0	24
Canines	**1 - Present**	--	--	0	0	0	0	0	6	9	6	5	3	7	36
	2 - AMTL	--	--	0	0	0	0	0	0	0	0	0	5	2	7
	3 - PMTL	--	--	0	0	0	0	1	2	5	4	1	0	4	17
	4 - Damaged	--	--	0	0	0	0	0	0	0	1	0	0	1	2
	5 - Partial	--	--	0	0	0	2	0	0	0	0	0	0	0	2
	6 - Unerupted	--	--	4	2	5	2	0	0	0	0	0	0	0	13
Incisors	**1 - Present**	0	--	0	0	1	6	2	9	14	3	6	5	10	56
	2 - AMTL	0	--	0	0	0	0	0	0	0	3	1	10	4	18
	3 - PMTL	0	--	0	0	0	0	0	6	15	14	4	3	14	56
	4 - Damaged	1	--	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	--	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	--	5	10	2	0	0	0	0	0	0	0	0	17
TOTAL	**1 - Present**	0	--	0	0	10	10	3	43	73	40	27	22	58	286
	2 - AMTL	0	--	0	0	0	0	0	0	1	5	4	38	12	60
	3 - PMTL	0	--	0	0	0	0	4	14	39	30	10	4	31	132
	4 - Damaged	1	--	0	0	0	0	0	0	1	1	0	0	1	4
	5 - Partial	0	--	0	4	0	6	0	2	0	0	0	0	0	12
	6 - Unerupted	1	--	15	21	20	11	1	1	0	0	0	0	0	70
	7 – Congenital***	--	--	--	--	--	--	1	2	0	1	0	4	1	2

***Note*. * Adult I = 18-30 years; **teeth = present + damaged + partial +unerupted; ***Congenital absence = M^3 only.**

Table 7.6 Ostojićevo female permanent dentition (lower) count by tooth category and age-at-death. SA = subadult, A = adult.

Type	Category	SA?	Neo.	Inf I	Inf II	Ch I	Ch II	Juv I	Juv II	AI*	AII	AIII	AIV	A?	TOTAL
	n-individual	1	2	4	3	5	2	1	4	8	11	3	4	7	55
	n-teeth	1	5	17	23	39	26	5	57	91	133	70	106	118	691
	avg. teeth/person**	1.0	2.5	4.3	7.7	7.8	13.0	2.0	12.3	7.9	7.0	9.0	6.5	9.9	7.7
	1 - Present	--	0	0	0	7	5	1	17	26	31	5	9	30	131
	2 - AMTL	--	0	0	0	0	0	0	0	1	9	14	28	8	60
	3 - PMTL	--	0	0	0	0	0	1	0	4	4	4	0	4	17
Molars	**4 - Damaged**	--	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	--	0	0	2	0	3	1	3	0	0	0	0	0	9
	6 - Unerupted	--	1	6	7	7	0	0	3	0	0	0	0	0	24
	7 – Congenital***	--	--	--	--	--	--	1	3	6	0	2	2	14	1
	1 - Present	--	--	0	0	0	0	0	12	19	18	9	7	21	86
	2 - AMTL	--	--	0	0	0	0	0	0	1	4	0	13	5	23
Premolars	**3 - PMTL**	--	--	0	0	0	0	2	3	6	11	7	6	5	40
	4 - Damaged	--	--	0	0	0	0	0	0	0	3	1	0	0	4
	5 - Partial	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	--	--	3	5	8	6	0	0	0	0	0	0	0	22
	1 - Present	1	0	0	0	0	0	--	5	9	12	4	4	7	42
	2 - AMTL	0	0	0	0	0	0	--	0	0	0	0	6	1	7
Canines	**3 - PMTL**	0	0	0	0	0	0	--	1	4	5	6	4	7	27
	4 - Damaged	0	0	0	0	0	0	--	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	--	0	0	0	0	0	0	0
	6 - Unerupted	0	1	2	1	5	4	--	0	0	0	0	0	0	13
	1 - Present	--	0	0	0	5	8	--	9	9	13	8	6	11	69
	2 - AMTL	--	0	0	0	0	0	--	0	0	0	1	14	6	21
Incisors	**3 - PMTL**	--	0	0	0	0	0	--	3	9	17	11	7	11	58
	4 - Damaged	--	0	0	0	4	0	--	0	0	0	0	0	0	4
	5 - Partial	--	0	0	0	0	0	--	0	0	0	0	0	0	0
	6 - Unerupted	--	3	6	8	3	0	--	0	0	0	0	0	0	20
	1 - Present	1	0	0	0	12	13	1	43	63	74	26	26	69	328
	2 - AMTL	0	0	0	0	0	0	0	0	2	13	15	61	20	111
	3 - PMTL	0	0	0	0	0	0	3	7	23	37	28	17	27	142
TOTAL	**4 - Damaged**	0	0	0	0	4	0	0	0	0	3	1	0	0	8
	5 - Partial	0	0	0	2	0	3	1	3	0	0	0	0	0	9
	6 - Unerupted	0	5	17	21	23	10	0	3	0	0	0	0	0	79
	7 – Congenital***	--	--	--	--	--	--	1	3	6	0	2	2	14	1

***Note*. * Adult I = 18-30 years; **teeth = present + damaged + partial +unerupted; ***Congenital absence = M^3 only.**

7.5.2 Deciduous Dentition

The inventory of deciduous "dentition" included erupted, partial-erupted, eruption stage unknown, and unerupted. Teeth lost postmortem (PMTL) were only recorded when the associated alveolar bone was present. A complete inventory of deciduous dentition by age-at-death can be found in Appendix Table 22 (upper) and Appendix Table 23 (lower). Table 7.7 includes tooth count data and elemental prevalence for upper and lower deciduous teeth by age-at-death. Subadult "sex" is based on body orientation. Sex-specific count data are listed in Tables 7.8 and 7.9 for male upper and lower deciduous teeth, respectively, and Tables 7.10 and 7.11 for female upper and lower deciduous teeth, respectively. Deciduous teeth were absent in individuals >12 years-at-death.

A total of 171 deciduous upper "teeth" were recorded for 41 individuals. Poor preservation of maxillae in subadults means that PMTL prevalence is likely much higher than reported here. Neonates were the only age class in which anterior teeth outnumbered cheek teeth (*ratio* = 0.8). The ratio of cheek teeth to anterior teeth increased with age, reflecting the timing of deciduous tooth loss to a lesser extent PMTL (*ratio-infant I* = 1.1; *ratio-infant II* = 1.3; *ratio-child I* = 2.1; *ratio-child II* = 7.0). Thus, anterior upper deciduous teeth are poorly represented in individuals >9-12 years-at-death despite low overall rates of PMTL (*TPR* = 11.1%).

A total of 199 deciduous lower "teeth" were recorded for 48 individuals. The greater prevalence of PMTL in lower compared to upper teeth is due to the better preservation of alveolar bone in the former. Cheek teeth outnumbered anterior teeth in each age class (*ratio-neonate* = 1.3; *ratio-infant I* = 2.5; *ratio-infant II* = 1.6; *ratio-child I* = 33.0; *ratio-child II* = 9.0). No lower deciduous canines were recorded in Child I or Child II individuals, no lower deciduous incisors were recorded in Child II individuals, and only one lower deciduous incisor was recorded in a Child I individual. The general absence of deciduous lower anterior teeth in individuals >6-12 years-at-death has implications for interpreting dental disease (*i.e.*, calculus and caries), as values reported for these individuals will ostensibly only reflect cheek teeth whereas anterior teeth and/or the entire lower dental arcade will be represented in individuals <6 years-at-death.

Table 7.7 Ostojićevo pooled male, female, and indeterminate TOTAL deciduous dentition

Jaw	Category	Neon.	% Neon.	Inf. I	% Inf. I	Inf. II	% Inf. II	Ch.I	% Ch. I	Ch. II	% Ch. II	TOTAL	% TOTAL
Upper	**n-individual**	12	--	9	--	7	--	9	--	4	--	41	--
	n-teeth*	42	--	44	--	35	--	34	--	16	--	171	--
	1 - Erupted	4	8.5	27	51.9	33	73.3	34	82.9	16	88.9	114	56.2
	2 - PMTL	5	10.6	8	15.4	10	22.2	7	17.1	2	11.1	32	15.8
	3 - Unerupted	16	34.0	11	21.2	0	0.0	0	0.0	0	0.0	27	13.3
	4 – Partial-Erupted	2	4.3	2	3.8	0	0.0	0	0.0	0	0.0	4	2.0
	5 – Erupted-Unknown	20	42.6	4	7.7	2	4.4	0	0.0	0	0.0	26	12.8
Lower	**n-individual**	16	--	12	--	8	--	9	--	3	--	48	--
	n-teeth*	73	--	49	--	34	--	34	--	9	--	199	--
	1 - Erupted	6	5.7	25	33.8	31	68.9	34	73.9	9	81.8	105	37.4
	2 - PMTL	32	30.5	25	33.8	11	24.4	12	26.1	2	18.2	82	29.2
	3 - Unerupted	37	35.2	15	20.3	0	0.0	0	0.0	0	0.0	52	18.5
	4 – Partial-Erupted	2	1.9	7	9.5	0	0.0	0	0.0	0	0.0	9	3.2
	5 – Erupted-Unknown	28	26.7	2	2.7	3	6.7	0	0.0	0	0.0	33	11.7

***Note*. * Excludes PMTL**

Table 7.8 Ostojićevo male deciduous dentition (upper) count by tooth category and age-at-death

Jaw/Tooth Type	Category	Neon.	Infant I	Infant II	Child I	Child II	TOTAL
Upper	**n-individual**	9	5	2	4	2	22
	n-teeth*	30	22	13	18	7	90
dm^2	**1 - Erupted**	0	1	4	4	4	13
	2 - PMTL	0	0	0	0	1	1
	3 - Unerupted	3	4	0	0	0	7
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	1	1	0	0	0	2
dm^1	**1 - Erupted**	1	4	2	7	1	15
	2 - PMTL	0	0	0	0	1	1
	3 - Unerupted	4	0	0	0	0	4
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	5	1	0	0	0	6
dc	**1 - Erupted**	0	0	3	4	2	9
	2 - PMTL	0	0	0	2	0	2
	3 - Unerupted	4	3	0	0	0	7
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	0	2	0	0	0	2
$di^2 + di^1$	**1 - Erupted**	2	6	4	3	0	15
	2 - PMTL	0	1	0	1	0	2
	3 - Unerupted	2	0	0	0	0	2
	4 – Partial-Erupted	2	0	0	0	0	2
	5 – Erupted-Unknown	6	0	0	0	0	6
TOTAL	**1 - Erupted**	3	11	13	18	7	52
	2 - PMTL	0	1	0	3	2	6
	3 - Unerupted	13	7	0	0	0	20
	4 – Partial-Erupted	2	0	0	0	0	2
	5 – Erupted-Unknown	12	4	0	0	0	16

***Note*. * Excludes PMTL**

Table 7.9 Ostojićevo male deciduous dentition (lower) count by tooth category and age-at-death

Jaw/Tooth Type	Category	Neon.	Infant I	Infant II	Child I	Child II	TOTAL
Lower	n-individual	10	7	2	4	1	24
	n-teeth*	40	26	6	16	3	91
dm_2	1 - Erupted	0	1	2	7	2	12
	2 - PMTL	1	0	0	0	0	1
	3 - Unerupted	8	8	0	0	0	16
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	6	0	0	0	0	6
dm_1	1 - Erupted	2	7	2	8	1	20
	2 - PMTL	1	1	1	0	1	4
	3 - Unerupted	4	1	0	0	0	5
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	4	1	0	0	0	5.0
dc	1 - Erupted	0	0	2	0	0	2
	2 - PMTL	4	1	1	5	0	11
	3 - Unerupted	2	2	0	0	0	4
	4 – Partial-Erupted	0	2	0	0	0	2
	5 – Erupted-Unknown	2	0	0	0	0	2
$di_2 + di_1$	1 - Erupted	1	1	0	1	0	3
	2 - PMTL	9	3	0	0	0	12
	3 - Unerupted	5	2	0	0	0	7
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	6	1	0	0	0	7
TOTAL	1 - Erupted	3	9	6	16	3	37
	2 - PMTL	15	5	2	5	1	28
	3 - Unerupted	19	13	0	0	0	32
	4 – Partial-Erupted	0	2	0	0	0	2
	5 – Erupted-Unknown	18	2	0	0	0	20

***Note*. * Excludes PMTL**

Table 7.10 Ostojićevo female deciduous dentition (upper) count by tooth category and age-at-death

Jaw/Tooth Type	Category	Neon.	Infant I	Infant II	Child I	Child II	TOTAL
Upper	**n-individual**	2	3	4	5	2	16
	n-teeth*	2	21	18	16	9	66
dm^2	**1 - Erupted**	0	3	5	6	6	20
	2 - PMTL	0	1	1	0	0	2
	3 - Unerupted	0	2	0	0	0	2
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	0	0	1	0	0	1
dm^1	**1 - Erupted**	0	4	5	6	3	18
	2 - PMTL	0	0	1	0	0	1
	3 - Unerupted	0	0	0	0	0	0
	4 – Partial-Erupted	0	2	0	0	0	2
	5 – Erupted-Unknown	1	0	0	0	0	1
dc	**1 - Erupted**	0	3	3	3	0	9
	2 - PMTL	1	1	2	3	0	7
	3 - Unerupted	0	2	0	0	0	2
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	0	0	1	0	0	1
$di^2 + di^1$	**1 - Erupted**	1	5	3	1	0	10
	2 - PMTL	4	2	6	1	0	13
	3 - Unerupted	0	0	0	0	0	0
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	0	0	0	0	0	0
TOTAL	**1 - Erupted**	1	15	16	16	9	57
	2 - PMTL	5	4	10	4	0	23
	3 - Unerupted	0	4	0	0	0	4
	4 – Partial-Erupted	0	2	0	0	0	2
	5 – Erupted-Unknown	1	0	2	0	0	3

***Note*. * Excludes PMTL**

Table 7.11 Ostojićevo female deciduous dentition (lower) count by tooth category and age-at-death

Jaw/Tooth Type	Category	Neon.	Infant I	Infant II	Child I	Child II	TOTAL
Lower	**n-individual**	2	4	4	5	2	17
	n-teeth*	8	20	24	18	6	76
dm_2	**1 - Erupted**	0	4	5	9	4	22
	2 - PMTL	0	0	0	0	0	0
	3 - Unerupted	1	2	0	0	0	3
	4 – Partial-Erupted	0	2	0	0	0	2
	5 – Erupted-Unknown	1	0	2	0	0	3
dm_1	**1 - Erupted**	1	5	7	9	2	24
	2 - PMTL	0	1	1	0	0	2
	3 - Unerupted	0	0	0	0	0	0
	4 – Partial-Erupted	1	2	0	0	0	3
	5 – Erupted-Unknown	0	0	0	0	0	0
dc	**1 - Erupted**	0	2	2	0	0	4
	2 - PMTL	2	4	3	7	1	17
	3 - Unerupted	1	0	0	0	0	1
	4 – Partial-Erupted	1	1	0	0	0	2
	5 – Erupted-Unknown	0	0	1	0	0	1
$di_2 + di_1$	**1 - Erupted**	2	2	7	0	0	11
	2 - PMTL	6	10	5	0	0	21
	3 - Unerupted	0	0	0	0	0	0
	4 – Partial-Erupted	0	0	0	0	0	0
	5 – Erupted-Unknown	0	0	0	0	0	0
TOTAL	**1 - Erupted**	3	13	21	18	6	61
	2 - PMTL	8	15	9	7	1	40
	3 - Unerupted	2	2	0	0	0	4
	4 – Partial-Erupted	2	5	0	0	0	7
	5 – Erupted-Unknown	1	0	3	0	0	4

***Note*. * Excludes PMTL**

7.6 Results: Ostojićevo Dental Disease

7.6.1 Antemortem Tooth Loss

Results of AMTL are reported in Appendix Table 24 for males, Appendix Table 25 for females, and Appendix Table 26 for pooled males, females, and indeterminate adults. All % refer to TPR, unless otherwise noted.

Posterior teeth (molars and premolars) were more likely to be lost antemortem than anterior teeth (incisors and canines). Canines were the least likely (*upper* = 5.5%, *lower* = 11.5%) and molars the most likely (*upper* = 11.8%, *lower* = 26.3%) to be lost antemortem for both upper and lower teeth. Males deviated slightly from this pattern in that no upper canines or incisors were lost antemortem. Several adults exhibited extensive AMTL (Figure 7.2). Among individuals with well-preserved upper dentition (≥50% dental arcade present), three Adult IV females (Graves 6, 115, and 264) were edentulous. Among individuals with well-preserved lower teeth (≥50% dental arcade present), three Adult IV females (Graves 6, 115, and 258), one Adult female (Grave 222A), and one Adult IV probable-male (Grave 68) were edentulous.

A Kruskal-Wallis H test was run to determine differences in AMTL prevalence (element) between four age and sex groups: Adult I/II males, Adult III/IV males, Adult I/II females, and Adult III/IV females. Prevalence was statistically significant between the four groups for both upper ($\chi^2 = 164.64$, $df = 3$, $p = .000$) and lower ($\chi^2 = 179.07$, $df = 3$, $p = .000$) dentition. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted *p*-values are reported in Table 7.12. The post hoc analysis revealed statistically significant differences in AMTL prevalence between all group combinations, except for Adult I/II males versus females for both the upper and lower dentition. In all cases, female prevalence was higher than that for males, and Adult III/IV prevalence was higher than that for Adult I/II. Finally, chi-square analysis found AMTL prevalence to be significantly higher in the lower compared to upper dentition ($\chi^2 = 4.15$, $df = 1$, $p = .042$).

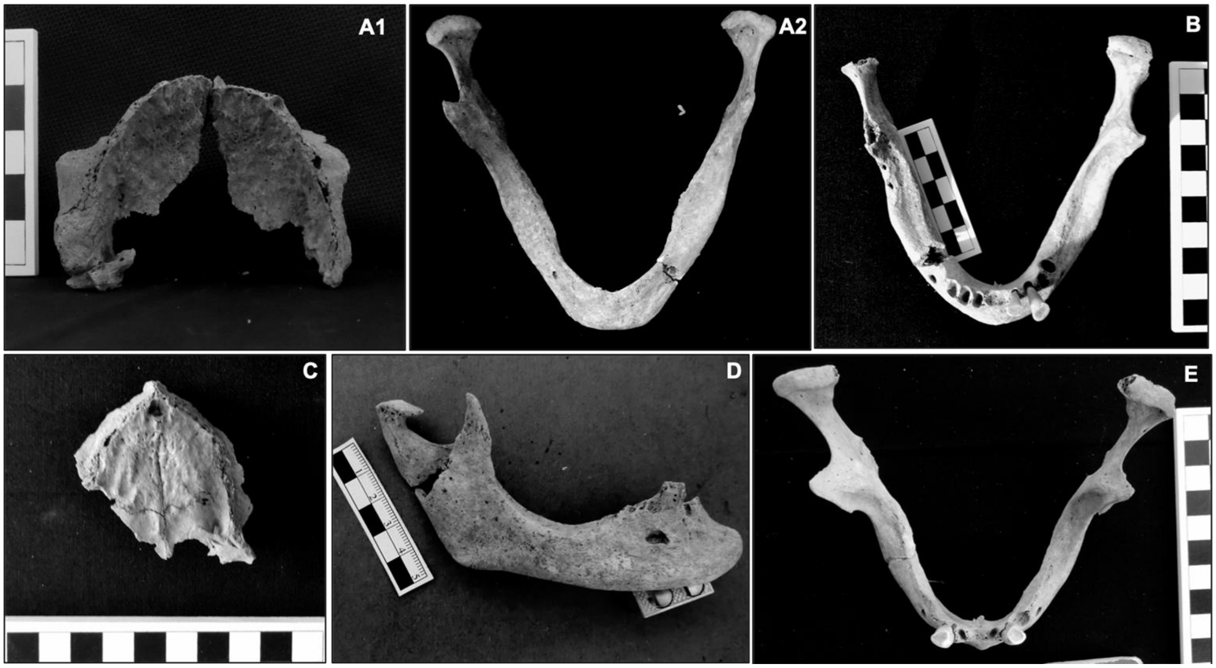


Figure 7.2 Extensive AMTL in individuals >40 years-at-death (Adults III and IV): (A1 and A2) Grave 115, Adult IV female; (B) Grave 246, Adult IV female; (C) Grave 264, Adult IV female; (D) Grave 222A, Adult? Female; (E) Grave 266, Adult III/IV male.

Table 7.12 Statistical analysis of AMTL TPR at Ostojićevo. Results of pairwise comparisons (*df* = 1) following a Kruskal-Wallis H test (*df* = 3) of AMTL prevalence in permanent dentition by sex and age-at-death. Values in bold are significant (α = .05).

Jaw	Variable	$\chi^2(1)$	Adjusted-*p*
Upper	M*F Adult I/II	3.13	.727
	M*F Adult III/IV	**66.93**	**.000**
	M Adult I/II * Adult III/IV	**58.75**	**.000**
	F Adult I/II * Adult III/IV	**122.55**	**.000**
Lower	M*F Adult I/II	8.96	1.000
	M*F Adult III/IV	**81.56**	**.000**
	M Adult I/II * Adult III/IV	**88.12**	**.000**
	F Adult I/II * Adult III/IV	**160.77**	**.000**

7.6.2 Periodontal Disease

Horizontal bone loss is reported with AMTL in the appendices. Data on 'horizontal bone loss' (bone loss) and alveolar resorption (AMTL) are reported for upper and lower dentition by tooth type (*i.e.*, molars, premolars, canines, and incisors) for males (Appendix Table 24), females (Appendix Table 25), and total adults (Appendix Table 26). Data on 'vertical bone loss' is reported in section 8.5. All % refer to TPR, unless otherwise noted.

Bone loss associated with upper teeth did not vary between tooth types. However, bone loss did show a distinct pattern in lower teeth, with almost twice as many posterior teeth affected compared to anterior teeth. Prevalence in lower teeth ranged from only 8.7% of incisors to 28.4% of molars. For upper teeth, premolars were the least and canines the most affected teeth in males, whereas canines were the least and premolars and molars the most affected teeth in females. In contrast, the lower canines in males and lower incisors in females were the least affected, and the lower molars were the most affected for both males and females. Among males, bone loss prevalence in upper and lower teeth showed a sharp increase between each consecutive age groups from Adult I to Adult III individuals, with almost no difference between Adult III and Adult IV individuals. Females displayed a more complex pattern, with bone loss prevalence in Adult IV individuals showing a sharp decrease due to extensive AMTL. Bone loss associated with upper teeth in females doubled from Adult I to Adult II and then quadrupled from Adult II to Adult III age classes. Bone loss prevalence associated with lower teeth in females doubled from Adult I to Adult II individuals, with only a small difference between Adult II and Adult III individuals. This difference in sex-specific bone loss between males and females suggests the progression of periodontal disease in females was more likely to produce AMTL than in males. As illustrated in Figure 7.3, many male individuals >40 years retained their teeth despite severe reductions in the height of the alveolus.

A Kruskal-Wallis H test was run to assess differences in bone loss prevalence (element) between four age and sex groups: Adult I/II males, Adult III/IV males, Adult I/II females, and Adult III/IV females. Prevalence was statistically significant between the four groups for both upper ($\chi^2 = 63.58$, $df = 3$, $p = .000$)

and lower (χ^2 = 37.75, *df* = 3, *p* = .000) dentition. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted *p*-values are reported in Table 7.13. The post hoc analysis revealed statistically significant differences in bone loss prevalence between all group combinations, except Adult I/II males and females (upper and lower teeth) and Adult I/II and Adult III/IV females (lower teeth). Female prevalence was higher than that of age-matched males for upper teeth. By contrast, bone loss prevalence for lower teeth in Adult III/IV males (*TPR* = 37.8%) was more than twice that of Adult III/IV females (*TPR* = 17.0%). This discrepancy is likely due to the high prevalence of AMTL of lower teeth in Adult III/IV females. Finally, chi-square analysis found no significant difference in bone loss prevalence in upper compared to lower teeth (χ^2 = 0.16, *df* = 1, *p* = .693).

Table 7.13 Statistical analysis of periodontal disease TPR at Ostojićevo. Results of pairwise comparisons (*df* = 1) following a Kruskal-Wallis H test (*df* = 3) of bone loss prevalence associated with permanent dentition by sex and age-at-death. Values in bold are significant (α = .05).

Jaw	Variable	$\chi^2(1)$	Adjusted-*p*
Upper	M*F Adult I/II	5.02	1.000
	M*F Adult III/IV	**45.30**	**.047**
	M Adult I/II * Adult III/IV	**103.01**	**.000**
	F Adult I/II * Adult III/IV	**52.69**	**.001**
Lower	M*F Adult I/II	26.15	.167
	M*F Adult III/IV	**70.05**	**.000**
	M Adult I/II * Adult III/IV	**96.73**	**.000**
	F Adult I/II * Adult III/IV	0.54	1.000

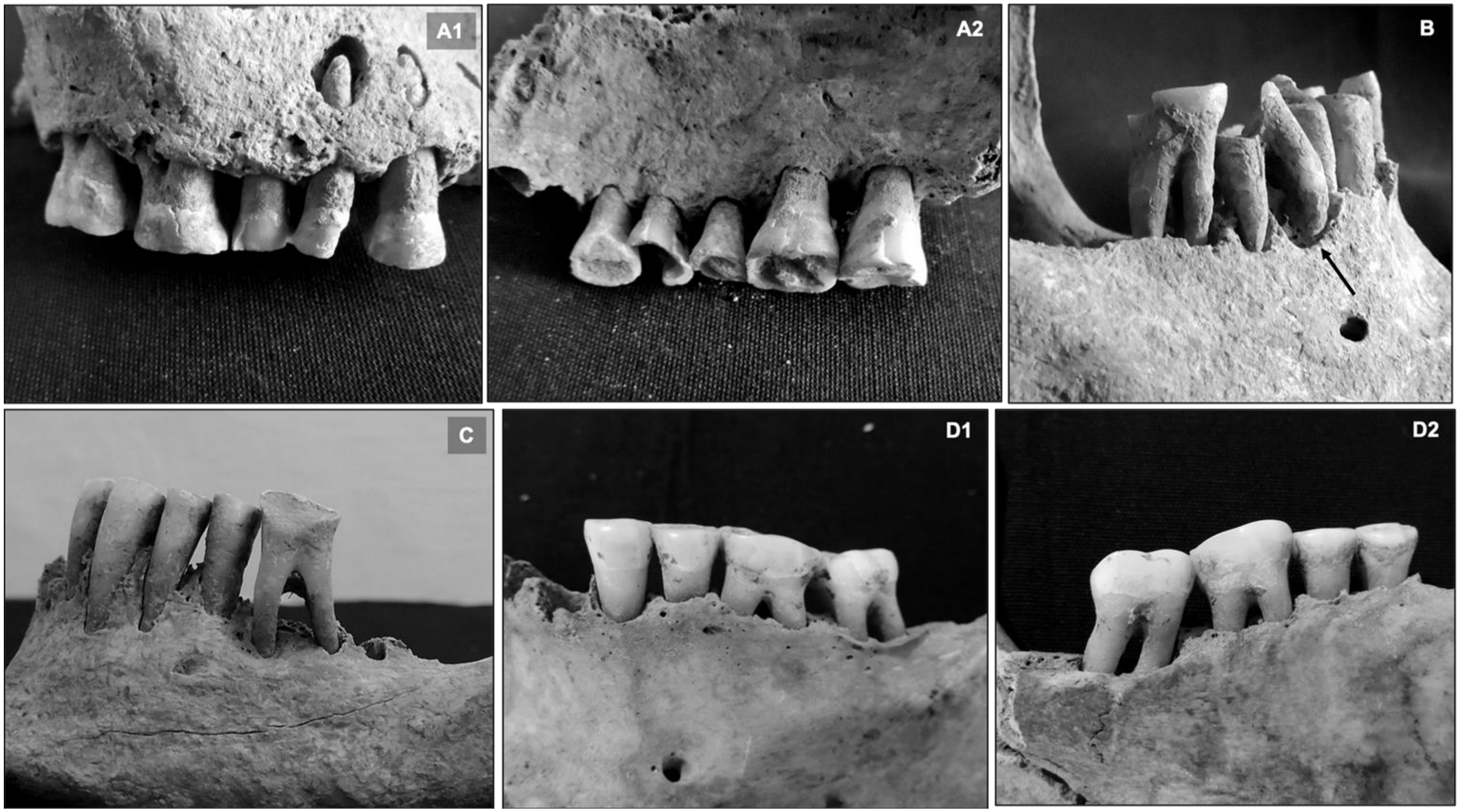


Figure 7.3 Examples of moderate to severe periodontal disease at Ostojićevo: Grave 92, moderate buccal (A1) and lingual (A2) bone loss at right M^1 and M^2 with antemortem loss of M^3 in an Adult II female; (B) Grave 101, severe bone loss at left M_1 and M_2 (some postmortem damage to alveolar margin) with antemortem loss of M_3 in an Adult III/IV male (arrow shows bone destruction from an apical abscess); (C) Grave 49, severe bone loss at left M_1 and moderate bone loss at left P_2 with antemortem loss of M_2 and M_3 in an Adult III male; Grave 186, moderate buccal (D1) and lingual (D2) bone loss at left M_1 and M_2 with antemortem loss of M_3 in an Adult II male.

7.6.3 Dental Caries – Permanent Dentition

Data on dental caries by upper and lower permanent tooth type is reported for males (Appendix Table 27), females (Appendix Table 28), and total (Appendix Table 29). Sex of individuals <18 years-at-death based on body orientation. All % refers to TPR, unless otherwise noted.

Total caries prevalence showed a clear distal to mesial distribution in upper teeth, ranging from 6.2% of upper incisors to 19.0% of upper molars. In contrast, lower premolars (*TPR* = 6.9%) were the least affected and lower molars (*TPR* = 14.5%) were the most affected. Overall caries prevalence was higher in upper (*TPR* = 15.0) compared to lower (*TPR* = 10.6%) teeth. Caries prevalence in the upper teeth increased with age from 6-12 years through 40-50 years, and then decreased after 50 years. Notably, there was a five-fold increase in caries TPR from Juvenile I/II to Adult I age classes. Caries TPR in lower teeth increased with each successive age class, with a four-fold increase in TPR from Adult I to Adult II. Dental caries was absent in both upper and lower permanent teeth for Child I/II individuals.

Caries TPR by age-at-death and tooth type is illustrated in Figure 7.4 for males and Figure 7.5 for females. To summarize, caries prevalence was greater in upper teeth compared to lower teeth for both males and females. Among males, lower canines were the least affected (*TPR* = 4.3%) and upper molars were the most affected (*TPR* = 15.3%); among females, upper incisors were the least affected (*TPR* = 5.4%) and upper premolars were the most affected (*TPR* = 22.1%). When age-at-death is considered, caries prevalence in males doubled from Juvenile I/II to Adult I individuals and then again from Adult I to Adult II, with a modest increase from Adult II to Adult III/IV. In contrast, females showed a ten-fold increase in caries prevalence from Juvenile I/II to Adult I, and an almost three-fold increase from Adult I to Adult II. The relative increase from Adult II to Adult III/IV individuals in females was similar to that for males, though actual prevalence was much greater (*e.g.*, 15.6% of Adult III/IV teeth in males versus 33.7% of Adult III/IV teeth in females). Caries were absent from permanent dentition in those <12 years for both males and females. Finally, caries prevalence is more likely to be underrepresented among Adult III/IV females than males due to the large proportion of edentulous individuals.

Caries severity ranged from 1 (none) to 7/8 (gross cavity, complete destruction of crown and involvement of neighboring teeth) (Figure 7.6). Caries severity TPR by age-at-death is reported in Figure 7.7 for males and Figure 7.8 for females. Overall, “large” caries that extended into and exposed the pulp cavity were the most common (*TPR* = 5.5%) followed by “small” caries extending into the dentine (*TPR* = 3.8%). “Slight” caries confined to the enamel and “gross” caries affected less than 2.0% of teeth, respectively. Prevalence was similar (<1.0% difference) between upper and lower teeth for “small” and “gross” caries; however, “slight” and “large” caries were more common in upper compared to lower teeth. Among males, “gross” caries were absent in the teeth of individuals <30 years, but represented the majority of carious lesions in individuals >40 years. This pattern corresponds to the initiation and slow progression of caries in males in the third and fourth decades with more rapid progression of carious lesions after the fifth decade. In contrast, “gross” caries were more common in the teeth of Adult I and Adult II females than Adult III/IV females. This suggests a pattern of caries-induced antemortem tooth loss affecting females in their third and, to a greater extent, fourth decades (Schwartz, 2007). The decline in women’s oral health as evidenced by higher caries prevalence compared to men during their peak reproductive years supports a relationship between greater initiation and more rapid progression of carious lesions with high fertility, biological changes during pregnancy (*i.e.*, hormonal, immune, and biochemical fluctuations), and behavioral factors such as food cravings (Chapple et al., 2017; Lukacs, 2008; 2011a).

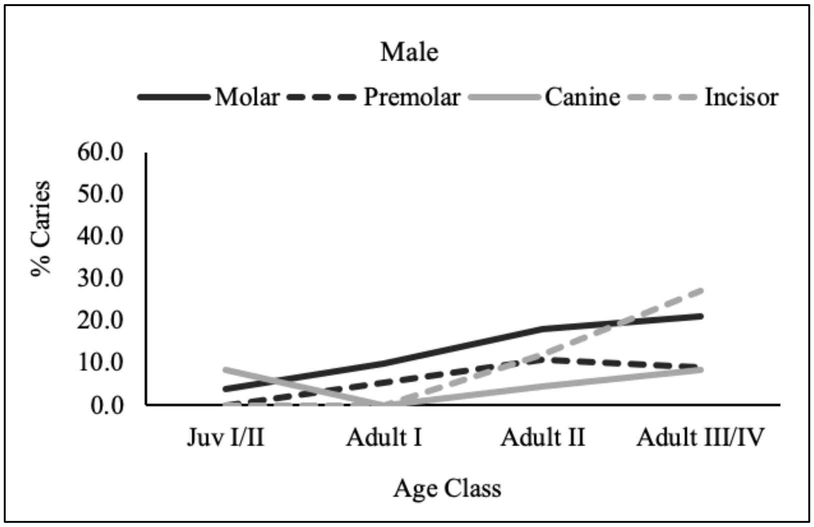


Figure 7.4 Ostojićevo caries TPR by tooth type and age-at-death in males. Combined upper and lower teeth.

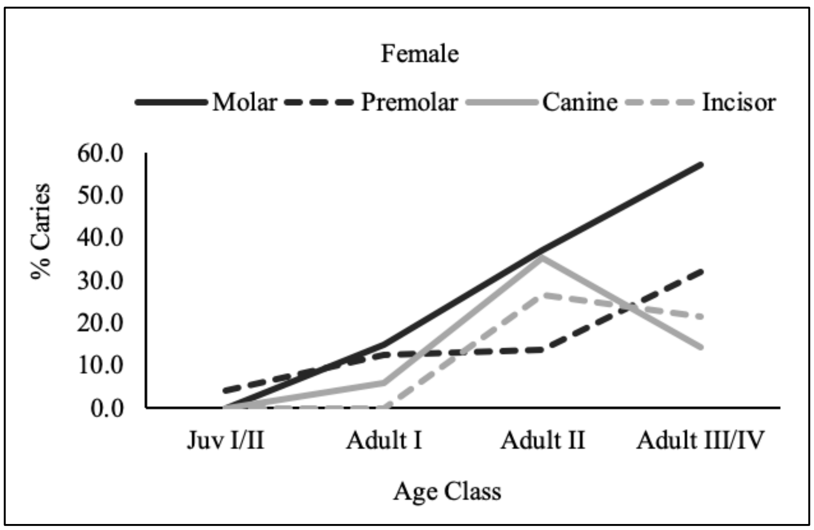


Figure 7.5 Ostojićevo caries TPR by tooth type and age-at-death in females. Combined upper and lower teeth.

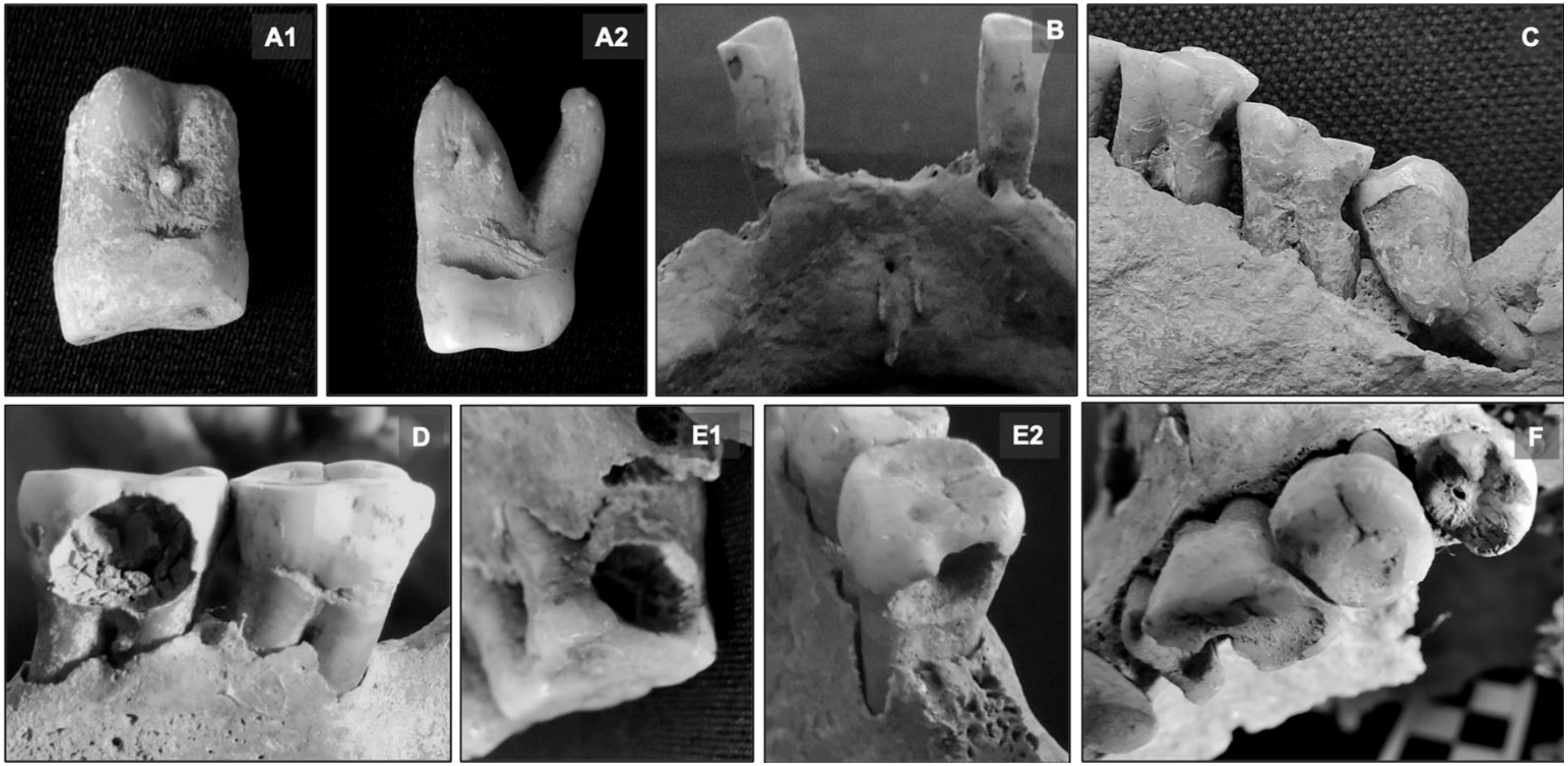


Figure 7.6 Examples of slight to gross carious lesions at Ostojićevo: Grave 86, Adult II male, left-M^2 score 4 distal (A1) and right-M^1 score 5 mesial (A2); (B) Grave 266, Adult III probable-male, left-C score 4 distal; (C) Grave 7, Adult female, multiple score 5/6 interstitial carious lesions on all three molars; (D) Grave 280, Adult II female, lingual on left-M^2 (score 7) and left-M^1 (score 4); Grave 69, Adult I female, score 7 mesial on left-M^1 (E1) and right-M$_2$ (E2); and (F) multiple carious lesions on all three molars, including score 7/8 on left-P^2, left-M^2 (distal aspect not picture), and left-M^3. Note enamel pearl in A1.

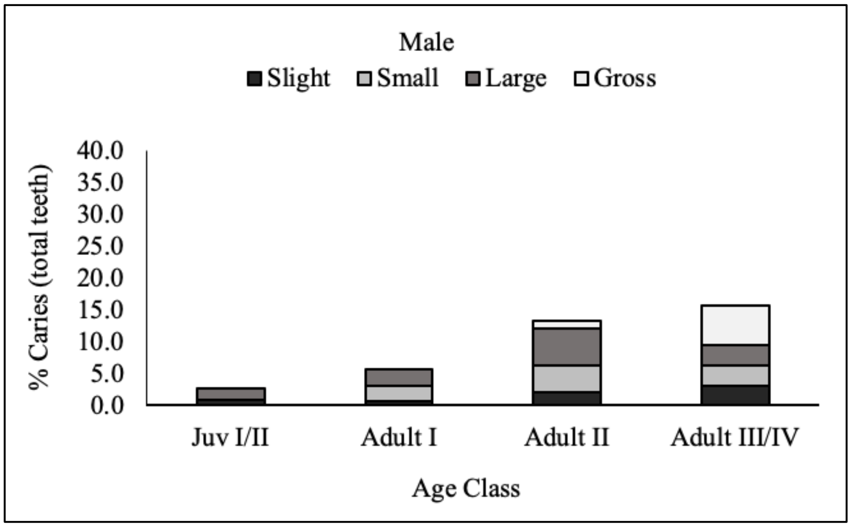


Figure 7.7 Age-related distribution (TPR) of caries severity in males at Ostojićevo. Combined upper and lower teeth. Categories indicate part of tooth affected (Score 3 = enamel; Score 4 = dentine; Score 5/6 = pulp; Score 7/8 = complete destruction of crown.

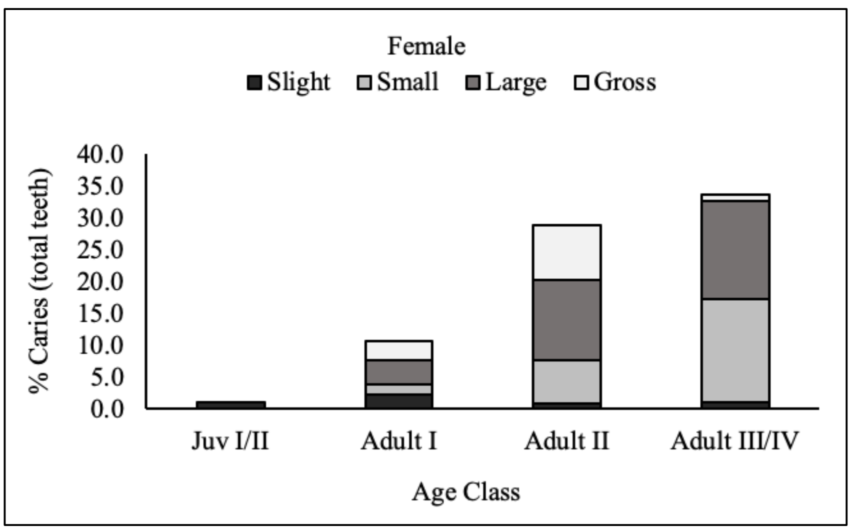


Figure 7.8 Age-related distribution (TPR) of caries severity in females at Ostojićevo. Combined upper and lower teeth. Categories indicate part of tooth affected (Score 3 = enamel; Score 4 = dentine; Score 5/6 = pulp; Score 7/8 = complete destruction of crown.

Chi-square analysis demonstrated that caries TPR differed significantly by age (*i.e.*, Adult I, Adult II, and Adult III/IV) for both upper (χ^2 = 11.957, *df* = 3, *p* = .041) and lower (χ^2 = 18.692, *df* = 3, *p* = .000) teeth, and by sex for upper (χ^2 = 4.190, *df* = 2, *p* = .103) but not lower (χ^2 = 3.468, *df* = 2, *p* = .063) teeth. There was no difference in caries TPR between upper and lower teeth for either males (χ^2 = 0.244, *df* = 2, *p* = .621) or females (χ^2 = 0.595, *df* = 2, *p* = .44).

A Kruskal-Wallis H test was run to determine if there were differences in caries TPR between six age and sex groups: Adult I males, Adult II males, Adult III/IV males, Adult I females, Adult II females, and Adult III/IV females. Prevalence was statistically significant between the four groups for both upper (χ^2 = 35.301, *df* = 5, *p* = .000) and lower (χ^2 = 35.764, *df* = 3, *p* = .000) teeth. Chi-square analysis (Table 7.14) found statistically significant results for both among-sex and between-sex comparisons. Among-sex comparisons found greater similarities in caries-prevalence for "younger" males (18-30 and 30-40 years) whereas greater similarities in TPR were seen in "older" females (30-40 and 40+ years). Statistical analysis supports age had a greater influence on caries prevalence than sex. Furthermore, these results show that the timing of significant increases in caries development occurred at a younger age in females compared to males.

Table 7.14 Statistical analysis of dental caries TPR at Ostojićevo. Results of pairwise comparisons (df = 1) of dental caries TPR in permanent dentition by sex and age-at-death. Values on bold are significant (α = .05).

Jaw	Variable	$\chi^2(1)$	*p*
Upper	M*F Adult I	0.22	.637
	M*F Adult II	**7.42**	**.006**
	M*F Adult III/IV	**28.07**	**.000**
	M Adult I * Adult II	3.47	.063
	M Adult II * Adult III/IV	**4.42**	**.036**
	F Adult I * Adult II	**16.26**	**.000**
	F Adult II * Adult III/IV	0.53	.465
Lower	M*F Adult I	**4.03**	**.045**
	M*F Adult II	**10.49**	**.001**
	M*F Adult III/IV	1.42	.234
	M Adult I * Adult II	2.41	.121
	M Adult II * Adult III/IV	**6.66**	**.010**
	F Adult I * Adult II	**7.79**	**.005**
	F Adult II * Adult III/IV	0.23	.631

7.6.4 Dental Caries – Deciduous Dentition

A complete caries inventory by jaw, tooth type, sex, and age-at-death can be found in Appendix Table 30. Caries number and TPR by jaw and age-at-death are reported in Table 7.15. Total caries prevalence is likely underestimated due to PMTL, antemortem loss of carious teeth, and replacement by permanent teeth. Six individuals displayed 12 caries, five in the upper teeth and seven in the lower teeth. These include five caries distributed among four "females" *(upper TPR* = 3.4%; *lower TPR* = 3.1%) and seven carious lesions distributed among two "males" *(upper TPR* = 5.8%; *lower TPR* = 13.2%). No carious lesions were found affecting Infant I teeth. The age distribution of affected individuals included one neonate, three Infant II, one Child I, and one Child II. All caries affected deciduous molars, except for one small lesion in the left di^2 in a neonate "female" (Grave 241). Two individuals displayed multiple affected teeth: an Infant II "female" (Grave 130) and a Child II "male" (Grave 209). Notably, the Grave 209 individual had six teeth with carious lesions ranging from small to gross. Finally, mean caries severity score per affected teeth was '4.3' (*95% CI* = 0.4, *range* = 3-7), with small lesions being more common in upper teeth and large lesions more common in lower teeth. Overall, most carious lesions had penetrated the pulp cavity by time-of-death.

Table 7.15 Carious lesions count and TPR (%) in deciduous teeth by jaw and age-at-death at Ostojićevo

	Jaw	Category	Neon.	Infant I	Infant II	Child I	Child II	TOTAL
n	UPPER	**n-individual***	4	9	7	9	4	33
		None	4	27	32	38	10	111
		Small	0	0	2	0	0	2
		Large	0	0	1	0	2	3
		Complete	0	0	0	0	0	0
		TOTAL Caries	0	0	3	0	2	5
	LOWER	**n-individual***	4	8	8	9	3	32
		None	5	26	33	33	6	103
		Small	1	0	1	1	2	5
		Large	0	0	0	0	1	1
		Complete	0	0	0	0	1	1
		TOTAL Caries	1	0	1	1	4	7
%	UPPER	**% None**	100.0	100.0	91.4	100.0	83.3	95.7
		% Small	0.0	0.0	5.7	0.0	0.0	1.7
		% Large	0.0	0.0	2.9	0.0	16.7	2.6
		% Complete	0.0	0.0	0.0	0.0	0.0	0.0
		% TOTAL Caries	0.0	0.0	8.6	0.0	16.7	4.3
	LOWER	**% None**	83.3	100.0	97.1	97.1	60.0	93.6
		% Small	16.7	0.0	2.9	2.9	20.0	4.5
		% Large	0.0	0.0	0.0	0.0	10.0	0.9
		% Complete	0.0	0.0	0.0	0.0	10.0	0.9
		% TOTAL Caries	16.7	0.0	2.9	2.9	40.0	6.4

***Note*. * Reflects number of individuals with at least one erupted deciduous tooth.**

7.6.5 Dental Abscesses – Permanent Dentition

Abscess count and TPR by age-at-death for upper and lower teeth are summarized in Table 7.16. Abscess data by jaw, tooth type, and age-at-death are reported for males (Appendix Table 31), females (Appendix Table 32), and total individuals >12 years (Appendix Table 33). Twenty-two individuals displayed 42 abscesses in the upper jaw, and 25 individuals displayed 47 abscesses in the lower jaw (Figure 7.9). The cheek teeth were more affected than the anterior teeth in both the upper and lower jaws. Overall, abscess TPR was similar in the upper (*TPR* = 4.6%) and lower (*TPR* = 4.2%) jaw. The lower canines were the least likely to be affected and the upper molars were the most likely. No abscesses were identified associated with permanent dentition in individuals <18 years. Total abscess prevalence showed a stronger association with age for the upper compared to lower teeth. For example, from Adult I to Adult IV, abscess prevalence increased almost eight-fold in upper teeth compared to an only three-fold increase for the same age range in lower teeth. The greatest increase occurred between Adult I and Adult II individuals for both jaws.

Abscess prevalence by age-at-death and tooth type is illustrated in Figure 7.10 for males and Figure 7.11 for females. Abscesses in males were concentrated in the molars for all age classes. In contrast, females exhibit a more complex relationship between age and affected teeth. Except for a single anomalous Adult I individual with two continuous abscesses on lower incisors (Grave 82), there is a gradual increase in abscess prevalence in the molars and premolars through the fifth decade, with a plateau or slight decrease after 50-years. An examination of abscess type by age-at-death identified additional differences between males (Figure 7.12) and females (Figure 7.13). Males showed a more gradual increase in abscess prevalence with age, whereas females showed a sharp increase from 12-18 years to 18-30 years followed by a gradual increase with age after 30 years. Additionally, “continuous” abscesses predominated in males >40 years, in contrast to a combination of “periapical”, “continuous”, and “other” abscesses documented in females >40 years. As older males tended to retain more teeth than their female counterparts, one possibility for this discrepancy in abscess type is that males may be more prone to nonapical periodontal abcesses of pulpal origin associated with severe attrition. The high prevalence of caries in females compared to males further supports a carious versus non-carious etiology for explaining sex-specific differences in patterns of dental abscesses, with older females more affected by the former.

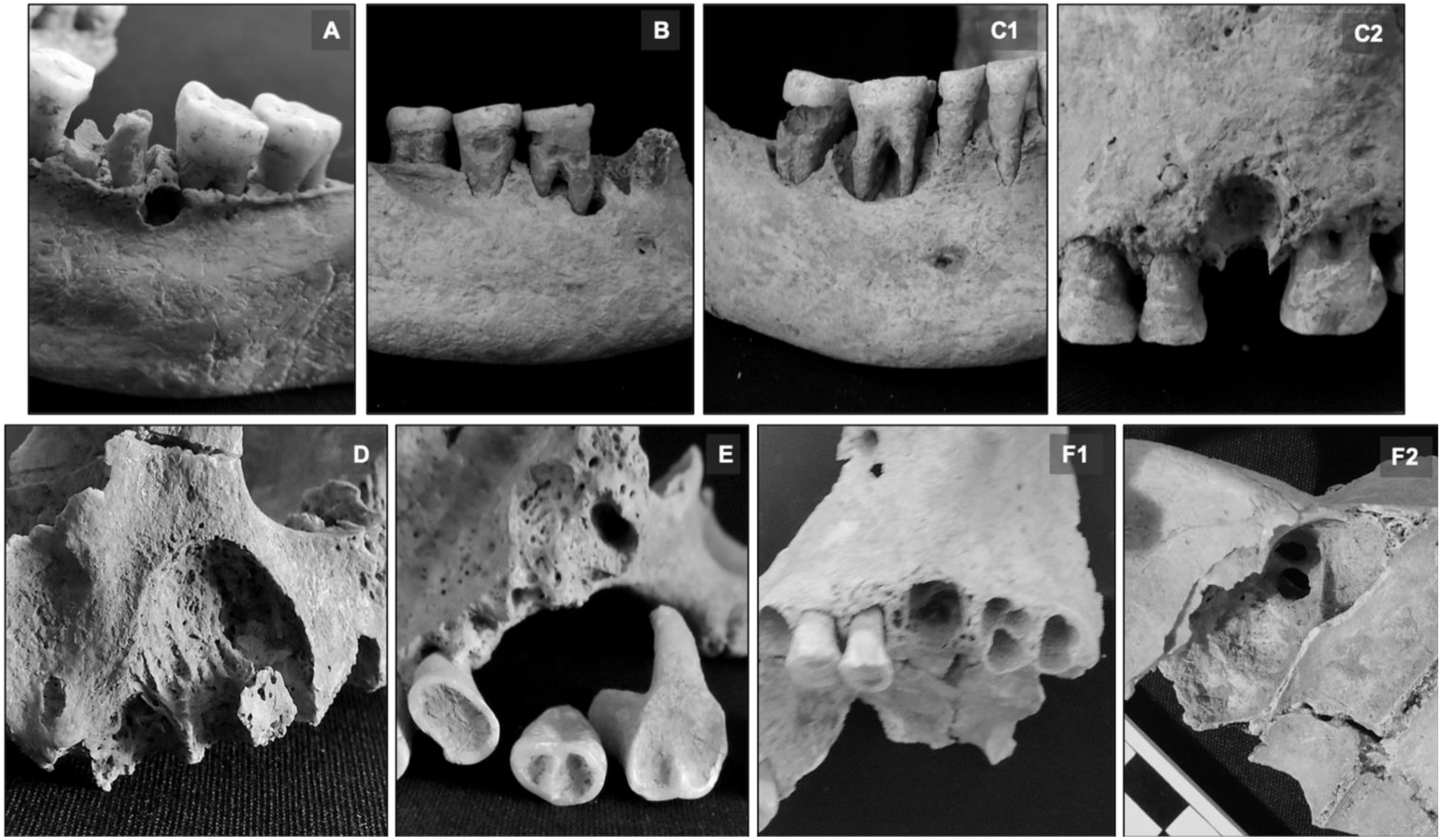


Figure 7.9 Examples of dental abscesses at Ostojićevo: (A) Left-M1"periapical" abscess in Grave 166, an -Adult female; (B) "Periapical" abscess in Grave 154, an Adult II female; Right-M1 and M2 (C1) and left-M1 (C2) "continuous" abscess in Grave 203, an Adult IV female; (D) Right-I2 to P1 large "continuous" abscess in Grave 199, an Adult III male; (E) Right-M1 "complex-continuous" abscess consistent with a nonapical periodontal abscess of pulpal origin in Grave 220, an Adult female; Facial view (F1) and view from maxillary sinus (F2) of a left-M1 "complex-periapical" abscess in Grave 256, an Adult II female.

Table 7.16 Abscess count and TPR (%) by jaw and age-at-death at Ostojićevo

	Jaw	Category	Juv. I/II	Adult I	Adult II	Adult III	Adult IV	Adult ?	Total
n	Upper	n-Individual	10	24	14	7	8	18	81
		Healthy	99	323	145	67	75	155	864
		Abscess-Periapical	0	2	1	1	3	3	9
		Abscess-Continuous	0	2	5	4	2	9	22
		Abscess-Other	0	0	4	1	1	4	11
		Abscess-TOTAL	0	4	10	6	6	16	42
	Lower	n-Individual	11	23	21	10	12	23	100
		Healthy	125	250	253	105	125	205	1063
		Abscess-Periapical	0	2	5	1	1	6	15
		Abscess-Continuous	0	4	6	4	6	10	30
		Abscess-Other	0	0	0	0	2	0	2
		Abscess-TOTAL	0	6	11	5	9	16	47
%	Upper	% Healthy	100.0	98.8	93.5	91.8	92.6	90.6	95.4
		% Abscess-Periapical	0.0	0.6	0.6	1.4	3.7	1.8	1.0
		% Abscess-Continuous	0.0	0.6	3.2	5.5	2.5	5.3	2.4
		% Abscess-Other	0.0	0.0	2.6	1.4	1.2	2.3	1.2
		% Abscess-TOTAL	0.0	1.2	6.5	8.2	7.4	9.4	4.6
	Lower	% Healthy	100.0	97.7	95.8	95.5	93.3	92.8	95.8
		% Abscess-Periapical	0.0	0.8	1.9	0.9	0.7	2.7	1.4
		% Abscess-Continuous	0.0	1.6	2.3	3.6	4.5	4.5	2.7
		% Abscess-Other	0.0	0.0	0.0	0.0	1.5	0.0	0.2
		% Abscess-TOTAL	0.0	2.3	4.2	4.5	6.7	7.2	4.2

Chi-square analysis demonstrated that abscess prevalence (TPR) did not differ significantly by age (*i.e.*, Adult I, Adult II, and Adult III/IV) for the upper ($\chi^2 = 5.656$, $df = 3$, $p = .059$) or lower ($\chi^2 = 2.083$, $df = 3$, $p = .035$) jaw. There was also no significant difference in TPR between males and females for either the upper ($\chi^2 = 0.116$, $df = 3$, $p = .073$) or lower ($\chi^2 = 2.96$, $df = 3$, $p = .09$) jaw. There was no significant difference in TPR between upper and lower jaws among males ($\chi^2 = 0.708$, $df = 3$, $p = .40$) or among females ($\chi^2 = 0.355$, $df = 3$, $p = .055$). A Kruskal-Wallis H test was run to determine if there were differences in abscess TPR between six age and sex groups. Prevalence was statistically significant between the six groups for both the upper ($\chi^2 = 16.314$, $df = 5$, $p = .006$) and lower ($\chi^2 = 20.007$, $df = 3$, $p = .001$) jaw. Pairwise chi-square comparisons between selected variables (Table 7.17) found significant differences for three between-sex groups and two among-sex groups. These results support the observation that age was associated with greater differences in abscess prevalence in males compared to females. Of note is the statistical similarity between Adult I and Adult II males and females, respectively, for the upper jaw but not the lower jaw.

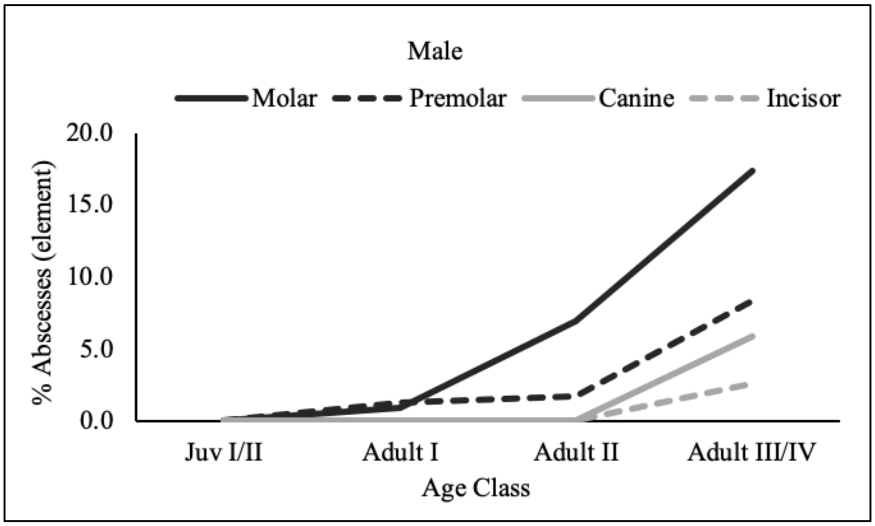


Figure 7.10 Abscess TPR (%) by tooth type and age-at-death in males at Ostojićevo. Combined upper and lower teeth.

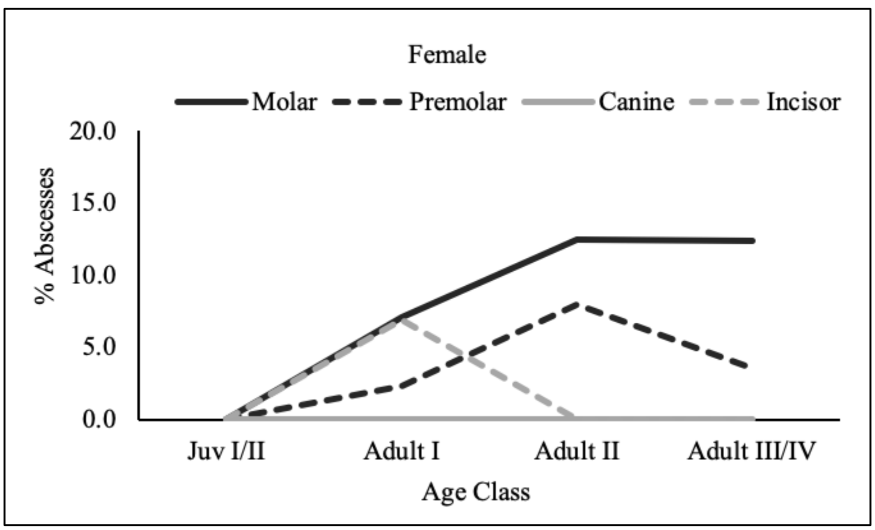


Figure 7.11 Abscess TPR (%) by tooth type and age-at-death in females at Ostojićevo. Combined upper and lower teeth.

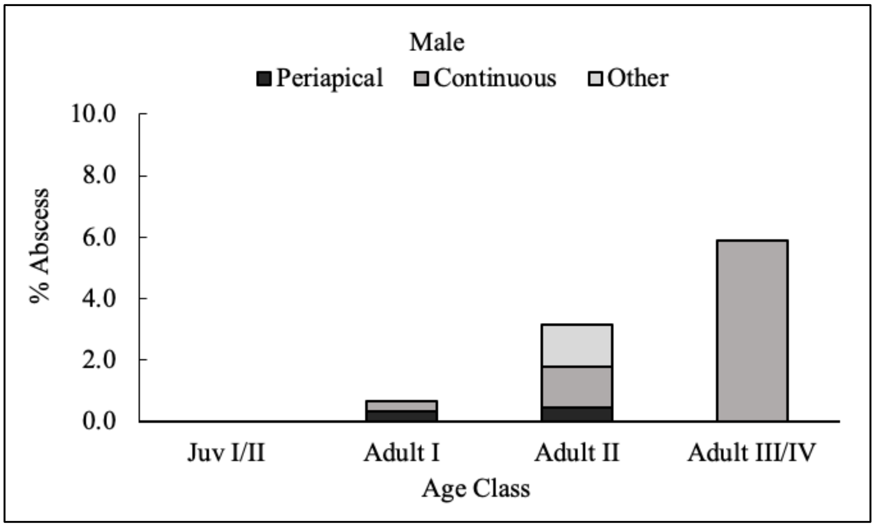


Figure 7.12 Abscess TPR (%) by type and age-at-death in males at Ostojićevo. Combined upper and lower jaws.

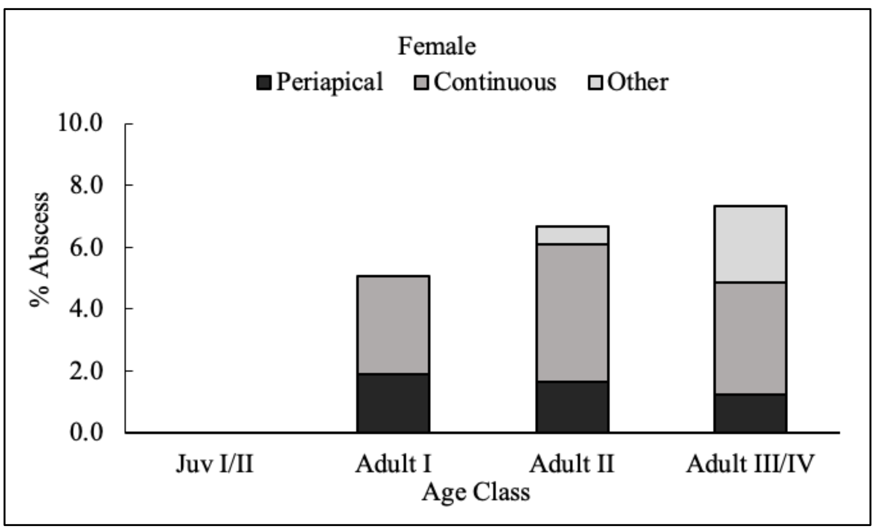


Figure 7.13 Abscess TPR (%) by type and age-at-death in females at Ostojićevo. Combined upper and lower jaws.

Table 7.17 Statistical analysis of dental abscess TPR at Ostojićevo. Results of pairwise comparisons (*df* = 1) of dental abscess TPR associated with permanent dentition by sex and age-at-death. Values in bold are significant (α = .05).

Jaw	Variable	$\chi^2(1)$	*p*
Upper	M*F Adult I	0.34	.561
	M*F Adult II	0.08	.774
	M*F Adult III/IV	**5.21**	**.002**
	M Adult I * Adult II	**4.69**	**.030**
	M Adult II * Adult III/IV	2.00	.157
	F Adult I * Adult II	3.08	.149
	F Adult II * Adult III/IV	0.41	.516
Lower	M*F Adult I	**10.42**	**.001**
	M*F Adult II	**4.69**	**.030**
	M*F Adult III/IV	0.08	.774
	M Adult I * Adult II	1.01	.316
	M Adult II * Adult III/IV	**4.67**	**.030**
	F Adult I * Adult II	0.55	.460
	F Adult II * Adult III/IV	0.08	.774

7.6.6 Dental Abscesses – Deciduous Dentition

No abscesses were found associated with deciduous dentition.

7.6.7 Calculus – Permanent Dentition

Data on calculus prevalence for upper and lower teeth is summarized in Table 7.18. Calculus data by jaw, tooth type, and age-at-death is reported for males (Appendix Table 34), females (Appendix Table 35), and total individuals >9 years (Appendix Table 36). Supragingival dental calculus was ubiquitous at Ostojićevo, with 67.5% of upper and 70.3% of lower teeth having some degree of calculus formation (Figure 7.14). Calculus prevalence in upper teeth increased steeply from late childhood through late adolescence, continued to rise between 20 and 30 years, and peaked between 30 and 40 years. Calculus TPR in the lower teeth almost doubled from late childhood through adolescence and peaked between 40 and 50 years, before rapidly declining after 50 years. This pattern is largely consistent with results from clinical studies (White, 1997), though the sharp decrease in prevalence after 50 years in lower teeth may be due to mechanical removal of calculus associated with increased exposure of calculus deposits from tooth loss (see Lieverse, 1999). Analysis of tube-fed patients has found correlations between elevated calculus development, lack of mastication, and number of teeth without opponents (Dicks & Banning, 1991; see Mandel, 1995). Thus, the results presented here indicate an inverse relationship between extensive tooth loss and calculus development.

The relationship between calculus TPR and location varied with age-at-death and sex. There was little overall difference in calculus prevalence between tooth type in upper teeth in males (*range* = 59.4%-66.0%), though 100.0% of incisors were affected in Adult III and Adult IV individuals (see Appendix Table 34). The calculus prevalence in the lower teeth in males ranged from 54.1% in the canines to 67.9% in the molars, with no clear relationship between tooth type and age-at-death. Females showed a similarly limited range of calculus prevalence between tooth types for the upper (*range* = 62.4%-70.2%) and lower (*range* = 60.8%-74.6%) teeth (see Appendix Table 35). However, the timing of peak calculus prevalence by tooth type did differ between upper versus lower teeth and age-at-death in females. For example, peak calculus prevalence in upper premolars and canines occurred between 20 and 30 years in contrast to >50 years for upper molars and >40 years for upper incisors. In the lower teeth, calculus prevalence increased up to 30-40 years for molars and up to 50 years for premolars, canines, and incisors. Female individuals >50 years showed a decrease in calculus prevalence compared to the prior age class for all lower teeth except molars. An examination of pooled upper and lower teeth for males and females shows calculus prevalence decreasing for all tooth types after 40 years except incisors in males (Figure 7.17) and decreases in canines and premolars after 30 years and molars after 40 years in females (Figure 7.18).

Figure 7.14 Examples of supragingival calculus at Ostojićevo (circles): (A) Grave 38, a Juv. II female, heavy-gross calculus on lingual surfaces of right M1 and M2; (B) Grave 79, a Juv. II female, moderate-heavy calculus on labial surface of right I1 and slight calculus on labial surface of left C; (C) Grave 223, an Adult II male, heavy calculus on lingual surfaces of right I2 to right P2 (some postmortem loss of calculus on right P2); (D1) Buccal aspect and (D1) lingual aspect of right lower teeth in Grave 71, an Adult I male, with slight (mesial) to heavy (distal) calculus deposits; (D3) Buccal aspect of left P2 to M2 with heavy to gross calculus deposits in the Grave 71 individual; (E) Grave 189, an Adult III female, gross calculus deposit covering mesial crown and root surfaces of right M1 (right M2 also pictured with no calculus); (F1) Buccal aspect and (F2) lingual aspect of left C to M2 in Grave 81, an Adult IV female (note moderate to heavy calculus deposits on buccal crown and root surfaces compared to slight to no calculus on lingual surface).

Table 7.18 Calculus count and TPR (%) by jaw and age-at-death at Ostojićevo

	Jaw	Category	Child II	Juv. I/II	Adult I	Adult II	Adult III	Adult IV	Adult?	Total
n	Upper	n-Individual	4	11	26	17	9	6	19	92
		Healthy	25	41	67	29	14	6	34	216
		Slight	3	20	68	33	9	1	26	160
		Moderate	6	23	49	30	14	10	31	163
		Heavy	6	13	41	18	1	5	31	115
		Gross	0	0	1	5	2	0	3	11
		Total Calculus	15	56	159	86	26	16	91	449
	Lower	n-Individual	4	11	24	22	9	5	20	95
		Healthy	27	34	56	35	10	21	30	213
		Slight	4	18	31	35	22	4	31	145
		Moderate	8	34	55	39	15	6	37	194
		Heavy	5	18	46	30	4	4	33	140
		Gross	0	2	3	11	1	0	9	26
		Total Calculus	17	72	135	115	42	14	110	505
%	Upper	% Healthy	62.5	42.3	29.6	25.2	35.0	27.3	27.2	32.5
		% Slight	7.5	20.6	30.1	28.7	22.5	4.5	20.8	24.1
		% Moderate	15.0	23.7	21.7	26.1	35.0	45.5	24.8	24.5
		% Heavy	15.0	13.4	18.1	15.7	2.5	22.7	24.8	17.3
		% Gross	0.0	0.0	0.4	4.3	5.0	0.0	2.4	1.7
		% Total Calculus	37.5	57.7	70.4	74.8	65.0	72.7	72.8	67.5
	Lower	% Healthy	61.4	32.1	29.3	23.3	19.2	60.0	21.4	29.7
		% Slight	9.1	17.0	16.2	23.3	42.3	11.4	22.1	20.2
		% Moderate	18.2	32.1	28.8	26.0	28.8	17.1	26.4	27.0
		% Heavy	11.4	17.0	24.1	20.0	7.7	11.4	23.6	19.5
		% Gross	0.0	1.9	1.6	7.3	1.9	0.0	6.4	3.6
		% Total Calculus	38.6	67.9	70.7	76.7	80.8	40.0	78.6	70.3

Total calculus prevalence based on pooled upper and lower teeth was lowest for Adult III/IV individuals among males (Figure 7.17) and Juvenile I/II individuals among females (Figure 7.18). Heavy or gross calculus as a proportion of total calculus was highest in Adult II individuals in males and Juvenile I/II and Adult III/IV individuals in females. Thus, calculus was most severe in the youngest and oldest female age classes, whereas males showed a gradual increase in the proportion of heavy or gross calculus up to 40 years, with heavy deposits likely lost through dental abrasion in male individuals >40 years. In contrast, while the teeth of females <18 years and >40 years were less likely to exhibit deposits of dental calculus, these deposits when present tended to be thicker and cover a greater portion of the tooth crown in affected teeth (Figure 7.18).

Chi-square analysis demonstrated that calculus prevalence (TPR) did not significantly differ by age (*i.e.*, Adult I, Adult II, and Adult III/IV) for the upper ($\chi^2 = 1.263$, $df = 3$, $p = .532$) or lower ($\chi^2 = 4.084$, df

= 3, p = .130) teeth. There was also no significant difference between males and females for either the upper (χ^2 = 2.079, df = 3, p = .149) or lower (χ^2 = 3.271, df = 3, p = .071) teeth. There was no significant difference between upper and lower jaws among males (χ^2 = 0.276, df = 3, p = .599) or among females (χ^2 = 0.024, df = 3, p = .878). A Kruskal-Wallis H test was run to determine if there were differences in calculus prevalence between six age and sex groups. Prevalence was statistically significant between the six groups for both the upper (χ^2 = 15.530, df = 5, p = .008) and lower (χ^2 = 17.570, df = 3, p = .004) teeth. Pairwise chi-square comparisons between selected variables (Table 7.19) found significant differences for three between-sex and four among-sex groups. A significant difference in caries prevalence was found for Adult III/IV males versus females for both the upper and lower teeth. No difference was found between Adult I males versus females in the upper teeth or Adult II males versus females in the lower teeth. Significant differences between age groups were more common in females compared to males. These results suggest greater uniformity in dental calculus presence in males across age classes, whereas females exhibited greater fluctuation in prevalence related to age, especially older females.

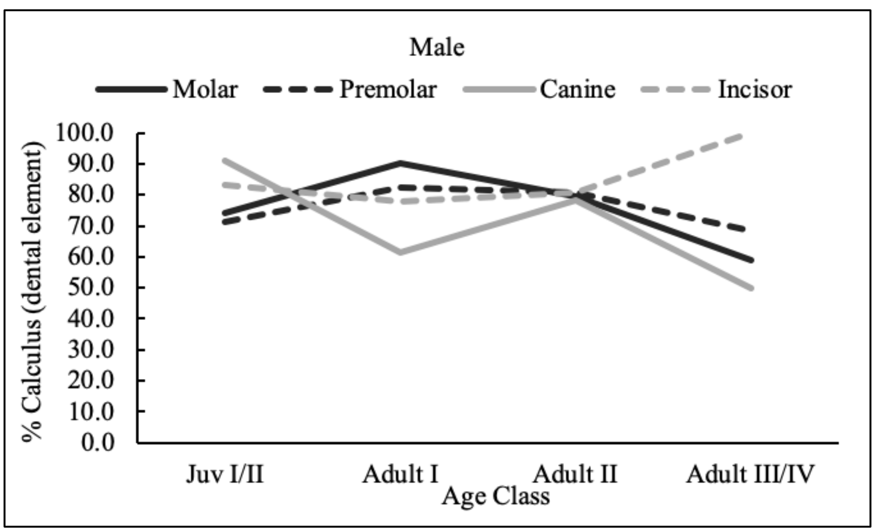


Figure 7.15 Calculus TPR by tooth type and age-at-death in males at Ostojićevo. Combined upper and lower teeth.

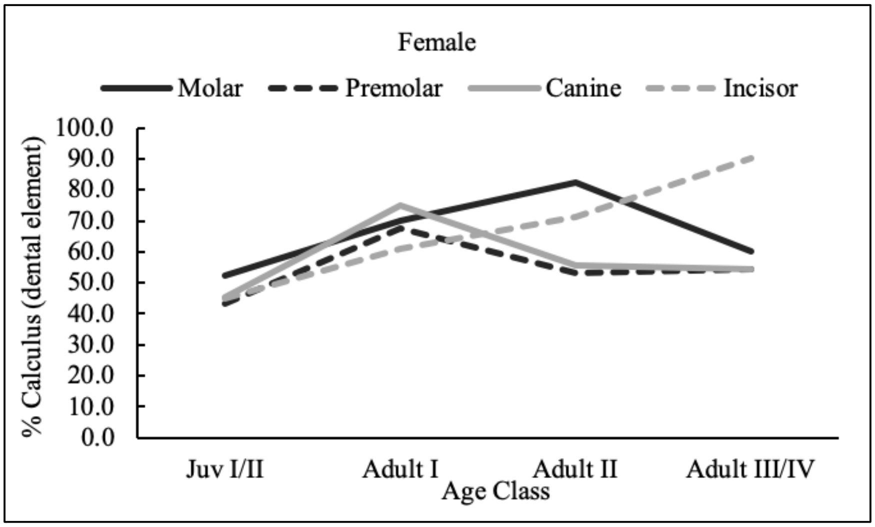


Figure 7.16 Calculus TPR by tooth type and age-at-death in females at Ostojićevo. Combined upper and lower teeth.

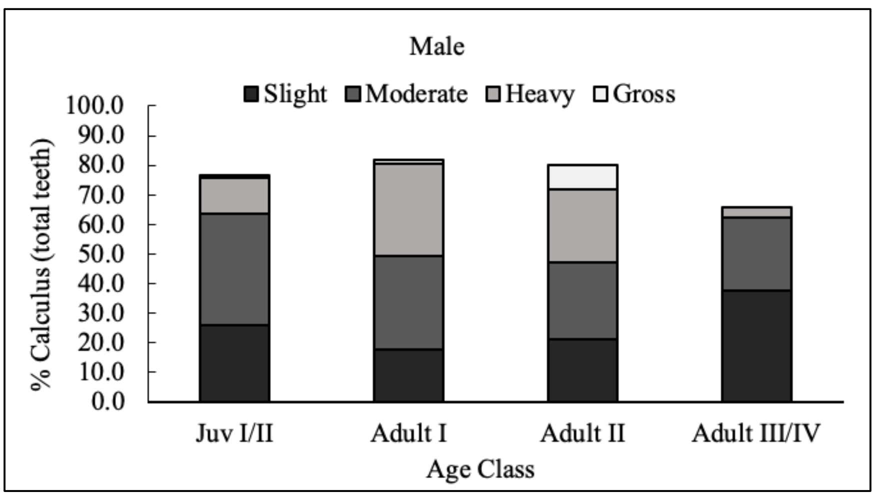


Figure 7.17 Calculus TPR by severity and age-at-death in males at Ostojićevo. Combined upper and lower teeth.

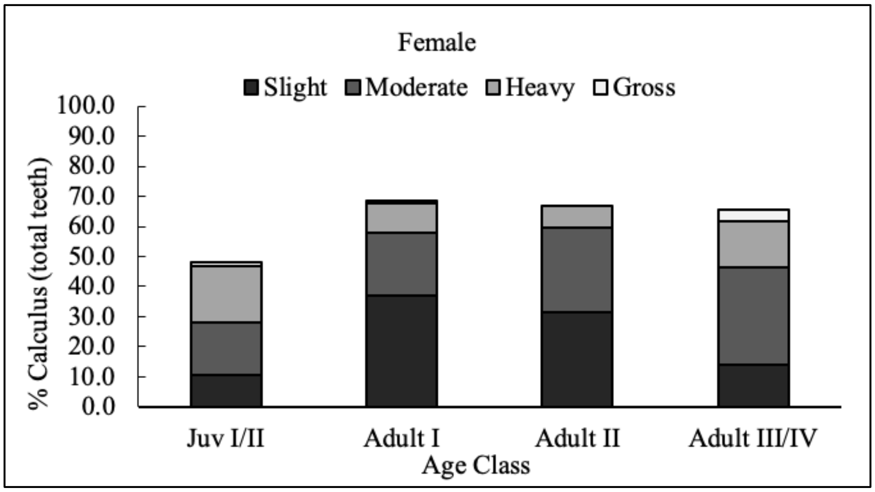


Figure 7.18 Calculus TPR by severity and age-at-death in females at Ostojićevo. Combined upper and lower teeth.

Table 7.19 Statistical analysis of dental calculus TPR at Ostojićevo. Results of pairwise comparisons (df = 1) of dental calculus TPR associated with permanent dentition by sex and age-at-death. Values in bold are significant (α = .05).

Jaw	Variable	$\chi^2(1)$	*p*
Upper	M*F Adult I	0.99	.321
	M*F Adult II	**15.80**	**.000**
	M*F Adult III/IV	**12.50**	**.000**
	M Adult I * Adult II	0.29	.592
	M Adult II * Adult III/IV	**20.35**	**.000**
	F Adult I * Adult II	**6.31**	**.012**
	F Adult II * Adult III/IV	**8.91**	**.003**
Lower	M*F Adult I	**12.91**	**.000**
	M*F Adult II	0.68	.411
	M*F Adult III/IV	**7.12**	**.008**
	M Adult I * Adult II	2.17	.141
	M Adult II * Adult III/IV	0.44	.508
	F Adult I * Adult II	1.88	.171
	F Adult II * Adult III/IV	**6.31**	**.012**

7.6.8 Calculus – Deciduous Dentition

Dental calculus in deciduous dentition is summarized by jaw, age-at-death, and severity in Table 7.20. Data on calculus by tooth type, subadult “sex”, and age-at-death can be found in Appendix Table 37. Despite the small sample size and replacement of deciduous teeth with permanent, several age-related trends were noted. Principally, that both calculus prevalence (TPR) and severity increased with age. No calculus was identified in deciduous dentition in individuals <3 years-at-death. Among the three subadult age classes with evidence of dental calculus, the small sample size of Child II individuals meant that values were more likely to be influenced by outliers (*i.e.*, excessive calculus in one or two individuals). To address the effect of sample size, I compared age-specific elemental and individual prevalence (Figure 7.19). The results showed that individual prevalence was greater than elemental prevalence for all age classes with evidence of dental calculus. This suggests that elemental prevalence was not disproportionately influenced by a few exceptional cases. Finally, “heavy” calculus was only observed for Child I and Child II individuals, accounting for a third of all calculus in the latter. In contrast, “slight” calculus was the most common category among both Infant II and Child I individuals.

Table 7.20 Calculus deposits and TPR (%) in deciduous teeth by jaw and age-at-death at Ostojićevo

Jaw		Category	Neon.	Infant I	Infant II	Child I	Child II	TOTAL
n	UPPER	**n-individual***	4	9	7	9	4	33
		None	4	27	24	24	4	83
		Slight	0	0	8	5	1	14
		Moderate	0	0	3	8	3	14
		Heavy	0	0	0	1	4	5
		Gross	0	0	0	0	0	0
		TOTAL Calculus	0	0	11	14	8	33
	LOWER	**n-individual***	4	8	8	9	3	32
		None	6	25	25	15	2	73
		Slight	0	0	5	7	1	13
		Moderate	0	0	3	6	3	12
		Heavy	0	0	0	6	3	9
		Gross	0	0	0	0	0	0
		TOTAL Calculus	0	0	8	19	7	34
%	UPPER	**% None**	100.0	100.0	68.6	63.2	33.3	71.6
		% Slight	0.0	0.0	22.9	13.2	8.3	12.1
		% Moderate	0.0	0.0	8.6	21.1	25.0	12.1
		% Heavy	0.0	0.0	0.0	2.6	33.3	4.3
		% Gross	0.0	0.0	0.0	0.0	0.0	0.0
		% TOTAL Calculus	0.0	0.0	31.4	36.8	66.7	28.4
	LOWER	**% None**	100.0	100.0	75.8	44.1	22.2	68.2
		% Slight	0.0	0.0	15.2	20.6	11.1	12.1
		% Moderate	0.0	0.0	9.1	17.6	33.3	11.2
		% Heavy	0.0	0.0	0.0	17.6	33.3	8.4
		% Gross	0.0	0.0	0.0	0.0	0.0	0.0
		% TOTAL Calculus	0.0	0.0	24.2	55.9	77.8	31.8

***Note*. * Reflects number of individuals with at least one erupted deciduous tooth.**

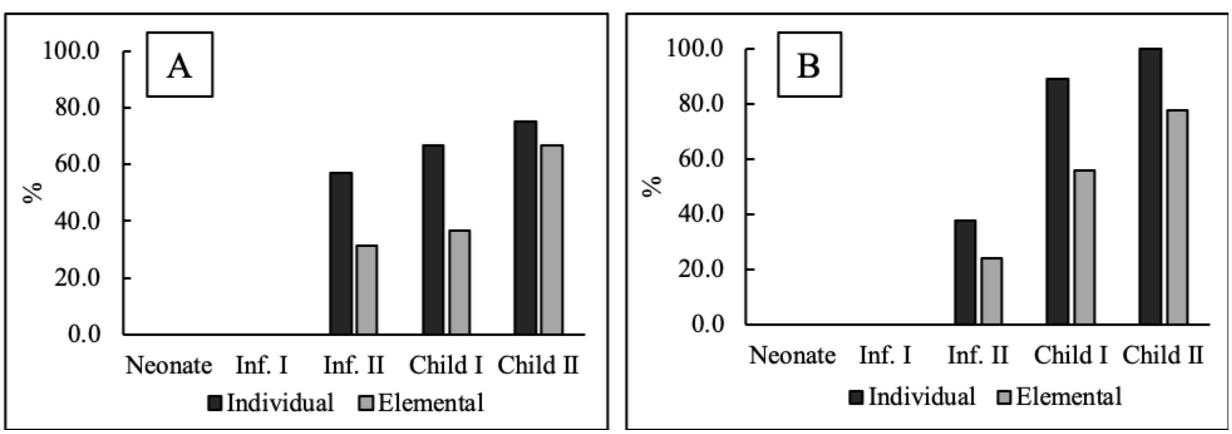


Figure 7.19 Comparison of individual (CPR) versus elemental (TPR) prevalence of dental calculus in deciduous teeth at Ostojićevo. (A) upper and (B) lower deciduous teeth. *Note: The only Child II individual with no dental calculus represented by a single deciduous tooth.

7.7 Results: Comparative Dental Disease

Data from Rega (1995: 134-42) on dental caries and AMTL in permanent dentition at Mokrin is reproduced in Table 7.21. Both individual and elemental sample size was smaller at Ostojićevo compared to Mokrin (Table 7.22). This discrepancy in sample size might contribute to extreme cases (*i.e.*, most teeth affected in one individual or an individual exhibiting multiple pathologies) having a disproportionate influence on dental disease averages calculated for the Ostojićevo samples. Nevertheless, all four sex-site groups had large elemental sample sizes and this effect is likely negligible (though see discussion below on a possible age-effect on AMTL prevalence in Ostojićevo females). Comparative data on caries prevalence at Ostojićevo is based on my analysis of male and female individuals >18 years and includes upper teeth in 60 individuals and lower teeth in 65 individuals; AMTL prevalence is based on my examination of the alveolar margin in the maxillae of 58 individuals and the mandible of 72 individuals. To match the demographic composition of the Mokrin sample, only data from adult males and females from Ostojićevo were included in comparative analyses.

Between-site comparisons of sex-specific TPR by jaw and tooth type are illustrated in Figure 7.20 for dental caries and Figure 7.21 for AMTL. Molars were the most likely to be affected by dental caries in both the upper and lower teeth among males and females at Mokrin and Ostojićevo. For upper teeth, incisors were the least likely to be affected among males and females at both sites. However, lower teeth showed a more complex pattern, with canines or incisors the least likely to be affected among males and females at Mokrin and males at Ostojićevo, whereas premolars were the least likely to be affected among females at Ostojićevo. As discussed in section 8.3.1, dental caries in permanent cheek teeth are likely underrepresented among females at Ostojićevo due to high rates of AMTL. Upper and lower molars, respectively, had the highest TPR of AMTL for three of the four study groups. This pattern was reversed in the upper teeth of Mokrin females, with upper incisors being the most and upper molars the least affected. Finally, Ostojićevo females exhibited the highest prevalence of dental caries and AMTL for all tooth types in both the upper and lower jaw. Ostojićevo males had consistently high dental caries prevalence for upper teeth compared to males and females at Mokrin, but in all other cases fell within or below the values obtained for Mokrin.

To ensure replicability, I conducted a chi-square analysis comparing dental disease prevalence between males and females at Mokrin. Using similar methods, Rega (1995: 142) found no significant difference at $p \leq .05$ in sex-specific prevalence of dental caries or AMTL. I conducted a series of ch-square analyses to examine site- and sex-specific differences in dental disease (Table 7.23). Overall, analysis of pooled male and female caries found prevalence to be significantly higher in upper ($\chi^2 = 7.35$, $df = 1$, $p = .007$) but not lower ($\chi^2 = 0.86$, $df = 1$, $p = .35$) teeth at Ostojićevo compared to Mokrin; no significant site-specific difference in AMTL presence was found for either the upper ($\chi^2 = 0.53$, $df = 1$, $p = .469$) or lower ($\chi^2 = 1.98$, $df = 1$, $p = .160$) jaw. There were no significant differences in sex-specific dental caries or AMTL at Mokrin. These results are consistent with findings reported by Rega (1995: 138, 140).

Several site-specific significant differences for males and females were identified. Females at Ostojićevo had significantly higher dental caries in the upper and lower teeth and AMTL in the upper jaw compared to males. Dental caries prevalence was significantly higher among females at Ostojićevo compared to Mokrin for both upper and lower teeth; AMTL prevalence was significantly higher among females at Ostojićevo compared to Mokrin females for the lower but not the upper jaw. Finally, among males, a site-specific significant difference was only found for caries in the upper teeth.

Comparative analysis of dental disease suggests differences in diet and behavior between males and females at Ostojićevo but not Mokrin. Based on dental disease alone, males at Ostojićevo were similar to males and females at Mokrin. A weakness of the current study is the lack of age-specific data from Mokrin. It is possible that an overrepresentation of older adult females at Ostojićevo could influence results, as the incidence of dental caries and AMTL tends to increase with age (Hillson, 2008; Manji et al., 1991). The results of a Kolmogorov-Smirnov test comparing the cumulative frequencies of Rega (1995: 138) compared age profiles between males and females for the Mokrin sample and found no significant difference in cumulative frequencies. A Kaplan-Meier test was used to test for differences in sex-specific age-at-death in the caries and AMTL groups at Ostojićevo. No difference in survivorship was found for the caries sample, but the distribution of males and females examined for AMTL differed significantly for upper ($\chi^2 = 4.43$, $df = 1$, $p = .035$) and lower ($\chi^2 = 5.58$, $df = 1$, $p = .018$) teeth. Thus, for AMTL, older females are overrepresented in the Ostojićevo sample. This might explain some, but not all, of the higher AMTL prevalence exhibited by Ostojićevo females compared to the other three sample groups. As illustrated in Table 7.12, there is no significant difference in sex-specific AMTL (TPR) for individuals <40 years at Ostojićevo. The tentative implications of these findings are that tooth loss at Ostojićevo was concentrated in females >40 years-at-death, and that females at Ostojićevo lost teeth at a higher rate irrespective of age than females at Mokrin.

Table 7.21 Mokrin dental pathology count and TPR (%) by jaw, tooth, and sex. Adapted from Rega (1995: 141).

		Upper						Lower						TOTAL	
Sex	Tooth	Total Teeth	Carious Teeth	% Caries	Total Alveolus	AMTL	% AMTL	Total Teeth	Carious Teeth	% Caries	Total Alveolus	AMTL	% AMTL	% Caries	% AMTL
Male	Molars	249	18	7.2	183	21	11.5	181	15	8.3	242	28	11.6	7.7	11.5
	Premolars	165	3	1.8	138	11	8.0	142	8	5.6	163	13	8.0	3.6	8
	Canines	74	1	1.4	67	6	9.0	68	3	4.4	57	4	7.0	2.8	8.1
	Incisors	95	0	0.0	79	14	17.7	81	3	3.7	94	12	12.7	1.7	15
	TOTAL	583	22	3.8	467	52	11.1	472	29	6.1	556	57	10.3	4.8	10.7
Female	Molars	231	22	9.5	192	6	3.1	206	40	19.4	231	43	18.6	14.2	11.6
	Premolars	160	10	6.3	147	8	5.5	139	9	6.5	161	12	7.5	6.4	6.5
	Canines	64	1	1.6	50	2	4.0	55	1	1.8	50	1	2.0	1.7	3.0
	Incisors	113	0	0.0	93	6	6.5	93	3	3.2	115	12	10.5	1.5	8.7
	TOTAL	568	33	5.8	481	22	4.6	493	53	10.8	556	68	12.2	8.1	8.7
TOTAL	Molars	867	40	8.3	848	27	7.2	387	55	14.2	473	71	15.0	11.0	11.6
	Premolars	606	13	4.0	608	19	6.7	281	17	6.0	323	25	7.7	5.0	7.2
	Canines	261	2	1.4	224	8	6.9	123	4	3.3	107	5	4.7	2.3	5.8
	Incisors	382	0	0.0	381	20	11.6	174	6	3.4	209	24	11.5	1.6	11.5
	TOTAL	2116	55	4.8	2061	74	7.8	965	82	8.5	1112	125	11.2	6.5	9.7

Table 7.22 Comparison of sex-specific dental pathology count and TPR (%) by tooth type at Ostojićevo and Mokrin. Total refers to combined healthy and diseased. M = molar, P = premolar, C = canine, and I = incisor.

		Upper – Caries*								Lower – Caries*							
Site	Sex	Total M	% M	Total P	% P	Total C	% C	Total I	% I	Total M	% M	Total P	% P	Total C	% C	Total I	% I
Ostojićevo	M	113	18.6	79	10.1	33	6.1	50	6.0	122	13.9	90	6.7	40	2.5	53	7.5
	F	87	29.9	65	24.6	31	19.4	37	8.1	84	27.4	70	11.4	32	15.6	49	14.3
Mokrin	M	249	7.2	165	1.8	74	1.4	95	0.0	181	8.3	142	5.6	68	4.4	81	3.7
	F	231	9.5	160	6.3	64	1.6	113	0.0	206	19.4	139	6.5	55	1.8	93	3.2
Site	Sex	Upper – AMTL**								Lower – AMTL**							
Ostojićevo	M	115	8.7	87	6.9	42	0.0	84	0.0	156	14.1	106	6.6	40	5.0	93	6.5
	F	104	19.2	86	14.0	32	15.6	71	18.3	181	35.4	103	19.4	37	16.2	83	18.1
Mokrin	M	183	11.5	138	8.0	67	9.0	79	17.7	242	11.6	163	8.0	57	7.0	94	12.7
	F	192	3.1	147	5.5	50	4.0	93	6.5	231	18.6	161	7.5	50	2.0	115	10.5

***Note*. *total = total teeth, % = % caries/total teeth; **total = total alveolus, % = % AMTL/total alveolus**

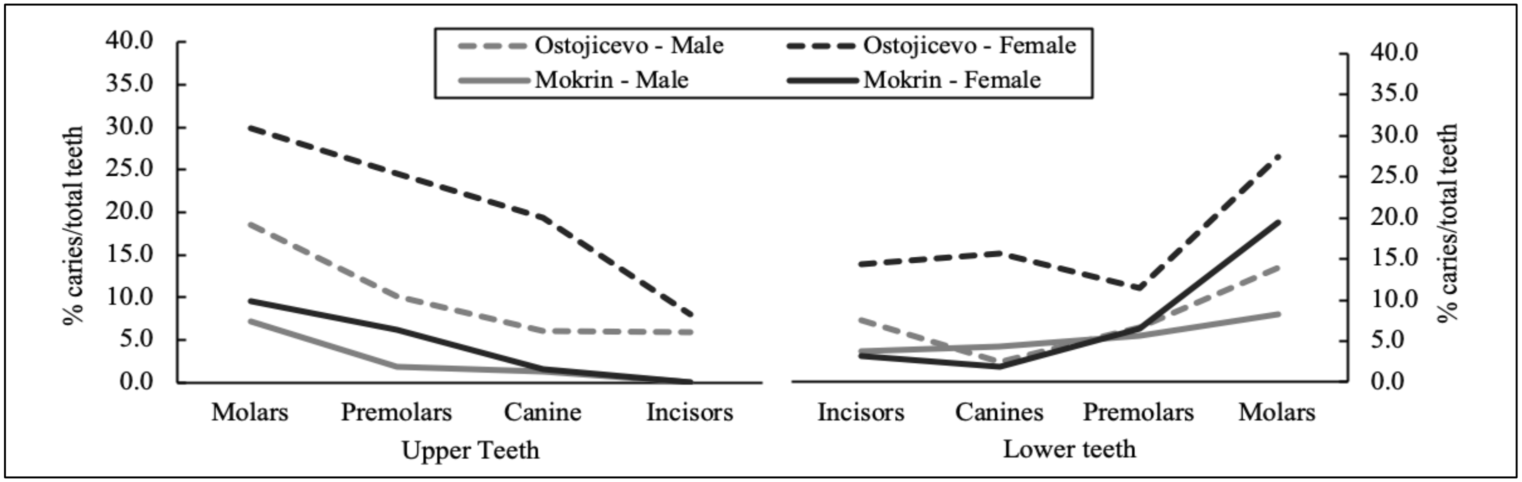


Figure 7.20 Comparison of Ostojićevo versus Mokrin TPR of sex-specific caries. Values represent % caries/total teeth in individuals >18 years.

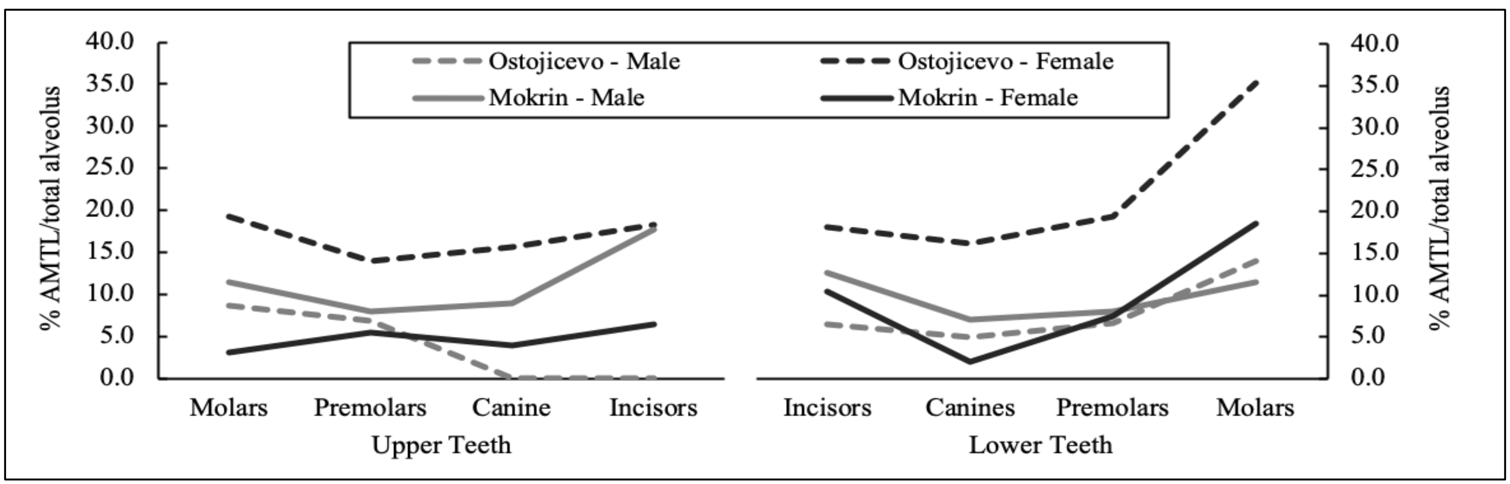


Figure 7.21 Comparison of Ostojićevo versus Mokrin TPR of sex-specific AMTL. Values represent % AMTL/total alveolus in individuals >18 years.

Table 7.23 Statistical analysis of dental disease at Ostojićevo and Mokrin. Results of pairwise comparisons (df = 1) of sex-specific dental disease at Mokrin and Ostojićevo. Values in bold are significant (α = .05).

Jaw	Pathology	Variable	$\chi^2(1)$	*p*
Upper	Caries	Ostojićevo M vs. F	**4.19**	**0.041**
		Mokrin M vs. F	0.42	0.516
		Mokrin vs. Ostojićevo F	**11.66**	**0.001**
		Mokrin vs. Ostojićevo M	**4.35**	**0.037**
	AMTL	Ostojićevo M vs. F	**7.35**	**0.007**
		Mokrin M vs. F	2.45	0.118
		Mokrin vs. Ostojićevo F	**7.35**	**0.007**
		Mokrin vs. Ostojićevo M	2.45	0.118
Lower	Caries	Ostojićevo M vs. F	3.47	0.063
		Mokrin M vs. F	1.61	0.205
		Mokrin vs. Ostojićevo F	1.98	0.16
		Mokrin vs. Ostojićevo M	0.65	0.421
	AMTL	Ostojićevo M vs. F	**10.01**	**0.002**
		Mokrin M vs. F	0.20	0.651
		Mokrin vs. Ostojićevo F	**6.37**	**0.012**
		Mokrin vs. Ostojićevo M	0.06	0.809

7.8 Results: Stable Isotopes

Stable isotope analysis of animal and human bone collagen was conducted to examine dietary patterns at Ostojićevo (2000-1500 BCE) and Mokrin (2100-1800 BCE). Stable isotope analysis included $\delta^{15}N_{collagen}$ and $\delta^{13}C_{collagen}$ from human (*n-total* = 118; Appendix Table 38) and faunal (*n-total* = 24; Appendix Table 39) remains. Samples with a carbon-to-nitrogen (C/N) ratio outside the range of 2.9 to 3.6 were excluded for potential contamination and/or insufficient preservation of biogenic carbon or nitrogen (DeNiro, 1985).

7.8.1 Fauna

Faunal analysis from two Maros settlements near the Tisza-Maros confluence, Klárafalva (2000-1700 BCE) and Kiszombor (2600-2000 BCE), was carried out by Nicodemus (2010; 2014) and is summarized in Table 7.24. Nicodemus (2010) reported both number of individual specimens (NISP) and minimum number of individuals (MNI) to provide an upper and lower limit, respectively, for each taxon.

The types and proportions of domestic and wild animals exploited for food at these two sites reflect different economic strategies linked to their particular ecological setting. While domestic species predominate at both sites, there are differences in the relative abundance of domestic taxa and reliance on high-ranking game (Table 7.25). For example, the inhabitants of Klárafalva heavily exploited freshwater resources (*e.g.*, carp, pike/perch, mussels, etc.), with fish more prevalent in Early Maros compared to Late Maros assemblages (Nicodemus, 2010). Large and small game were also more abundant at Klárafalva (12%) compared to Kiszombor (5%), indicating increased exploitation of forested environments in the former. Both sites are similar in that caprines and pigs predominant among domestic taxa. However, animal husbandry practices at Klárafalva relied more-or-less equally on sheep/goat herding and pig husbandry. Overall, greater heterogeneity in the animal economy is documented in the archaeological record for Klárafalva compared to Kiszombor, with fishing and hunting of high-ranking wild game prioritized during the Early Maros Period at Klárafalva. In contrast, the faunal assemblage recovered from Kiszombor suggests a more stable animal economy centered on sheep/goat herding, with little to no change in the relative proportion of mammal and fish species exploited overtime. Finally, cattle herding was more important at Kiszombor than Klárafalva. An increase in the proportion of cattle in the Early Maros phase at Klárafalva corresponds to a decrease in fishing, whereas cattle increase as sheep/goat decline during the Late Maros occupation at Kiszombor. This pattern suggests a shift to more grassland adapted species and higher value livestock between the Early and Late Maros occupation phases at settlements near the Tisza-Maros confluence.

Baseline isotopic datasets included faunal samples from Kiszombor, Klárafalva, and Ostojićevo. A total of 23 faunal specimens were sampled, with 22 samples yielding C/N ratios of 2.9 to 3.6 (Dobberstein et al., 2009; DeNiro, 1985; Katzenberg, 2008) (Appendix Table 39). Results are summarized in Table 7.26 by site and taxa. Faunal $\delta^{15}N$ values ranged from 4.7‰ (horse, Kiszombor) to 9.8‰ (dog, Ostojićevo); faunal $\delta^{13}C$ values ranged from -21‰ (horse, Kiszombor) to -18.5‰ (sheep, Ostojićevo) (Figure 7.22).

There was little difference in average nitrogen and carbon isotopic values of cattle and pigs between the three sites, and sheep-goat between Kiszombor and Klárafalva. Sheep/goat from Ostojićevo displayed an isotopic signature enriched in $\delta^{15}N$ and $\delta^{13}C$ compared to sheep/goat from Kiszombor and Klárafalva. The lack of a corresponding shift in carbon and nitrogen values for cattle suggest that herding strategies differed between cattle and sheep/goat at Ostojićevo. Finally, there is no difference in the age profiles of taxa between sites (Appendix Table 39).

Table 7.24 Maros settlement and cemetery NISP of major meat animals (*i.e.*, mammals, fish, and mollusk). Counts based on unmodified bone. Dominant mammalian and fish/mollusk taxa for each site in bold. Data adapted from Nicodemus (2010; 2017).

Taxon	Common Name	Kiszombor Early		Klárafalva Late		Mokrin Early		Ostojićevo Late	
		NISP	%	NISP	%	NISP	%	NISP	%
Bos Taurus	cow (domestic)	160	18.5	273	12.3	1	14.3	21	38.9
Sus scrofa	pig	175	20.3	**806**	**36.2**	**3**	**42.9**	4	7.4
Ovicapridae	sheep/goat	**449**	**52.0**	**838**	**37.6**	2	28.6	**26**	**48.1**
Equus caballus	horse	42	4.9	67	3.0	1	14.3	2	3.7
Cervus elaphus	red deer	28	3.2	170	7.6	0	0.0	0	0.0
Sus ferrus	wild boar	2	0.2	19	0.9	0	0.0	0	0.0
Large game	(*e.g.*, aurochs, roe deer)	7	0.8	19	0.9	0	0.0	0	0.0
Small game	(*e.g.*, hare, beaver)	1	0.1	34	1.5	0	0.0	1	1.9
	TOTAL MAMMAL	864		2226		7		54	
Cyprinus sps.	carp	**17**	**54.8**	**1785**	**79.9**	0	0.0	**4**	**80.0**
Esox lucius	northern pike	1	3.2	215	9.6	0	0.0	0	0.0
Siluris glanis	wels catfish	0	0.0	145	6.5	0	0.0	0	0.0
Percidae/*Acipenser sp.*	perch/sturgeon	0	0.0	51	2.3	0	0.0	0	0.0
Unio sp.	freshwater mussel	13	41.9	38	1.7	0	0.0	1	20.0
TOTAL FISH + MOLLUSK		31		2234		0		5	

Table 7.25 Meat contribution (kg/individual) for major mammalian taxa. Two most prevalent taxa at each site in bold. Adapted from Nicodemus (2010).

Common Name	(kg)/ind.	Kiszombor	Klárafalva
		% Total	% Total
Sheep/Goat	25	10.6	9.9
Pig	40	**13.9**	14.4
Cattle	250	**51.2**	**46.7**
Red deer	100	7.9	**17.3**
Roe deer	30	1.4	1.7
Wild boar	75	2.4	7.3
Aurochs	400	12.6	2.8

Table 7.26 $\delta^{15}N$ and $\delta^{13}C$ descriptive statistics for faunal specimens

Scientific Name	Common Name	Kiszombor Early (2600-2000 BC)					Klárafalva Late (2000-1700 BC)					Ostojićevo Late (c. 1950-1800, 1650-1550 BC)					TOTAL				
		n	$\delta^{15}N$		$\delta^{13}C$		n	$\delta^{15}N$		$\delta^{13}C$		n	$\delta^{15}N$		$\delta^{13}C$		n	$\delta^{15}N$		$\delta^{13}C$	
			avg	σ	avg	σ		avg	σ	avg	σ		avg	σ	avg	σ		avg	σ	avg	σ
Bos Taurus	cow	4	7.7	1.1	-19.7	0.6	1	8.0		-19.0		1	7.9		-19.6		6	7.8	0.8	-19.6	0.6
Sus scrofa	pig	2	8.3	1.1	-20.3	0.4	3	9.3	1.2	-21.1	0.1	0					5	8.9	1.2	-20.8	0.5
Ovicapridae	sheep/ goat	2	6.9	1.1	-19.3	0.5	1	6.7		-19.6		3	9.2	1.1	-18.5	1.5	6	8.0	1.5	-18.9	1.1
Equus caballus	horse	1	4.7		-21.0		0					1	7.3		-20.0		2	6.0		-20.5	
Canis familiaris	dog	0					0					1	9.8		-20.6		1	9.8		-20.6	
Cervus elaphus	red deer	0					2	7.3		-20.8		0					2	7.3		-20.8	

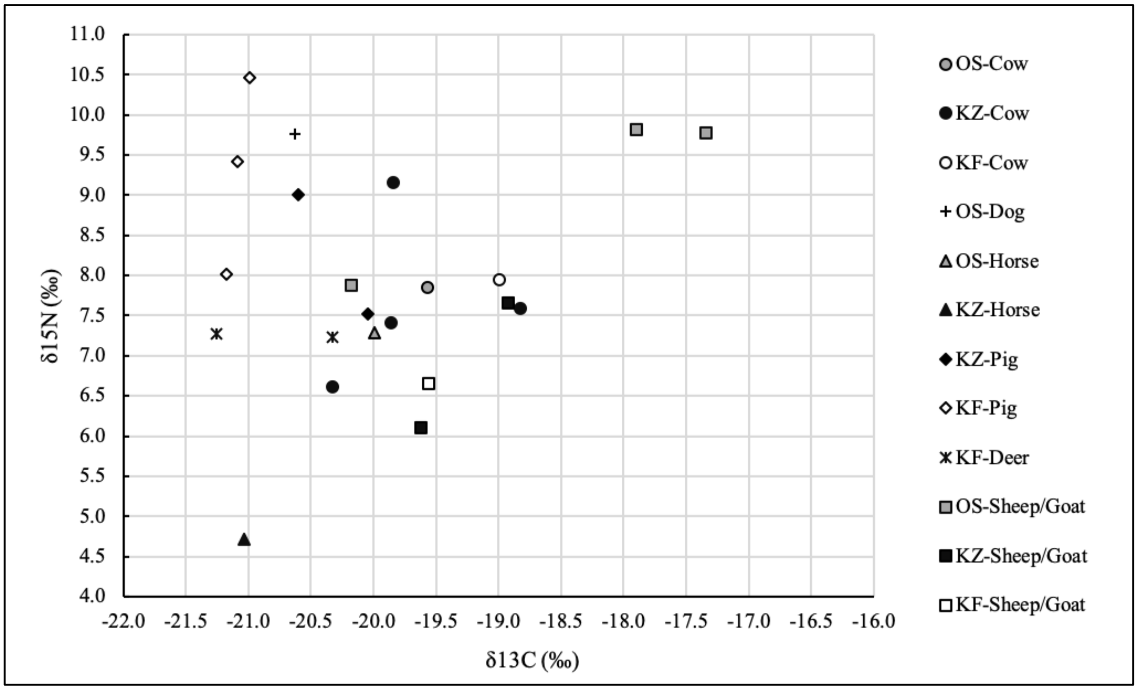


Figure 7.22 Carbon and nitrogen isotopic distribution for faunal specimens from Ostojićevo (OS), Kiszombor (KZ), and Klárafalva (KF)

7.8.2 Ostojićevo

A total of 54 adults (>18 years) were analyzed. Samples were taken from ribs in all cases. Of 54 original samples, 16 specimens (29.6%) did not meet criteria for collagen preservation and were excluded from analysis (Appendix Table 38). The adjusted sample included 21 females, 3 probable-females, and 14 males. This accounts for 28.6% of all adults at Ostojićevo. To examine the potential impact of age and sex on individual differences in isotope values, individuals were grouped into two age groups: Adult I/II (>18-40 years) and Adult III/IV (>40 years). Individuals were also categorized as “high” or “low” status based on association with prestige grave goods (Milašinović, 2009; O’Shea, 1996; Pompeani, 2018).

Nitrogen isotopic values at Ostojićevo ranged from 9.6‰ to 12.8‰, with an average of 11.1 ±0.6‰ (Table 7.27; Figure 7.23). Average human values of $\delta^{15}N$ are elevated ca. 2.2‰ to 5.1‰ relative to average faunal values, which range from 6.0‰ for horses to 8.9‰ for pigs. Assuming a 3-4‰ stepwise enrichment in mean $\delta^{15}N$ between trophic levels, these values are consistent with consumption of terrestrial herbivore meat and milk (Ambrose, 1991; Bocherens & Drucker, 2003; Katzenberg et al., 2009). High nitrogen isotopic values ≥12‰ (n = 3) in humans may indicate greater consumption of pigs and/or lamb/young goat, with lower $\delta^{15}N$ mutton/goat and/or cattle comprising the primary source of animal protein at Ostojićevo. This data is consistent with faunal analysis suggesting an animal husbandry strategy focused on the exploitation of cattle and sheep/goat at Ostojićevo (see Nicodemus, 2017). There is no evidence that low-$\delta^{15}N$ terrestrial herbivores such as red deer and horse were regularly consumed at Early or Late Maros sites near the Tisza-Maros confluence. Individuals with values ≤10.0‰ (n = 4) may indicate a greater proportion of dietary protein coming from plant rather than animal sources.

There was no significant difference in $\delta^{15}N$ between males and females (Mann Whitney U-test, p = .235), Adult I/II and Adult III/IV individuals (Mann Whitney U-test, p = .181), or high- and low-status individuals (Mann Whitney U-test, p = .745). A two-way ANOVA was used to identify the effects of sex and age on $\delta^{15}N$ (Figure 7.24). Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were identified by inspection of a boxplot; normality was assessed using Shapiro-Wilk's normality test for each test group and homogeneity of variances was assessed by a Levene's test. A single extreme outlier was identified (Grave 230, $\delta^{15}N$ = 12.8‰). The decision was made to exclude this value from subsequent analysis as it affected normality. This sample is considered separately below. Residuals were normally distributed (p > .05) and there was homogeneity of variances (p = .101). There was no significance interaction between sex and age for $\delta^{15}N$ ($F(1, 33) = 2.547$, p = .120, *partial* η^2 = .072). Post-hoc analysis included an independent-samples t-test to determine differences in $\delta^{15}N$ values between Adult I/II males and females. Mean $\delta^{15}N$ values were enriched for Adult I/II males (μ = 11.4‰, σ = 0.6‰) compared to age-matched females (μ = 10.7‰, σ = 0.7‰). This difference was statistically significant ($t(20) = 2.198$, p = .040). The small sample size of Adult III/IV males did not allow for separate statistical comparison.

A two-way ANOVA was used to identify the effects of sex and status on $\delta^{15}N$ following the methods described in the previous paragraph (Figure 7.25). Residuals were normally distributed (p > .05), however the hypothesis of equal variances was not supported (p = .048). There was no significant interaction between sex and age for $\delta^{15}N$ ($F(1, 33) = 0.071$, p = .792, *partial* η^2 = .002). To address the potential effect of unequal variances on the results of the two-way ANOVA, post-hoc analysis was conducted using a Mann-Whitney U-test, which tests for differences in distribution shape and differences in medians (Mann & Whitney, 1947). There was no significant difference in $\delta^{15}N$ between high- versus low-status for males (p = .724) or females (p = .901). Additionally, there was no significant difference in $\delta^{15}N$ between low-status males and females (p = .549) or high-status males and females (p = .530).

Table 7.27 $\delta^{15}N$ descriptive statistics for Ostojićevo. All values in ‰.

Var. 1	Var. 2	n	Median	Average	σ	95% Confidence Interval		Min.	Max.
						Lower	Upper		
Male	Adult I/II	10	11.2	11.4	0.6	11.0	11.8	10.8	12.8
	Adult III/IV	4	11.1	11.3	0.6	10.3	12.2	10.6	12.1
	High-Status	5	11.1	11.2	0.4	10.7	11.8	10.8	11.9
	Low-Status	9	11.2	11.4	0.6	10.9	11.9	10.6	12.8
	TOTAL	14	11.2	11.4	0.6	11.0	11.7	10.6	12.8
Female	Adult I/II	13	10.8	10.7	0.7	10.3	11.1	9.6	11.6
	Adult III/IV	11	11.3	11.3	0.4	11.1	11.6	10.8	12.2
	High-Status	7	10.9	11.1	0.3	10.8	11.3	10.7	11.5
	Low-Status	17	11.1	11.0	0.7	10.6	11.3	9.6	12.0
	TOTAL	24	11.1	11.0	0.6	10.7	11.3	9.6	12.0
TOTAL	Adult I/II	23	11.1	11.0	0.7	10.7	11.3	9.6	12.8
	Adult III/IV	15	11.2	11.3	0.4	11.1	11.6	10.6	12.1
	High-Status	12	11.1	11.1	0.4	10.9	11.4	10.7	11.9
	Low-Status	26	11.2	11.1	0.7	10.8	11.4	9.6	12.8
	TOTAL	38	11.2	11.1	0.6	10.9	11.3	9.6	12.8

Carbon isotope values of humans at Ostojićevo ranged from -17.2‰ to -20.3‰, with an average of -19.5 ± 0.5‰ (Table 7.28; Figure 7.23). Average values of $\delta^{13}C$ were enriched ca. 1.0‰ to 1.3‰ relative to average values reported for pigs (-20.8‰), red deer (-20.8‰), and horse (-20.5‰), and depleted -0.6‰ relative to sheep/goat (-18.9‰). Humans and cattle (-19.6‰) exhibited almost identical average $\delta^{13}C$ values. Typically, bone collagen $\delta^{13}C$ is ~5 ± 1.5‰ greater than $\delta^{13}C$ of the diet, with a slight trophic level effect of ~1 ± 0.5‰ between carnivores and herbivores (Hedges, 2003; Katzenberg, 2008). The relationship between the $\delta^{13}C$ of the diet and the $\delta^{13}C$ of bone collagen is more complex than for nitrogen, as non-protein carbon in the diet can be incorporated in body protein (*e.g.*, greater synthesis of non-essential amino acids in a low-protein diet) (Ambrose et al., 1997; Hedges, 2003).

There was no significant difference in $\delta^{13}C$ between males and female (Mann Whitney U-test, p = .643) or Adult I/II and Adult III/IV individuals (Mann Whitney U-test, p = .273). The median values of high-status individuals were found to be enriched in $\delta^{13}C$ by 0.4‰ compared to their low-status counterparts (Mann Whitney U-test, p = .019). A two-way ANOVA was used to identify the effect of sex and age on $\delta^{13}C$ (Figure 7.24). Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were assessed by inspection of a boxplot, normality was assessed using Shapiro-Wilk's normality test for each test group, and homogeneity of variances was assessed by a Levene's test. A single extreme outlier was identified (Grave 155, $\delta^{13}C$ = -17.2‰). The decision was made to exclude this value from subsequent analysis as it affected normality. This sample is considered separately below. The assumptions of normal distribution of residuals ($p > .05$) and homogeneity of variances (p = .624) were upheld. There was no significant interaction between sex and age for $\delta^{13}C$ ($F(1, 33) = 0.991$, p = .327, *partial* η^2 = .029). Post-hoc analysis included an independent-sample t-test to determine differences in $\delta^{13}C$ values between Adult I/II males and females. There was no significant difference in mean $\delta^{13}C$ between Adult I/II males and females ($t(21) = 0.935$, p = .361). The small sample size of Adult III/IV males does not allow for separate statistical comparison.

A two-way ANOVA was used to investigate the effects of sex and status on $\delta^{13}C$ (Figure 7.25). The assumption of homogeneity of variance was upheld (p = .692), however high-status females exhibited a left-skewed distribution that departed from normality (Shapiro-Wilk, $p = .039$). There was no significant interaction between sex and status for $\delta^{13}C$ ($F(1, 33) = 2.644$, $p = .113$, *partial* $\eta^2 = .074$). Research has shown that ANOVAs are considered to be "robust" to deviations of normality (Maxwell & Delaney, 2004), especially with respect to Type I errors (Wilcox, 2012). However, to address the potential effect of non-normally distributed data on the results of the two-way ANOVA, post-hoc analysis was conducted using a Mann-Whitney U-test. High-status males were found to be enriched in $\delta^{13}C$ by 0.5‰ compared to low-status males (Mann-Whitney U-test, $p = .007$). No significant difference was found between high- and low-status females ($p = .222$). There was no significant difference between low-status males and females ($p = .890$) or high-status males and females ($p = .073$).

Two individuals were identified as extreme outliers (Figure 7.23): Grave 155, a low-status Adult III/IV probable-female, and Grave 230 a high-status Adult I/II male. The Grave 155 individual was 0.8‰ greater than the total $\delta^{15}N$ average and 2.4‰ greater than the total $\delta^{13}C$ average for adults at Ostojićevo. Burial attributes, principally body position, suggest the Grave 155 individual may have been a gender non-conforming female. The individual, a probable-female based on the pelvis, was buried in a flexed position with their head to the north. This deviates from the normative female placement of the head to the south or west. No grave offerings were associated with this individual, suggesting they may have held a liminal position within their community. This treatment is consistent with other possible gender non-conforming adult females identified at Ostojićevo (Pompeani, 2018). In addition to Grave 155, stable isotopes were analyzed for two additional gender non-conforming "females". Grave 208 is an Adult II low-status female ($\delta^{15}N$ = 9.6‰, $\delta^{13}C$ = -19.7‰) and Grave 246 is an Adult IV low-status female ($\delta^{15}N$ = 10.83‰, $\delta^{13}C$ = -19.4‰). The Grave 246 individual contains no grave offerings, whereas the Grave 208 individual was buried with two ceramic vessels. The Grave 208 "female" is 1.6‰ less than the adult $\delta^{15}N$ average, whereas the Grave 246 "female" is only 0.4‰ less than the adult $\delta^{15}N$ average. Both the Grave 208 and 246 individuals are within ±0.2‰ the adult $\delta^{13}C$ average. Thus, no consistent pattern can be identified in the diets of gender non-conforming "females". It is possible that additional samples may produce $\delta^{13}C$ outliers consistent with the Grave 155 "female".

Table 7.28 $\delta^{13}C$ descriptive statistics for Ostojićevo. All values in ‰.

Var. 1	Var. 2	*n*	Median	Average	σ	95% Confidence Interval		Min.	Max.
						Lower	Upper		
Male	Adult I/II	10	-19.5	-19.4	0.4	-19.7	-19.2	-20.2	-18.9
	Adult III/IV	4	-19.8	-19.7	0.2	-20.1	-19.4	-19.9	-19.4
	High-Status	5	-19.2	-19.2	0.3	-19.5	-18.9	-19.6	-18.9
	Low-Status	9	-19.7	-19.7	0.3	-19.9	-19.5	-20.2	-19.3
	TOTAL	14	-19.6	-19.5	0.4	-19.7	-19.3	-20.2	-18.9
Female	Adult I/II	13	-19.6	-19.6	0.4	-19.8	-19.4	-20.3	-18.9
	Adult III/IV	11	-19.7	-19.4	0.8	-19.9	-18.9	-20.0	-17.2
	High-Status	7	-19.6	-19.5	0.2	-19.7	-19.3	-19.7	-19.2
	Low-Status	17	-19.7	-19.5	0.7	-19.9	19.2	-20.3	-17.2
	TOTAL	24	-19.7	-19.5	0.6	-19.7	-19.3	-20.3	-17.2
TOTAL	Adult I/II	23	-19.6	-19.5	0.4	-19.7	-19.4	-20.3	-18.9
	Adult III/IV	15	-19.7	-19.5	0.7	-19.9	-19.1	-20.0	-17.2
	High-Status	12	-19.3	-19.4	0.3	-19.6	-19.2	-19.7	-18.9
	Low-Status	26	-19.7	-19.6	0.6	-19.8	-19.3	-20.3	-17.2
	TOTAL	38	-19.6	-19.5	0.5	-19.7	-19.3	-20.3	-17.2

The second statistical outlier, the Grave 230 high-status male, was 0.7‰ greater than the adult $\delta^{15}N$ average and 0.7‰ greater than the adult $\delta^{13}C$ average at Ostojićevo. Grave offerings included a ceramic bowl with animal bones (taxa unknown), a headdress made from copper beads, and a shell- and stone-beaded necklace. The Grave 230 individual exhibited cranial injuries consistent with perimortem trauma associated with interpersonal violence, specifically multiple blows to the head with a stone axe (see Chapter 7). Four adult biological males displayed antemortem or perimortem injuries consistent with interpersonal violence (*i.e.*, Graves 223, 226, 230, and 274), with all four buried with prestige offerings. Of these, stable isotopes were analyzed for the Grave 226 individual, an Adult I/II high-status male and the most "decorated" individual in the cemetery in terms of grave good number and type. This individual was within 0.2‰ of the adult $\delta^{15}N$ average and 0.4‰ of the adult $\delta^{13}C$ average. Based on these two samples, there is no evidence of systematic dietary provisioning of high-status adult males involved in combat.

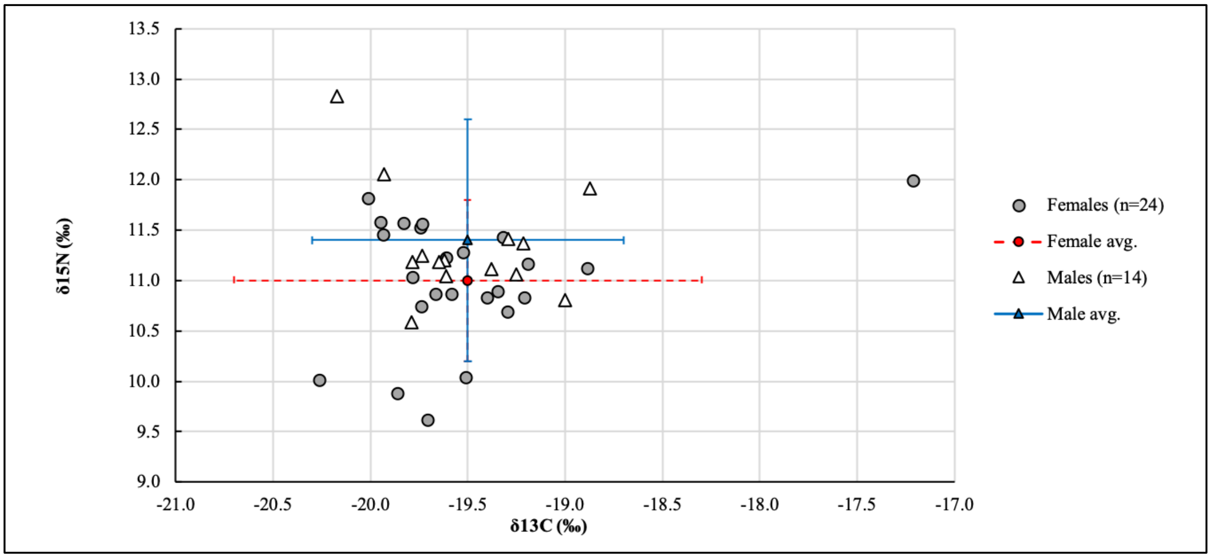


Figure 7.23 δ^{15}N and δ^{13}C distribution by biological sex at Ostojićevo. Human specimens (>18 years), showing average values for males (triangle) and females (circle). Error bars ± 2 σ. Grave #s labeled for extreme statistical outliers.

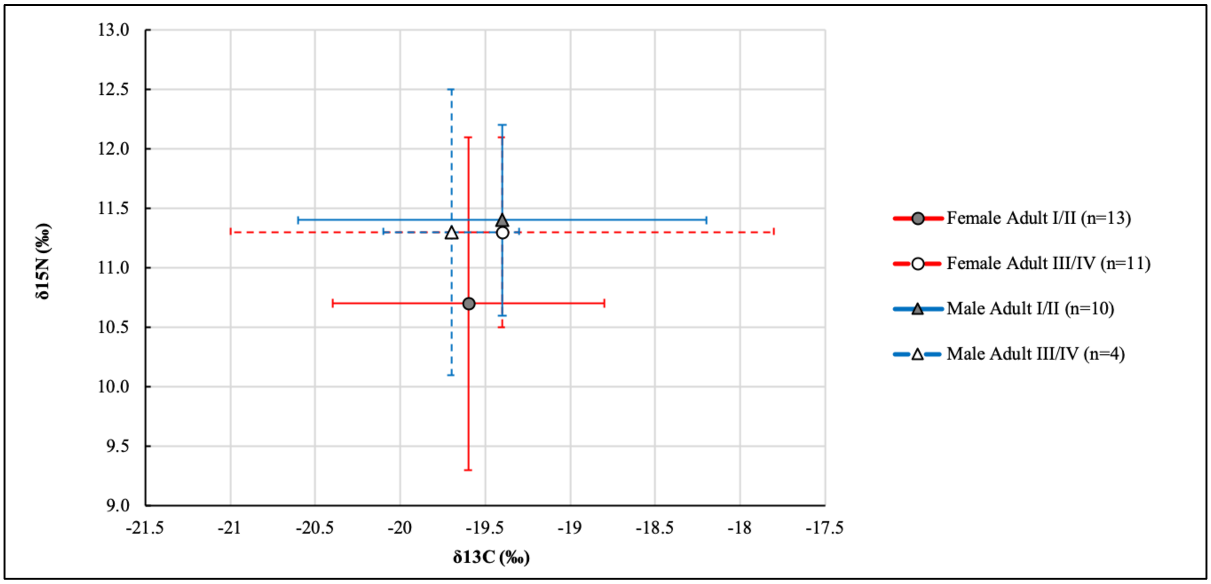


Figure 7.24 δ^{15}N and δ^{13}C distribution by biological sex and age-at-death at Ostojićevo. Human specimens (>18 years), showing average values for males (triangle) and females (circle) and Adult I/II (solid lines) and Adult III/IV (dotted lines) individuals (excluded extreme outliers). Error bars ± 2 σ.

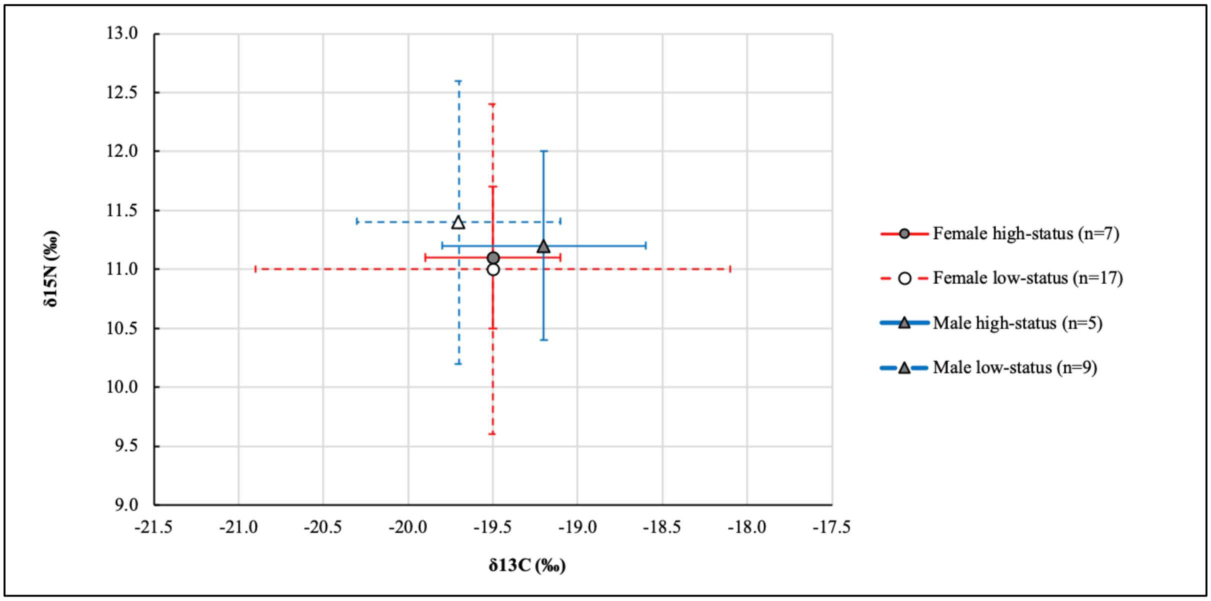


Figure 7.25 δ^{15}N and δ^{13}C distribution by biological sex and social status at Ostojićevo. Human specimens (>18 years), showing average values for males (triangle) and females (circle) and high-status (solid lines) and low-status (dotted lines) individuals (excludes extreme outliers). Error bars ± 2 σ.

7.8.3 Mokrin

A total of 25 adults (>18 years) were analyzed. Samples were taken from ribs whenever possible. However, due to curation practices that disposed of minor skeletal elements (*e.g.*, vertebrae, ribs, extremities, etc.), samples were taken from long bones (*i.e.*, femur, fibula, tibia) in nine cases (Appendix Table 38). Of 25 original samples, 12 (48.0%) did not meet criteria for collagen preservation and were excluded from analysis. The adjusted sample included five females and eight males (Tables 7.29 and 7.30). This accounts for 8.0% of the total Mokrin adult sample. Individuals were further distinguished by age-at-death (Adult I/II and Adult III/IV) and status (high and low) based on criteria outlined in section 7.4.

Values of δ^{15}N and δ^{13}C were homogenous among both males and females, though this is likely influenced by the small sample size (Figure 7.26). The Levene's test for equality of variances supported equal variances for values of δ^{15}N (p = .353) and δ^{13}C (p = .480). The result of a two-sample independent t-test assuming equal variances found no significant difference in δ^{15}N ($t(11)$ = 0.698, p = .500) or δ^{13}C

($t(11) = 0.553$, $p = .591$) between males and females. The small sample sizes of sex-age and sex-status categories did not allow for separate statistical comparison. However, two-sample independent t-tests were conducted across age and status categories, respectively. A two-sample independent t-test assuming equal variances ($p = .942$; $p = .211$) found no significant difference between Adult I/II and Adult III/IV individuals for $\delta^{15}N$ ($t(11) = .972$, $p = .352$) or $\delta^{13}C$ ($t(11) = 0.553$, $p = .591$). Similarly, a two-sample independent t-test assuming equal variances ($p = .397$; $p = .395$) found no significant difference between high- and low-status individuals for $\delta^{15}N$ ($t(11) = .698$, $p = .500$) or $\delta^{13}C$ ($t(11) = 0.553$, $p = .591$).

Table 7.29 $\delta^{15}N$ descriptive statistics for Morkin. All values in ‰.

Var. 1	Var. 2	*n*	Median	Average	StDev	95% Confidence Interval		Min.	Max.
						Lower	Upper		
Male	Adult I/II	5	10.7	10.5	0.5	9.9	11.1	9.7	11.0
	Adult III/IV	3	11.0	10.7	--	--	--	10.1	11.0
	High-Status	2	--	10.9	--	--	--	10.7	11.0
	Low-Status	6	10.5	10.5	0.5	9.9	11.0	9.7	11.0
	TOTAL	8	10.7	10.6	0.5	10.2	11.0	9.7	11.0
Female	Adult I/II	3	10.8	10.6	--	--	--	10.2	10.9
	Adult III/IV	2	--	10.9	--	--	--	10.6	11.2
	High-Status	3	10.6	10.7	--	--	--	10.2	11.2
	Low-Status	2	--	10.9	--	--	--	10.8	10.9
	TOTAL	5	10.8	10.7	0.4	10.3	11.2	10.2	11.2
TOTAL	Adult I/II	8	10.7	10.6	0.4	10.2	10.9	9.7	11.0
	Adult III/IV	5	11.0	10.8	0.4	10.2	11.3	10.1	11.2
	High-Status	5	10.7	10.7	0.4	10.3	11.2	10.2	11.2
	Low-Status	8	10.8	10.6	0.5	10.2	11.0	9.7	11.0
	TOTAL	13	10.7	10.6	0.4	10.4	10.9	9.7	11.2

Table 7.30 δ13C descriptive statistics for Morkin. All values in ‰.

Var. 1	Var. 2	*n*	Median	Average	StDev	95% Confidence Interval		Min.	Max.
						Lower	Upper		
Male	Adult I/II	5	-19.2	-19.2	0.1	-19.3	-19.1	-19.3	-19.1
	Adult III/IV	3	-19.1	-19.2	--	--	--	-19.4	-19.1
	High-Status	2	--	-19.1	--	--	--	-19.1	-19.1
	Low-Status	6	-19.2	-19.2	0.1	-19.3	-19.1	-19.4	-19.1
	TOTAL	8	-19.2	-19.2	0.1	-19.3	-19.1	-19.4	-19.1
Female	Adult I/II	3	-19.2	-19.2	--	--	--	-19.3	-19.1
	Adult III/IV	2	--	-19.3	--	--	--	-19.3	-19.2
	High-Status	3	-19.2	-19.2	--	--	--	-19.3	-19.1
	Low-Status	2	--	-19.2	--	--	--	-19.3	-19.1
	TOTAL	5	-19.2	-19.2	0.1	-19.3	-19.1	-19.3	-19.1
TOTAL	Adult I/II	8	-19.2	-19.2	0.1	-19.3	-19.1	-19.3	19.1
	Adult III/IV	5	-19.2	-19.2	0.0	-19.4	-19.1	-19.4	-19.1
	High-Status	5	-19.2	-19.2	0.1	-19.3	-19.1	-19.3	-19.1
	Low-Status	8	-19.2	-19.2	0.1	-19.3	-19.1	-19.4	-19.1
	TOTAL	14	-19.2	-19.2	0.1	-19.3	-19.1	-19.4	-19.1

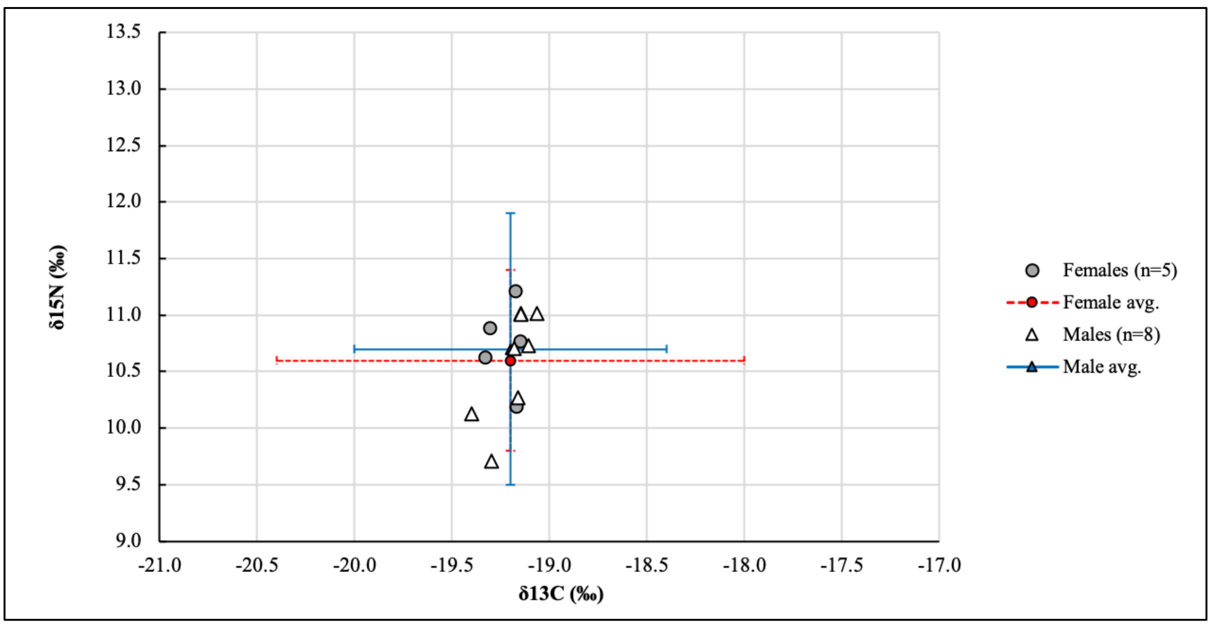


Figure 7.26 δ15N and δ13C distribution by biological sex at Mokrin. Human specimens (>18 years), with average values for males (triangle) and females (circle). Error bars ± 2 σ.

7.8.4 Discussion

This approach to dietary reconstruction seeks to examine local differences in subsistence economy, especially animal husbandry, and individual differences in diet associated with age, sex, and/or status. Human $\delta^{15}N$ values from bone collagen are typically enriched 3-5‰ relative to diet (Shoeninger & DeNiro, 1984), whereas human $\delta^{13}C$ values demonstrate a smaller enrichment of 0-2‰ (Bocherens & Drucker, 2003; DeNiro & Epstein, 1978). Controlled-feeding studies have found that bone collagen $\delta^{15}N$ and $\delta^{13}C$ reflects the protein portion of the diet in mammals, with routing of dietary amino acid >50% for collagen carbon and ca. 72% for collagen nitrogen (Ambrose & Norr, 1993; Jim et al., 2006; Robbins et al., 2005). Thus, nitrogen values are more representative of the protein component of diet than carbon.

7.8.4.1 Subsistence Economy: Inter-cemetery Comparison

Figure 7.27 illustrates the relationship between human and faunal nitrogen and carbon values. Human $\delta^{13}C$ values at Ostojićevo were enriched +0.1‰ relative to cattle and sheep/goat and ca. +1.2‰ relative to pigs/dog and horse/red deer. Human $\delta^{13}C$ values at Mokrin were enriched +0.3‰ relative to cattle and sheep/goat and ca. +1.6‰ relative to pigs/dog and horse/red deer. The depleted $\delta^{13}C$ values among humans at Ostojićevo contrast with their enriched $\delta^{15}N$ values compared to Mokrin. This suggests that individuals at Ostojićevo may have consumed a wider variety of animals (and plants). This is further evidenced by the larger standard deviation for values of $\delta^{13}C$ at Ostojićevo.

The apparent contradiction in diet source based on analysis of carbon versus nitrogen isotopes does not refute the interpretation that, on average, cattle meat and/or milk comprised a greater proportion of dietary protein at Ostojićevo compared to increased consumption of sheep/goat at Mokrin. This apparent shift over time in local economies from sheep and goat to higher value livestock such as in the southern Maros area mirrors events at Maros settlements near the Tisza-Maros confluence (Nicodemus, 2010). However, consumption of freshwater resources leading to a depleted $\delta^{13}C$ and enriched $\delta^{15}N$ isotopic signature characteristic of pigs and some Ostojićevo humans cannot be ruled out from the present data

(Bonsall et al., 2004). Thus, in contrast to findings based on faunal analysis from sites near the Tisza-Maros confluence, stable isotope data presented here supports an increase in diet breadth from the Early to Late Maros periods in the southern Maros region.

Human skeletal remains from Mokrin were more likely to be missing smaller skeletal elements, such as ribs. This is due to curation practices associated with the original excavation rather than burial environment (see Rega, 1995). This hampered sample collection, as many samples from Mokrin had to be taken from long bones. Thus, fewer samples were originally collected from Mokrin than Ostojićevo. Collagen preservation also differed between the two sites, with 52.0% of the Mokrin adult sample (n = 24) compared to 70.4% of the Ostojićevo adult sample (n = 54) not affected by diagenesis. All the samples from Ostojićevo were ribs, with 64% of the Mokrin samples ribs and the rest taken from long bones (*i.e.*, femur, tibia, and fibula). Of 16 rib samples from Mokrin, ten were excluded for not meeting %C, %N, or C/N criteria. It is not clear what produced this discrepancy in collagen preservation between the two sites. Despite similar storage conditions (*e.g.*, cardboard boxes and newspaper wrappings), Mokrin was excavated ca. 20 years before Ostojićevo. Most discussions of bone preservation reference characteristics of the burial environment (*e.g.*, soil pH, moisture, microbial activity, etc.) (Dobberstein et al., 2009; Lee-Thorp, 2002). However, comparatively little work has been done on post-excavation conservation and curation on bone collagen preservation (see Cleland et al., 2016; Pruvost et al., 2007).

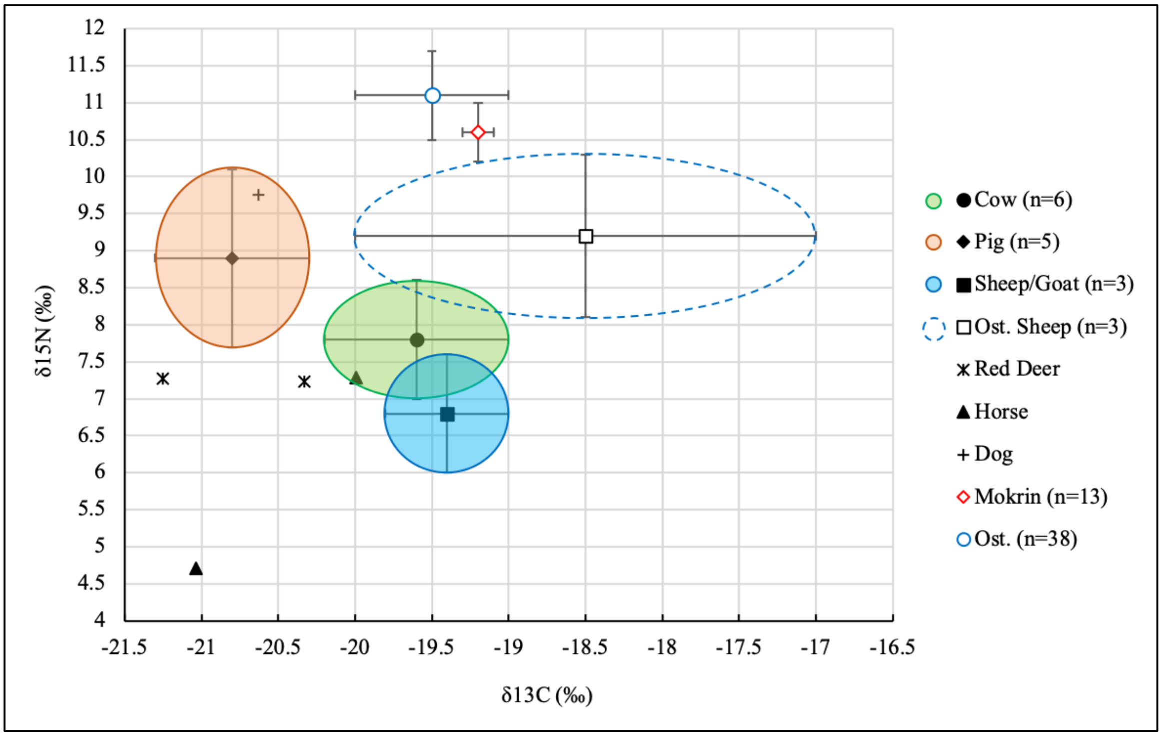


Figure 7.27 Carbon and nitrogen distribution of human (>18 years) and faunal specimens. Error bars ± 1 σ. Ost = Ostojićevo.

7.8.4.2 Dietary Trends: Intra-cemetery Comparison

The results of the δ^{15}N and δ^{13}C analysis of human collagen did not find significant differences in isotopic signatures between males and females at either Ostojićevo or Mokrin. Males and females at both sites were consuming similar proportions of similar types of food. Sample size at Mokrin (*n* = 13) was too small to examine the interaction of sex with age or status on diet. There was no isotopic association between sex, age, or status and diet at Mokrin. However, an Adult IV high-status female exhibited the highest δ^{15}N value (11.2‰) and an Adult I low-status male had the lowest δ^{15}N value (9.7 ‰). This contrasts with the pattern at Ostojićevo, in which the highest δ^{15}N value (12.8‰) was documented for an Adult I low-status male and the lowest δ^{15}N value (9.6‰) for an Adult II low-status female.

The larger sample size at Ostojićevo (*n* = 38) allowed for robust statistical analysis of demographic and mortuary groups. Adult I/II females had nitrogen isotopic signatures depleted relative to older females and both older and younger males. Subsequent analysis found no difference in mean isotopic values across sex and status groups. Low-status males and females, however, displayed significantly greater variation in nitrogen values than their high-status counterparts. The results show that females experienced dietary transitions throughout their lives irrespective of status. Reproductive-age females (<40 years-at-death) consumed a wider range of foods compared to likely post-reproductive females. As a group, Adult I/II females exhibited low nitrogen, but comparable carbon values, relative to other age-sex groupings. If these low values are diet-related, then they reflect greater protein routing from plant sources or consumption of low $\delta^{15}N$ value grazers/browsers such as sheep or goats. Of interest is the similarity between mean $\delta^{15}N$ of Adult I/II females at Ostojićevo (10.7‰) and the total adult average at Mokrin (10.6‰), though $\delta^{13}C$ values of Adult I/II females (-19.6‰) are depleted relative to the Mokrin total average (-19.2‰). However, as discussed in section 8.7.4.2, this is consistent with a pattern of depleted carbon values at Ostojićevo.

These findings support hypothesis number three and partially support hypothesis number two, in that lower nitrogen values among young women may indicate reduced access to animal protein. However, diet alone cannot account for the differences in dental health, especially in older males and females. Thus, reproductive history (*e.g.*, high fertility, maternal depletion syndrome) in conjunction with diet provides the most likely explanation for the higher prevalence of AMTL and dental caries in women. The identification of age-related differences in diet specific to Adult I/II females reinforces the ways in which status was differentially embodied for males and females.

Previous analysis of mortuary patterns found higher frequencies of prestige items and greater variety of items in the graves of older females and younger males (Pompeani, 2018). In her study of gender relations inferred from sex-specific mortality, body position, and grave goods at Mokrin, Rega (1997) argued that males and females exhibited complementary gender hierarchies. At Ostojićevo, these complementary gender hierarchies strongly correlated with age, corresponding to a pattern of high-status older women and high-status younger men. Dietary strategies among younger women and low-status women seemed to have more opportunistic, in that they exploited a greater variety of foods. High-status males, high-status females, younger males, and older females had access to a more stable (homogenous) diet.

One possibility for these differences, which has been documented ethnographically, is the practice of mother-child provisioning, whereby mothers with dependent offspring switch to alternative food sources or forego meals to feed their children during periods of resource instability or scarcity (Hawkes et al., 1998; Pike et al., 2010). For example, among indigenous northern Kenyan herders, gendered division of labor tied to herding strategies mean that males have greater access to primary animal products (*i.e.*, meat and blood) and women and young children have greater access to secondary animal products (*e.g.*, milk) (Nathan et al., 1996). Drought, disease, or conflict affect livestock production and can lead to resource scarcities that disproportionately affect the health of women and young children (Pike et al., 2010). In response, nutritional buffering follows cultural perceptions of moral responsibilities, with older women provisioning younger women and all women foregoing food to feed children (Gray, 1996; Pike et al., 2010). In a cross-cultural comparison of complementary child feeding strategies, Pelto et al. (2003) found that mothers were primarily responsible for preparing and feeding complementary foods (*i.e.*, in addition to breastfeeding). Decisions on what and when to feed children were just as, if not more, likely to be influenced by alternative caregivers, often older family members. Thus, economic position and social organization within households affected maternal and infant diets via labor demands on the mother and unequal distribution of limited household resources.

Based on the stable isotope evidence, if the lower nitrogen values among young adult women are reflective of mother-child provisioning, then the bulk of the responsibility of nutritional buffering was placed on young women. Women who survived past their late-30s/early-40s seemed to have acquired a level of social prestige that afforded them privileged access to animal protein. Stable isotope data compared across sex, age, and status groups underpins how female social agency and status was tied to age, with older women wielding a degree of social power and influence equal to or greater than that of men. Assuming these sex-age groupings are representative of Maros families and households, within-group social dynamics prioritized the feeding (and feasting) of older women and adult males over young adult females. Further research on bone collagen stable isotopes from infants, children, and adolescents compared to adults is needed to identify the effect of household and family social dynamics on subadult feeding practices.

7.9 Conclusion: Dental Disease and Diet

Dental disease found in human skeletal remains has been used to infer patterns of diet (Clarke et al., 1986; Cucina & Tiesler, 2003; Eshed et al., 2006; Hillson, 1979; 2001; Larsen, 2015; Kerr, 1998) and behavior (Belcastro et al., 2007; Lieverse et al., 2007; Watson et al., 2010) linked to subsistence practices and social organization in past societies. My analysis focused on assessment of dental disease to: (1) document the prevalence of dental disease in the Late Maros EBA/MBA population from Ostojićevo; and (2) compare dental disease prevalence between Ostojićevo and previously published data on caries and AMTL from the nearby Early Maros EBA cemetery at Mokrin. I applied stable isotope evidence of diet to examine variation in dental pathology due to dietary and non-dietary factors among adults at Ostojićevo and Mokrin. The purpose of stable isotope analysis was twofold: (1) to elucidate local differences in subsistence strategies as a product of environmental and socio-economic factors; and (2) to examine how dietary patterns correlate with age, sex, and social status.

7.9.1 Ostojićevo: Age- and Sex-Specific Dental Disease

Population, sex-specific, and age-specific prevalence of dental pathology prevalence (TPR) is summarized in Table 7.31 for the upper jaw/teeth and Table 7.32 for the lower jaw/teeth. At the population level, over twice as many teeth were lost antemortem from the lower jaw compared to the upper jaw. Periodontal bone loss was slightly more common in the lower jaw, whereas dental caries were slightly more common in the upper teeth. This pattern supports progressive resorption of alveolar bone and loss of the attachment at the periodontal ligament due to periodontal disease as the primary cause of AMTL (Hillson, 1996). Studies have found sex-differences in causes of tooth loss, with AMTL secondary to periodontal disease more common in men (Albander, 2000; Lukacs, 2011b). In contrast, caries have been found to be a major cause of AMTL in women (Lukacs, 2011b; Meisel et al., 2008). This assertion is supported by females at Ostojićevo having fewer teeth than age-matched males due to AMTL. Additionally, caries also affected significantly more teeth in women (upper only) than men. AMTL was ca. 3.5 times higher and caries were ca. 1.9 times higher in the maxilla of females compared to males; for the mandible, women lost ca. 2.8 times as many teeth and had ca. 2.0 times as many teeth with caries than men. There was no significant difference in prevalence of periodontal disease between males and females. Thus, the data demonstrates a gender bias in causes of tooth loss, with women experiencing greater tooth loss due to caries than men.

Prevalence of AMTL, periodontal disease, and caries were significantly higher in "older" adults (>40 years) compared to "younger" adults (18-40 years). For the maxilla, the greatest age-related increase was AMTL (ca. 34.8 times), followed by periodontal disease (ca. 4.4 times), and caries (ca. 1.9 times); a similar pattern was identified for the mandible, with AMTL 9.1 times greater, periodontal disease 3.8 times greater, and caries 3.0 greater in "older" adults than "younger" adults.

An examination of sex- and age-specific trends in combined maxillary and mandibular AMTL, periodontal disease, and caries found that the greatest relative increase in dental disease prevalence was between Adult I (>18-30 years) and Adult II (>30-40 years) individuals (Table 7.33). Excessive AMTL in Adult IV (>50 years) individuals meant that dental disease seemed to "decrease" in this age cohort relative to Adult III (>40-50 years) individuals. However, it is likely that this "decrease" is an artifact of high dental attrition in older individuals. Among individuals dying between 18 and 30 years, males and females exhibited similar AMTL prevalence, but females exceeded males in the prevalence of periodontal disease (2.8 times), caries (ca. 1.9 times), and abscesses (8.5 times). Notably, the incidence of dental caries and abscesses in females dying between 18 and 50 years was similar to males dying between 40 and 50 years. Thus, females tended to be affected by infectious processes (*i.e.*, caries and abscesses) beginning about ten to 20 years earlier than males. Of additional note is age-related changes in AMTL and periodontal disease. While both are higher in Adult I females, progression was more rapid in males. For example, there was a ca. 6.0 times increase in the prevalence of AMTL and periodontal disease from Adult I to Adult II males (compared to a change in age-matched females of ca. 4.1 times and ca. 2.3 times, respectively). Taken together, the data supports both behavioral (*e.g.*, diet) and biological (*e.g.*, parity) factors affecting differences in dental health between males and females. Except for calculus, which showed minimal age-related changes in adults less than 50 years-at-death, all-disease prevalence increased with age-at-death, which is consistent with the age-progressive nature of dental disease (Hillson, 1996; 2001). However, the magnitude of change in dental disease from the third to fourth decade was greater in males than females, whereas males and females exhibited a similar degree of change from the fourth to fifth decade. Thus, disease burden was higher in young females and remained high throughout the life course. In contrast, males in their fourth decade experience marked declines in dental health, with sex-specific differences plateauing after 40 years.

Table 7.31 Ostojićevo total, age-specific, and sex-specific dental pathology TPR (%) based on element count for the upper teeth/maxillae

Pathology/Condition	% Total	% Adult I/II (>18-40 yrs)	% Adult III/IV (>40 yrs)	% Male	% Female	Sig. Sex (α < .05)	Sig. Age (α < .05)
AMTL	9.2	1.1	38.3	4.9	17.1	Yes	Yes
Periodontal Disease	17.5	8.4	36.9	17.4	21.2	No	Yes
Caries	18.1	15.4	29.3	12.4	23.2	Yes	Yes
Abscesses	5.2	2.9	7.8	5.0	5.9	No	No
Calculus	71.6	71.9	67.7	78.1	69.4	No	No

Table 7.32 Ostojićevo total, age-specific, and sex-specific dental pathology TPR (%) based on element count for the lower teeth/mandible

Pathology/Condition	% Total	% Adult I/II (>18-40 yrs)	% Adult III/IV (>40 yrs)	% Male	% Female	Sig. Sex (α < .05)	Sig. Age (α < .05)
AMTL	19.3	5.4	49.2	9.4	26.0	Yes	Yes
Periodontal Disease	20.3	12.7	48.3	14.9	23.8	No	Yes
Caries	12.9	8.9	26.3	9.2	18.3	No	Yes
Abscesses	4.8	3.3	5.7	1.8	8.2	No	No
Calculus	73.2	73.3	64.4	81.1	69.6	No	No

Table 7.33 Ostojićevo age- and sex-specific TPR (%) for combined upper and lower jaws/teeth

Sex	Pathology/ Condition	Adult I (>18-30 yrs)	Adult II (>30-40 yrs)	Adult III (>40-50 yrs)	Adult IV (>50 yrs)	x Increase (Adult I to II)	x Increase (Adult II to III)
Male	AMTL	1.0	6.0	17.1	51.0	6.0	2.9
	Periodontal Disease	3.0	17.4	42.7	40.8	5.8	2.5
	Caries	5.6	13.2	11.5	33.3	2.4	0.9
	Abscesses	0.6	3.1	5.9	15.4	1.0	1.9
	Calculus	81.9	79.9	73.5	33.3	1.0	0.9
Female	AMTL	1.9	7.8	22.8	67.5	4.1	2.9
	Periodontal Disease	8.4	19.2	44.3	11.0	2.3	2.3
	Caries	10.6	28.8	44.0	22.9	2.7	1.5
	Abscesses	5.1	6.7	7.3	4.7	1.3	1.1
	Calculus	68.4	66.7	72.5	57.9	1.0	1.1

Research on modern populations in the U.S. and the U.K. (Beiswanger et al., 1989; Christersson et al., 1992; Morris et al., 2001) have demonstrated a strong correlation between male sex, calculus, and periodontal disease. The results of a 1985-86 survey conducted by the U.S. Department of Health and Human Services found that 84% of adults ages 16-64 years had dental calculus compared to 89% of adults over 65 years (Miller et al., 1987). Among adults ages 16-64 years, males (87%) were more affected than females (80%). Subsequent research has suggested this connection is due, in part, to differences in oral hygiene practices between males and females (Albander, 2000). The prevalence of periodontal disease and calculus have also been found to be significantly higher in smokers than non-smokers, which further supports a behavioral rather than biological cause for sex-differences in calculus and periodontal disease in modern western populations (Abander et al., 2000; Bergström, 1999; Krall, 1999). In contrast, rates of caries and AMTL in females have been found to correlate with parity and periodontal status (González-Jaranay et al., 2017; Lukacs, 2008; 2011a; 2011b; Lukacs & Largaespada, 2006). Several studies have proposed that hormonal fluctuations during pregnancy affect oral biology as well as trigger cravings for carbohydrate-rich foods (Lukacs, 2008; Lukacs & Largaespada, 2006). Specifically, it has been suggested that higher estrogen levels during pregnancy results in a lower saliva flow rate and changes to the biochemical composition of saliva, which decreases the antimicrobial properties of saliva and ability of saliva to clear food residue (Lukacs, 2008; Salvolini et al., 1998). Furthermore, pregnancy-related immune suppression leading to increased systemic inflammation has been posited as contributing to worsening periodontal disease and subsequent tooth loss (González-Jaranay et al., 2017). However, this connection between pregnancy and worsening periodontal inflammation has been disputed (Larsen et al., 1991; Morelli et al., 2018). For example, Morelli et al. (2018) posited that socioeconomic status was more important than parity in accounting for rates of periodontal disease in women. González-Jaranay et al. (2017) measured periodontal status (*i.e.*, plaque index, gingival inflammation, and probing depth) in pregnant women in Spain in the first, second, and third trimesters plus 40 days postpartum. They found that plaque, gingival inflammation, and probing index increased significantly throughout pregnancy and decreased during the postpartum period, but remained significantly higher than at baseline. These observations support Lukacs' analysis of fertility and dental health from clinical records in Hungary, Brazil, and India. Lukac's (2011b) study emphasizes the importance of several key confounding factors that contribute to the impact of pregnancy on caries, tooth loss, and periodontal disease. Notably, oral health disparities linked to hormonal changes during pregnancy are exacerbated by the cumulative impact of multiple pregnancies, malnutrition or undernutrition caused by dietary restrictions and fasting during pregnancy and preexisting dental disease.

The timing of significant disparities in dental disease among females relative to males at Ostojićevo is as follows: after 20 years (30 years for upper teeth) for caries, after 30 years (40 years for lower teeth) for AMTL, and after 40 years for periodontal disease. This pattern suggests that caries, and not periodontal disease, preceded tooth loss in females beginning around 30 years. In males, AMTL is age-related and more closely tied to loss of support secondary to severe periodontal disease (inflammation) rather than caries (infection). While all dental disease is largely age-dependent, the prevalence and timing of caries and AMTL experience among females is consistent with the expected pattern for high fertility (*i.e.*, multiple pregnancies) having a negative effect on female dental health. The overall high rates of dental disease at Ostojićevo compared to Mokrin (see section 7.7) supports males and females consuming a cariogenic diet that predisposed them to dental disease. Demographic data presented in Chapter 4 demonstrates high infant mortality, which is an indirect indicator of high fertility (Wood et al., 1992). Marked differences in caries and AMTL between males and females is not universal among prehistoric agricultural societies (Larsen, 1983; Lieff et al., 2004; Russell et al., 2008). The paleodemographic and dental data from Ostojićevo present evidence as to the social, behavioral, and biological contexts under which these disparities emerge (see Cucina & Tiesler, 2003; Lieverse et al., 2007; Watson et al., 2010).

7.9.2 Ostojićevo and Mokrin: Dental Disease and Diet

The connection between dental disease and diet is complex, and is influenced by both internal (*e.g.*, genetic predisposition, hormonal changes) and external/behavioral (*e.g.*, macronutrient composition of diet, socioeconomic status, access to food, food processing and texture, tooth wear, etc.) factors. Thus, it can be difficult to tease apart key dietary and non-dietary influences that contribute to dental health disparities between populations and variation among individuals within a given population or sub-population. Analysis of stable isotopes of carbon and nitrogen from bone collagen reflect the protein component of diet (Bocherens & Drucker, 2003). Though climate and environment can influence isotope ratios (Ambrose, 1991; Ambrose & Norr, 1993; Britton et al., 2008) in terrestrial food webs, comparisons of human values to a faunal baseline derived from contemporaneous animal samples can help account for regional and local differences in isotope values (Bocherens & Drucker, 2003; Katzenberg et al., 2012).

Comparative dental pathology from adults buried at Mokrin was based on data published in Rega (1995). Rega (1995) only reported on AMTL and caries between males and females for the Mokrin sample, with no distinction for age-at-death. However, Rega (1995:138) noted that there was no significant difference in the age profiles of males and females from whom AMTL and caries were assessed. There was no significant difference in AMTL or caries prevalence for the upper or lower jaw/teeth between males and females at Mokrin. Ostojićevo males displayed significantly more teeth with caries (upper only) compared to males at Mokrin. However, AMTL prevalence among males from Ostojićevo was similar to the Mokrin sample. Ostojićevo females were significantly more affected by caries and AMTL (lower jaw only) compared to Mokrin females. Based on dental evidence, population and sex differences in caries and AMTL experience suggests that adults at Ostojićevo population consumed a more cariogenic diet that was higher in carbohydrates (*e.g.*, grains) and lower in animal protein compared to adults at Mokrin. Furthermore, poor oral health and high fertility among females at Ostojićevo led to sex-specific disparities at dental health that were absent from Mokrin.

Stable isotope analysis of carbon and nitrogen from bone collagen from the Mokrin sample supports conclusions about gender-based dietary differences based on dental evidence. There was no difference in diet between males and females. Additionally, examination of diet in relation to age ("young" ages 18-40 years vs. "old" ages >40 years) and social status ("low" vs. "high") found no relationship between diet and age or status. Average $\delta^{15}N$ was depleted -0.5‰ at Mokrin (10.6‰) relative to Ostojićevo (11.1‰). The difference in average $\delta^{13}C$ between the two sites was 0.3‰, with Mokrin slightly depleted. Placed in the context of faunal isotopic signatures, stable isotope evidence from Mokrin suggests greater reliance on $\delta^{15}N$-depleted browsers and grazers, chiefly sheep/goat, whereas the population at Ostojićevo were consuming more isotopically enriched animals, such cattle. The offset in $\delta^{13}C$ between the two sites is consistent with the difference between sheep/goat versus cattle. The expected pattern if one population was consuming more pigs, red deer, or horses would be an average $\delta^{13}C$ closer to -20.5-20‰.

Estimation of differences in dietary breadth between the two cemeteries was hampered by sample size. The smaller sample size from Mokrin means that the data is less likely to capture the "true" degree of variation present in the sample. Variation in nitrogen values was similar between Mokrin (σ = 0.4‰) and Ostojićevo (σ = 0.6‰). However, variation in $\delta^{13}C$ was five-times greater at Ostojićevo (σ = -0.5‰) compared to Mokrin (σ = -0.1‰). This pattern suggests that individuals at Ostojićevo were consuming different types of foods with similar $\delta^{15}N$ signatures but that varied in $\delta^{13}C$. One possibility is greater reliance on wild game, such as red deer, or consumption of horse meat at Ostojićevo. Future research should focus on expanding the comparative faunal data set to better model diet breadth.

There was no difference in carbon or nitrogen isotope values by sex, age, or status at Ostojićevo. This contrasts with the stark sex-specific differences in dental disease that support lower terrestrial animal protein consumption among Ostojićevo females. Further analysis of stable isotope values among males and females did identify covariance between variables. Notably, females >18-40 years formed a distinct dietary group with respect to $\delta^{15}N$, but not $\delta^{13}C$, relative to males and age-matched females. On average, young adult females were depleted -0.6‰ compared to older females and older males were depleted -0.7‰ compared to younger males. Three low-status young adult females had $\delta^{15}N$ values ≤10‰ (Graves 30, 69, 96, and 208).

Compared to faunal values, these individuals are closer to the $\delta^{15}N$ signature for pigs and dogs than Ostojićevo adults. The implications of low nitrogen values for diet and health among females >18-40 years are twofold: (1) diet improved among females with age; however, the effects of high fertility and dietary restriction (either self-imposed or due to unequal access to high-quality foods associated with gender, age, and status) contributed to a rapid progression of caries and AMTL beginning in the third decade of life.

Dietary changes later in life were not enough to reverse these effects. In an analysis of sex- and age-specific impacts on oral health (*i.e.*, caries and AMLT) in an Early Agricultural (1600 B.C.-A.D. 200) skeletal sample from northwest Mexico, Watson et al. (2010) found that a shift to a more cariogenic diet in males and females produced similar prevalence of caries in males and females but a higher burden of tooth loss in females, especially in postreproductive females. (2) Poor diet contributed to higher risk of death among females under 40 years. Cross-cultural analysis of caregiver roles in provisioning infants and children show mothers to be most responsible for feeding infants and small children, in addition to their involvement in a range of domestic and non-domestic activities (Pelto et al., 2003; Pike et al., 2010). The second most common caregiving scenario includes the mother plus an older sibling or adult female relative (Pelto et al., 2003). These two caregiving scenarios often occur at the expense of the health and nutritional status of the mother and/or closely related juvenile or young adult females (Pelto et al., 2003; Pike et al., 2010).

Cultural concepts and beliefs surrounding pregnancy and childbirth may further influence what women eat and have negative effects on maternal health. For example, Lukacs (2011b) cites examples from India of women choosing to restrict food intake during pregnancy, referred to as “eating down”, in the belief that this will produce a smaller fetus and easier birth. Either due to economic circumstances or socio-religious beliefs, dietary restriction during and after pregnancy can affect pregnancy outcomes and increase risk of maternal morbidity and mortality (King, 2003). Maternal depletion syndrome refers to changes in maternal nutritional status due to inadequate nutritional reserves (macronutrient and micronutrient) and short interpregnancy intervals (King, 2003; Winkvist et al., 1992). Interestingly, this effect is most apparent among marginally malnourished women, in which nutrient partitioning sustains the mother at the expense of the developing fetus (Winkvist et al., 1992). Thus, rather than affecting isotope mass balance vis-a-vis increased urea excretion under conditions of insufficient or reduced protein intake, women with marginally inadequate diets are able to metabolically buffer against low energy intake (Ambrose, 1991; King, 2003; Winkvist et al., 1992). The combined effects of marginal undernutrition and interpregnancy intervals under 24 months include an increased risk of low birth weight and preterm birth; however, the extent to which “maternal depletion” negatively affects maternal morbidity and mortality remains controversial (Conde-Agudela et al., 2012).

The composition of diet based on stable isotope analysis of adults from Ostojićevo is at odds with diet inferred from dental pathology data. At the population level, adults buried at Ostojićevo consumed similar proportions of terrestrial animal protein to those buried at Mokrin, albeit with a greater reliance on cattle at the former and sheep/goat at the latter. Furthermore, there was no association between sex, age, or status with diet at either site. In contrast, the marked discrepancies in oral health between age-matched males and females at Ostojićevo suggest dietary differences were not paralleled in the stable isotope data. However, when stable isotope results were examined in the context of age and sex at Ostojićevo, lower nitrogen values among women under 40 years indicated reduced access to animal protein. The progressive nature of dental disease and effects of fertility on dental health meant that increased access to terrestrial animal protein in women over 40 years was insufficient to reverse gender biases in caries or AMTL prevalence. Incongruencies between dental and stable isotope evidence of diet at the population level demonstrate the need to examine health and dietary trends in light of environmental, behavioral, and biological factors. Principally, the effects of age and fertility on dental health. Future research is needed to examine sex differences in tooth wear due to dietary abrasiveness and non-alimentary tooth use on caries experience, periodontal disease, and AMTL.

8.0 Conclusion

This dissertation has examined concepts of Bronze Age social organization and culture change in the context of demography, health, and diet based on analysis of human skeletal remains from the Late Maros EBA/MBA cemetery at Ostojićevo (1930-1550 BCE). The purpose of this research was to apply skeletal correlates of demography and health to investigate the impact of regional processes of culture change (*i.e.*, economic, political, and social) precipitated by shifts in regional exchange networks on local communities at the EBA to MBA transition in the Carpathian Basin (Kristiansen & Earle, eds., 2010; Kristiansen, 1998; Shennan, 1993a; 1993b). The approach presented here integrates demography, paleopathology, and paleodiet into a framework that considers how culture is embodied vis-à-vis intersections between age, gender, social status, and occupation (Joyce, 2005). Critical to this embodied approach is a consideration of the human life course as mediated by biology, society, and the environment (see Agarwal, 2016; Sofaer, 2006a; 2006b).

The basic overarching question that has guided this study is: *how did age and gender affect morbidity and mortality at Ostojićevo?* Expanding on this central question, the dissertation research examined the social and economic implications of individual differences in health and mortality, framing this in the context of a second essential question: *how was adult health and longevity affected by behavior and early childhood health* (Gowland, 2016b; Lewis & Gowland, 2007; Wood, 1992)? Specifically, was high infant mortality a result of environmental factors, such as poor diet and hygiene, or does it reflect maternal health status and childcare practices? Were males more likely to exhibit evidence of interpersonal violence and, if so, does this support the existence of a 'warrior class' in the EBA/MBA (see Harding, 2000; O'Shea, 1996; Treherne, 1995)? Finally, how was the social position of reproductive-age women reflected in their experiences of non-specific stress in early childhood, trauma, and dietary status relative to adult males and older females?

The interpretations presented in this chapter are based on the results of physical analysis of neonate, infant, child, adolescent, and adult human skeletal remains. Data collection included assessment of skeletons for preservation, age-at-death, dental disease including alveolar changes and antemortem tooth loss, bone disease, and evidence of skeletal trauma. Biological sex and stature from long bones were also assessed in individuals >18 years-at-death. Bone samples were taken from a subset of adults (>18 years) from the Late Maros MBA cemetery at Ostojićevo (1930-1550 BCE) and the Early Maros EBA cemetery at Mokrin (2100-1800 BCE). Samples were analyzed for stable isotopes of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) from bone collagen. These results were compared to bone collagen analysis of $\delta^{15}N$ and $\delta^{13}C$ from faunal (mammal) samples from Ostojićevo and two Maros settlements in southeastern Hungary, the Early and Classic Maros village at Kiszombor (2500-2400 BCE, 2000-1700 BCE) and the Classic/Late Maros tell at Klárafalva (2300-2000 BCE, 1800-1500 BCE). Together, human carbon and nitrogen profiles relative to faunal baseline signatures provide insight into intra- and inter-cemetery variation in diet and subsistence.

In the following sections, I provide a summary of the major findings on health and longevity, gender, age, trauma, and diet and dental health. The implications for how experiences of morbidity and mortality intersect with social status and gendered lifeways at Ostojićevo, and evidence for change in local practices over time from the Early Maros (Mokrin) to the Late Maros (Ostojićevo) period, are discussed. The concluding section revisits the research questions and hypotheses introduced in Chapter 1, with a focus on how my study supports or challenges existing narratives on gender, social status, and political economy in the Early-to-Middle Bronze Ages in central Europe. This chapter concludes with recommendations for future research, specifically the potential for expanding on the current research program in building a social bioarchaeology of the Bronze Age.

8.1 Health and Longevity

8.1.1 Infant and Child Mortality

Subadults (<20 years) at Ostojićevo constitute ~46% of the entire skeletal sample (~57% if "missing" burial urns are included in the total count). Over a third of individuals buried at Ostojićevo died in their first year. Mortality dropped steeply after the first year, and gradually declined from one to 15 years, before rising after 15 years. Analysis of non-specific stress in early childhood as inferred from skeletal indicators of stress (*i.e.*, cribra orbitalia (CO), porotic hyperostosis (PH), and linear enamel hypoplasia (LEH)) found that a quarter to half of subadults exhibited active PH or CO, respectively, at time of death. This is compared to a CPR of <5% for PH and <20% for CO in adults. Furthermore, LEH was present in almost 67% (permanent incisors) to 75% (canines) of subadults 6-20 years. This is compared to a CPR of ~46% for permanent incisor(s) and ~46% for permanent canines in adults.

Among subadults, there was no difference in CO or PH between "males" and "females". Most neonates did not survive long enough for cranial porosity to heal following prolonged and/or recurrent health insults. Differential diagnosis of cranial porosity affecting the outer table of the cranial vault in children at Ostojićevo includes acquired and inherited anemias, scurvy, and/or rickets (Armelagos et al., 2014; Brickley & Ives, 2006; Cole & Waldron, 2019; Walker et al., 2009). Acquired anemias are multifactorial and often co-present with other metabolic diseases, especially scurvy (Armelagos et al., 2014; Dagnelie et al., 1989). More recently, iron-deficiency anemia has been questioned as the primary cause of CO and PH (McIlvaine, 2015; Walker et al., 2009). Rather, nutrient loss via malabsorption and diarrhea secondary to gastrointestinal infection have been found to lead to iron and vitamin B-12 deficiencies, the latter associated with megaloblastic anemia and large-scale marrow hypertrophy leading to marked PH (Walker et al., 2009).

Diarrheal disease is associated with crowded, unsanitary living conditions and is a major cause of death in children under five years today and in the past (Black et al., 2008; Lanata et al., 2013; Schwartz et al., 2010). The weaning process is often marked by acute gastroenteritis, or “weaning diarrhea”, linked to the introduction of low nutritional value foods prepared in unsanitary conditions (Lewis, 2007). The prevalence of PH at Ostojićevo was similar between neonates (birth-1 year) and infants (1-3 years), but overall CO prevalence in infants was double that for neonates. Assuming complementary feeding began around 4-6 months (Lewis, 2007; Pelto et al., 2003), this pattern suggests that CO and PH are responses to different systemic problems. CO is likely caused by subperiosteal hematomas rather than marrow hypertrophy; vitamin C deficiency (Scurvy) may be a more appropriate differential diagnosis for individuals exhibiting CO without PH (Armelagos et al., 2014; Cole & Waldron, 2019; Walker et al., 2009).

That weaning contributed to increased morbidity and mortality at Ostojićevo is reinforced by the location of LEH in the crowns of permanent incisors and canines. Linear defects were most common in the mid-third of permanent incisor and lower-third of canine crowns, respectively. These locations correspond to the onset of stress between 2 and 3 years (Ten Cate, 1989 *in* Schwartz, 2007:222-223). LEH is biased towards individuals who survived periodic stress early in life during the period of enamel deposition. Thus, among these survivors, the period from ca. 2-3 years seems to be associated with common experiences of episodic stress in the Ostojićevo population. Further research is needed, but the timing of stress suggests behavioral factors such as transition to a complete adult diet resulting in a nutritionally inadequate diet, decreased immunity from the cessation of breastfeeding, and consuming contaminated food (Judd et al., 2018; UNICEF & WHO, 2009). An interesting hypothesis that remains to be tested is whether individuals with LEH benefited from delayed weaning, which allowed them to survive neonatal and early infant health insults (*e.g.*, respiratory infection, diarrhea), despite some eventually succumbing to a premature death (Arifeen et al., 2001; Armelagos et al., 2009; Wood et al., 1992; Ventresca Miller et al., 2017). Together, the association between PH, CO, LEH, and infant mortality indicates early childhood morbidity and mortality was a product of weaning stress and unsanitary living conditions compounded by possible food shortages.

There is little direct evidence of infection in infants and children at Ostojićevo. The true prevalence of periostitis is likely underestimated due to poor preservation of long bones in the youngest age classes.

While periostitis was relatively uncommon compared to CO and PH, it was mostly a “disease” of infants and young children. I found six cases of periostitis in individuals under 20 years, compared to only three cases of periostitis on long bones in individuals over 20 years. Four of the nine cases of periostitis were associated with infants under three years, affecting 9.3% of individuals with extant postcrania dying between birth and three years. Of the four cases of periostitis that affected multiple long bones, three were associated with individuals under 3 years. This pattern of diffuse, bilateral, and symmetrical distribution of subperiosteal new bone formation is consistent with systemic infection (endogenous origin) rather than reactive bone formation due to trauma or a skin ulcer (Boel & Ortner, 2011; Buckley & Dias, 2002; Ortner, 2011). Differential diagnosis includes haematogenous or lymphatic spread of microbes (bacteraemia), especially treponemal spirochetes (Buckley & Dias, 2002). Granulomatous lesions in the cranial vault were observed in a single individual, an Adult female. However, the postcrania appeared healthy. Additionally, a 15-18-year-old probable-female exhibited circumscribed cortical bone resorption extending into the diploë on the right frontal bone as well as periosteal bone formation on a long bone (right and left femora and tibiae near the knee). There is not enough evidence to conclude that treponemal disease was endemic in southeastern Europe in the EBA or MBA (*cf.* Stefanović et al., 2013). However, the pattern whereby children under 15 years are primarily affected is consistent with the transmission of endemic syphilis (betel) occurring through non-sexual contact (Antal et al., 2002; Grin, 1953). Furthermore, direct transmission to infants could occur through contact with mucous membranes during breastfeeding or indirectly through shared utensils or drinking vessels (Grin, 1953).

8.1.2 Early Childhood Health, Longevity, and Activity

The pattern of CO, PH, and LEH in subadults versus adults demonstrates higher frailty in the former. This includes a mixture of subadults dying both before skeletal changes could manifest and before existing skeletal changes could heal. The presence of healed and active CO and PH in adults 20 to 30 years-at-death demonstrates that they were healthy enough to survive childhood health insults, but that longevity was compromised by stress in early life (Kuh et al., 2002; Yaussy & DeWitte, 2018). Among adults, overall CO prevalence was similar in males and females, though females (especially those under 40 years) were more likely to exhibit active or mixed active-healed porosity compared to a preponderance of mixed and healed porosity in males. PH was absent in adult females under 50 years, except for a single Adult II female with active porosity. By contrast, PH prevalence in Adult I males was double that of Adult II and III males. Most cases of PH in adult males were well-healed at time of death.

LEH was slightly more common in adult females compared to adult males. LEH-C prevalence was lowest among Adults >40-to-50-years and highest among individuals 12-to-15-years-at-death; LEH-I prevalence was lowest among Adults >20-to-40-years and highest among individuals 12-to-15-years-at-death. There is a sharp reduction after 30 years in the proportion of individuals displaying LEH on at least one incisor or canine. This pattern supports a tendency for those who experienced – and survived – early childhood stress to have reduced longevity. Accounting for differences in sex-specific timing of mineralization of permanent crowns, the location of defects is consistent with undergoing a period of stress beginning around two years in both adolescent and adult males and females.

Pathways existed for alternative identities among adults who may have experienced disability at a young age due to injury or illness, especially among men. This is evidenced by a ca. 25-35-year-old biological male buried as a "female" with their head to the south (Grave 107). This individual was buried with a beaded sash made of animal tooth and bone beads. Beaded sashes in Maros cemeteries are exclusively associated with adult and subadult "female-oriented" burials and are taken to represent a special category of engendered status (O'Shea, 1996; Rega, 1997). The Grave 107 individual exhibited skeletal anomalies that may have affected their ability to participate in traditional "masculine" activities. For example, they may have experienced prolonged illness or poor nutrition in early childhood, as indicated by their short stature (161.5 cm, ~5'4") and presence of LEH in a lower incisor. They also may have experienced pain and loss of mobility from complete ankylosis of the right sacroiliac joint. Nevertheless, robust muscle attachment sites on the clavicles, humeri, radii, and ulnae indicates heavy, repetitive muscle use involving the shoulders, arms, and forearms.

In general, tall stature and/or physical strength were not associated with social status as inferred from grave goods in adult males. “Older” (>40 years) adult males were often physically robust but were frequently buried with no offerings or the most basic assemblage – a single ceramic cup. Of the five tallest adult males based on stature estimation from the femur, the tallest at 188.2 cm (6’2”) (Grave 59) died in their 20s and was buried in the “female” position with a single ceramic cup, and three (Graves 233, 53, and 129) were buried with no grave offerings. The Grave 229 individual, the fifth tallest male at 176.0 cm (~5’9”), displayed bilateral retrocalcaneal exostoses and was buried with a ceramic bowl. A curious deposit of copper and animal tooth beads was found in the northern part of the burial pit for the Grave 229 individual, which was interpreted by the excavator as an unworn beaded necklace. Concepts of “masculine ideals” and the “masculine body” as it relates to Bronze Age peoples need to be reconsidered in light of the physical evidence of alternative “masculine” identities at Ostojićevo (*cf.* Harding, 2000; Treherne, 1995). Most research emphasizes the embodiment of engendered status in the context of material culture, rather than skeletal plasticity as an indicator of health and activity (see Hanks, 2006; Rebay-Salisbury, Sørensen, & Hughes (eds.), 2010). Future research might consider how musculo-skeletal markers (msms) of activity correlate with stature, age, or evidence of trauma, rather than the presence or absence of investigator-defined prestige offerings.

8.1.3 Health and Social Status in Older Adults (>40 years)

Little attention has been given in bioarchaeology to examining relationships between social status and health in individuals >40 years-at-death (Appleby, 2011; Gowland, 2016a; 2016b), despite ethnographic and anthropological evidence of “older” individuals holding positions of power and authority in their communities (Brown, 1970; Hawkes et al., 1998; Rice, 1981). Attitudes toward senescence, what Gowland (2016b) refers to as the “ageing body”, vary cross-culturally. These attitudes range from reverence and respect to fear, ambivalence, or hostility (Brogden, 2003). Mortuary evidence indicates that older women enjoyed a privileged social status within the Ostojićevo “community”, whereas older males experienced a reduction in social status and political authority (Pompeani, 2018). There is no evidence that old age and/or disability resulted in physical abuse or social denigration at Ostojićevo.

"Older" adult males participated in heavy, repetitive physical labor in Maros societies. Porčić and Stefanović (2009) found a positive correlation between shoulder and arm muscle use and status in males 35-50-years-at-death at Mokrin, whereas the reverse was noted for females. However, they found that this correlation between social status and labor did not apply to males >50-years-at-death. MSMs were not systematically analyzed in the current study, but cases of exceptional hypertrophy at muscle attachments sites were noted. Notably, all three of the individuals identified as biological males surviving past 50-years at Ostojićevo (Graves 101, 233, and 269) displayed robust MSMs on the arms, forearms, and lower limbs. Rather than experiencing a life of comparative leisure in their "old age", these individuals continued to engage in heavy physical labor that left tell-tale signs on their bones. Striking physical testaments to the lived experiences of older males include the fusion of the right sacroiliac joint and chronic dislocation of the right knee in the Grave 101 individual or the marked superior and inferior marginal osteophytes on the bodies of L2 to L5, retrocalcaneal enthesopathy, and bilateral hypertrophy of muscle attachments in the upper and lower limbs in the edentulous Grave 269 individual. Thus, while these individuals remained active in their relative old age, their bodies had been shaped by a lifetime of heavy physical labor.

The most common health problem in "older" females was extensive antemortem tooth loss (AMTL). Males experienced a heavier dental caries burden later in life, but this is due in part to a greater tendency to retain diseased or heavily worn teeth. The prevalence of degenerative changes affecting vertebral bodies (*e.g.*, osteophytosis) and synovial joints (*i.e.*, osteoarthritis) increased after 40 years. Whereas males >40-years-at-death were more likely to exhibit trauma and age- and activity-related changes (*i.e.*, marginal osteophytes, Schmorl's nodes) to the lower thoracic and lumbar vertebrae, the cervical and mid-to-upper thoracic vertebrae were most likely to be affected in females. Schmorl's nodes (SN) were twice as common in males as females >40-years-at-death, with SNs more likely to occur in the lumbar vertebrae in males and the thoracic vertebrae in females. Marginal osteophytes were common in both males and females. Osteophytes >3 mm affected 12% of vertebrae in males >40-to-50-years and ~53% of vertebrae in males over 50-years; osteophytes were present in ~14% of vertebrae in females >40-to-50-years and ~37% of vertebrae in in females over 50-years. Thus, after 50 years, males were more likely to develop vertebral osteophytes than females. The distribution of osteophytes within the vertebral column also differed between males and females, with osteophytes concentrated in cervical and thoracic vertebrae in females and the thoracic and lumbar vertebrae in males.

The pattern of vertebral pathology and trauma at Ostojićevo demonstrates greater stress being placed on the upper back in females and lower back in males. Further research is needed to examine patterns of osteoarthritis affecting superior and inferior articular facets, but osseous remodeling in the vertebrae of older adults suggests sex differences in activity-induced stressors on the spine indicative of the types of labor performed by males and females. The concentration of osteophytosis and SNs in the lumbar and thoracic vertebrae in males is consistent with repeated heavy lifting or digging (Sofaer-Derevenski, 2000; Tyrrell et al., 1985). However, the greater involvement of the thoracic and cervical vertebrae in females may indicate their role in supporting/carrying heavy loads on their head or via a tumpline (Lovell, 1994).

Skeletal pathologies exhibited by "older" adults at Ostojićevo are consistent with a lifetime of heavy agricultural labor in males and agricultural and domestic labor in females. Age-related changes in the vertebrae and joints were likely compounded by activity. In contrast to degenerative diseases affecting the axial and appendicular skeleton, skeletal evidence of infection was uncommon. Multifocal mycotic lesions were observed in one female >50-years and one probable-male >40-50-years, with a unifocal circular lesion present on the hamate in a male >50-years. Immunocompromised individuals or those with an underlying chronic illness have an increased risk of experiencing prolonged negative health outcomes from exposure to soil-born bacteria or fungus (Chang et al., 1984; Ortner, 2003). The occurrence of these lesions in older adults are thus suggestive of both health status and occupation, in that healthy individuals are less likely to experience long term effects of mycotic infection. Thus, physical labor continued to shape "ageing bodies" at Ostojićevo. Females and especially males continued to engage in activities – domestic and agricultural – that affected their physical appearance and health throughout their lives. However, there is no evidence that older individuals were subjected to abuse or marginalization. Rather, "older" adults continued to contribute to the labor pool.

8.2 Gender, Trauma, and Life History

Overall, there was no significant difference in survivorship between males and females. However, only ~7% of males survived past 50 years compared to ~20% of females. This is despite the remains of older females to be, on average, less well-preserved than for males and younger females. Thus, the proportion of females surviving past 50 years is likely higher. Sex-specific mortality in subadults was inferred from body orientation, with individuals placed with their heads to the south or west identified as "female" and those with their heads to the north or east as "male". Males and females exhibited identical mortality under three years. There is a slight increase in female mortality among 3-to-10-year-olds, but male mortality exceeds that of females for adolescents.

Of the 14 "males" that died between 12 and 18 years, two exhibited violent trauma, with at least one case of perimortem blunt force trauma. There were no cases of trauma among age-matched females. Furthermore, at least four males greater than 20-years-at-death exhibited antemortem or perimortem injuries consistent with interpersonal violence, specifically hand-to-hand combat using blunt instruments (Hershkovitz et al., 1996; Tung, 2007). Injuries were restricted to the cranium in three of the four cases. Age-at-death was between 20 and 40 years, with three individuals between 30 and 40 years. These account for 25% of all male deaths between 30 and 40 years and for ~9.5% of total adult male deaths.

Male mortality exceeds that of females between 20 and 50 years at Ostojićevo, with the greatest disparity among 20-30-year-olds. This is the reverse of what would be expected given increased female mortality due to complications from pregnancy and childbirth (Black et al., 2008; Boldsen & Paine, 1995; Stone, 2016). This difference is taken to indicate behavioral differences tied to age and gender roles. Trauma and demographic evidence indicate males engaged in risky – and occasionally violent – activities that led to an increased probability of early death. The relative absence of "older" males is due to the preferential removal of "young" adult males. By contrast, skeletal evidence of violent trauma in females is rare. Only two individuals exhibited antemortem or perimortem trauma, and both were greater than 40 years at their time of death. The Grave 191 and Grave 115 individuals are exceptions in that they represent the only two biological females with skeletal evidence of violent trauma. The Grave 191, who was in her 40s at time of death, survived a blow to her left forehead. However, the 50+ Grave 115 woman succumbed to penetrating trauma, notably a perimortem circular puncture wound to the body of the sternum.

The pattern of violent injuries in females – the type of injury, the timing of injury, who was targeted - has interesting implications for the social context of violent trauma among males and females. While the age profile and trauma pattern among males strongly supports combat-related injuries and deaths, the situation for females is less clear. There are three possibilities: (1) violence directed towards "older" females reflects acts of elder abuse and marginalization (see Gowland, 2016b). This is unlikely as violent trauma in women at Ostojićevo is uncommon and older women seemed to hold a privileged position in society, as evidenced by grave good associations (Pompeani, 2018). Age seemed to enhance the position of women in their community. The Grave 115 female was buried with a baroque pot and copper bracelet, which suggests she held an esteemed place in the community at her time of death. The Grave 191 female was buried with a single ceramic vessel, which is the most common grave assemblage at Ostojićevo. Thus, apart from their injuries, there is nothing in how these women were treated in death to suggest that they were marginalized in life. The second (2) possibility is that the Grave 191 and 115 women were victims of raids (see Kelly, 2000; Maschner & Reedy-Maschner, 1998; Milner, 1999; Parker Pearson, 2005; Walker, 2001). Rather than engaging in organized warfare and mass violence, such as targeting settlements (Meyer et al., 2015; Meyer et al., 2018; Redfern, 2013; Willey & Emerson, 1993), "warriors" in the EBA represented predominantly male social groupings that placed a certain value on aggressive behavior (Vandkilde, 2006). These warrior bands or war parties would have lacked political centralization, with mobility within the organization based on personality and individual accomplishments. Decisions to "go to war" in the village-based Maros societies were motivated by symbolic or social factors such as revenge and/or status and prestige (see Maschner & Reedy-Maschner, 1998; Wilson & Daly, 1985). In this context of male competitiveness and risk-taking, the object is not to annihilate the enemy, but to seriously wound or kill a relative of the enemy (Kelly, 2000). Rather than stay and engage with the enemy, “war parties” followed a pattern of what Maschner and Reedy-Maschner (1998) characterize as “raid, retreat, defend (repeat)”. While there is no evidence for women’s participation in warfare or “war parties”, they were not immune to becoming targets of violence vis-à-vis familial or ethnic affiliation. Considering the age profile of women with injuries, it is possible that when encountering younger women, “war parties” would take them as captives, whereas older women would be killed (Bamforth, 1994; Martin et al., 2010). (3) Accidental injury cannot be ruled out. Cognitive declines, visual impairment, loss of neuromuscular coordination, and other chronic diseases and conditions associated with aging can mimic the signs and symptoms of elder abuse or neglect (Chen & Koval, 2002; Switzer & Michienzi, 2012). However, the isolated nature of the wounds in the Grave 115 and 191 individuals preclude an accidental etiology (*i.e.*, lack of comorbidities associated with accidental falls, immobility, and/or age-related loss in bone mass) (Gowland, 2016b). Furthermore, head, neck, or facial injuries, especially BFT or SFT above the ‘hat rim’ line, and skeletal trauma in the location of the breasts have been found to be specific to intimate partner violence in women (Gowland, 2016b; Wu et al., 2010).

8.3 Diet, Dental Health, and Life History

Maternal and child undernutrition are major issues in low- and middle-income countries (Black et al., 2008). Complications of undernutrition (insufficient macronutrient consumption) or malnutrition (vitamin or mineral deficiency) in women of childbearing age include poor dental health, maternal depletion syndrome, low birth weight, and fetal or infant death (Hayward et al., 2013; Lawson et al., 2012; Lukacs, 2011a; Victora et al., 2008; Winkvist, 1992).

Cultural beliefs and practices surrounding the role of women in communities, especially mothers as caregivers, mean that women with dependent offspring may be expected to sacrifice their nutritional status in favor of men, older women, and children (Lukacs, 2011b; Pike et al., 2010; Pelto et al., 2011). These practices place strain on the health of mothers, which in turn can have negative consequences for the survival and health of their offspring (Conde-Agudelo et al., 2012; Lawson et al., 2012). These consequences of moderate to severe dietary restriction in young women include metabolic trade-offs between high fertility and infant mortality. Sex- and age-specific patterns in dental disease and paleodietary reconstruction using collagen stable isotopes support a trade-off between nutritional status, systemic health, and fertility in women at Ostojićevo, but not Mokrin.

Prevalence of antemortem tooth loss, periodontal disease, dental caries, and dental abscesses was higher in adult females than males at Ostojićevo. Statistically significant differences in disease prevalence between males and females in the upper and/or lower jaw were found for antemortem tooth loss (AMTL) in individuals >40-years, periodontal disease in individuals >40-years, caries in individuals >20-30-years, individuals >30-40-years, and individuals >50-years, and abscesses in individuals >20-40-years and >40-years. Retention of upper (~18.5% AMTL) and lower (~23.5% AMTL) teeth was higher in males >40-years, compared to an AMTL prevalence of ~32.5% for upper teeth and ~36% for lower teeth in females >40-years. Thus, older males were more likely to retain "diseased" and/or heavily worn teeth than older females. Together, these results suggest a lag in the onset and proliferation of infectious processes (*i.e.*, caries and abscesses) and inflammatory processes (*i.e.*, periodontal disease) affecting the oral cavity and alveolar bone. While dental disease is strongly correlated with age, females dying in their 20s and 30s experienced a greater disease burden at time of death compared to their age-matched male counterparts.

Female dental health at Ostojićevo was affected by non-dietary factors. Specifically, a cariogenic diet coupled with high fertility had a negative effect on female oral health (Lukacs, 2008; 2011a). Hormonal changes during pregnancy have been found to affect the oral microbiome and increase systemic inflammation (Komine-Aizawa, 2019) and saliva composition and flow (Lukacs & Largaespada, 2006). While these changes return to pre-pregnancy levels a few months postpartum, the "cumulative impact of multiple pregnancies on oral health exacerbates the sex differences in oral health…" (Lukacs, 2011a:650). Thus, parity is a major cause of tooth loss in women already at risk for caries and/or periodontal disease due to diet and oral hygiene (Gonzalez-Jaranay et al., 2017; Morelli et al., 2018; Russell et al., 2008). High rates of infant mortality coupled with poor dental health among childbearing age and postreproductive women at Ostojićevo demonstrates the short- and long-term effects of high fertility and poor diet (*e.g.*, high plant carbohydrates, low animal protein) on female dental health.

No significant differences in dental disease were found between males and females at Mokrin. This contrast between the two sites indicates local and diachronic differences in gendered access to resources. While there was no difference in overall survivorship between the two sites for individuals >3-years-at-death, the presence of neonates and young infants at Ostojićevo but not Mokrin means that reconstructions of infant mortality reflect inferences derived from statistical comparisons rather than physical evidence. It is possible that women at Mokrin experienced lower fertility rates, and thus had a reduced risk of pregnancy loss and infant mortality than women at Ostojićevo. Future research should focus on examining weaning patterns between survivors and non-survivors at Mokrin and Ostojićevo. Based on dental, demographic, and stable isotope results from the current study, the expectation is that prolonged breastfeeding at Mokrin reduced fertility through lactational amenorrhea and increased infant survival (Halcrow & Tayles, 2011; Lewis & Gowland, 2007).

The pattern of sex-specific differences in dental disease at Ostojićevo and Mokrin is interpreted as reflecting the impact of non-dietary factors on oral health. This hypothesis was assessed through stable isotope analysis of bone collagen. Dietary protein is the primary source of carbon and nitrogen in bone collagen. Trophic level enrichment follows that bone carbon nitrogen values in omnivores and carnivores are on average 3-5‰ greater than their diet, whereas carbon has a smaller trophic level effect of 1-2‰. Stable isotope analysis of nitrogen showed a small difference in mean adult values between Mokrin and Ostojićevo, with Ostojićevo slightly elevated. When compared to faunal baseline values from Maros sites in southeastern Hungary and animal offerings at Ostojićevo, this offset was interpreted to reflect greater consumption of sheep-goat at Mokrin versus cattle at Ostojićevo.

There was no association between diet and sex, age, or status at Mokrin. Sample size was too small for in depth analysis of within-group differences. Additionally, there was no association between diet and sex, age, or status at Ostojićevo. However, several within-group differences were identified for the Ostojićevo sample. Variation in nitrogen values was greatest for low status females dying between >20-30-years, whereas females >40-years and high-status males had more homogenous values. Variation in carbon values was greatest for low status females and females >40-years, whereas variation was lower in males >40-years and high-status females. Differences in within- and between-group isotope signatures for nitrogen and carbon may indicate that bone collagen carbon values are influenced by factors other than dietary protein source and the proportions of plant versus animal protein consumed. It is unclear what these factors might be, though experimental studies support the incorporation of carbon from nonprotein sources in low protein diets (Ambrose & Norr, 1993; Hedges, 2006). Analysis of bone collagen and apatite spacing could provide insight into differences in terrestrial protein consumption relative to bulk diet (Hedges, 2003; Jim et al., 2006; Kellner & Schoeninger, 2007).

Variation in isotopic signatures, especially for $\delta^{15}N$ values, tentatively support differences in diet breadth between different gender, age, and status groups at Ostojićevo. Females dying in their peak reproductive years, between 20 and 40 years, consumed on average less animal protein and a more diverse diet than males and older females. The $\delta^{15}N$ values of some young adult, low status females were closer to values observed for pigs and dogs than humans. By contrast, the diets of post-reproductive (>40 years) females were almost identical to males, with high status females exhibiting limited diet breadth. Social pressures placed on younger women with dependent offspring may have meant that they were expected to rely on alternative low-prestige foods. Mothers may have been expected to feed other family members, including elders and their children, before eating. This means they went without food or had to rely on alternative sources of protein (*e.g.*, wheat, barley, lentils).

Finally, the difference in dietary patterns between younger and older women, especially the indication that older women had preferential access to high-quality animal protein, has implications for understanding transformations in gender and status throughout the life course. The suggestion here is that women cultivated social status over time, achieving considerable authority and retaining their status into advanced age, at least for those who survived. Conditions of high fertility, and consequent high child mortality, may have tied female social capital to familial relationships and kin-group membership. Wives were more likely to outlive their husbands. By their fifth or sixth decades of life, women would have transitioned to a post-reproductive life surrounded by children, grandchildren, great-grandchildren (and great-great grandchildren). It is conceivable that older women were adept at managing their expanding social network to exert considerable influence within their community.

8.4 Conclusion

The EBA to MBA transition in the southeastern Carpathian Basic was marked by increasing social and economic decentralization (and possibly isolation) after ~1700 BCE (Nicodemus, 2014; O'Shea et al., 2019). By 1500/1400 BCE, most settlements in the Maros area were abandoned, and there is a shift to increased settlement in Transdanubia to the west (Kiss, 2003; Poroszlai, 2003) and to the south along the Danube and into the Morava valley in present-day central Serbia (Garašanin, 1972; Tasić, 2003-2004). The impetus for these changes is unclear. At the supraregional scale, metal sources shifted from the Carpathian Mountains to the Alpine lake district of France, Switzerland, and southern Germany (Kristiansen, 1992; Shennan, 1993a). Regionally, the large Maros tell site of Pecica, which is located at a strategic location on the Maros river as it flows into the Carpathian Basin, emerged as an important focus for horse breeding and metal production around 2000 BCE (Nicodemus & O'Shea, 2019). Despite its location and specialized economy, this locality never developed into a true economic or social center within the Maros region (Nicodemus & O'Shea, 2019; O'Shea, 2011). The decline of Pecica after 1700 BCE coincides with a period of increased burial activity at Ostojićevo, tentatively suggesting the movement of refugees from Maros settlements from the east in Romania or the north near the Tisza-Maros confluence into the southern Maros area. Compared to the earlier inhabitants of the southern Maros area buried in the cemetery at Mokrin, those interred at Ostojićevo were adorned in less ostentatious, though similarly patterned, types of dress and personal adornment, and suffered from a higher prevalence of CO, dental disease, and infant mortality. Those buried at Ostojićevo reflect a community that attempted to maintain traditional lifeways at the expense of increasing social and economic isolation. Their economy was considerably reduced in scope, shifting to more localized (and domestic) means of production. Perhaps the implications of these changes are best summarized by Peregrine (1999: 37): "I suggest collapse is equally likely to stem from a crisis of social reproduction – from an inability of individuals to sustain themselves socially – and not from individuals' inability to sustain themselves physically".

Several other Maros settlements are known from southeastern Hungary, near the Tisza-Maros confluence. However, Ostojićevo and Mokrin remain the only two well-documented Maros cemeteries in terms of skeletal evidence of demography, health, and diet. This dissertation research sought to expand on this limited understanding of local population dynamics, social and economic transition, subsistence, and health within the Maros region. Differences in skeletal evidence of health and diet at Ostojićevo and Mokrin speak to the diversity of experiences of Bronze Age communities in the southeastern Carpathian Basin. Specifically, the documentation of within-group variation in health in the context of age, sex, and diet. To this end, analysis focused on three themes: (1) the effects of early childhood health on child mortality and adult longevity; (2) the impact of (violent) trauma on adult mortality; and (3) the intersection between diet, fertility, and dental health.

8.4.1 Research Questions and Hypotheses

The research questions presented in Chapter 1 provided a general framework for outlining expectations as to the interplay between metanarratives and local scale social lives. These questions, which were drawn from archaeological research in the Carpathian Basin, were paired with two alternate hypotheses, respectively, as to the biocultural effects of culture change and social complexity on the Early Maros population at Mokrin versus the Late Maros population at Ostojićevo. Specifically, the hypotheses focused on expectations for demography, health, violence (trauma), and diet (subsistence) in the context of how these two communities engaged with problems of political economy and social stratification. The goal here is to address the capacity for human agency and cultural traditions as they speak to how persons and communities attempt to adapt to social, economic, and political change.

8.4.1.1 Question 1: Social Interaction, Health, and Diet

How did changes in regional scale interaction and integration through trade and political economy affect local populations in terms of health and diet in the Early and Middle Bronze Ages?

The disparities in health, diet, and to a certain extent, infant and child mortality between Mokrin and Ostojićevo reflect conditions of economic and social isolation at the latter (**Hypothesis 1**). Further evidence for this is supported through stable isotope analysis, which demonstrates increased diet breadth at Ostojićevo, especially among young adult females and low status males. This greater diet breadth may reflect conditions of resource scarcity, with certain members of the Ostojićevo community expected to “go without” to provision high status males, older females, and children (Pike et al., 2008; Winterhalder et al., 1999). Finally, the dearth of prestige grave goods at Ostojićevo compared to Mokrin is taken to reflect differences in the economic reality between the two populations. There is a collapse of regional economic and social networks between 1800 BCE, when the Mokrin cemetery was abandoned, and ca. 1650 when the southern Maros region seems to be repopulated following the decline of Maros tell settlements in western Romania and southeast Hungary. The implications of this demographic and socio-economic shifts over a few centuries meant an increased reliance on local resources. This would have made populations in the southern Maros region, such as that buried at Ostojićevo, more susceptible to seasonal or more prolonged food shortages.

8.4.1.2 Question 2: Biocultural Implications of Social Complexity, Social Inequality, and Violence

What was the biocultural impact of increasing social complexity and social inequality on violence in the Carpathian Basin? How did the timing of fluctuations the importance of the Carpathian Basin as a regional economic center affect the pattern and incidence of warfare and violence?

The evidence presented supports small-scale conflict targeting individuals, primarily adolescent and young males and older females at Ostojićevo. This pattern is intermediate between **Hypothesis 1** (violence sporadic and random, not associated with status) and **Hypothesis 2** (elite warrior-male status tied to participation in warfare). In contrast to evidence of EBA and MBA warfare and violence from central Europe (*i.e.*, Slovakia and the Czech Republic), and Mesolithic and Neolithic groups from western Serbia, there is no indication that projectiles were used in fighting in the Maros region (Hårde, 2006; Hukelova, 2017; Roksandić et al., 2006). On the contrary, violent trauma at Ostojićevo is consistent with hand-to-hand combat using stone clubs, stone axes, and copper axes.

8.4.1.3 Question 3: The Intersection of Gender, Age, and Social Status on Morbidity and Mortality

How did diet, age, gender, and social status affect health at Ostojićevo versus Mokrin? How did fertility and childcare practices affect inter-cemetery and intra-cemetery patterns of morbidity and mortality in infants and children under five years and reproductive-age women (ca. 20-40 years)?

Despite their geographic proximity, chronological overlap, and identical mortuary practices, the communities that used the cemeteries at Ostojićevo and Mokrin differed in subsistence practices and health (especially among females). Furthermore, the unique practice of burying stillborn fetuses and infants under 3-years at Ostojićevo is unprecedented among other Maros cemeteries and reflects local variation in cultural attitudes and beliefs towards fertility and personhood. Expectations of gendered-labor, including possibly carrying heavy loads, and childcare placed on young, low status women would have put them at an increased risk of negative health consequences such as maternal depletion syndrome (Winkvist, 1992). While this would not have affected their mortality, it would increase the risk of stillbirths, preterm births, and low birth weight (Victora et al., 2008). The shift to the inclusion of neonates and young infants in the cemetery at Ostojićevo may reflect cultural responses to high <1-year infant mortality (**Hypothesis 2**). Preferential removal of high-risk infants by one year would not be reflected in demographic comparisons of mortality profiles that only account for deaths >3 years. This scenario is further supported by paleodemographic analysis of the Ostojićevo sample, which shows a steep decline in mortality after one year. Thus, at Ostojićevo, risk of death during the first postnatal year was much higher than risk of death associated with weaning. The pattern at Mokrin is difficult to interpret in the context of biocultural factors as infants <3 were excluded from cemetery burial.

8.4.2 Future Research

Future research should prioritize investigating connections between childcare practices (*e.g.*, weaning age, complementary feeding), female mortality and morbidity, and intersections between female social status and age. The hypothesis derived from the current research program suggests that high fertility and childcare responsibilities negatively affected both the health and social status of young mothers but worked to enhance social standing for older women. Stable isotope analysis of strontium and aDNA analysis focusing on mitochondrial DNA and Y-chromosome could also be applied to investigating patterns of endogamy and exogamy linked to gender and status. For example, how did family affiliation and gender affect patterns of mobility within and between Maros communities? Were conditions of poor diet among young women influenced by their status as outsiders removed from their natal communities?

Life history theory and life course analysis present intriguing frameworks for future analysis of health in prehistoric communities in the Carpathian Basin. Life history theory postulates that an organism's reproductive success is tied to trade-offs in energy expenditure and resource allocation, including parental investment, between the organism and its offspring (Hill & Kaplan, 1999). Walker et al. (2006) found that among modern hunter-gatherers and horticulturalists, societies characterized by low subadult survival often exhibit accelerated development in terms of faster growth, earlier puberty, and younger age at first reproduction. This scenario is associated with reproductive and parenting strategies that maximize the number of children at the expense of having fewer healthy children (Marlowe, 2010). Furthermore, the osteological paradox dictates that risk of disease and death varies not only between individuals, but over the life course (Agarwal, 2016; Wood et al., 1992). For example, there was no difference in LEH prevalence between subadult males and females at either Mokrin or Ostojićevo. However, there was an association with age, with LEH much more common in individuals dying in childhood and adolescence compared to those who survived to adulthood. This relationship between stress indicators such as LEH and early mortality has been documented elsewhere (Armelagos et al., 2009). Thus, it is possible that parenting strategies differed within Maros communities. Stable isotope analysis to document weaning patterns in non-survivors (*i.e.*, children) versus survivors (*i.e.*, adults) combined with skeletal indicators of non-specific stress could elucidate intra-group variation in childcare practices that contributed to variation in individual susceptibility to disease and death at different life stages. Tentative support for this hypothesis is provided by the relatively low prevalence of PH and LEH in "older" adults at Mokrin, LEH and CO in "older" males at Ostojićevo, and LEH in "older" females at Ostojićevo.

Additional research is needed to identify variation in patterns of warfare and violence over time in the Carpathian Basin in the context of culture change and social complexity. There is little direct (*i.e.*, skeletal) evidence of local, regional, and diachronic variation in violent conflict for Copper Age, Bronze Age, and Iron Age groups in the Carpathian Basin. Several studies have documented skeletal evidence of trauma in prehistoric groups from northeastern Hungary (Ubelaker & Pap, 1996; 1998; 2009). However, no recent systematic analysis has been conducted for trauma at Mokrin or Copper or Bronze Age cemetery samples from southeastern Hungary or northern or central Serbia. Discussions of violent conflict in the Bronze Age, and its association with social change and male identities, has relied on indirect evidence such as settlement fortifications and weapons recovered from hoards (Chapman, 1999; Harding, 1999; Osgood, 2001; Treherne, 1995). There is a need not only to document regional (and local) variation in the frequency and scale of interpersonal violence, but also examine patterns of trauma on human skeletal remains to identify differences in combat practices. Finally, comparison of microscopic analysis of clefts, punctures, and cuts on human skeletal remains from Maros sites with bladed weapons recovered from Maros settlements would provide further insight into the physical aspects and cultural context of interpersonal violence.

Appendix A Taphonomy and Demography

Skeletal Inventory Recording Form

Site Name: **Observer:**
Burial Number: **Date:**

Methods:
The skeleton was inventoried by assessing each bone for presence and completeness. Completeness was scored for the bones of the cranium, axial skeleton, vertebrae, and extremities. The long bones were divided into 5 separate parts for the inventory: the proximal articulation, proximal diaphysis, mid-diaphysis, distal diaphysis and distal articulation. Complete bones or parts of long bones received a score of 1. Incomplete bones received a score of <1 and missing bones received a score of 0.

CRANIAL

Bone	L	R	Bone	L	R	Bone	L	R	Bone	Mid
Frontal			Mandible			Sphenoid			Vomer	
Temporal			Maxilla			Lacrimal			Ethmoid	
Parietal			Palatine			Nasals			Hyoid	
Occipital										
Zygomatic										

LONG BONES

	LEFT						RIGHT					
Bone	P-art	Prox	Mid	Dist	D-art	Total	P-art	Prox	Mid	Dist	D-art	Total
Clavicle												
Humerus												
Radius												
Ulna												
Femur												
Tibia												
Fibula												

AXIAL

Bone	L	R	Sternum	Mid		Ribs	L	R	?
Scapula			Manubrium			Complete			
Ilium			Sternal body			Head only			
Ischium			Xiphyoid			End only			
Pubis						Shaft only			
Patella									

VERTEBRAE

	Body	Neural Arch
Atlas		
Axis		
C3-C7	/5	/5
T1-T12	/12	/12
L1-L5	/5	/5
Unidentified		
Sacrum (#segments):		
Coccyx (#segments):		

EXTREMETIES

CARPALS	L	R	?	Hand	L	R	?	TARSALS	L	R	?	Foot	L	R	?
Scaphoid				MC1				Calcaneus				MT1			
Lunate				MC2				Cun-med				MT2			
Triquetral				MC3				Cun-inter				MT3			
Pisiform				MC4				Cun-lat				MT4			
Trapezium				MC5				Cuboid				MT5			
Trapezoid				Proximal				Navicular				Proximal			
Capitate				Middle				Talus				Middle			
Hamate				Distal								Distal			
Unknown				Sesmoid				Unknown				Sesmoid			

Demography:

Sex - Skull –

Sex - Pelvis –

Estimated Age Category:
(Juv. II, AI, AII, AIII, AIV, A?)

Pubic Symphysis (Suchey-Brooks, 1990: STAGES 1-6):

Auricular Surface (Meindl and Lovejoy, 1989):

Taphonomic Overview (present/absent, damage – i.e. weathering/discoloration/cutmarks/rodent and carnivore gnawing, etc.):

Height estimate:

	Bone Length (cm)	Height (cm)
Femur		
Tibia		
Fibula		
Radius		
Ulna		
Humerus		

Appendix Figure 1 Skeletal inventory recording form

Appendix Table 1 Ostojićevo adult cranial inventory by biological sex

Element	Male (n = 41)			Female (n = 44)			Indeterminate (n = 31)		
	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI
Frontal	65	79.3	0.76	72	81.8	0.84	31	50.0	0.66
Parietal	68	82.9	0.78	71	80.7	0.78	31	50.0	0.66
Temporal	71	86.6	0.77	74	84.1	0.78	34	54.8	0.57
Occipital	71	86.6	0.68	74	84.1	0.67	34	54.8	0.43
Sphenoid	56	68.3	0.93	55	62.5	0.90	16	25.8	0.75
Nasal	67	81.7	0.84	68	77.3	0.80	33	53.2	0.67
Lacrimal	60	73.2	0.65	60	68.2	0.57	18	29.0	0.64
Ethmoid	19	23.2	0.54	15	17.0	0.50	3	4.8	0.50
Vomer	27	32.9	0.86	23	26.1	0.83	4	6.5	0.88
Zygoma	42	51.2	0.49	49	55.7	0.56	12	19.4	0.42
Palatine	5	6.1	0.70	4	4.5	1.00	0	0.0	0.00
Maxilla	3	7.3	0.67	2	4.5	1.00	0	0.0	0.00
Mandible	2	4.9	0.63	2	4.5	1.00	0	0.0	0.00
Hyoid	5	12.2	0.55	3	6.8	0.58	0	0.0	0.00

Appendix Table 2 Ostojićevo adult postcranial inventory by biological sex

Region	Element	Male (n = 43)			Female (n = 45)			Indeterminate (n = 37)		
		Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI
Upper Limbs	Clavicle	70	81.4	0.83	81	90.0	0.74	41	55.4	0.75
	Scapula	67	77.9	0.55	76	84.4	0.47	41	55.4	0.45
	Humerus	69	80.2	0.84	79	87.8	0.79	58	78.4	0.70
	Radius	62	72.1	0.88	80	88.9	0.81	48	64.9	0.78
	Ulna	64	74.4	0.82	83	92.2	0.78	49	66.2	0.72
	Carpals	116	16.9	--	117	16.3	--	98	16.6	--
	Metacarpals	171	39.8	--	231	51.3	--	129	34.9	--
	Hand Phal.	257	21.3	--	274	21.7	--	182	17.6	--
Thoracic	Sternum – Man.	18	41.9	0.75	9	20.0	0.83	11	29.7	0.86
	Sternum – Body	18	41.9	0.68	12	26.7	0.54	9	24.3	0.67
	Rib Heads	419	40.6	--	381	35.3	--	152	8.6	--
	Rib Bodies	308	29.8	--	245	22.7	--	90	5.1	--
	Rib Ends	167	16.2	--	95	8.8	--	53	3.0	--
Vertebral Column	Atlas	28	65.1	--	26	57.8	--	11	29.7	--
	Axis	25	58.1	--	25	55.6	--	17	45.9	--
	C3-C7	43	20.0	--	127	56.4	--	48	25.9	--
	T1-T12	218	42.2	--	281	52.0	--	125	28.2	--
	L1-L5	110	51.2	--	112	49.8	--	43	23.2	--
	Sacrum	30	69.8	--	32	71.1	--	12	32.4	--
Os Coxae	Ilium	71	82.6	0.69	76	84.4	0.69	31	41.9	0.52
	Ischium	65	75.6	0.68	63	70.0	0.69	27	36.5	0.45
	Pubis	56	65.1	0.65	47	52.2	0.65	18	24.3	0.56
Lower Limbs	Femur	75	87.2	0.86	82	91.1	0.80	50	67.6	0.69
	Patella	39	45.3	0.93	47	52.2	0.90	24	32.4	0.95
	Tibia	77	89.5	0.83	78	86.7	0.78	54	73.0	0.69
	Fibula	75	87.2	0.75	76	84.4	0.64	45	60.8	0.61
	Tarsals	301	50.0	--	290	46.0	--	171	33.0	--
	Metatarsals	208	48.4	--	207	46.0	--	125	33.8	--
	Foot Phal.	105	8.7	--	70	5.6	--	74	7.1	--

Appendix Table 3 Ostojićevo adult cranial inventory by age-at-death

Element	Adult I (n = 21)			Adult II (n = 23)			Adult III (n = 16)			Adult IV (n = 17)		
	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI
Frontal	30	71.4	0.81	41	89.1	0.8	20	62.5	0.85	29	85.3	0.78
Parietal	31	73.8	0.82	41	89.1	0.7	26	81.3	0.86	25	73.5	0.74
Temporal	32	76.2	0.84	42	91.3	0.8	27	84.4	0.72	27	79.4	0.76
Occipital	32	76.2	0.73	41	89.1	0.7	25	78.1	0.68	28	82.4	0.63
Sphenoid	28	66.7	0.89	28	60.9	1.0	20	62.5	0.83	16	47.1	0.86
Nasal	35	83.3	0.89	40	87.0	0.8	26	81.3	0.71	24	70.6	0.79
Lacrimal	33	78.6	0.77	27	58.7	0.7	22	68.8	0.55	15	44.1	0.50
Ethmoid	6	14.3	0.67	9	19.6	0.6	8	25.0	0.44	3	8.8	0.42
Vomer	10	23.8	0.93	19	41.3	0.8	11	34.4	0.86	4	11.8	0.88
Zygoma	24	57.1	0.47	20	43.5	0.6	20	62.5	0.54	13	38.2	0.44
Palatine	4	9.5	1.00	3	6.5	0.8	2	6.3	0.50	0	0.0	0.00
Maxilla	2	9.5	1.00	2	8.7	0.6	1	6.3	0.75	0	0.0	0.00
Mandible	2	9.5	1.00	1	4.3	1.0	1	6.3	0.25	0	0.0	0.00
Hyoid	1	4.8	0.75	4	17.4	0.6	2	12.5	0.50	1	5.9	0.50

Appendix Table 4 Ostojićevo adult postcranial inventory by age-at-death

Region	Element	Adult I (n = 24)			Adult II (n = 24)			Adult III (n = 18)			Adult IV (n = 19)		
		Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI
Upper Limbs	Clavicle	37	77.1	0.89	46	95.8	0.78	32	88.9	0.72	30	78.9	0.75
	Scapula	35	50.7	0.73	44	91.7	0.52	28	77.8	0.52	27	71.1	0.51
	Humerus	37	77.1	0.90	46	95.8	0.83	30	83.3	0.73	33	86.8	0.82
	Radius	32	66.7	0.92	45	93.8	0.86	31	86.1	0.75	31	81.6	0.87
	Ulna	33	68.8	0.86	46	95.8	0.82	32	88.9	0.82	34	89.5	0.74
	Carpals	57	14.8	--	94	24.5	--	40	13.9	--	55	18.1	--
	Metacarpals	105	43.8	--	141	58.8	--	83	46.1	--	92	48.4	--
	Hand Phal.	135	20.1	--	171	25.4	--	116	23.0	--	119	22.4	--
Thoracic	Sternum-Body	11	45.8	0.84	7	29.2	0.68	7	38.9	0.79	5	26.3	0.65
	Sternum-Man.	11	45.8	0.73	12	50.0	0.56	5	27.8	0.60	2	10.5	0.75
	Rib Bodies	258	44.8	--	235	40.8	--	185	42.8	--	117	25.7	--
	Rib Ends	139	24.1	--	186	32.3	--	123	28.5	--	56	12.3	--
	Rib Heads	48	8.3	--	80	13.9	--	72	16.7	--	56	12.3	--
Vertebral Column	Atlas	15	62.5	--	12	50.0	--	11	61.1	--	9	47.4	--
	Axis	13	54.2	--	12	50.0	--	12	66.7	--	12	63.2	--
	C3-C7	66	55.0	--	61	50.8	--	48	53.3	--	39	41.1	--
	T1-T12	158	54.9	--	157	54.5	--	97	44.9	--	107	46.9	--
	L1-L5	70	58.3	--	73	60.8	--	47	52.2	--	44	46.3	--
	Sacrum	17	70.8	--	21	87.5	--	15	83.3	--	13	68.4	--
Os Coxae	Ilium	39	81.25	0.78	45	93.8	0.75	34	94.4	0.68	32	84.2	0.54
	Ischium	35	72.92	0.74	42	87.5	0.59	29	80.6	0.74	24	63.2	0.67
	Pubis	33	68.75	0.64	34	70.8	0.61	24	66.7	0.70	15	39.5	0.70
Lower Limbs	Femur	39	81.3	0.87	48	100.0	0.89	31	86.1	0.81	36	94.7	0.78
	Patella	27	100.0	0.56	19	39.6	0.92	21	58.3	0.86	20	52.6	0.88
	Tibia	40	83.3	0.84	48	100.0	0.87	32	88.9	0.76	38	100.0	0.73
	Fibula	43	89.6	0.82	47	97.9	0.75	31	86.1	0.59	29	76.3	0.67
	Tarsals	167	49.7	--	218	64.9	--	111	44.0	--	118	44.4	--
	Metatarals	127	52.9	--	128	53.3	--	83	46.1	--	99	52.1	--
	Foot Phal.	75	11.2	--	51	7.6	--	36	7.1	--	42	7.9	--

Appendix Table 5 Ostojićevo subadult cranial inventory by age-at-death

Element	Neonate (n = 33)			Infant I/II (n = 20)			Child I/II (n = 13)			Juvenile I/II (n = 19)		
	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI
Frontal	29	43.9	0.37	35	87.5	0.51	22	84.6	0.55	33	86.8	0.75
Parietal	43	65.2	0.35	34	85.0	0.49	25	96.2	0.57	34	89.5	0.76
Temporal	27	40.9	0.31	26	65.0	0.41	18	69.2	0.47	33	86.8	0.75
Occipital	27	40.9	0.34	29	72.5	0.51	19	73.1	0.62	32	84.2	0.70
Basiocranium	5	15.2	0.65	8	40.0	0.56	6	46.2	0.88	11	57.9	0.82
Sphenoid	2	3.0	0.38	13	32.5	0.50	8	30.8	0.41	13	34.2	0.65
Nasal	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00	8	21.1	0.94
Lacrimal	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00
Vomer	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00
Ethmoid	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00
Zygoma	4	6.1	0.88	11	27.5	0.93	9	34.6	0.94	22	57.9	0.98
Palatine	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00	6	15.8	0.92
Maxilla	3	4.5	0.25	12	30.0	0.33	20	76.9	0.48	31	81.6	0.70
Mandible	23	34.8	0.44	24	60.0	0.55	22	84.6	0.84	31	81.6	0.93
Hyoid	0	0.0	0.00	0	0.0	0.00	0	0.0	0.00	1	5.3	0.50

Appendix Table 6 Ostojićevo subadult postcranial inventory by age-at-death

Region	Element	Neonate (n = 30)			Infant I/II (n = 20)			Child I/II (n = 14)			Juvenile I/II (n = 22)		
		Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI	Count	TPR (%)	MPI
Upper Limbs	Clavicle	21	35.0	0.63	23	57.5	0.66	14	50.0	0.79	38	86.4	0.83
	Scapula	2	3.3	0.50	8	20.0	0.38	12	42.9	0.33	36	81.8	0.46
	Humerus	26	43.3	0.63	27	67.5	0.74	20	71.4	0.86	41	93.2	0.93
	Radius	18	30.0	0.54	18	45.0	0.61	18	64.3	0.78	37	84.1	0.91
	Ulna	21	35.0	0.57	24	60.0	0.61	18	64.3	0.69	38	86.4	0.89
Thoracic	Manubrium	0	0.0	__	1	5.0	__	4	28.6	__	8	36.4	1.00
	Body	0	0.0	__	0	0.0	__	1	7.1	__	9	40.9	0.72
Vertebral Column	Atlas	5	16.7	__	7	17.5	__	7	50.0	__	10	45.5	__
	Axis	0	0.0	__	3	7.5	__	6	42.9	__	15	68.2	__
	C3-C7	9	6.0	__	29	29.0	__	32	45.7	__	54	49.1	__
	T1-T12	17	4.7	__	61	25.4	__	36	21.4	__	141	53.4	__
	L1-L5	0	0.0	__	8	8.0	__	16	22.9	__	70	63.6	__
	Sacrum	0	0.0	__	3	15.0	__	6	42.9	__	13	59.1	__
Os Coxae	Ilium	3	5.0	0.67	16	40.0	0.56	17	60.7	0.62	36	81.8	0.83
	Ischium	0	0.0	0.00	6	15.0	0.88	7	25.0	0.89	33	75.0	0.87
	Pubis	0	0.0	0.00	4	10.0	1.00	6	21.4	1.00	26	59.1	0.85
Lower Limbs	Femur	32	53.3	0.61	33	82.5	0.70	24	85.7	0.82	42	95.5	0.93
	Patella	0	0.0	0.00	1	2.5	1.00	7	25.0	1.00	23	52.3	1.00
	Tibia	29	48.3	0.53	26	65.0	0.69	20	71.4	0.70	38	86.4	0.88
	Fibula	10	16.7	0.65	18	45.0	0.58	16	57.1	0.67	36	81.8	0.81

Appendix Table 7 Ostojićevo adult demographic parameters. ***Note. * = crania only; ** = postcrania only.***

Grave #	Sex			Orientation	Age-at-Death						Other
	Sex	Skull	Os Coxa		Category	Age Min	Age Max	Survivorship Age	Auricular surface	Pubic symphysis	
6	F	F	F	S	Adult IV	50	80	50-60	7/8		
7	F	F	FI	S	Adult	18	80	18-60			Cranial suture fusion
21	F	F	F	W	Adult II	35	40	30-40	4		
23	MI	MI		?	Adult	18	80	18-60			
28	F		F	S	Adult I	25	30	20-30	2		
29	F	I	F	S	Adult I	18	25	20-30	2		Fusion 21-24 yrs
30	F		F	S	Adult I	18	25	20-30	1		Fusion 21-24 yrs
34	M	I	M	N	Adult III	40	50	40-50	6	4	
35	I			S	Adult I	18	25	20-30		1	Fusion 18-24
36B	I			SW	Adult I	18	25	20-30			Fusion 21-24 yrs
41	F		F	S	Adult I	25	30	20-30	2/3	2	
42	FI		FI	S	Adult IV	50	80	50-60	8		
49	M	MI	M	SW	Adult III	40	50	40-50	6/7	6	
51	F	F	F	S	Adult III/IV	40	80	40-60	6/7		
52	M	M	M	E	Adult	18	80	18-60			
53	M	M	M	N	Adult II	35	50	30-40	4		
56	I			S	Adult	18	80	18-60			
57	F	F	F	S	Adult II	30	40	30-40	3		
58	M	M	M	N	Adult II/III	35	50	30-50	7/8	4	
59	M	MI	M	S	Adult I	25	30	20-30	1	2	
60	F		F	S	Adult III	35	45	40-50	5		
63	MI		M	N	Adult IV	50	80	50-60		6	
64	F	FI	F	S	Adult III	35	50	40-50	4/5		
66B	M	M	M	S	Adult II	30	35	30-40	3		
67	F	FI	FI	S	Adult IV	50	80	50-60	7		

Grave #	Sex			Orientation	Age-at-Death						
	Sex	Skull	Os Coxa		Category	Age Min	Age Max	Survivorship Age	Auricular surface	Pubic symphysis	Other
68	MI	MI	FI	S	Adult IV	50	80	50-60	7		
69	F	F	F	S	Adult I	18	25	20-30	1		
72	FI	F	I	S	Adult	18	80	18-60			
78	F	F	F	SE	Adult II	30	35	30-40	3	4	
81	F	F	F	S	Adult IV	50	80	50-60	7		
82	F	F	F	S	Adult I	18	25	20-30	1/2	1	
86	M	M	M	E	Adult II	25	35	30-40	2/3	3	
88	M	M	M	N	Adult III	40	50	40-50	4/5		
92	F	F	F	SE	Adult II	25	35	30-40	3		
94	M	M	M	N	Adult I	25	35	20-30		1	
96	F	F	F	W	Adult II	25	35	30-40	4		
98	M	FI	M	S	Adult II	35	40	30-40	4	4	
100	M	M	M	N	Adult I	25	35	20-30	3	2	
101	M	M	M	I	Adult III/IV	40	80	40-60			Cranial suture fusion
106	M	M	M	N	Adult I	18	25	20-30	1/2		Fusion 18-21 yrs
107	M	M	M	S	Adult I	25	35	20-30	3		
108B	I	I		I	Adult	18	80	18-60			
110	I			I	Adult IV	50	80	50-60	6/7		
113	F	F		S	Adult	18	80	18-60			
114	M	M	M	S	Adult I	25	30	20-30	2	2	
115	F	F	F	S	Adult IV	50	80	50-60	7		
117	MI	MI		SW	Adult	18	80	18-60			
120	F	FI	F	S	Adult I	25	35	20-30	2		
121	M	M	M	S	Adult II	30	40	30-40	3		
126	I			S	Adult	18	80	18-60			
128	F	F	F	S	Adult I	18	25	20-30		1	Fusion 21-23 yrs
129	M	M	M	N	Adult I	25	35	20-30		2	
131	M	M		S	Adult	18	80	18-60			

Grave #	Sex			Orientation	Age-at-Death						
	Sex	Skull	Os Coxa		Category	Age Min	Age Max	Survivorship Age	Auricular surface	Pubic symphysis	Other
136	F	F		N	Adult	18	80	18-60			
138	F	F	F	S	Adult	18	25	20-30	1		
141_138 C*-A	F	F		N/A	Adult	18	60	18-60			
141_138 C-C	M	M		N/A	Adult	18	60	18-60			
141_138 PC**-A	M		M	N/A	Adult	18	60	18-60			
141_138 PC-C	I			N/A	Adult	18	60	18-60			
139 C-A	F	F		N/A	Adult	18	60	18-60			
139 C-B	M	M		N/A	Adult	18	60	18-60			
139 C-C	I			N/A	Adult	18	60	18-60			
139 PC	M		M	NW	Adult II	30	40	30-40	3	4/5	
147	F	F	F	S	Adult I	25	35	20-30	2	2	
148	M		M	N	Adult	18	80	18-60			
154	F	F	F	S	Adult II	30	40	30-40	3		
155	FI	FI	FI	NW	Adult II	35	40	30-40	4		
156	M	M	M	N	Adult II	25	35	30-40	3	2/3	
158	FI	F		E	Adult	18	80	18-60			
159	MI	MI		E	Adult	18	80	18-60			
161	I			E	Adult	18	80	18-60			
162 A	M	M		N	Adult	18	80	18-60			
164	FI	F		I	Adult	18	80	18-60			
166	F	F		S	Adult	18	80	18-60			
167	FI	FI		E	Adult	18	80	18-60			
169	I			E	Adult	18	80	18-60			
170A	F		F	S	Adult III	40	50	40-50	5		
171 A and B	M	M	M	N	Adult I	25	30	20-30	1/2		
171 C	FI		FI	N/A	Adult	18	80	18-60			
182	F	F	F	W	Adult III	40	50	40-50	6		
184	F	F	F	S	Adult III/IV	40	80	40-60	5	6	

Grave #	Sex			Orientation	Age-at-Death						
	Sex	Skull	Os Coxa		Category	Age Min	Age Max	Survivorship Age	Auricular surface	Pubic symphysis	Other
186	M	M	M	N	Adult II	25	35	30-40	2/3	3/4	
188	FI	FI	F	I	Adult	18	80	18-60			
189	F	F	F	S	Adult III	35	50	40-50	4/5		
190	FI		FI	I	Adult I	18	25	20-30	1		Fusion 18-24 yrs
186	M	M	M	N	Adult II	25	35	30-40	2/3	3/4	
191	F	F	F	S	Adult III	40	50	40-50	5		
192	M	MI	M	S	Adult III	35	50	40-50	5/6	3	Sternal rib end Stage 7/8
193	I			S	Adult	18	80	18-60			
194	M	M		N	Adult	18	80	18-60			
197	I			N	Adult	18	80	18-60			
199	M		M	E	Adult III	40	50	40-50	5		
202	FI	FI		W	Adult	18	80	18-60			
203	F	F	FI	N	Adult IV	50	80	50-60	7		
204	FI		FI	SW	Adult III/IV	40	80	40-60	~7		
208	F	F	F	N	Adult II	30	40	30-40	~5		
210	FI	FI	FI	S	Adult	18	80	18-60			
212	M	M	I	S	Adult II	35	50	30-40	4		
213	F	I	F	S	Adult III	40	50	40-50	5		
215 C	F	F		N/A	Adult	18	80	18-60			
215_220 PC	F		F	N/A	Adult III	40	45	40-50	5		
215_220 PC-B	F		F	N/A	Adult IV	50	80	50-60	7		
216	F		F	S	Adult	18	80	18-60			
220	F	F		N	Adult	18	80	18-60			
222A C	F	F		N	Adult	18	80	18-60			
222A PC	F		F	N/A	Adult	18	80	18-60			
222B	MI	MI		N/A	Adult	18	80	18-60			
223	M	M	M	N	Adult II	35	50	30-40	4/5		

Grave #	Sex			Orientation	Age-at-Death						
	Sex	Skull	Os Coxa		Category	Age Min	Age Max	Survivorship Age	Auricular surface	Pubic symphysis	Other
224	F	F	F	S	Adult II	35	40	30-40	4	3/4	
225	M	M		E	Adult	18	80	18-60			
226	M	M	M	N	Adult II	30	40	30-40	3/4	3	
229	M	M	M	N	Adult I	25	35	20-30		2	
230	M	M	M	N	Adult I	25	35	20-30	2	2	
232	M		M	N	Adult II	30	40	30-40	3/4	4	
233	M		M	N	Adult IV	50	80	50-60	7	5	
234	I			I	Adult	18	80	18-60			
235	M	M	MI	NW	Adult I	18	25	20-30			Fusion 18-21 yrs
236	I			N	Adult	18	80	18-60			
244	FI	F	I	S	Adult	18	80	18-60			
246	F	F		NW	Adult IV	50	80	50-60	7		
251	M	M	M	N	Adult III	35	50	40-50		4	
256	F	F	F	S	Adult II	35	40	30-40	4/5	4	
258	F	F	F	S	Adult IV	50	80	50-60	5/6		
263	F	FI	F	S	Adult II	35	50	30-40	4	4	
264	F	F	F	S	Adult IV	50	80	50-60		6	
265	FI	FI	I	S	Adult	18	80	18-60			
266	MI	FI	M	N	Adult III	35	50	40-50	4/5	5	
268	I	I	MI	N	Juv II/Adult I	17	21	10-20	1	1	Fusion 17-21 yrs
269	M	M	M	N	Adult IV	50	80	50-60	8		
270	M	I	M	E	Adult I	18	25	20-30			Fusion 18-21 yrs
273	M		M	N	Adult III	35	50	40-50	6		
274	M	M	M	N	Adult II	25	30	20-30	3	2	
278	FI	FI		S	Adult	18	80	18-60			
279	FI	FI		S	Adult	18	80	18-60			
280	F		F	SE	Adult II	30	40	30-40	3/4		
283	I			S	Adult	18	80	18-60			

Appendix Table 8 Ostojićevo subadult demographic parameters

Grave	Head Orientation	Age Category	Age Min	Age Max	Survivorship Age
1	UI	neonate	0	1	0-10
2	UI	neonate	0	1	0-10
4	NW	Infant IA	1	3	0-10
5	UI	neonate	0	1	0-10
10	US	neonate	0	1	0-10
12	US	neonate	0	1	0-10
13	UN	Infant IA	1	3	0-10
14	S	Child I	6	9	0-10
15	USE	neonate	0	1	0-10
16	UNW	neonate	0	1	0-10
17A	N	Child II	9	12	10-20
17B	N	Juvenile I	12	15	10-20
18	US	Child I	6	9	0-10
19	UN	neonate	0	1	0-10
20	UN	neonate	0	1	0-10
24	US	neonate	0	1	0-10
26	US	neonate	0	1	0-10
32	UN	neonate	0	1	0-10
36A	SW	Juvenile II	17	21	10-20
37	UNW	neonate	0	1	0-10
38	W	Juvenile II	15	18	10-20
39	UE	neonate	0	1	0-10
48	UN	neonate	0	1	0-10
66A	N	Juvenile II	18	21	10-20
70	UN	neonate	0	1	0-10
71	N	Juvenile II	18	21	10-20
73	UN	neonate	0	1	0-10
76	UNW	neonate	0	1	0-10
77	US	Infant IB	3	6	0-10
79	SE	Juvenile II	15	18	10-20
84	US	neonate	0	1	0-10
87	S	Infant IA	1	3	0-10
89	N	Infant IA	1	3	0-10
91	US	neonate	0	1	0-10
95	S	neonate	0	1	0-10
102	N	Juvenile II	15	18	10-20
104	S	Juvenile II	15	18	10-20
105	N	Infant IA	1	3	0-10

Grave	Head Orientation	Age Category	Age Min	Age Max	Survivorship Age
108A	N	Juvenile I	12	15	10-20
111	S	Child I	6	9	0-10
112	S	SA	0	18	0-20
116	S	Child II	9	12	0-10
119	N	Child I	6	9	0-10
123	S	SA	0	18	0-20
124	UW	neonate	0	1	0-10
127	W	Juvenile I	12	15	10-20
130	S	Infant IB	3	6	0-10
133A	UN	neonate	0	1	0-10
133B	UN	neonate	0	1	0-10
135	S	Child I	6	9	0-10
145	N	Infant IA	1	3	0-10
146	S	Juvenile II	18	21	10-20
149	UN	Infant IA	1	3	0-10
150	US	neonate	0	1	0-10
153	W	Juvenile II	18	21	10-20
157	N	Infant IB	3	6	0-10
160	N	Child I	6	9	0-10
163	UN	Infant IA	1	3	0-10
162 SA	I	Infant IB	3	6	0-10
165	E	Child II	9	12	0-10
170B	I	neonate	0	1	0-10
173	USW	Infant IB	3	6	0-10
176	S	Juvenile II	18	21	10-20
177	UNE	neonate	0	1	0-10
179	UE	Infant IB	3	6	0-10
181	N	Juvenile II	18	21	10-20
183	UW	Infant IA	1	3	0-10
185	N	Juvenile I	12	15	10-20
187	UI	SA (neo-inf B)	0	6	0-10
195	UE	Infant IA	1	3	0-10
198	S	SA (neo-inf B)	0	6	0-10
205	UN	neonate	0	1	0-10
207	US	Infant IA	1	3	0-10
209	N	Child II	9	12	0-10
214	E	neonate	0	1	0-10
217	S	Child II	9	12	0-10
218	UN	neonate	0	1	0-10
219	S	Juvenile I	12	15	10-20
227	N	Juvenile I	12	15	10-20

Grave	Head Orientation	Age Category	Age Min	Age Max	Survivorship Age
228	N	Juvenile II	15	18	10-20
231	SW	Juvenile II	15	18	10-20
237	E	Juvenile II	18	21	10-20
238A	US	SA (neo-inf B)	0	6	0-10
238B	US	SA (neo-inf B)	0	6	0-10
240	US	neonate	0	1	0-10
241	W	neonate	0	1	0-10
242	I	neonate	0	1	0-10
243	UE	SA	0	18	0-20
245	N	Juvenile II	15	18	10-20
247	US	neonate	0	1	0-10

Appendix B Stature and Paleopathology

PATHOLOGY AND TRAUMA RECORDING FORM

Site Name: Ostojićevo **Observer:**
Burial Number: Grave **Date:**

CRANIAL LESIONS

	Cribra Orbitalia		Porotic Hyperostosis	
	Right	Left	Right	Left
Present/Absent				
Score (if present)				
Location				
Activity				

OTHER (Use criteria from Buikstra and Ubelaker, 1994: 113-114)

Region*	Pathology	Bone	Side	Section/Location	Aspect	Description
Skull						
C1/C2						
Cervical Vert.						
Thoracic Vert.						
Lumbar Vert.						
Sacrum						
Sternum						
Clavicle						
Scapula						
Upper limb						
Lower limb						
Pelvis						

* If multiple pathologies, add additional rows to table

FRACTURE AND DISLOCATIONS (only fill-out if present)

BFT

Grave #	Bone type	Bone side	Location (rule of 5)

Configuration (bone length + corresponding bone length)	Configuration (distance from distal end)	Configuration (Height, Width M-L, Width A-P)	Apposition (overlap – D-P, A-P, M-L)	Rotation (D-P)	Angulation (displacement from midline)

Timing	Healing	Complications

Notes:

SFT

Grave #	Bone type	Bone side	Location (rule of 5)

Depth >< Width*	Flaking**	Feathering (hinge)**	Cracking**	Fracture (complete separation)	Kerf shape***

* Record with and depth (if >1mm)
**Note if unilateral or bilateral along margins, describe for both sides of cut (Flaking = breaking-off pieces of bone; Feathering = lateral raising or pulling away of bone; Cracking = cracks or fissures next to mark)
*** kerf (wall and floor) shape – flat, V-shaped, obtuse, U-shaped; jagged or smooth

Timing	Healing	Complications

Notes:

Appendix Figure 2 Skeletal pathology and trauma recording form

Appendix Table 9 Ostojićevo abnormalities in bone size or shape

Grave	Sex	Age Class	Bone	Side and Aspect	Description
29	F	Adult I	Os Coxae	Right + Left, dorsal	Bilateral hypertrophy of the Acetabular-Sacral buttress (posterior iliac pillar) and bilateral hypertrophy of the Acetabulo-Cristal buttress (anterior iliac pillar). Posterior pillar originates in area of anterior superior iliac spine and continues inferiorly to apex of sciatic notch. Robust expansion of posterior superior iliac spines and posterior inferior iliac spines. Anterior pillar originates in area of anterior superior iliac spine and continues inferiorly to superior margin of acetabulum. Well-defined gluteus medius fossa. Very broad and deep pelvis. Extensive woven bone formation covering acetabular fossa surface. Stage 2 OA (marginal porosity; surface osteophytes near teres ligament insertion) on right and left proximal femora, more pronounced on right side.
29	F	Adult I	Os Coxa	Right	Posterior central iliac exostosis or "horns". Poor preservation of iliac crest. Normal patellae.
30	F	Adult I	Scapula	Right	Os acromiale.
34	M	Adult III	Lower lumbar (L4 + L5)	n/a	Spondylolysis; bilateral ununited fracture with well-modelled margins. Neural arch not recovered.
66B	M	Adult II	Humerus	Right	Septal aperture (left side normal)
69	F	Adult I	Humerus	Right + Left	Septal aperture
71	M?	Adult I	Sphenoid + Maxilla	Right	Hyopoplastic defects, including pinprick porosity and fenestration, in cortical bone of lateral pterygoid plate and greater wing of sphenoid and posterior maxilla. Left side not preserved.
92	F	Adult II	Sphenoid	Left	Hypoplastic defects (fenestrations) in greater wing of left sphenoid. Right side not preserved. Poor preservation of maxillae.
96	F	Adult II	Skull	n/a	Plagiocephaly without synostosis attributed to left deformational frontal plagiocephaly with right frontal bossing (see Bruneteau & Mulliken, 1992; Di Rocco et al., 2012). Skull resembles a parallelogram when viewed from above. Left superior orbital rim tilted slightly down.
96	F	Adult II	Os Coxa	Right, dorsal	Hypertrophy of the Acetabulo-Sacral buttress (posterior iliac pillar). Pillar originates in area of anterior superior iliac spine and continues inferiorly to apex of sciatic notch. Extent of iliac pillar roughly corresponds to origin of gluteus maximus and posterior sacroiliac ligaments. Robust expansion of posterior superior iliac spine and posterior inferior iliac spine. Associated remodeling in acetabulum, with expansion of joint supero-anteriorly. Extensive woven bone formation covering surface of acetabular fossa surface. Stage 2 OA on right and left femoral heads with some lipping and displacement superiorly, as evidence by slight superior expansion of lunate surface.
96	F	Adult II	Femur, Tibia, & Fibula	Right + Left	Abnormally bowed femora (lateral) and tibiae and fibulae (medial).
98	M	Adult III	Lower Lumbar (L5)	n/a	Spondylolysis; bilateral ununited fracture with well-modelled margins. Neural arch not recovered
100	M	Adult I	Os Coxae	Right + Left	Enlarged, flattened (shallow) acetabula associated with bilateral subluxation of hip; slight exostosis and depression around right fovea capitis (teres ligament).
115	F	Adult IV	Lower Lumbar (L5)	n/a	Spondylolysis; bilateral ununited fracture with well-modelled margins. Neural arch not recovered

Grave	Sex	Age Class	Bone	Side and Aspect	Description
147	F?	Adult I	Sternum	n/a	Sternal aperture.
153	F?	Juv. II /Adult I	Lower Lumbar (L5)	n/a	Spondylolysis; bilateral ununited fracture with well-modelled margins. Neural arch not recovered.
155	F?	Adult II	Hamate	Right	Aplastic hook of hamate (hamulus). Left hamate absent.
170	F	Adult III	Os Coxa	Right, dorsal	Hypertrophy of the Acetabulo-Cristal buttress (anterior iliac pillar). Pillar originates in area of iliac tubercle (not preserved) and continues inferiorly to level of anterior inferior iliac spine. Thickest at inferior root. Extent of iliac pillar roughly corresponds to anterior origin of gluteus minimus. Well-defined gluteus medius fossa. No changes to acetabulum or sacroiliac join. Mediolaterally broad, but shallow pelvis. Iliac crest and left os coxa poorly preserved. Femora absent.
216	F	Adult?	Lower Thoracic	Dorsal	Incomplete union of T10? spinous process.
234	A?	Adult ?	Calcaneus	Right, Distal	Enlarged and distally projecting anterior process. Normal variant. Left calcaneus not preserved.
266	M?	Adult III	Sphenoid	Right + Left	Hypoplastic defects (fenestrations) in the greater wing of the right and left sphenoid. Maxillae not preserved.
280	F	Adult II	Calcaneus	Right, Distal	Enlarged and distally projecting anterior process. Normal variant. Left side normal.

Appendix Table 10 Ostojićevo abnormal bone loss

Grave	Sex	Age Class	Bone	Side and Aspect	Description
104	F?	Juv. II	Frontal	Left, Ectocranial	Active oblong (ca. 25.0 mm medial-lateral x 14.0 mm superior-inferior) area of focal resorption of cortical bone with sclerotic bone formation on left side of frontal bone just anterior to coronal suture. No endocranial involvement.
104	F?	Juv. II	Femur (Tibia)	Right + Left (Right)	Periosteal bone formation with focal cortical bone loss on posterior aspect of distal femora above metaphyses. Resorption more affects larger area on medial compared to lateral side. Patch of periosteal bone also present on medial aspect of right proximal tibia, just inferior to medial condyle.
104	F?	Juv. II	3rd Metatarsal	Left	Unicameral bone cyst of tarsometatarsal joint.
121	M	Adult II	Upper Thoracic	Spinous process	Osteomyelitis with circular abscess that opens laterally and inferiorly on spinous process near where joins left pedicle. Wide, smooth, rounded opening on left-lateral aspect of spinous process transitions to narrow, irregular opening with sclerotic margins on inferior surface.
210	F?	Adult ?	Temporal	Left, External	Destruction of area around external acoustic meatus and tympanic tube with involvement of mastoid process. Possible bony reaction to soft tissue lesion or osteochondroma (*e.g.*, dermatosis infection or benign tumor; see Aufderheide & Rodriguez-Martin, 1998).
216	F	Adult ?	Parietal + Occipital	Right + Left, Ectocranial	Active granulomatous and lytic lesions of cranium. Areas of focal bone destruction with adjacent deposition of irregular (reactive) sclerotic bone. At least two diffuse granulomas on posterior aspect of right parietal, with two lytic lesions on anterior aspect of right parietal. No endocranial involvement.
258	F	Adult IV	Navicular	Right + Left	Three (one on left and two on right) circular mycotic lesions on posterior articular surface. Smooth, regular margins. Non-involvement of corresponding articular surface.
258	F	Adult IV	1st Metatarsal	Left	Ovoid mycotic lesion on lateral aspect of distal shaft. Smooth, regular margins.
258	F	Adult IV	1st Prox. Pedal Digit	Proximal	Round mycotic lesion on proximal end.
264	F	Adult IV	Pubis	Left	Resorptive lesion causing disequilibrium of the inguinal ligament attachment. Right side not preserved.
266	M?	Adult III	Temporal	Right + Left	Erosive lesion anterior to the articular fossa in area of articular eminence due to artificially induced anterior displacement of the mandible.
266	M?	Adult III	Clavicle	Right, Sternal end	Osteomyelitis with large abscess on inferior aspect of sternal end of right clavicle. Taphonomic damage to sternal end exposed enlarged air cells, which indicates the presence of active infection at death.
266	M?	Adult III	Tibia	Right, Distal end	Circular mycotic lesion on distal articular surface, near medial malleolus. Smooth, regular margin. Non-involvement of corresponding articular surface. Slight (Stage 3) periosteal reaction on lateral aspect of distal third of right and left tibiae.
266	M?	Adult III	Calcaneus	Right, Medial	Circular mycotic lesion on medial talar facet. Smooth, regular margin. Non-involvement of corresponding articular surface.
269	M	Adult IV	Hamate	Left	Circular mycotic lesion on capitate facet. Smooth, regular margin. Non-involvement of corresponding articular surface.
280	F	Adult II	Clavicle	Left, Sternal end	Large circular cavity on inferior portion of joint face, expanding partially onto body. Smooth, regular margins. Cyst or osteochondroma.

Appendix Table 11 Ostojićevo abnormal bone loss - periostitis

Grave	Sex	Age Class	Bone	Side and Aspect	Description
30	F	Adult I	Tibia	Right + Left, Distal 1/3	Stage 2 – medial and lateral aspect of distal-third of right and left diaphyses.
87	SA 'F'	Infant IA	Humerus	Right + Left, Distal 1/3	Stage 2-3 – posterior surface along medial border.
87	SA 'F'	Infant IA	Femur	Right + Left, Proximal 1/2	Stage 3-4 – stage 3 periosteal reaction on posterior surface extending along proximal-third of medial border and stage 4 periosteal reaction along proximal-half of antero-lateral border.
87	SA 'F'	Infant IA	Tibia	Right + Left, Distal 1/3	Stage 3-4 – stage 3 periosteal reaction along distal-third of right anterior crest and medial border; stage 4 periosteal reaction with slight fusiform swelling to distal-third of anterior margin, wrapping around to medial border and posterior surface.
87	SA 'F'	Infant IA	Fibula	Right, Distal 1/3	Stage 4 – distal-third antero-medial surface (left fibula not preserved).
156	M	Adult II	Tibia	Right, Mid 1/3	Stage 2 – mid-third of lateral surface adjacent to anterior crest (left tibia not affected).
177	SA 'M'	Neonate	Femur	Right, Diaphysis	Stage 4 – fusiform swelling along entire length of diaphysis, most pronounced on posterior and medial surfaces (right femur not preserved).
177	SA 'M'	Neonate	Tibia	Right, Diaphysis	Stage 4 – fusiform swelling along entire length of diaphysis, most pronounced along medial surface (poor preservation of left tibia).
179	SA 'M'	Infant IB	Fibula	Distal 1/2	Stage 4 – fusiform swelling of distal-half of diaphysis. Poor long bone preservation.
195	SA 'M'	Infant IA	Femur	Right + Left, Proximal 1/2	Stage 2-3 – periosteal reaction on posterior surface in area of linear aspera, more severe on right femur compared to left.
195	SA 'M'	Infant IA	Tibia	Right + Left, Proximal 2/3	Stage 3 – fusiform swelling along lateral surface.
205	SA 'M'	Neonate	Tibia	Right + Left, Mid 1/3	Stage 2-3 – mid-third of lateral surface.
231	F?	Juv. II	Femur	Right + Left, Distal 1/2	Stage 2 – distal-half of medial aspect of anterior and posterior surface, partially obscured by postmortem weathering of cortical bone on right femur.
231	F?	Juv. II	Tibia	Right + Left, Mid 1/3	Stage 2 – mid-third of medial surface.
231	F?	Juv. II	Fibula	Right, Distal 1/2	Stage 2 – distal-half of medial aspect of posterior surface (left side unaffected). Changes partially obscured by postmortem weathering or cortical bone.
266	M?	Adult III	Tibia	Right + Left, Distal	Stage 2 – distal end of lateral surface corresponding to area surrounding fibular notch.

Appendix Table 12 Ostojićevo abnormal bone formation – other (extraverberal syndesmophytes/enthesophytes, exostosis, and tumor-like growths).

Grave	Sex	Age Class	Bone	Side and Aspect	Description
6	F	Adult IV	Tibia	Right + Left, Distal 1/3	Syndesmophytes with periostitis along distal 1/3 of interosseous membrane.
6	F	Adult IV	Fibula	Right + Left, Distal 1/3	"Syndesmophytes with periostitis along distal 1/3 of intraosseous membrane.
6	F	Adult IV	Ilium	Left	Syndesmophytes >3.0 mm near posterior inferior iliac spine. Right ilium normal.
63	M	Adult IV	Calcaneus	Right + Left	Ossification of achilles tendon insertion (retrocalcaneal enthesopathy).
115	F	Adult IV	Ulna	Right + Left, Proximal	Ossification of triceps brachii tendon insertion on posterior olecranon process (triceps enthesopathy).
158	F?	Adult ?	Patella	Right	Syndesmophytes ca. 3.1 mm on inferomedial margin of posterior surface. Left patella asbent.
170	F	Adult III	Ulna	Left, Distal 1/3	Nora lesion on lateral aspect of distal third of diaphysis (differential diagnosis: osteochondroma).
197	A?	Adult ?	Tibia	Right + Left, Proximal (lateral)	Bone spicules (syndesmophytes) extending ca. 0.5 mm from inferior margin of tibiofibular joint.
202	F?	Adult ?	Maxilla	Left + Right	Maxillary sinusitis (woven bone present on walls and floor of maxillary sinuses).
229	M	Adult I	Proximal pedal digit	Proximal	Circular bony nodules (syndesmophytes) on corresponding medial and lateral surface of 2nd and 3rd proximal pedal digits.
229	M	Adult I	Calcaneus	Right + Left	Ossification of achilles tendon insertion (retrocalcaneal enthesopathy).
234	A?	Adult ?	Calcaneus	Right	Ossification of achilles tendon insertion (retrocalcaneal enthesopathy). Left calcaneus absent.
251	M	Adult IV	Humerus	Right, Distal	Bone spicule (syndesmophyte/enthesopathy) just above medial epicondyle (corresponds to pronator teres muscle insertion). Robust lateral epicondyle. Left humerus normal.
251	M	Adult IV	Ulna	Right + Left, Proximal	Ossification of triceps brachii tendon insertion on posterior olecranon process (triceps enthesopathy).
251	M	Adult IV	Fibula	Right + Left, Distal 1/3	"Syndesmophytes with periostitis along distal 1/3 of intraosseous membrane.
251	M	Adult IV	Calcaneus	Right + Left	Ossification of achilles tendon insertion (retrocalcaneal enthesopathy).
269	M	Adult IV	Ulna	Right + Left, Proximal	Ossification of triceps brachii tendon insertion on posterior olecranon process (triceps enthesopathy).
269	M	Adult IV	Calcaneus	Right + Left	Ossification of achilles tendon insertion (retrocalcaneal enthesopathy).

Appendix C Trauma

Appendix Table 13 Ostojićevo craniofacial blunt force (BFT) and sharp force (SFT) trauma

Grave	Sex	Age Class	Bone	Side	Timing	Description
131	M	Adult ?	Parietal; C1	Right	Perimortem	Two cleft injuries to right parietal. More anterior injury in similar location to Grave 174 incision. Injury is ca. 15.5 mm wide (medial-lateral) and 5.9 mm long (anterior-posterior). Second smaller injury near sagittal suture more posterior and superior (still located in anterior half of right parietal). Injury is ca. 8.0 mm wide by 3.0 mm long. Both injuries do not expose diploë, though larger injury characterized by crushing of cortical bone into underlying diploë. Ectocranial surface not affected. Two cutmarks (short, narrow incisions) present on C1, anterior margin of left superior articular facet and lateral margin of right superior articular facet.
191	F	Adult III	Frontal	Mid-Left	Antemortem	Superior third of frontal bone, left of midline. Presents as oblong shallow depression ca. 8.4 mm mediolateral x 18.4 mm superoinferior x 1.3 mm depth. Margins smooth with ectocranial thickening. Woven bone and porosity on floor of depression. No endocranial involvement.
223	M	Adult II	Frontal; Zygoma	Left	Antemortem	Left frontal adjacent to coronal suture midway between pterion and bregma. Presents as shallow oblong circular depression ca. 28.3 mm anteroposterior x 16.1 mm superoinferior. Margins smooth with slight ectocranial cortical thickening. Woven bone and porosity on floor of depression. No endocranial involvement. Body of left zygoma near inferior border displays small circular patch of periostitis, possibly from a soft tissue laceration.
230	M	Adult I	Parietal; Frontal	Right; Mid-Left	Perimortem	Semicircular fracture of superoanterior right parietal. Ectocranial and endocranial hinging and terminal radiating fracture lines present. Superior third of frontal just left of midline – ovoid ectocranial compression fracture ca. 26.7 mm mediolateral x 27.8 mm superorinferior with concentric ca. 10.8 mm semicircular fracture line. Endocranial displacement of cortical bone plug. Semicircular fracture exhibits bone hinging and radiating terminal fracture lines superiorly (ectocranial) and inferolaterally (endocranial). Radiating lines do not cross margins of larger circular fracture.
268	SA	Juvenile II	Parietal; Occipital	Right + Left; Mid	Perimortem	Five overlapping circular fractures to posterior parietals, moving from right to left across sagittal suture. Removal of interior bone from four of five fractures. Maximum anteroposterior width ca. 33.5 mm. Cutmarks present along inferior (ca. 25.4 mm) and superior (ca. 26.3 mm) left-lateral margins. Cutmarks display slight unilateral cracking and square kerf. Sixth circular fracture present on occipital bone (inferior aspect absent). All fractures exhibit smooth, somewhat polished edges. No evidence of healing. Radiating linear fracture lines present on endocranial surface of parietals.
274	M	Adult II	Parietal	Right	Perimortem	Cutmark (incision) c. 9.2 mm long running anterior-posterior on anterior aspect of right parietal. Narrow, V-shaped kerf. Unilateral flaking present.

Appendix Table 14 Ostojićevo postcranial blunt force (BFT), sharp force (SFT), and penetrating trauma

Grave	Sex	Age Class	Bone	Side	Timing	Description
41	F	Adult I	Fibula	Right	Antemortem	Oblique fracture of lateral malleolus with lateral displacement and slight angulation, well-healed, no rotation.
52	M	Adult ?	Clavicle + Scapula	Right + Left	Antemortem	Dislocation of right and left acromioclavicular joints with associated costaclavicular ligament avulsion. Formation of new acromioclavicular joint face on clavicle in area of conoid tubercle.
64	F	Adult III	Radius	Right	Antemortem	Colles' fracture with volar angulation of distal radius. Well-healed, no rotation, no apposition. 2˚ osteoarthritis on radioulnar joint and distal radius.
66B	M	Adult II	Radius	Right	Antemortem	Smith's fracture with palmar angulation and inferior displacement of distal radius. Well-healed, no rotation, no apposition. 2˚ osteoarthritis on radioulnar joint and distal articular surface of radius.
69	F	Adult I	11^{th} + 12^{th} Ribs	Left	Antemortem	Transverse fracture of 11^{th} and 12^{th} rib bodies, no angulation or rotation, no apposition, well-healed.
113	F	Adult ?	2^{nd} Metacarpal	Left	Antemortem	Mid-shaft oblique fracture of 2^{nd} metacarpal with slight vertical apposition and medial angulation. Well-healed, no rotation. Slight 2˚ osteoarthritis on proximal joint.
115	F	Adult IV	Sternum	Anterior	Perimortem	Circular puncture wound to sternal body, inferior third anterior aspect. Incomplete hinge fxs displaced inward. Posterior surface not affected.
147	F	Adult I	7^{th} Rib	Left	Antemortem	Oblique fracture of 7^{th} rib at angle with ca. 3.3 mm inferior displacement of body relative to neck and head, no angulation or rotation, woven bone present on dorsal margin, well-healed.
156	M	Adult II	Pubis; 4^{th} + 5^{th} Ribs	Left; Right	Antemortem	(1) Superior pubic ramus fracture with slight medial rotation and inferior displacement, formation of irregular dense bone on ventral aspect, well-healed; (2) Transverse fracture of ventral third of bodies of 4^{th} and 5^{th} ribs, slight ca. 3.0 mm inferior displacement of ventral end, well-healed.
185	SA	Juv. I	Shoulder; Elbow	Right + Left; Right	Antemortem	(1) Hill-Sachs deformity to right and left humeral heads with associated Bankart deformity to right and left glenoid processes. Bilateral deformation of shoulders associated with joint instability and dislocation secondary to blunt force trauma. Extensive remodeling, no apposition. Damage to growth plate resulting in premature fusion of right humeral head, lateral bowing of proximal half of right and left humeral diaphyses and possible dislocation of right sternoclavicular joint. (2) Impaction with greenstick facture to right capitulum (left side absent) resulting in anterior and medial displacement and traumatic myositis ossificans to forearm flexor tendons (*i.e.*, supinator and flexor digitorum superficialis).
226	M	Adult II	Shoulder; Wrist	Left; Left	Antemortem	(1) Mid-shaft transverse fracture of left clavicle, anterior and inferior apposition, posterior angulation of proximal half, bony callus well-formed, presence of cloacae on inferior surface indicates active osteomyelitis at time-of-death; dislocation of left shoulder with expansion of glenoid fossa inferiorly and 2˚ osteoarthritis; (2) Smith's fracture with secondary osteoarthritis and myositis ossificans; Transverse fracture (Parry fracture) to distal third of ulnar diaphysis with no apposition or angulation; 2˚ osteoarthritis on distal radius and carpal bones.
251	M	Adult III	Fibula	Right	Antemortem	Oblique fracture of lateral malleolus with slight distal displacement, well-healed, no angulation or rotation, no apposition. 2˚ osteoarthritis on fibulotalar joint.

Appendix Table 15 Ostojićevo vertebral trauma. All cases antemortem.

Grave	Sex	Age Class	Vertebrae	Description	Force
21	Female	Adult II	Mid-thoracic (T8?)	Endplate avulsion; bow-shaped antero-inferior border after avulsion of inferior endplate with anterior displacement.	Hyperflexion
52	Male	Adult?	Lower lumbar (L4)	Endplate avulsion with secondary compression; Crushed and cavitated annular epiphysis with "step-off" deformity associated with compression fracture of antero-superior body and associated endplate.	Hyperflexion
67	Female	Adult IV	Mid-thoracic (T6 + T7)	Split fracture; incomplete sagittal split fracture involving inferior-posterior T6 body and superior-posterior T7 body. Well-healed with no signs of displacement. Neural arches not preserved.	Rotation
81	Female	Adult IV	Upper and mid-thoracic (T2 to T6)	Complete vertebral collapse (senile kyphosis) secondary to intervertebral disc degeneration and attrition; Superior and inferior marginal lipping arising from anterior endplate with osteosclerosis of superior and inferior body surfaces.	Osteoporotic compression
101	Male	Adult IV	Mid-lumbar (L2 + L3)	Wedge impaction fracture; loss of vertebral height resulting in angulation of left-lateral wall of L3 (more severe) and L2. Posterior and anterior walls intact.	Axial compression with lateral flexion
106	Male	Adult I	Mid-cervical (C3)	Endplate avulsion with secondary compression; antero-superior "step-off" deformity with intact annular epiphysis from localized avulsion and compression of antero-superior body.	Hyperflexion
170	Female	Adult III	Lower thoracic (T10)	Burst fracture with lateral subluxation; reduction of height throughout body with most extreme changes to anterior corner. Transverse widening of body due to supero-lateral displacement of left half. Injury likely associated with ligamentous posterior disruption. Well-healed at time-of-death.	Flexion-subluxation with rotation
176	Female?	Adult I	Lower thoracic (T9)	Inferior wedge fracture; superior surface and posterior height intact. Loss of body height anteriorly with slight inferior wedging. Slight porosity with sclerotic margins. Annular epiphysis intact.	Mild hyperflexion and compression
192	Male	Adult III	Upper thoracic	Endplate avulsion with secondary compression; Crushed and cavitated annular epiphysis with "step-off" deformity associated with compression fracture of antero-superior body and associated endplate. Destruction of annular epiphyses. Uniform porotic endplates represents replaced hematoma following endplate separation.	Hyperflexion
197	Adult?	Adult?	Mid-thoracic (T3 to T7); Lumbar (L1, L5)	Likely Scheuermann's kyphosis (T3 to T7) and endplate avulsion with anterior displacement (L1 + L5); Anterior extension of body beyond annular ring inferiorly (T3 + T4), inferiorly and superiorly (T5), and superiorly (T6 + T7) with slight wedging. 'Bow-shaped' antero-superior border (L1 + L5) from avulsion of superior annular epiphysis with anterior displacement (indicates injury occurred prior to fusion of annular epiphysis).	Juvenile Osteochondrosis; Hyperflexion
251	Male	Adult III	Mid-cervical (C3 + C4); Upper thoracic (T1)	Endplate avulsion with secondary compression (C3+C4, T1); Crushed and cavitated annular epiphysis with "step-off" deformity associated with compression fracture of antero-superior body and associated endplate. Destruction of annular epiphyses (C3+C4). Uniform porotic endplates represents replaced hematoma following endplate separation.	Hyperflexion
258	Female	Adult IV	Lower cervical (C6)	Vertebral body collapse.	Osteoporotic compression

Appendix D Dental Disease and Diet

DENTAL RECORDING FORM

Site Name: Ostojicevo **Observer:**
Burial Number: Grave **Date:**

Photographs (X when complete):

Buccal	Lingual	Occlusal	Pathology

Periodontitis (note evidence for preservation, resorption, woven bone, remodeling, or trauma):

	Right	Left
Maxillary		
Mandibular		

DEH (lingual surface of U and L incisors and canines, examined under low power)

	Left			Right		
Maxillary	ULC	ULI2	ULI1	URI1	URI2	URC
Present/Absent						
Description						
#						
Location (1/3rds)						
Mandibular	LLC	LLI2	LLI1	LRI1	LRI2	LRC
Present/Absent						
Description						
#						
Location (1/3rds)						

Other notes/observations:

MAXILLA:

		UPPER RIGHT								UPPER LEFT							
MAX.	Tooth	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Description	UR M3	UR M2	UR M1	UR P2	UR P1	UR C	UR I2	UR 11	UL I1	UL I2	UL C	UL P1	UL P2	UL M1	UL M2	UL M3
	Pres/Absence																
	Alveolar bone																
Calculus	Pres/Absence																
	Location - M, B, D, L, O																
	Score																
Caries	Pres/Absence																
	Location: crown, root, CEJ (if present)																
	Location - M, B, D, L, O (if present)																
	Severity																
Alveolar Cavity or Sinus	Pres/Absence																
	Wall shape																
Notes																	

MANDIBLE:

		LOWER LEFT								LOWER RIGHT							
MAND.	Tooth	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	Description	LL M3	LL M2	LL M1	LL P2	LL P1	LL C	LL I2	LL I1	LR I1	LR I2	LR C	LR P1	LR P2	LR M1	LR M2	LR M3
	Pres/Absence																
	Alveolar bone																
Calculus	Pres/Absence																
	Location - M, B, D, L, O																
	Score																
Caries	Pres/Absence																
	Location: crown, root, CEJ (if present)																
	Location - M, B, D, L, O (if present)																
	Description/Severity																
Alveolar Cavity or Sinus	Pres/Absence																
	Wall shape																
Notes																	

Appendix Figure 3 Permanent teeth recording form

DECIDUOUS TEETH RECORDING FORM

Site Name: Ostojićevo **Observer:**
Burial Number: Grave **Date:**

Photographs (X when complete):

Buccal	Lingual	Occlusal	Pathology

Periodontitis (note evidence for preservation, resorption, woven bone, remodeling, or trauma):

	Right	Left
Maxillary		
Mandibular		

MAXILLA:

		UPPER RIGHT								UPPER LEFT							
MAX.	**Tooth**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
	Description	**UR M3**	**UR M2**	**UR M1**	**UR P2**	**UR P1**	**UR C**	**UR I2**	**UR 11**	**ULI 1**	**ULI 2**	**UL C**	**UL P1**	**UL P2**	**UL M1**	**UL M2**	**UL M3**
	Pres/Absence																
	Alveolar bone																
Calculus	Pres/Absence																
	Location - M, B, D, L, O																
	Score																
Caries	Pres/Absence																
	Location: crown, root, CEJ																
	Location - M, B, D, L, O																
	Severity																
Alveolar Cavity or Sinus	Pres/Absence																
	Wall shape																
Notes																	

MANDIBLE:

		LOWER LEFT								LOWER RIGHT							
MAND.	**Tooth**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
	Description	**LL M3**	**LL M2**	**LL M1**	**LL P2**	**LL P1**	**LL C**	**LL I2**	**LL I1**	**LR I1**	**LR I2**	**LR C**	**LR P1**	**LR P2**	**LR M1**	**LR M2**	**LR M3**
	Pres/Absence																
	Alveolar bone																
Calculus	Pres/Absence																
	Location - M, B, D, L, O																
	Score																
Caries	Pres/Absence																
	Location: crown, root, CEJ (																
	Location - M, B, D, L, O																
	Description/Severity																
Alveolar Cavity or Sinus	Pres/Absence																
	Wall shape																
Notes																	

Appendix Figure 4 Deciduous teeth recording form

Appendix Table 16 Ostojićevo dental inventory: Male permanent teeth (upper). *Note*. *Adult I = 18-30 years.

Tooth	Category (Male)	SA	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult
	n-individual	0	3	3	2	4	2	4	2	12	10	4	2	3
URM^3	**1 - Present**	0	0	0	0	0	0	1	1	6	3	1	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	3	1	0	1	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	1	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	1	0	0	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	1	0	2	0	0	0	0
URM^2	**1 - Present**	0	0	0	0	0	0	3	2	10	6	3	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	1	0	1	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	1	3	0	0	0	0	0	0	0
URM^1	**1 - Present**	0	0	0	0	3	2	3	2	11	7	2	1	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	1	0	0	0	0	0	0	0	0	0	0
URP^2	**1 - Present**	0	0	0	0	0	0	2	1	11	5	1	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	0	0	1	1	1	0	1	1	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	1	0	0	0	0	0	0	0
URP^1	**1 - Present**	0	0	0	0	0	0	3	1	9	7	1	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	1	3	0	1	2	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	0	0	0	0	0	0	0	0
URC	**1 - Present**	0	0	0	0	0	0	3	1	4	6	1	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	1	0	1	1	7	0	1	2	0
	4 - Damaged	0	0	0	0	0	1	0	0	1	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	2	0	0	0	0	0	0	0	0

URI²	**1 - Present**	0	0	0	0	0	0	2	0	5	5	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	1	0
	3 - PMTL	0	0	0	0	0	1	2	1	7	1	2	1	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	2	0	0	0	0	0	0	0	0
URI¹	**1 - Present**	0	0	0	0	1	1	3	1	7	6	1	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	1	0
	3 - PMTL	0	0	0	0	0	0	1	1	5	1	1	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	1	0	0	0	0	0	0	0	0
ULI¹	**1 - Present**	0	0	0	0	1	1	0	0	5	4	0	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	1	0
	3 - PMTL	0	0	0	0	0	0	2	1	6	2	3	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	1	2	1	0	0	0	0	0	0	0	0
ULI²	**1 - Present**	0	0	0	0	1	0	0	0	7	3	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	0	0	2	1	5	2	3	2	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
ULC	**1 - Present**	0	0	0	0	0	0	2	0	6	4	2	2	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	0	0	1	1	5	1	1	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	2	2	1	0	0	0	0	0	0	0
ULP¹	**1 - Present**	0	0	0	0	0	0	2	1	10	6	2	2	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	1	0	2	0	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	0	0	0	0	0	0	0	0
ULP²	**1 - Present**	0	0	0	0	0	1	3	1	7	6	2	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	1	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	3	0	0	2	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	4	1	0	0	0	0	0	0	0

ULM[1]	**1 - Present**	0	0	0	0	3	1	3	2	11	5	3	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	2	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	2	2	1	0	0	0	0	0	0	0	0	0
ULM[2]	**1 - Present**	0	0	0	0	0	0	1	2	10	7	0	1	1
	2 - AMTL	0	0	0	0	0	0	0	0	1	0	0	1	0
	3 - PMTL	0	0	0	0	0	0	1	0	0	1	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	1	0	0	0	0	0	0	0
ULM[3]	**1 - Present**	0	0	0	0	0	0	0	0	6	4	1	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	2	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	1	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	1	0	0	0	0	0	0
	7 - Congenital	0	0	0	0	1	0	1	0	2	0	0	0	0

Appendix Table 17 Ostojićevo dental inventory: Female permanent teeth (upper). *Note*. *Adult I = 18-30 years.

Tooth	Category (Female)	SA	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult
	n-individual	2	0	3	3	5	2	1	4	8	7	3	6	7
URM3	1 - Present	0	0	0	0	0	0	0	1	3	1	2	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	2	0
	3 - PMTL	0	0	0	0	0	0	0	1	4	1	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	1	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	1	0	0	0	0	0
	7 - Congenital	0	0	0	0	0	1	0	0	0	1	0	0	0
URM2	1 - Present	0	0	0	0	0	0	0	4	5	4	2	0	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	2	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	0	0	0	0	0	0	0	0
URM1	1 - Present	0	0	0	0	4	2	0	4	7	4	0	3	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	2	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	1	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	2	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	2	0	0	0	0	0	0	0	0	0	0
URP2	1 - Present	0	0	0	0	0	0	0	3	5	3	1	1	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	1	3	0
	3 - PMTL	0	0	0	0	0	0	0	1	3	2	1	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	2	0	0	0	0	0	0	0
URP1	1 - Present	0	0	0	0	0	0	0	3	7	2	1	1	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	1
	3 - PMTL	0	0	0	0	0	0	0	1	1	4	2	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	2	2	2	0	0	0	0	0	0	0
URC	1 - Present	0	0	0	0	0	0	0	3	5	3	2	1	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	1
	3 - PMTL	0	0	0	0	0	0	0	1	2	1	1	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	1
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	2	1	3	1	0	0	0	0	0	0	0

URI^{2}	**1 - Present**	0	0	0	0	0	2	0	2	3	1	1	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	3	1
	3 - PMTL	0	0	0	0	0	0	0	2	4	4	1	0	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	2	1	0	0	0	0	0	0	0	0
URI^{1}	**1 - Present**	0	0	0	0	0	0	0	2	5	0	1	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	3	1
	3 - PMTL	0	0	0	0	0	0	0	2	2	4	1	1	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	2	0	0	0	0	0	0	0	0	0
ULI^{1}	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	4	0	0	0	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
ULI^{2}	**1 - Present**	0	0	0	0	0	0	0	0	2	0	0	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	1	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	6
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0
ULC	**1 - Present**	0	0	0	0	0	0	0	0	3	1	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	3	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	1	0	0	0	0	0	0	0	0	0
ULP^{1}	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0
ULP^{2}	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	1	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0

ULM^1	**1 - Present**	0	0	0	1	0	0	0	0	5	0	0	0	7
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
ULM^2	**1 - Present**	0	0	0	0	0	0	0	0	5	0	0	0	6
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	1
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
ULM^3	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	1	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	2	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table 18 Ostojićevo dental inventory: Indeterminate permanent teeth (upper). *Note*. *Adult I = 18-30 years.

Tooth	Category (?)	SA	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult
	n-individual	0	1	1	1	0	0	0	0	6	1	1	1	9
URM3	1 - Present	0	0	0	0	0	0	0	0	0	0	1	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	4	0	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	1	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	0	0	0	0	0
URM2	1 - Present	0	0	0	0	0	0	0	0	5	0	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
URM1	1 - Present	0	0	0	0	0	0	0	0	5	0	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
URP2	1 - Present	0	0	0	0	0	0	0	0	4	0	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
URP1	1 - Present	0	0	0	0	0	0	0	0	3	1	0	0	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
URC	1 - Present	0	0	0	0	0	0	0	0	3	1	0	0	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0

URI²	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	4	0	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0
URI¹	**1 - Present**	0	0	0	0	0	0	0	0	2	0	0	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	1	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	3	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	1	0	0	0	0	0	0	0	0	0
ULI¹	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	4	0	0	0	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
ULI²	**1 - Present**	0	0	0	0	0	0	0	0	2	0	0	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	1	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	6
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0
ULC	**1 - Present**	0	0	0	0	0	0	0	0	3	1	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	3	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	1	0	0	0	0	0	0	0	0	0
ULP¹	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0
ULP²	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	1	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0

ULM[1]	**1 - Present**	0	0	0	1	0	0	0	0	5	0	0	0	7
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
ULM[2]	**1 - Present**	0	0	0	0	0	0	0	0	5	0	0	0	6
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	1
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
ULM[3]	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	1	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	2	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table 19 Ostojićevo dental inventory: Male permanent teeth (lower). ***Note*. *Adult I = 18-30 years. Note. *Adult I = 18-30 years.**

Tooth	Category (Male)	SA	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult
	n-individual	0	5	7	2	4	2	4	2	12	10	5	2	5
LLM_3	1 - Present	0	0	0	0	0	0	0	1	7	6	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	2	2	0
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	1	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	2	1	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	2	0	0	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	0	2	1	0	0
LLM_2	1 - Present	0	0	0	0	0	0	4	2	7	7	2	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	2	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	2	1	2	1	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	3	0	0	0	0	0	0	0	0
LLM_1	1 - Present	0	0	0	0	4	1	4	2	9	7	2	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	1	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	2	1	1	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	5	1	0	0	0	0	0	0	0	0	0
LLP_2	1 - Present	0	0	0	0	0	0	3	0	10	8	3	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	2	1	0	0
	3 - PMTL	0	0	0	0	0	0	1	1	0	0	1	2	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	1	0	0	0	0	0	0	0
LLP_1	1 - Present	0	0	0	0	0	0	3	0	10	7	2	1	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	1	1	1	2	1	1	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	1
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	1	0	0	0	0	0	0	0
LLC	1 - Present	0	0	0	0	0	0	2	0	9	6	4	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	2	1	2	2	0	2	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	2	0	0	0
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	0	0	0	0	0	0	0	0

LLI$_2$	**1 - Present**	0	0	0	0	2	1	4	0	7	4	2	1	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	2
	3 - PMTL	0	0	0	0	0	0	0	1	3	5	1	1	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	2	1	1	0	0	0	0	0	0	0	1
LLI$_1$	**1 - Present**	0	0	0	0	2	0	2	0	5	1	1	0	0
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	0	0	2	1	5	6	2	2	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	2	1	1	1	0	0	0	0	0	0	0	0
LRI$_1$	**1 - Present**	0	0	0	0	1	1	2	1	5	2	0	0	0
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	0	0	2	1	6	6	4	2	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	1	1	0	0	0	0	0	0	0	0	1
LRI$_2$	**1 - Present**	0	0	0	0	1	0	2	1	10	7	3	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	2	1	2	1	2	2	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	2	2	1	0	0	0	0	0	0	0	0	1
LRC	**1 - Present**	0	0	0	0	0	0	3	1	10	4	2	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	1	1	2	3	1	2	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	2	0	0	0	0	0	0	0	0
LRP$_1$	**1 - Present**	0	0	0	0	0	0	3	1	7	7	3	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	1	0
	3 - PMTL	0	0	0	0	0	0	1	1	5	1	1	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	2	1	0	0	0	0	0	0	0
LRP$_2$	**1 - Present**	0	0	0	0	0	0	3	2	10	6	2	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	3 - PMTL	0	0	0	0	0	0	1	0	2	0	1	1	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	3	1	0	0	0	0	0	0	0

LRM_1	**1 - Present**	0	0	0	0	4	2	4	2	11	7	2	1	1
	2 - AMTL	0	0	0	0	0	0	0	0	1	1	1	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	1	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	2	2	1	0	0	0	0	0	0	0	0	0
LRM_2	**1 - Present**	0	0	0	0	0	1	4	2	12	7	1	1	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	2	1	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	1	1	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	4	0	0	0	0	0	0	0	0
LRM_3	**1 - Present**	0	0	0	0	0	0	0	1	9	7	1	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	2	0
	3 - PMTL	0	0	0	0	0	0	1	0	1	0	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	1	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	1	0	0	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	1	0	2	1	1	0	0

Appendix Table 20 Ostojićevo dental inventory: Female permanent teeth (lower). ***Note*****. *Adult I = 18-30 years.**

Tooth	Category (Female)	SA	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult
	n-individual	1	2	4	3	5	2	1	4	8	11	5	8	8
LLM$_3$	**1 - Present**	0	0	0	0	0	0	0	0	5	5	1	2	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	2	4	1
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	1	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	1	1	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	2	0	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	1	1	4	0	1	1
LLM$_2$	**1 - Present**	0	0	0	0	0	0	0	4	4	7	2	3	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	2	4	2
	3 - PMTL	0	0	0	0	0	0	1	0	2	2	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	2	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	2	4	0	0	0	0	0	0	0	0
LLM$_1$	**1 - Present**	0	0	0	0	4	2	1	4	5	5	0	1	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	3	3	6	1
	3 - PMTL	0	0	0	0	0	0	0	0	1	1	2	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	3	1	0	0	0	0	0	0	0	0	0
LLP$_2$	**1 - Present**	0	0	0	0	0	0	0	2	5	6	3	2	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	2	0	3	1
	3 - PMTL	0	0	0	0	0	0	1	1	2	0	2	2	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	1	2	0	0	0	0	0	0	0
LLP$_1$	**1 - Present**	0	0	0	0	0	0	0	4	6	4	2	2	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	2
	3 - PMTL	0	0	0	0	0	0	1	0	1	5	3	2	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	2	3	2	0	0	0	0	0	0	0
LLC	**1 - Present**	1	0	0	0	0	0	0	3	4	4	1	2	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	1
	3 - PMTL	0	0	0	0	0	0	0	0	3	4	4	2	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	1	2	2	0	0	0	0	0	0	0

LLI_2	**1 - Present**	0	0	0	0	1	2	0	3	2	4	2	2	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	2
	3 - PMTL	0	0	0	0	0	0	0	1	3	4	3	2	2
	4 - Damaged	0	0	0	0	1	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	1	2	1	0	0	0	0	0	0	0	0
LLI_1	**1 - Present**	0	0	0	0	1	2	0	1	1	2	1	1	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	4	2
	3 - PMTL	0	0	0	0	0	0	0	1	3	6	4	2	2
	4 - Damaged	0	0	0	0	1	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	2	2	0	0	0	0	0	0	0	0	0
LRI_1	**1 - Present**	0	0	0	0	1	2	0	3	3	1	3	2	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	4	1
	3 - PMTL	0	0	0	0	0	0	0	0	1	6	1	1	3
	4 - Damaged	0	0	0	0	1	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	1	2	1	0	0	0	0	0	0	0	0
LRI_2	**1 - Present**	0	0	0	0	2	2	0	2	3	6	2	1	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	1
	3 - PMTL	0	0	0	0	0	0	0	1	2	1	3	2	4
	4 - Damaged	0	0	0	0	1	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	2	2	1	0	0	0	0	0	0	0	0
LRC	**1 - Present**	0	0	0	0	0	0	0	2	5	8	3	2	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	3	0
	3 - PMTL	0	0	0	0	0	0	0	1	1	1	2	2	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	2	0	3	2	0	0	0	0	0	0	0
LRP_1	**1 - Present**	0	0	0	0	0	0	0	3	5	4	3	1	6
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	3	0
	3 - PMTL	0	0	0	0	0	0	0	1	2	3	1	2	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	1	2	0	0	0	0	0	0	0	0
LRP_2	**1 - Present**	0	0	0	0	0	0	0	3	3	4	1	2	6
	2 - AMTL	0	0	0	0	0	0	0	0	1	1	0	4	2
	3 - PMTL	0	0	0	0	0	0	0	1	1	3	1	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	1	1	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	1	2	2	0	0	0	0	0	0	0

	1 - Present	0	0	0	0	3	2	0	4	3	4	0	2	5
	2 - AMTL	0	0	0	0	0	0	0	0	1	3	2	4	2
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	1	0	1
LRM_1	**4 - Damaged**	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	3	2	0	0	0	0	0	0	0	0	0
	1 - Present	0	0	0	0	0	1	0	4	5	6	0	1	6
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	3	5	1
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	1
LRM_2	**4 - Damaged**	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	1	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	2	3	0	0	0	0	0	0	0	0
	1 - Present	0	0	0	0	0	0	0	1	4	4	2	0	6
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	2	5	1
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
LRM_3	**4 - Damaged**	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	2	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	1	0	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	2	2	0	1	1

Appendix Table 21 Ostojićevo dental inventory: Indeterminate permanent teeth (lower). ***Note*****. *Adult I = 18-30 years.**

Tooth	Category	SA	Neon.	Infant I	Infant II	Child I	Child II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult
	n-individual	0	3	1	2	0	0	0	0	5	1	1	2	12
LLM_3	**1 - Present**	0	0	0	0	0	0	0	0	2	0	0	0	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	1	0	1	0
	3 - PMTL	0	0	0	0	0	0	0	0	0	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	2	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	0	0	1	0	1
LLM_2	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	0	7
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
LLM_1	**1 - Present**	0	0	0	1	0	0	0	0	4	0	0	1	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	3	1	0	0	0	0	0	0	0	0	0	0
LLP_2	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	1	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	0	2
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	1
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
LLP_1	**1 - Present**	0	0	0	0	0	0	0	0	2	0	0	1	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	0	1
	3 - PMTL	0	0	0	0	0	0	0	0	2	1	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	1	0	0	0	0	0	0	0	0	0
LLC	**1 - Present**	0	0	0	0	0	0	0	0	3	1	1	0	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	1
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	1	0	0	0	0	0	0	0	0	0

LLI_2	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	5
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	0	0
	3 - PMTL	0	0	0	0	0	0	0	0	3	1	1	0	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
LLI_1	**1 - Present**	0	0	0	0	0	0	0	0	1	0	0	0	1
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	1
	3 - PMTL	0	0	0	0	0	0	0	0	3	1	0	0	6
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	1	0	0	0	0	0	0	0	0	0	0
LRI_1	**1 - Present**	0	0	0	0	0	0	0	0	0	0	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	4	1	0	0	5
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	0	0	0	0	0
LRI_2	**1 - Present**	0	0	0	0	0	0	0	0	3	0	0	0	2
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	1	1	1	0	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	1	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
LRC	**1 - Present**	0	0	0	0	0	0	0	0	4	0	1	1	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
LRP_1	**1 - Present**	0	0	0	0	0	0	0	0	3	0	0	0	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	1	1	0	0	4
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	1	0	0	0	0	0	0	0	0	0	0	0
LRP_2	**1 - Present**	0	0	0	0	0	0	0	0	3	0	0	0	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	3
	3 - PMTL	0	0	0	0	0	0	0	0	1	1	0	0	3
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	1	0	0	0	0	0	0	0	0	0	0

LRM_1	**1 - Present**	0	0	0	1	0	0	0	0	4	0	0	0	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	4
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	2	1	0	0	0	0	0	0	0	0	0	0
LRM_2	**1 - Present**	0	0	0	0	0	0	0	0	4	0	0	1	4
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	1	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	0	1	0	0	0
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	1	0	0	0	0	0	0	0	0	0
LRM_3	**1 - Present**	0	0	0	0	0	0	0	0	2	1	0	1	3
	2 - AMTL	0	0	0	0	0	0	0	0	0	0	0	1	2
	3 - PMTL	0	0	0	0	0	0	0	0	1	0	0	0	2
	4 - Damaged	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - Partial	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 - Unerupted	0	0	0	0	0	0	0	0	1	0	0	0	0
	7 - Congenital	0	0	0	0	0	0	0	0	0	0	1	0	0

Appendix Table 22 Ostojićevo dental inventory: Deciduous teeth (upper)

Tooth	Category	Neon.	Infant I	Infant II	Child I	Child II
	n-individual	12	9	7	9	4
URdm²	**1 – Present/Erupted**	0	1	6	3	7
	2 - PMTL	0	1	0	0	1
	3 – Present/Unerupted	1	3	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	1	1	1	0	0
URdm¹	**1 – Present/Erupted**	0	4	4	7	1
	2 - PMTL	0	0	0	0	1
	3 – Present/Unerupted	2	0	0	0	0
	4 – Present/Partial	0	1	0	0	0
	5 – Present/Eruption Unknown	3	1	0	0	0
URc	**1 – Present/Erupted**	0	1	4	3	1
	2 - PMTL	1	1	0	3	0
	3 – Present/Unerupted	4	2	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	0	1	0	0	0
URi²	**1 – Present/Erupted**	2	4	2	0	0
	2 - PMTL	1	0	1	2	0
	3 – Present/Unerupted	0	0	0	0	0
	4 – Present/Partial	1	0	0	0	0
	5 – Present/Eruption Unknown	3	0	0	0	0
URi¹	**1 – Present/Erupted**	1	4	0	1	0
	2 - PMTL	1	0	2	0	0
	3 – Present/Unerupted	0	0	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	3	0	0	0	0
ULi¹	**1 – Present/Erupted**	0	2	2	1	0
	2 - PMTL	1	3	1	0	0
	3 – Present/Unerupted	0	0	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	3	0	0	0	0
ULi²	**1 – Present/Erupted**	0	1	3	2	0
	2 - PMTL	1	2	2	0	0
	3 – Present/Unerupted	2	0	0	0	0
	4 – Present/Partial	1	0	0	0	0
	5 – Present/Eruption Unknown	1	0	0	0	0
ULc	**1 – Present/Erupted**	0	2	3	4	1
	2 - PMTL	0	1	2	2	0
	3 – Present/Unerupted	2	3	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	0	1	1	0	0
ULdm¹	**1 – Present/Erupted**	1	5	4	6	3
	2 - PMTL	0	0	1	0	0
	3 – Present/Unerupted	2	0	0	0	0
	4 – Present/Partial	0	1	0	0	0
	5 – Present/Eruption Unknown	5	0	0	0	0
ULdm²	**1 – Present/Erupted**	0	3	5	7	3
	2 - PMTL	0	0	1	0	0
	3 – Present/Unerupted	3	3	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	1	0	0	0	0

Appendix Table 23 Ostojićevo dental inventory: Deciduous teeth (lower)

Tooth	Category	Neon.	Infant I	Infant II	Child I	Child II
	n-individual	16	12	8	9	3
$LLdm_2$	**1 – Present/Erupted**	0	4	6	7	3
	2 - PMTL	1	0	0	0	0
	3 – Present/Unerupted	8	5	0	0	0
	4 – Present/Partial	0	1	0	0	0
	5 – Present/Eruption Unknown	5	0	1	0	0
$LLdm_1$	**1 – Present/Erupted**	2	7	6	8	2
	2 - PMTL	0	1	1	0	0
	3 – Present/Unerupted	5	0	0	0	0
	4 – Present/Partial	1	1	0	0	0
	5 – Present/Eruption Unknown	3	1	0	0	0
LLc	**1 – Present/Erupted**	0	1	1	0	0
	2 - PMTL	4	2	2	6	1
	3 – Present/Unerupted	3	0	0	0	0
	4 – Present/Partial	0	3	0	0	0
	5 – Present/Eruption Unknown	3	0	1	0	0
LLi_2	**1 – Present/Erupted**	1	1	2	1	0
	2 - PMTL	4	5	1	0	0
	3 – Present/Unerupted	5	0	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	2	0	0	0	0
LLi_1	**1 – Present/Erupted**	0	1	2	0	0
	2 - PMTL	5	5	1	0	0
	3 – Present/Unerupted	2	0	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	4	0	0	0	0
LRi_1	**1 – Present/Erupted**	2	0	2	0	0
	2 - PMTL	5	3	2	0	0
	3 – Present/Unerupted	1	1	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	2	0	0	0	0
LRi_2	**1 – Present/Erupted**	0	1	2	0	0
	2 - PMTL	5	3	1	0	0
	3 – Present/Unerupted	2	1	0	0	0
	4 – Present/Partial	0	0	0	0	0
	5 – Present/Eruption Unknown	2	1	0	0	0
LRc	**1 – Present/Erupted**	0	2	3	0	0
	2 - PMTL	6	3	2	6	0
	3 – Present/Unerupted	1	2	0	0	0
	4 – Present/Partial	1	0	0	0	0
	5 – Present/Eruption Unknown	1	0	0	0	0
$LRdm_1$	**1 – Present/Erupted**	1	6	4	9	1
	2 - PMTL	2	2	1	0	1
	3 – Present/Unerupted	4	1	0	0	0
	4 – Present/Partial	0	1	0	0	0
	5 – Present/Eruption Unknown	2	0	0	0	0
$LRdm_2$	**1 – Present/Erupted**	0	2	3	9	3
	2 - PMTL	0	1	0	0	0
	3 – Present/Unerupted	6	5	0	0	0
	4 – Present/Partial	0	1	0	0	0
	5 – Present/Eruption Unknown	4	0	1	0	0

Appendix Table 24 Ostojićevo male alveolar margin inventory by tooth location, tooth category, and age-at-death. ***Note*****. *Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Adult I*	Adult II	Adult III	Adult IV	Adult?	TOTAL
Upper	Molar	Bone loss	1	8	4	3	2	18
		AMTL	1	0	4	4	1	10
		Present	57	30	10	7	11	115
		%Bone loss	1.8	26.7	40.0	42.9	18.2	15.7
		%AMTL	1.8	0.0	40.0	57.1	9.1	8.7
	Premolar	Bone loss	1	5	2	2	2	12
		AMTL	1	0	4	1	0	6
		Present	41	21	9	7	9	87
		%Bone loss	2.4	23.8	22.2	28.6	22.2	13.8
		%AMTL	2.4	0.0	44.4	14.3	0.0	6.9
	Canine	Bone loss	0	6	4	1	1	12
		AMTL	0	0	0	0	0	0
		Present	20	10	6	2	4	42
		%Bone loss	0.0	60.0	66.7	50.0	25.0	28.6
		%AMTL	0.0	0.0	0.0	0.0	0.0	0.0
	Incisor	Bone loss	0	0	7	4	4	15
		AMTL	0	0	0	0	0	0
		Present	39	19	11	5	10	84
		%Bone loss	0.0	0.0	63.6	80.0	40.0	17.9
		%AMTL	0.0	0.0	0.0	0.0	0.0	0.0
	Total	Bone loss	2	19	17	10	9	57
		AMTL	2	0	8	5	1	16
		Present	157	80	36	21	34	328
		%Bone loss	1.3	23.8	47.2	47.6	26.5	17.4
		%AMTL	1.3	0.0	22.2	23.8	2.9	4.9
Lower	Molar	Bone loss	4	13	7	4	2	30
		AMTL	1	8	5	8	0	22
		Present	57	55	18	12	14	156
		%Bone loss	7.0	23.6	38.9	33.3	14.3	19.2
		%AMTL	1.8	14.5	27.8	66.7	0.0	14.1
	Premolar	Bone loss	3	4	6	4	0	17
		AMTL	0	3	1	3	0	7
		Present	40	36	12	8	10	106
		%Bone loss	7.5	11.1	50.0	50.0	0.0	16.0
		%AMTL	0.0	8.3	8.3	37.5	0.0	6.6
	Canine	Bone loss	0	2	1	0	0	3
		AMTL	0	0	0	2	0	2
		Present	15	16	4	2	3	40
		%Bone loss	0.0	12.5	25.0	0.0	0.0	7.5
		%AMTL	0.0	0.0	0.0	100.0	0.0	5.0
	Incisor	Bone loss	0	0	4	2	3	9
		AMTL	0	2	0	4	0	6
		Present	36	31	12	6	8	93
		%Bone loss	0.0	0.0	33.3	33.3	37.5	9.7
		%AMTL	0.0	6.5	0.0	66.7	0.0	6.5
	Total	Bone loss	7	19	18	10	5	59
		AMTL	1	13	6	17	0	37
		Present	148	138	46	28	35	395
		%Bone loss	4.7	13.8	39.1	35.7	14.3	14.9
		%AMTL	0.7	9.4	13.0	60.7	0.0	9.4

Appendix Table 25 Ostojićevo female alveolar margin inventory by tooth location, tooth category, and age-at-death. ***Note*. *Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Adult I*	Adult II	Adult III	Adult IV	Adult?	TOTAL
Upper	Molar	Bone loss	3	4	8	3	9	27
		AMTL	1	2	2	13	2	20
		Present	39	21	10	19	15	104
		%Bone loss	7.7	19.0	80.0	15.8	60.0	26.0
		%AMTL	2.6	9.5	20.0	68.4	13.3	19.2
	Premolar	Bone loss	3	5	6	2	6	22
		AMTL	0	0	0	11	1	12
		Present	24	17	9	18	18	86
		%Bone loss	12.5	29.4	66.7	11.1	33.3	25.6
		%AMTL	0.0	0.0	0.0	61.1	5.6	14.0
	Canine	Bone loss	0	0	1	1	0	2
		AMTL	0	0	0	5	0	5
		Present	9	6	2	9	6	32
		%Bone loss	0.0	0.0	50.0	11.1	0.0	6.3
		%AMTL	0.0	0.0	0.0	55.6	0.0	15.6
	Incisor	Bone loss	1	0	7	0	3	11
		AMTL	0	0	1	12	0	13
		Present	19	14	10	15	13	71
		%Bone loss	5.3	0.0	70.0	0.0	23.1	15.5
		%AMTL	0.0	0.0	10.0	80.0	0.0	18.3
	Total	Bone loss	7	9	22	6	18	62
		AMTL	1	2	3	41	3	50
		Present	91	58	31	61	52	293
		%Bone loss	7.7	15.5	71.0	9.8	34.6	21.2
		%AMTL	1.1	3.4	9.7	67.2	5.8	17.1
Lower	Molar	Bone loss	2	15	7	6	33	63
		AMTL	1	9	13	34	7	64
		Present	32	44	21	41	43	181
		%Bone loss	6.3	34.1	33.3	14.6	76.7	34.8
		%AMTL	3.1	20.5	61.9	82.9	16.3	35.4
	Premolar	Bone loss	2	6	3	2	7	20
		AMTL	1	2	1	13	3	20
		Present	20	29	11	21	22	103
		%Bone loss	10.0	20.7	27.3	9.5	31.8	19.4
		%AMTL	5.0	6.9	9.1	61.9	13.6	19.4
	Canine	Bone loss	0	1	2	1	1	5
		AMTL	0	0	0	6	0	6
		Present	3	13	5	10	6	37
		%Bone loss	0.0	7.7	40.0	10.0	16.7	13.5
		%AMTL	0.0	0.0	0.0	60.0	0.0	16.2
	Incisor	Bone loss	2	1	1	2	2	8
		AMTL	0	0	1	10	4	15
		Present	8	23	11	21	20	83
		%Bone loss	25.0	4.3	9.1	9.5	10.0	9.6
		%AMTL	0.0	0.0	9.1	47.6	20.0	18.1
	Total	Bone loss	6	23	13	11	43	96
		AMTL	2	11	15	63	14	105
		Present	63	109	48	93	91	404
		%Bone loss	9.5	21.1	27.1	11.8	47.3	23.8
		%AMTL	3.2	10.1	31.3	67.7	15.4	26.0

Appendix Table 26 Ostojićevo total adult alveolar margin inventory by tooth location, tooth category, and age-at-death. ***Note*****. * Includes indeterminate adults; **Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Adult I**	Adult II	Adult III	Adult IV	Adult?	TOTAL
Upper TOTAL*	Molar	Bone loss	5	12	12	6	15	50
		AMTL	2	2	6	17	5	32
		Present	122	51	20	26	52	271
		%Bone loss	4.1	23.5	60.0	23.1	28.8	18.5
		%AMTL	1.6	3.9	30.0	65.4	9.6	11.8
	Premolar	Bone loss	4	10	8	4	11	37
		AMTL	1	0	4	12	2	19
		Present	85	38	18	25	45	211
		%Bone loss	4.7	26.3	44.4	16.0	24.4	17.5
		%AMTL	1.2	0.0	22.2	48.0	4.4	9.0
	Canine	Bone loss	0	6	5	2	4	17
		AMTL	0	0	0	5	0	5
		Present	37	16	8	11	19	91
		%Bone loss	0.0	37.5	62.5	18.2	21.1	18.7
		%AMTL	0.0	0.0	0.0	45.5	0.0	5.5
	Incisor	Bone loss	1	0	14	4	9	28
		AMTL	0	0	1	12	0	13
		Present	71	33	21	20	36	181
		%Bone loss	1.4	0.0	66.7	20.0	25.0	15.5
		%AMTL	0.0	0.0	4.8	60.0	0.0	7.2
	Total	Bone loss	10	28	39	16	39	132
		AMTL	3	2	11	46	7	69
		Present	315	138	67	82	152	754
		%Bone loss	3.2	20.3	58.2	19.5	25.7	17.5
		%AMTL	1.0	1.4	16.4	56.1	4.6	9.2
Lower TOTAL*	Molar	Bone loss	6	33	17	10	53	119
		AMTL	2	18	21	48	21	110
		Present	108	105	45	59	102	419
		%Bone loss	5.6	31.4	37.8	16.9	52.0	28.4
		%AMTL	1.9	17.1	46.7	81.4	20.6	26.3
	Premolar	Bone loss	5	14	12	6	13	50
		AMTL	1	5	3	18	11	38
		Present	69	69	27	31	56	252
		%Bone loss	7.2	20.3	44.4	19.4	23.2	19.8
		%AMTL	1.4	7.2	11.1	58.1	19.6	15.1
	Canine	Bone loss	0	5	3	1	3	12
		AMTL	0	0	0	9	2	11
		Present	22	31	11	13	19	96
		%Bone loss	0.0	16.1	27.3	7.7	15.8	12.5
		%AMTL	0.0	0.0	0.0	69.2	10.5	11.5
	Incisor	Bone loss	2	1	5	4	7	19
		AMTL	0	2	3	18	8	31
		Present	57	58	27	31	45	218
		%Bone loss	3.5	1.7	18.5	12.9	15.6	8.7
		%AMTL	0.0	3.4	11.1	58.1	17.8	14.2
	Total	Bone loss	13	53	37	21	76	200
		AMTL	3	25	27	93	42	190
		Present	256	263	110	134	222	985
		%Bone loss	5.1	20.2	33.6	15.7	34.2	20.3
		%AMTL	1.2	9.5	24.5	69.4	18.9	19.3

Appendix Table 27 Ostojićevo male permanent dental caries by tooth location, tooth category, and age-at-death. ***Note*****. *Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Child I/II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult?	TOTAL
Upper	Molar	None	9	10	11	48	26	8	1	9	122
		Slight	0	1	0	2	0	0	0	1	4
		Small	0	0	0	3	4	0	0	1	8
		Large	0	0	0	3	6	0	0	1	10
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	0.0	9.1	0.0	14.3	27.8	0.0	0.0	25.0	15.3
	Premolar	None	1	10	4	34	22	6	2	7	86
		Slight	0	0	0	0	2	0	0	0	2
		Small	0	0	0	2	1	0	0	0	3
		Large	0	0	0	1	2	0	0	0	3
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	0.0	0.0	0.0	8.1	18.5	0.0	0.0	0.0	8.5
	Canine	None	1	5	1	11	12	4	1	3	38
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	0	0	0	0	0
		Large	0	0	0	0	0	0	1	1	2
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	0.0	0.0	0.0	0.0	0.0	0.0	50.0	25.0	5.0
	Incisor	None	5	5	1	24	16	1	0	6	58
		Slight	0	0	0	0	1	0	0	0	1
		Small	0	0	0	0	0	0	0	0	0
		Large	0	0	0	0	1	0	0	0	1
		Complete	0	0	0	0	0	1	0	0	1
		% Caries	0.0	0.0	0.0	0.0	11.1	50.0	--	0.0	4.9
	Total	None	16	30	17	117	76	19	4	25	304
		Slight	0	1	0	2	3	0	0	1	7
		Small	0	0	0	5	5	0	0	1	11
		Large	0	0	0	4	9	0	1	2	16
		Complete	0	0	0	0	0	1	0	0	1
		% Caries	0.0	3.2	0.0	8.6	18.3	5.0	20.0	13.8	10.3
Lower	Molar	None	12	17	12	52	37	5	1	10	146
		Slight	0	0	0	0	1	2	0	1	4
		Small	0	0	0	1	1	0	0	2	4
		Large	0	1	0	2	2	0	0	2	7
		Complete	0	0	0	0	0	0	2	1	3
		% Caries	0.0	5.6	0.0	5.5	9.8	28.6	66.7	37.5	11.0
	Premolar	None	0	12	3	36	28	10	2	8	99
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	1	0	0	2	3
		Large	0	0	0	1	0	1	0	0	2
		Complete	0	0	0	0	0	0	1	0	1
		% Caries	--	0.0	0.0	2.7	3.4	9.1	33.3	20.0	5.7
	Canine	None	0	4	1	19	10	6	0	4	44
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	1	0	0	0	1
		Large	0	1	0	0	0	0	0	0	1
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	--	20.0	0.0	0.0	9.1	0.0	--	0.0	4.3

Incisor	**None**	5	10	2	27	13	6	1	2	66
	Slight	0	0	0	0	0	0	0	0	0
	Small	0	0	0	0	0	2	0	0	2
	Large	0	0	0	0	0	0	0	0	0
	Complete	0	0	0	0	2	0	0	0	2
	% Caries	0.0	0.0	0.0	0.0	13.3	25.0	0.0	0.0	5.7
Total	**None**	17	43	18	134	88	27	4	24	355
	Slight	0	0	0	0	1	2	0	1	4
	Small	0	0	0	1	3	2	0	4	10
	Large	0	2	0	3	2	1	0	2	10
	Complete	0	0	0	0	2	0	3	1	6
	% Caries	0.0	4.4	0.0	2.9	8.3	15.6	42.9	25.0	7.8

Appendix Table 28 Ostojićevo female permanent dental caries by tooth location, tooth category, and age-at-death. *Note*. *Adult I = 18-30 years.

Jaw	Tooth Type	Category	Child I/II	Juv. I	Juv. II	Adult I*	Adult II	Adult III	Adult IV	Adult?	TOTAL
Upper	Molar	None	16	1	19	25	11	1	5	19	97
		Slight	0	0	0	2	0	0	0	0	2
		Small	0	0	0	0	1	2	2	2	7
		Large	0	0	0	1	4	4	3	2	14
		Complete	0	0	0	1	1	0	0	1	3
		% Caries	0.0	0.0	0.0	13.8	35.3	85.7	50.0	20.8	21.1
	Premolar	None	0	0	11	18	10	2	4	15	60
		Slight	0	0	1	1	0	0	0	0	2
		Small	0	0	0	0	1	2	1	1	5
		Large	0	0	0	2	0	3	0	1	6
		Complete	0	0	0	1	2	0	0	1	4
		% Caries	--	--	8.3	18.2	23.1	71.4	20.0	16.7	22.1
	Canine	None	2	0	6	8	3	5	3	6	33
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	2	0	0	2	4
		Large	0	0	0	0	2	0	0	0	2
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	0.0	--	0.0	0.0	57.1	0.0	0.0	25.0	15.4
	Incisor	None	7	2	10	13	2	4	5	10	53
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	0	1	0	0	1
		Large	0	0	0	0	0	1	0	0	1
		Complete	0	0	0	0	1	0	0	0	1
		% Caries	0.0	0.0	0.0	0.0	33.3	33.3	0.0	0.0	5.4
	Total	None	25	3	46	64	26	12	17	50	243
		Slight	0	0	1	3	0	0	0	0	4
		Small	0	0	0	0	4	5	3	5	17
		Large	0	0	0	3	6	8	3	3	23
		Complete	0	0	0	2	4	0	0	2	8
		% Caries	0.0	0.0	2.1	11.1	35.0	52.0	26.1	16.7	17.6
Lower	Molar	None	14	1	21	20	16	0	6	19	97
		Slight	0	0	0	0	0	1	0	0	1
		Small	0	0	0	1	3	0	1	0	5
		Large	0	0	0	2	5	2	1	3	13
		Complete	0	0	0	1	2	0	0	1	4
		% Caries	0.0	0.0	0.0	16.7	38.5	100.0	25.0	17.4	19.2
	Premolar	None	0	0	12	17	15	8	5	17	74
		Slight	0	0	0	0	1	0	0	1	2
		Small	0	0	0	1	0	1	1	1	4
		Large	0	0	0	0	0	0	1	1	2
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	--	--	0.0	5.6	6.3	11.1	28.6	15.0	9.8
	Canine	None	1	0	5	8	8	1	3	7	33
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	0	1	0	0	1
		Large	0	0	0	0	2	0	0	0	2
		Complete	0	0	0	1	0	0	1	0	2
		% Caries	0.0	--	0.0	11.1	20.0	50.0	25.0	0.0	13.2

Incisor	**None**	13	0	9	9	9	7	6	11	64
	Slight	0	0	0	0	0	0	0	0	0
	Small	0	0	0	0	0	4	0	0	4
	Large	0	0	0	0	0	0	0	0	0
	Complete	0	0	0	0	3	0	0	0	3
	% Caries	0.0	--	0.0	0.0	25.0	36.4	0.0	0.0	9.9
Total	**None**	28	1	47	54	48	16	20	54	268
	Slight	0	0	0	0	1	1	0	1	3
	Small	0	0	0	2	3	6	2	1	14
	Large	0	0	0	2	7	2	2	4	17
	Complete	0	0	0	2	5	0	1	1	9
	% Caries	0.0	0.0	0.0	10.0	25.0	36.0	20.0	11.5	13.8

Appendix Table 29 Ostojićevo total adult permanent dental caries by tooth location, tooth category, and age-at-death. *Note*. *Includes indeterminate adults; **Adult I = 18-30 years.

Jaw	Tooth Type	Category	Child I/II	Juv. I	Juv. II	Adult I**	Adult II	Adult III	Adult IV	Adult?	TOTAL
Upper*	Molar	None	25	11	30	95	37	9	6	43	256
		Slight	0	1	0	4	0	0	0	2	7
		Small	0	0	0	3	5	2	2	5	17
		Large	0	0	0	5	10	5	3	7	30
		Complete	0	0	0	1	1	0	0	4	6
		% Caries	0.0	8.3	0.0	12.0	30.2	43.8	45.5	29.5	19.0
	Premolar	None	1	10	15	62	32	8	7	34	169
		Slight	0	0	1	3	2	0	0	1	7
		Small	0	0	0	2	2	2	1	1	8
		Large	0	0	0	4	3	3	0	2	12
		Complete	0	0	0	1	2	0	0	2	5
		% Caries	0.0	0.0	6.3	13.9	22.0	38.5	12.5	15.0	15.9
	Canine	None	3	5	7	24	15	9	4	17	84
		Slight	0	0	0	0	0	0	0	0	0
		Small	0	0	0	0	2	0	0	2	4
		Large	0	0	0	1	4	0	1	1	7
		Complete	0	0	0	0	0	0	0	0	0
		% Caries	0.0	0.0	0.0	4.0	28.6	0.0	20.0	15.0	11.6
	Incisor	None	12	7	11	42	18	5	5	22	122
		Slight	0	0	0	0	1	0	0	0	1
		Small	0	0	0	0	0	1	0	0	1
		Large	0	0	0	1	1	1	0	1	4
		Complete	0	0	0	0	1	1	0	0	2
		% Caries	0.0	0.0	0.0	2.3	14.3	37.5	0.0	4.3	6.2
	Total	None	41	33	63	223	102	31	22	116	631
		Slight	0	1	1	7	3	0	0	3	15
		Small	0	0	0	5	9	5	3	8	30
		Large	0	0	0	11	18	9	4	11	53
		Complete	0	0	0	2	4	1	0	6	13
		% Caries	0.0	2.9	1.6	10.1	25.0	32.6	24.1	19.4	15.0
Lower*	Molar	None	26	18	33	92	53	5	7	50	284
		Slight	0	0	0	0	1	3	0	1	5
		Small	0	0	0	2	4	0	1	4	11
		Large	0	1	0	4	7	2	1	8	23
		Complete	0	0	0	1	3	0	3	2	9
		% Caries	0.0	5.3	0.0	7.1	22.1	50.0	41.7	23.1	14.5
	Premolar	None	0	12	15	65	43	18	8	42	203
		Slight	0	0	0	0	1	0	0	1	2
		Small	0	0	0	1	1	1	1	3	7
		Large	0	0	0	1	0	1	2	1	5
		Complete	0	0	0	0	0	0	1	0	1
		% Caries	--	0.0	0.0	3.0	4.4	10.0	33.3	10.6	6.9
	Canine	None	1	4	6	34	18	8	4	19	94
		Slight	0	0	0	0	0	0	0	1	1
		Small	0	0	0	0	2	2	0	0	4
		Large	0	1	0	0	2	0	0	0	3
		Complete	0	0	0	1	0	0	1	0	2
		% Caries	0.0	20.0	0.0	2.9	18.2	20.0	20.0	5.0	9.6

Incisor	**None**	18	10	11	41	22	13	7	20	142
	Slight	0	0	0	0	0	0	0	0	0
	Small	0	0	0	0	0	6	0	1	7
	Large	0	0	0	0	0	0	0	1	1
	Complete	0	0	0	0	5	0	0	0	5
	% Caries	0.0	0.0	0.0	0.0	18.5	31.6	0.0	9.1	8.4
Total	**None**	45	44	65	232	136	44	26	131	723
	Slight	0	0	0	0	2	3	0	3	8
	Small	0	0	0	3	7	9	2	8	29
	Large	0	2	0	5	9	3	3	10	32
	Complete	0	0	0	2	8	0	5	2	17
	% Caries	0.0	4.3	0.0	4.1	16.0	25.4	27.8	14.9	10.6

Appendix Table 30 Ostojićevo carious lesions in deciduous teeth count and prevalence by tooth category, sex, and age-at-death. ***Note*****. 'Sex' based on body orientation (head location).**

Jaw/Tooth Type	Category	Male						Female					
		Neon.	Inf. I	Inf. II	Ch. I	Ch. II	Total	Neon.	Inf. I	Inf. II	Ch. I	Ch. II	Total
UPPER	**n-individual***	3	5	2	4	2	16	1	3	4	5	2	15
dm^1+dm^2	**None**	1	5	5	13	1	25	--	7	9	14	7	37
	Slight/Small	0	0	0	0	0	0	--	0	2	0	0	2
	Large	0	0	1	0	2	3	--	0	0	0	0	0
	Complete	0	0	0	0	0	0	--	0	0	0	0	0
	% Caries	0.0	0.0	16.7	0.0	66.7	10.7	--	0.0	18.2	0.0	0.0	5.1
dc	**None**	--	--	3	4	2	9	--	3	4	3	--	10
	Slight/Small	--	--	0	0	0	0	--	0	0	0	--	0
	Large	--	--	0	0	0	0	--	0	0	0	--	0
	Complete	--	--	0	0	0	0	--	0	0	0	--	0
	% Caries	--	--	0.0	0.0	0.0	0.0	--	0.0	0.0	0.0	--	0.0
di^2 + di^1	**None**	2	6	4	3	--	15	1	5	3	1	--	10
	Slight/Small	0	0	0	0	--	0	0	0	0	0	--	0
	Large	0	0	0	0	--	0	0	0	0	0	--	0
	Complete	0	0	0	0	--	0	0	0	0	0	--	0
	% Caries	0.0	0.0	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0	--	0.0
TOTAL	**None**	3	11	12	20	3	49	1	15	16	18	7	57
	Slight/Small	0	0	0	0	0	0	0	0	2	0	0	2
	Large	0	0	1	0	2	3	0	0	0	0	0	0
	Complete	0	0	0	0	0	0	0	0	0	0	0	0
	% Caries	0.0	0.0	7.7	0.0	40.0	5.8	0.0	0.0	11.1	0.0	0.0	3.4
LOWER	**n-individual***	2	4	2	4	1	13	2	3	4	5	2	16
dm_1+dm_2	**None**	2	8	4	14	0	28	1	10	13	18	6	48
	Slight/Small	0	0	0	1	2	3	0	0	1	0	0	1
	Large	0	0	0	0	1	1	0	0	0	0	0	0
	Complete	0	0	0	0	1	1	0	0	0	0	0	0
	% Caries	0.0	0.0	0.0	6.7	100.0	15.2	0.0	0.0	7.1	0.0	0.0	2.0
dc	**None**	--	--	2	--	--	2	--	2	3	--	--	5
	Slight/Small	--	--	0	--	--	0	--	0	0	--	--	0
	Large	--	--	0	--	--	0	--	0	0	--	--	0
	Complete	--	--	0	--	--	0	--	0	0	--	--	0
	% Caries	--	--	0.0	--	--	0.0	--	0.0	0.0	--	--	0.0
di_2 + di_1	**None**	1	1	--	1	--	3	1	2	7	--	--	10
	Slight/Small	0	0	--	0	--	0	1	0	0	--	--	1
	Large	0	0	--	0	--	0	0	0	0	--	--	0
	Complete	0	0	--	0	--	0	0	0	0	--	--	0
	% Caries	0.0	0.0	--	0.0	--	0.0	50.0	0.0	0.0	--	--	9.1
TOTAL	**None**	3	9	6	15	0	33	2	14	23	18	6	63
	Slight/Small	0	0	0	1	2	3	1	0	1	0	0	2
	Large	0	0	0	0	1	1	0	0	0	0	0	0
	Complete	0	0	0	0	1	1	0	0	0	0	0	0
	% Caries	0.0	0.0	0.0	6.3	100.0	13.2	33.3	0.0	4.2	0.0	0.0	3.1

Appendix Table 31 Ostojićevo male abscess count and prevalence by tooth type and age-at-death. ***Note*****.**

***Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Juv. I/II	Adult I*	Adult II	Adult III	Adult IV	Adult?	Total
Upper		n-Individual	5	12	7	4	2	3	33
	Molars	Healthy	15	56	27	8	4	8	118
		Abscess-Periapical	0	0	0	0	2	0	2
		Abscess-Continuous	0	1	3	1	0	0	5
		Abscess-Other	0	0	2	0	1	0	3.0
		% Abscess	0.0	1.8	15.6	11.1	42.9	0.0	7.8
	Premolars	Healthy	14	40	21	8	6	8	97
		Abscess-Periapical	0	1	0	0	1	0	2
		Abscess-Continuous	0	0	0	1	0	0	1
		Abscess-Other	0	0	1	0	0	1	2
		% Abscess	0.0	2.4	4.5	11.1	14.3	11.1	4.9
	Canines	Healthy	7	21	10	6	4	5	53
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	1	0	0	1
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	14.3	0.0	0.0	1.9
	Incisors	Healthy	10	43	21	13	6	10	103
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	1	0	0	1
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	7.1	0.0	0.0	1.0
	TOTAL	Healthy	46	160	79	35	20	31	371
		Abscess-Periapical	0	1	0	0	3	0	4
		Abscess-Continuous	0	1	3	4	0	0	8
		Abscess-Other	0	0	3	0	1	1	5
		% Abscess	0.0	1.2	7.1	10.3	16.7	3.1	4.4
Lower		n-Individual	6	12	10	4	2	4	38
	Molars	Healthy	31	57	54	17	9	13	181
		Abscess-Periapical	0	0	1	0	0	1	2
		Abscess-Continuous	0	0	0	1	3	0	4
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	1.8	5.6	25.0	7.1	3.2
	Premolars	Healthy	22	40	36	12	7	10	127
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	1	0	1
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	12.5	0.0	0.8
	Canines	Healthy	7	15	16	4	2	3	47
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	0	0	0
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Incisors	Healthy	13	36	31	12	6	8	106
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	0	0	0
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	Healthy	73	148	137	45	24	34	461
		Abscess-Periapical	0	0	1	0	0	1	2
		Abscess-Continuous	0	0	0	1	4	0	5
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.7	2.2	14.3	2.9	1.5

Appendix Table 32 Ostojićevo female abscess count and prevalence by tooth type and age-at-death. ***Note*****.**

***Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Juv. I/II	Adult I*	Adult II	Adult III	Adult IV	Adult?	Total
Upper		n-Individual	5	7	7	3	6	7	35
	Molars	Healthy	18	37	17	8	17	7	104
		Abscess-Periapical	0	1	0	1	0	1	3
		Abscess-Continuous	0	1	1	0	0	6	8
		Abscess-Other	0	0	1	1	0	2	4
		% Abscess	0.0	5.1	10.5	20.0	0.0	56.3	12.6
	Premolars	Healthy	14	23	19	9	14	21	100
		Abscess-Periapical	0	0	1	0	0	0	1
		Abscess-Continuous	0	0	1	0	2	0	3
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	9.5	0.0	12.5	0.0	3.8
	Canines	Healthy	8	12	10	4	8	11	53
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	0	0	0
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Incisors	Healthy	13	21	20	11	16	18	99
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	0	0	0
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	Healthy	53	93	66	32	55	57	356
		Abscess-Periapical	0	1	1	0	0	1	3
		Abscess-Continuous	0	1	2	0	2	6	11
		Abscess-Other	0	0	1	2	0	2	5
		% Abscess	0.0	2.1	5.7	5.9	3.5	13.6	5.1
Lower		n-Individual	5	7	10	5	9	8	44
	Molars	Healthy	23	29	39	17	36	36	180
		Abscess-Periapical	0	2	2	1	1	3	9
		Abscess-Continuous	0	1	4	3	2	3	13
		Abscess-Other	0	0	0	0	2	0	2
		% Abscess	0.0	9.4	13.3	19.0	12.2	14.3	11.8
	Premolars	Healthy	12	19	27	11	21	19	109
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	1	2	0	0	3	6
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	5.0	6.9	0.0	0.0	13.6	5.2
	Canines	Healthy	6	3	13	5	10	6	43
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	0	0	0
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Incisors	Healthy	11	6	23	11	21	19	91
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	2	0	0	0	1	3
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	25.0	0.0	0.0	0.0	5.0	3.2
	TOTAL	Healthy	52	57	102	44	88	80	423
		Abscess-Periapical	0	2	2	1	1	3	9
		Abscess-Continuous	0	4	6	3	2	7	22
		Abscess-Other	0	0	0	0	2	0	2
		% Abscess	0.0	9.5	7.3	8.3	5.4	11.1	7.2

Appendix Table 33 Ostojićevo total adult abscess count and prevalence by tooth type and age-at-death. ***Note*****.**

***Includes indeterminate adults; **Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Juv. I/II	Adult I**	Adult II	Adult III	Adult IV	Adult?	Total
Upper*		n-Individual	10	24	14	7	8	18	81
	Molars	Healthy	33	119	44	16	21	37	270
		Abscess-Periapical	0	1	0	1	2	2	6
		Abscess-Continuous	0	2	4	1	0	9	16
		Abscess-Other	0	0	3	1	1	3	8
		% Abscess	0.0	2.5	13.7	15.8	12.5	27.5	10.0
	Premolars	Healthy	28	83	40	17	20	45	233
		Abscess-Periapical	0	1	1	0	1	1	4
		Abscess-Continuous	0	0	1	1	2	0	4
		Abscess-Other	0	0	1	0	0	1	2
		% Abscess	0.0	1.2	7.0	5.6	13.0	4.3	4.1
	Canines	Healthy	15	42	20	10	12	26	125
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	1	0	0	1
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	9.1	0.0	0.0	0.8
	Incisors	Healthy	23	79	41	24	22	47	236
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	1	0	0	1
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	4.0	0.0	0.0	0.4
	TOTAL	Healthy	99	323	145	67	75	155	864
		Abscess-Periapical	0	2	1	1	3	3	10
		Abscess-Continuous	0	2	5	4	2	9	22
		Abscess-Other	0	0	4	1	1	4	10
		% Abscess	0.0	1.2	6.5	8.2	7.4	9.4	4.6
Lower*		n-Individual	11	23	21	10	12	23	100
	Molars	Healthy	54	105	97	40	51	90	437
		Abscess-Periapical	0	2	5	1	1	5	14
		Abscess-Continuous	0	1	4	4	5	6	20
		Abscess-Other	0	0	0	0	2	0	2
		% Abscess	0.0	2.8	8.5	11.1	13.6	10.9	7.6
	Premolars	Healthy	34	68	67	27	30	52	278
		Abscess-Periapical	0	0	0	0	0	1	1
		Abscess-Continuous	0	1	2	0	1	3	7
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	1.4	2.9	0.0	3.2	7.1	2.8
	Canines	Healthy	13	22	31	11	13	19	109
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	0	0	0	0	0	0
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Incisors	Healthy	24	55	58	27	31	44	239
		Abscess-Periapical	0	0	0	0	0	0	0
		Abscess-Continuous	0	2	0	0	0	1	3
		Abscess-Other	0	0	0	0	0	0	0
		% Abscess	0.0	3.5	0.0	0.0	0.0	2.2	1.2
	TOTAL	Healthy	125	250	253	105	125	205	1063
		Abscess-Periapical	0	2	5	1	1	6	15
		Abscess-Continuous	0	4	6	4	6	10	30
		Abscess-Other	0	0	0	0	2	0	2
		% Abscess	0.0	2.3	4.2	4.5	6.7	7.2	4.2

Appendix Table 34 Ostojićevo male calculus count and prevalence by tooth type and age-at-death. ***Note*****.**

***Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Child II	Juv. I/II	Adult I*	Adult II	Adult III	Adult IV	Adult?	Total
Upper		n-Individual	2	6	12	10	5	2	3	40
	Molars	Healthy	4	7	6	6	3	1	2	29
		Slight	0	6	7	4	0	0	0	17
		Moderate	2	6	16	3	4	1	3	35
		Heavy	2	3	20	9	1	0	3	38
		Gross	0	0	1	5	0	0	0	6
		% Calculus	50.0	68.2	88.0	77.8	62.5	50.0	75.0	76.8
	Premolars	Healthy	1	6	10	4	3	1	0	25
		Slight	0	3	9	9	1	0	0	22
		Moderate	0	3	5	5	2	1	3	19
		Heavy	0	2	10	4	0	0	4	20
		Gross	0	0	0	0	0	0	0	0
		% Calculus	0.0	57.1	70.6	81.8	50.0	50.0	100.0	70.9
	Canines	Healthy	0	0	4	1	2	1	0	8
		Slight	1	2	3	4	0	0	0	10
		Moderate	0	4	3	3	1	0	1	12
		Heavy	0	0	1	3	0	0	2	6
		Gross	0	0	0	0	0	0	0	0
		% Calculus	100.0	100.0	63.6	90.9	33.3	0.0	100.0	77.8
	Incisors	Healthy	3	2	5	3	0	--	1	14
		Slight	0	1	10	4	1	--	0	16
		Moderate	2	2	6	10	0	--	1	21
		Heavy	0	1	1	1	0	--	4	7
		Gross	0	0	0	0	0	--	0	0
		% Calculus	40.0	66.7	77.3	83.3	100.0	--	83.3	75.9
	TOTAL	Healthy	8	15	25	14	8	3	3	76
		Slight	1	12	29	21	2	0	0	65
		Moderate	4	15	30	21	7	2	8	87
		Heavy	2	6	32	17	1	0	13	71
		Gross	0	0	1	5	0	0	0	6
		% Calculus	46.7	68.8	78.6	82.1	55.6	40.0	87.5	75.1
Lower		n-Individual	2	6	12	10	5	1	5	41
	Molars	Healthy	8	6	2	6	2	3	3	30
		Slight	0	4	2	2	5	0	3	16
		Moderate	2	12	16	11	1	0	3	45
		Heavy	0	5	9	9	0	1	0	24
		Gross	0	1	2	3	0	0	2	8
		% Calculus	20.0	78.6	93.5	80.6	75.0	25.0	72.7	75.6
	Premolars	Healthy	--	2	1	5	1	2	1	12
		Slight	--	5	4	3	8	1	6	27
		Moderate	--	7	12	5	2	0	3	29
		Heavy	--	0	12	9	0	0	0	21
		Gross	--	0	0	3	0	0	0	3
		% Calculus	--	85.7	96.6	80.0	90.9	33.3	90.0	87.0
	Canines	Healthy	--	1	6	4	2	--	0	13
		Slight	--	0	1	3	3	--	1	8
		Moderate	--	3	4	2	1	--	1	11
		Heavy	--	1	4	2	0	--	1	8
		Gross	--	0	0	1	0	--	0	1
		% Calculus	--	80.0	60.0	66.7	66.7	--	100.0	68.3

Incisors	**Healthy**	5	1	5	3	0	--	0	14
	Slight	3	7	2	5	4	--	1	22
	Moderate	0	3	6	2	2	--	0	13
	Heavy	0	1	10	2	0	--	1	14
	Gross	0	0	0	1	0	--	0	1
	% Calculus	37.5	91.7	78.3	76.9	100.0	--	100.0	78.1
TOTAL	**Healthy**	13	10	14	18	5	5	4	69
	Slight	3	16	9	13	20	1	11	73
	Moderate	2	25	38	20	6	0	7	98
	Heavy	0	7	35	22	0	1	2	67
	Gross	0	1	2	8	0	0	2	13
	% Calculus	27.8	83.1	85.7	77.8	83.9	28.6	84.6	78.4

Appendix Table 35 Ostojićevo female calculus count and prevalence by tooth type and age-at-death. ***Note*****.**

***Adult I = 18-30 years.**

Jaw	Tooth Type	Category	Child II	Juv. I/II	Adult I*	Adult II	Adult III	Adult IV	Adult?	Total
Upper		n-Individual	2	5	8	6	3	3	7	34
	Molars	Healthy	12	9	7	3	3	0	6	40
		Slight	1	2	10	4	1	0	2	20
		Moderate	1	6	5	5	0	4	3	24
		Heavy	2	3	0	1	0	3	7	16
		Gross	0	0	0	0	2	0	1	3
		% Calculus	25.0	55.0	68.2	76.9	50.0	100.0	68.4	61.2
	Premolars	Healthy	--	6	5	8	2	2	5	28
		Slight	--	4	11	2	1	0	4	22
		Moderate	--	2	3	2	2	1	4	14
		Heavy	--	0	1	0	0	1	3	5
		Gross	--	0	0	0	0	0	0	0
		% Calculus	--	50.0	75.0	33.3	60.0	50.0	68.8	59.4
	Canines	Healthy	2	4	1	3	1	1	2	14
		Slight	0	1	3	2	1	0	1	8
		Moderate	0	0	3	2	2	1	3	11
		Heavy	0	1	0	0	0	0	1	2
		Gross	0	0	0	0	0	0	0	0
		% Calculus	0.0	33.3	85.7	57.1	75.0	50.0	71.4	60.0
	Incisors	Healthy	3	7	3	1	0	0	2	16
		Slight	1	1	3	1	4	0	4	14
		Moderate	1	0	2	0	2	2	2	9
		Heavy	2	3	2	0	0	1	0	8
		Gross	0	0	0	0	0	0	0	0
		% Calculus	57.1	36.4	70.0	50.0	100.0	100.0	75.0	66.0
	TOTAL	Healthy	17	26	16	15	6	3	15	98
		Slight	2	8	27	9	7	0	11	64
		Moderate	2	8	13	9	6	8	12	58
		Heavy	4	7	3	1	0	5	11	31
		Gross	0	0	0	0	2	0	1	3
		% Calculus	32.0	46.9	72.9	55.9	71.4	81.3	70.0	61.4
Lower		n-Individual	2	5	8	11	3	3	7	39
	Molars	Healthy	4	11	5	3	3	4	5	35
		Slight	1	1	4	6	0	2	4	18
		Moderate	2	5	3	7	0	2	3	22
		Heavy	5	5	6	5	0	1	5	27
		Gross	0	0	0	0	0	0	7	7
		% Calculus	66.7	50.0	72.2	85.7	0.0	55.6	79.2	67.9
	Premolars	Healthy	--	7	8	6	2	4	2	29
		Slight	--	1	6	4	1	0	6	18
		Moderate	--	3	4	7	3	2	5	24
		Heavy	--	0	1	1	1	0	4	7
		Gross	--	0	1	0	0	0	0	1
		% Calculus	--	36.4	60.0	66.7	71.4	33.3	88.2	63.3
	Canines	Healthy	1	2	3	5	0	3	3	17
		Slight	0	0	3	5	1	0	0	9
		Moderate	0	0	2	1	1	0	1	5
		Heavy	0	3	1	0	0	0	2	6
		Gross	0	0	0	0	0	0	0	0
		% Calculus	0.0	60.0	66.7	54.5	100.0	0.0	50.0	54.1

Incisors	**Healthy**	9	4	4	3	0	2	0	22
	Slight	0	0	2	6	0	0	0	8
	Moderate	4	1	2	3	3	0	5	18
	Heavy	0	3	0	0	3	2	4	12
	Gross	0	1	0	0	1	0	0	2
	% Calculus	30.8	55.6	50.0	75.0	100.0	50.0	100.0	64.5
TOTAL	**Healthy**	14	24	20	17	5	13	10	103
	Slight	1	2	15	21	2	2	10	53
	Moderate	6	9	11	18	7	4	14	69
	Heavy	5	11	8	6	4	3	15	52
	Gross	0	1	1	0	1	0	7	10
	% Calculus	46.2	48.9	63.6	72.6	73.7	40.9	82.1	64.1

Appendix Table 36 Ostojićevo total calculus count and prevalence by tooth type and age-at-death. *Note*. *Includes indeterminate adults; **Adult I = 18-30 years.

Jaw	Tooth Type	Category	Child II	Juv. I/II	Adult I**	Adult II	Adult III	Adult IV	Adult?	Total
Upper*		n-Individual	4	11	26	17	9	6	19	92
	Molars	Healthy	16	16	23	9	6	1	11	82
		Slight	1	8	22	8	1	0	11	51
		Moderate	3	12	24	8	5	5	11	68
		Heavy	4	6	25	10	1	3	14	63
		Gross	0	0	1	5	2	0	3	11
		% Calculus	33.3	61.9	75.8	77.5	60.0	88.9	78.0	70.2
	Premolars	Healthy	1	12	24	12	5	3	13	70
		Slight	0	7	24	12	2	1	7	53
		Moderate	0	5	10	7	4	2	10	38
		Heavy	0	2	11	4	0	1	7	25
		Gross	0	0	0	0	0	0	0	0
		% Calculus	0.0	53.8	65.2	65.7	54.5	57.1	64.9	62.4
	Canines	Healthy	2	4	9	4	3	2	3	27
		Slight	1	3	7	8	1	0	3	23
		Moderate	0	4	7	5	3	1	7	27
		Heavy	0	1	1	3	0	0	4	9
		Gross	0	0	0	0	0	0	0	0
		% Calculus	33.3	66.7	62.5	80.0	57.1	33.3	82.4	68.6
	Incisors	Healthy	6	9	11	4	0	0	7	37
		Slight	1	2	15	5	5	0	5	33
		Moderate	3	2	8	10	2	2	3	30
		Heavy	2	4	4	1	0	1	6	18
		Gross	0	0	0	0	0	0	0	0
		% Calculus	50.0	47.1	71.1	80.0	100.0	100.0	66.7	68.6
	TOTAL	Healthy	25	41	67	29	14	6	34	216
		Slight	3	20	68	33	9	1	26	160
		Moderate	6	23	49	30	14	10	31	163
		Heavy	6	13	41	18	1	5	31	115
		Gross	0	0	1	5	2	0	3	11
		% Calculus	37.5	57.7	70.4	74.8	65.0	72.7	72.8	67.5
Lower*		n-Individual	4	11	24	22	9	5	20	95
	Molars	Healthy	12	17	13	9	5	9	14	79
		Slight	1	5	10	9	5	2	10	42
		Moderate	4	17	22	18	1	3	15	80
		Heavy	5	10	17	16	0	2	13	63
		Gross	0	1	2	5	0	0	9	17
		% Calculus	45.5	66.0	79.7	84.2	54.5	43.8	77.0	71.9
	Premolars	Healthy	--	9	17	11	3	6	5	51
		Slight	--	6	12	7	9	2	12	48
		Moderate	--	10	17	12	5	3	13	60
		Heavy	--	0	14	10	1	0	12	37
		Gross	--	0	1	4	0	0	0	5
		% Calculus	--	64.0	72.1	75.0	83.3	45.5	88.1	74.6
	Canines	Healthy	1	3	14	9	2	4	5	38
		Slight	0	0	4	8	4	0	6	22
		Moderate	0	3	7	4	4	0	4	22
		Heavy	0	4	5	2	0	0	3	14
		Gross	0	0	0	1	0	0	0	1
		% Calculus	0.0	70.0	53.3	62.5	80.0	0.0	72.2	60.8

Incisors	**Healthy**	14	5	12	6	0	2	6	45
	Slight	3	7	5	11	4	0	3	33
	Moderate	4	4	9	5	5	0	5	32
	Heavy	0	4	10	2	3	2	5	26
	Gross	0	1	0	1	1	0	0	3
	% Calculus	33.3	76.2	66.7	76.0	100.0	50.0	68.4	67.6
TOTAL	**Healthy**	27	34	56	35	10	21	30	213
	Slight	4	18	31	35	22	4	31	145
	Moderate	8	34	55	39	15	6	37	194
	Heavy	5	18	46	30	4	4	33	140
	Gross	0	2	3	11	1	0	9	26
	% Calculus	38.6	67.9	70.7	76.7	80.8	40.0	78.6	70.3

Appendix Table 37 Ostojićevo dental calculus in deciduous teeth count and prevalence by tooth category, sex, and age-at-death. ***Note*****. * Number of individuals with at least one erupted deciduous tooth.**

Jaw/Tooth Type	Category	Male						Female					
		Neon.	Inf. I	Inf. II	Ch. I	Ch. II	Total	Neon.	Inf. I	Inf. II	Ch. I	Ch. II	Total
UPPER	**n-individual***	3	5	2	4	2	16	1	3	4	5	2	15
dm^1+dm^2	**None**	1	5	4	6	0	16	--	7	6	7	3	23
	Slight	0	0	1	2	0	3	--	0	4	3	1	8
	Moderate	0	0	1	5	1	7	--	0	1	3	1	5
	Heavy	0	0	0	0	2	2	--	0	0	1	2	3
	Gross	0	0	0	0	0	0	--	0	0	0	0	0
	% Calculus	0.0	0.0	33.3	53.8	100.0	42.9	--	0.0	45.5	50.0	57.1	41.0
dc	**None**	--	--	2	4	1	7	--	3	2	3	--	8
	Slight	--	--	1	0	0	1	--	0	1	0	--	1
	Moderate	--	--	0	0	1	1	--	0	1	0	--	1
	Heavy	--	--	0	0	0	0	--	0	0	0	--	0
	Gross	--	--	0	0	0	0	--	0	0	0	--	0
	% Calculus	--	--	33.3	0.0	50.0	22.2	--	0.0	50.0	0.0	--	20.0
di^2 + di^1	**None**	2	6	4	3	--	15	1	5	3	1	--	10
	Slight	0	0	0	0	--	0	0	0	0	0	--	0
	Moderate	0	0	0	0	--	0	0	0	0	0	--	0
	Heavy	0	0	0	0	--	0	0	0	0	0	--	0
	Gross	0	0	0	0	--	0	0	0	0	0	--	0
	% Calculus	0.0	0.0	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0	--	0.0
TOTAL	**None**	3	11	10	13	1	38	1	15	11	11	3	41
	Slight	0	0	2	2	0	4	0	0	5	3	1	9
	Moderate	0	0	1	5	2	8	0	0	2	3	1	6
	Heavy	0	0	0	0	2	2	0	0	0	1	2	3
	Gross	0	0	0	0	0	0	0	0	0	0	0	0
	% Calculus	0.0	0.0	23.1	35.0	80.0	26.9	0.0	0.0	38.9	38.9	57.1	30.5
LOWER	**n-individual***	2	4	2	4	1	13	2	3	4	5	2	16
dm_1+dm_2	**None**	2	8	3	5	1	19	1	9	12	9	1	32
	Slight	0	0	1	4	1	6	0	0	1	3	0	4
	Moderate	0	0	0	2	1	3	0	0	1	4	2	7
	Heavy	0	0	0	4	0	4	0	0	0	2	3	5
	Gross	0	0	0	0	0	0	0	0	0	0	0	0
	% Calculus	0.0	0.0	25.0	66.7	66.7	40.6	0.0	0.0	14.3	50.0	83.3	33.3
dc	**None**	--	--	1	--	--	1	--	2	2	--	--	4
	Slight	--	--	0	--	--	0	--	0	1	--	--	1
	Moderate	--	--	1	--	--	1	--	0	0	--	--	0
	Heavy	--	--	0	--	--	0	--	0	0	--	--	0
	Gross	--	--	0	--	--	0	--	0	0	--	--	0
	% Calculus	--	--	50.0	--	--	50.0	--	0.0	33.3	--	--	20.0
di_2 + di_1	**None**	1	1	--	1	--	3	2	2	4	--	--	8
	Slight	0	0	--	0	--	0	0	0	1	--	--	1
	Moderate	0	0	--	0	--	0	0	0	1	--	--	1
	Heavy	0	0	--	0	--	0	0	0	0	--	--	0
	Gross	0	0	--	0	--	0	0	0	0	--	--	0
	% Calculus	0.0	0.0	--	0.0	--	0.0	0.0	0.0	33.3	--	--	20.0
TOTAL	**None**	3	9	4	6	1	23	3	13	18	9	1	44
	Slight	0	0	1	4	1	6	0	0	3	3	0	6
	Moderate	0	0	1	2	1	4	0	0	2	4	2	8
	Heavy	0	0	0	4	0	4	0	0	0	2	3	5
	Gross	0	0	0	0	0	0	0	0	0	0	0	0
	% Calculus	0.0	0.0	33.3	62.5	66.7	37.8	0.0	0.0	21.7	50.0	83.3	30.2

Appendix Table 38 Human sample description, anthropological and archaeological information, and measurement data (i.e., stable isotope results, elemental composition, C/N ratios, and extraction yields). *Note*. Highlighted samples excluded based on low %N, %C, and/or C/N ratio outside 2.9-3.6. Note. High status inferred from presence of metal offering (i.e., copper, bronze, or gold), beaded necklace or belt (i.e., stone, shell, and/or copper beads), weapon burial (i.e., stone axe, copper axe, or copper dagger), baroque ceramic vessel, and/or >3 ceramic vessels (Milasinovic, 2009; O'Shea, 1995; 1996). High status further distinguished between metal and no metal.

Lab ID	Site	Grave #	Sex	Age	Head	Goods	Status	Status Notes	Element	$\delta^{15}N$	$\delta^{13}C$	%N	%C	C/N
4753	Ost.	6	F	Adult IV	S	1	Low		rib	11.6	-19.8	15.4	42.2	3.2
4759	Ost.	21	F	Adult II	W	1	High	metal	rib	10.9	-19.6	15.1	41.2	3.2
4760	Ost.	28	F	Adult I	S	1	Low		rib	11.2	-19.6	15.6	42.2	3.2
4761	Ost.	29	F	Adult I	S	0	Low		rib	11.5	-19.9	15.9	42.7	3.1
4762	Ost.	30	F	Adult I	S	1	Low		rib	10.0	-20.3	15.6	42.2	3.1
4763	Ost.	34	M	Adult III	N	1	Low		rib	12.1	-19.9	16.0	42.9	3.1
4765	Ost.	41	F	Adult I	S	1	High	no metal	rib	10.7	-19.7	16.1	43.4	3.2
4766	Ost.	42	F	Adult IV	S	1	Low		rib	11.6	-19.9	14.3	38.3	3.1
4767	Ost.	53	M	Adult II	N	0	Low		rib	11.2	-19.6	15.6	41.2	3.1
4768	Ost.	59	M	Adult I	S	1	Low		rib	11.2	-19.7	15.2	40.0	3.1
4769	Ost.	63	MI	Adult IV	N	0	Low		rib	10.2	-20.0	9.3	24.3	3.0
4770	Ost.	64	F	Adult III	S	1	Low		rib	11.8	-20.0	15.5	40.9	3.1
4771	Ost.	67	F	Adult IV	S	1	High	no metal	rib	10.9	-19.3	16.4	43.9	3.1
4772	Ost.	68	F?	Adult IV	S	1	High	no metal	rib	10.9	-19.7	15.1	39.8	3.1
4773	Ost.	69	F	Adult I	S	1	Low		rib	9.9	-19.9	11.5	30.6	3.1
4774	Ost.	78	F	Adult II	SE	0	Low		rib	10.8	-19.2	15.7	41.2	3.1
4776	Ost.	81	F	Adult IV	S	1	High		rib	11.5	-19.7	16.5	43.6	3.1
4777	Ost.	82	F	Adult I	S	1	High	metal	rib	11.4	-19.3	13.8	36.5	3.1
4778	Ost.	86	M	Adult II	E	1	High*	no metal; disturbed	rib	12.2	-20.3	5.3	14.9	3.3
4780	Ost.	92	F	Adult II	SE	1	Low		rib	11.1	-18.9	15.2	40.2	3.1
4781	Ost.	94	M	Adult I	N	1	High	metal	rib	11.0	-19.6	15.9	41.9	3.1
4782	Ost.	96	F	Adult II	W	0	Low		rib	10.0	-19.5	16.4	43.1	3.1
4783	Ost.	98	M	Adult II	S	1	Low		rib	11.2	-19.6	15.4	39.7	3.0
4784	Ost.	100	M	Adult I	N	1	High	no metal	rib	10.3	-19.5	9.2	25.1	3.2

Lab ID	Site	Grave #	Sex	Age	Head	Goods	Status	Status Notes	Element	$\delta^{15}N$	$\delta^{13}C$	%N	%C	C/N
4786	Ost.	106	M	Adult I	N	1	Low		rib	12.8	-20.2	14.4	37.1	3.0
4787	Ost.	107	M	Adult I	S	1	High	no metal	rib	11.1	-19.3	15.9	41.6	3.0
4788	Ost.	114	M	Adult I	S	1	High	no metal	rib	10.8	-19.0	15.3	40.3	3.1
4789	Ost.	115	F	Adult IV	S	1	High	metal	rib	11.2	-19.2	14.9	39.1	3.1
4792	Ost.	120	F	Adult I	S	1	High	metal	rib	11.4	-19.2	7.2	19.4	3.2
4793	Ost.	121	M	Adult II	S	1	High	metal	rib	10.1	-19.7	9.0	24.0	3.1
4797	Ost.	153	F	Juv II/Adult I	W	0	Low		rib	11.5	-19.7	8.7	23.3	3.1
4798	Ost.	155	F?	Adult III	NW	0	Low		rib	12.0	-17.2	16.5	42.9	3.0
4799	Ost.	156	M	Adult II	N	1	Low		rib	11.4	-19.3	11.6	30.6	3.1
4804	Ost.	176	F?	Juv II/Adult I	S	1	Low		rib	10.7	-19.3	12.4	32.9	3.1
4806	Ost.	191	F	Adult III	S	1	Low		rib	11.0	-19.8	15.4	39.7	3.0
4807	Ost.	199	M	Adult III	E	0	Low		rib	11.2	-19.8	13.5	35.2	3.0
4808	Ost.	203	M?	Adult IV	N	1	Low		rib	10.9	-19.5	5.0	14.1	3.3
4811	Ost.	208	F	Adult II	N	1	Low		rib	9.6	-19.7	16.3	41.6	3.0
4813	Ost.	212	M	Adult II	S	1	Low		rib	10.8	-20.1	10.0	26.0	3.0
4814	Ost.	213	F	Adult III	S	0	Low		rib	11.3	-19.5	16.2	41.3	3.0
4817	Ost.	224	F	Adult II	S	1	Low		rib	11.6	-19.7	13.1	34.0	3.0
4818	Ost.	226	M	Adult II	N	1	High	metal; stone ax	rib	11.4	-19.2	11.9	31.2	3.1
4821	Ost.	230	M	Adult I	N	1	High	metal	rib	11.9	-18.9	11.4	30.1	3.1
4823	Ost.	233	M	Adult IV	N	0	Low		rib	11.3	-19.5	15.5	37.8	2.8
4824	Ost.	235	M	Adult I	NW	0	Low		rib	11.6	-19.4	3.9	10.7	3.2
4826	Ost.	246	F	Adult IV	NW	0	Low		rib	10.8	-19.4	13.1	32.2	2.9
4828	Ost.	258	F	Adult IV	S	1	High	no metal	rib	10.8	-19.7	8.2	20.9	3.0
4829	Ost.	260	M	Juv II/Adult I	N	1	Low		rib	11.7	-19.4	9.8	24.4	2.9
4831	Ost.	264	F	Adult IV	S	1	High	metal	rib	11.8	-19.8	8.3	20.9	2.9
4832	Ost.	266	M	Adult III	N	1	Low	animal offering	rib	10.6	-19.8	14.0	36.3	3.0
4833	Ost.	269	M	Adult IV	N	1	Low	animal offering	rib	11.1	-19.4	11.5	30.0	3.0
4834	Ost.	270	M	Adult I	E	1	High	no metal	rib	11.1	-19.0	6.8	18.3	3.1
4835	Ost.	273	M	Adult III	N	1	Low	disturbed	rib	10.9	-18.9	5.2	14.0	3.2
4841	Ost.	66B	M	Adult II	S	1	High	no metal	rib	11.5	-19.7	11.0	29.9	3.2
4850	Mokrin	50	M	Adult I	N	0	Low		femur	9.7	-19.3	14.1	36.9	3.0
4851	Mokrin	69	F	Adult I	S	1	High	metal; stone ax (broken)	femur	10.2	-19.2	15.7	40.5	3.0
4852	Mokrin	81	M	Adult III	N	0	Low		femur	11.0	-19.1	14.2	36.8	3.0
4853	Mokrin	84	F	Adult IV	S	1	High	metal	femur	11.2	-19.2	16.4	41.4	3.0

Lab ID	Site	Grave #	Sex	Age	Head	Goods	Status	Status Notes	Element	$\delta^{15}N$	$\delta^{13}C$	%N	%C	C/N
4854	Mokrin	88	F	Adult I	N	0	Low		femur	10.9	-19.3	16.3	41.7	3.0
4855	Mokrin	92	M	Adult II	N	1	Low		femur	10.7	-19.2	16.8	43.1	3.0
4856	Mokrin	209	F	Adult III/IV	S	1	High	metal	fibula	10.6	-19.3	15.1	39.1	3.0
4857	Mokrin	217	M	Adult I/II	I	1	Low		rib	10.3	-19.2	16.1	41.8	3.0
4858	Mokrin	222	F	Adult II	SE	1	Low		rib	10.8	-19.1	17.4	43.9	2.9
4859	Mokrin	232	M	Adult I	N	1	High	no metal	rib	11.0	-19.1	17.0	43.0	3.0
4861	Mokrin	240	M	Adult III	N	1	High	metal	rib	10.2	-19.4	8.5	22.9	3.1
4862	Mokrin	243	M	Adult I	N	1	High	no metal; stone ax	rib	11.3	-19.0	6.7	18.1	3.1
4863	Mokrin	246	F	Adult III/IV	S	1	High	metal	rib	10.5	-19.2	3.0	8.7	3.4
4865	Mokrin	248	F	Adult III	S	1	High	metal	fibula	12.0	-19.4	9.9	26.4	3.1
4866	Mokrin	249	M	Adult IV	N	1	Low		rib	11.0	-19.1	15.9	41.5	3.0
4867	Mokrin	251	M	Adult III/IV	N	1	Low*	animal offering	rib	10.9	-19.1	5.7	15.9	3.2
4868	Mokrin	253	M	Adult I	N	0	Low		rib	10.9	-19.4	9.0	24.0	3.1
4869	Mokrin	259	M	Adult I/II	N	1	High	metal	rib	10.7	-19.1	13.6	37.1	3.2
4871	Mokrin	261	F	Adult I	S	1	Low*	1x cu bead	rib	10.2	-18.9	3.4	10.4	3.6
4872	Mokrin	270	F	Adult I	S	1	Low*	animal offering	rib	10.9	-19.4	3.4	10.3	3.6
4873	Mokrin	273	M	Adult IV	N	1	Low*	animal offering	rib	10.1	-19.4	15.6	41.9	3.1
4874	Mokrin	279	F	Adult I	S	1	Low		rib	10.6	-19.4	5.4	15.9	3.4
4875	Mokrin	281	M	Adult IV	S	1	Low		tibia	11.2	-19.2	5.5	15.8	3.4
4876	Mokrin	287	F	Adult II	S	1	High	metal	rib	10.9	-19.4	10.9	30.2	3.2
4878	Mokrin	293	F	Adult I	S	0	Low		rib	11.0	-19.5	5.7	16.8	3.4

Appendix Table 39 Faunal sample description, zooarchaeological and archaeological information, and measurement data (i.e., stable isotope results, elemental composition, C/N ratios, and extraction yields). ***Note*****. Highlighted samples excluded from analysis based on C/N. Note. Ost = Ostojićevo, KV = Klárafalva, KZ = Kiszombor.**

Lab ID	Site	Taxon	Common Name	Age	Context	Element	$\delta^{15}N$	$\delta^{13}C$	%N	%C	C/N
4842	Ost	*Canis familiaris*	dog	>6 mo.	Grave 14	3rd metatarsal	9.8	-20.6	15.4	38.0	2.9
4843	Ost	*Equus caballus*	horse		Grave 101	astragalus	7.3	-20.0	15.5	38.5	2.9
4844	Ost	*Ovis aries*	sheep	~10 mo.	Grave 106	humerus	7.9	-20.2	15.3	38.3	2.9
4845	Ost	*Bos taurus*	cow	~7-30 mo.	Grave 131	scapula	7.9	-19.6	16.6	41.0	2.9
4846	Ost	*Ovis aries*	sheep	>10 mo.	Grave 131	humerus	8.0	-18.4	16.5	40.0	2.8
4848	Ost	*Ovis aries*	sheep	<30-36 mos	Grave 209	femur	9.8	-17.3	16.3	40.8	2.9
4849	Ost	*Ovis aries*	sheep	10-36 mo.	Grave 270	humerus	9.8	-17.9	16.1	40.1	2.9
4879	KZ	Ovicapridae	sheep/goat	>10 mo.	Lot 127, Unit A	humerus	7.7	-18.9	17.2	46.5	3.2
4880	KZ	*Sus scrofa*	pig	>12 mo.	Lot 183, Unit A	radius	7.5	-20.0	18.3	49.5	3.2
4881	KZ	*Sus scrofa*	pig	<36-42 mo.	Lot 309, Trench 5 Unit 3/4 Feature 6	ulna	9.0	-20.6	17.1	46.6	3.2
4882	KZ	Ovicapridae	sheep/goat		Lot 321, Trench 5 Unit 3/4 Feature 6	metatarsal	6.1	-19.6	18.1	48.8	3.1
4883	KZ	*Bos taurus*	cow		Lot 349, Ditch Unit 3	metapodial	7.4	-19.9	18.1	49.3	3.2
4884	KZ	*Equus caballus*	horse	>24 mo.	Lot 409, Unit A	scapula	4.7	-21.0	16.3	44.2	3.2
4885	KZ	*Bos taurus*	cow	>27-36 mo.	Lot 491, Trench 1 Unit 1	metatarsal	7.6	-18.8	16.5	45.2	3.2
4886	KZ	*Bos taurus*	cow		Lot 572, Trench 1 Unit 2	ulna	6.6	-20.3	17.0	46.0	3.2
4887	KZ	*Bos taurus*	cow	>24-30 mo.	Lot 622, Trench 1 Unit 3	tibia	9.2	-19.8	18.1	48.8	3.1
4892	KF	*Sus scrofa*	pig	>12 mo.	Lot 91, Level C1	humerus	9.4	-21.1	18.2	48.1	3.1
4893	KF	*Cervus elaphus*	red deer		Lot 100, Level D1	humerus	7.2	-20.3	17.5	46.9	3.1
4894	KF	*Sus scrofa*	pig	<36-42 mo.	Lot 221, Level B2	ulna	8.0	-21.2	18.3	48.6	3.1
4895	KF	Ovicapridae	sheep/goat	>10 mo.	Lot 269, Level B (A) Feature 24 IL-1	radius	6.7	-19.6	18.0	47.9	3.1
4896	KF	*Bos taurus*	cow	>18 mo.	Lot 400, Level D1	phalanx 1	8.0	-19.0	18.3	48.3	3.1
4897	KF	*Cervus elaphus*	red deer		Lot 733, Level G1	phalanx 1	7.3	-21.3	17.2	45.6	3.1
4898	KF	*Sus scrofa*	pig	>24 mo.	Lot 737, Level G1	phalanx 1	10.5	-21.0	18.1	48.0	3.1

Bibliography

Acsádi, G., & Nemeskéri, J. (1970). *History of human life span and mortality*. Budapest, Hungary: Akadémiai Kiadó.

Adams, M. A., & Roughley, P. J. (2006). What is intervertebral disc degeneration, and what causes it? *Spine, 31*(18), 2151-2161. http://doi.org/10.1097/01.brs.0000231761.73859.2c

Agarwal, S. C. (2016). Bone morphologies and histories: Life course approaches in bioarchaeology. *American Journal of Physical Anthropology, 159*(S61), 130-149. http://doi.org/10.1002/ajpa.22905

Agel, J., Ransone, J., Dick, R., Oppliger, R., & Marshall, S. W. (2007). Descriptive epidemiology of collegiate men's wrestling injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *Journal of Athletic Training, 42*(2), 303-310.

Albandar, J. M. (2002). Global risk factors and risk indicators for periodontal diseases. *Periodontology, 29*(1), 177-206. http://doi.org/10.1034/j.1600-0757.2002.290109.x

Albanese, J. (2003). A metric method for sex determination using the hipbone and the femur. *Journal of Forensic Sciences, 48*(2), 263-273. http://doi.org/10.1520/JFS2001378

Allentoft, M. E., Sikora, M., Sjögren, K. G., Rasmussen, S., Rasmussen, M., Stenderup, J., ... & Malaspinas, A. S. (2015). Population genomics of bronze age Eurasia. *Nature, 522*(7555), 167-172. https://doi.org/10.1080/00438243.2016.1209124

Alvi, H. M., Kalainov, D. M., Biswas, D., Soneru, A. P., & Cohen, M. S. (2014). Surgical management of symptomatic olecranon traction spurs. *Orthopaedic Journal of Sports Medicine, 2*(7), 2325967114542775. http://doi.org/10.1177/2325967114542775

Ambrose, S. H. (1991). Effects of diet, climate and physiology on nitrogen isotope abundances in terrestrial foodwebs. *Journal of Archaeological Science, 18*(3), 293-317. http://doi.org/10.1016/0305-4403(91)90067-Y

Ambrose, S. H., Butler, B. M., Hanson, D. B., Hunter-Anderson, R. L., & Krueger, H. W. (1997). Stable isotopic analysis of human diet in the Marianas Archipelago, Western Pacific. *American Journal of Physical Anthropology, 104*(3), 343-361. http://doi.org/10.1002/(SICI)1096-8644(199711)104:3<343::AID-AJPA5>3.0.CO;2-W

Ambrose, S. H., & Norr, L. (1993). Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate. In J. B. Lambert & G. Grupe (Eds.), *Prehistoric human bone - archaeology at the molecular level* (pp. 1-38). Berlin: Springer-Verlag.

Amit, A., Sudish, K., & Pople, I. K. (2008). Primary calvarial cryptococcal osteomyelitis in a patient with idiopathic lymphopenia. *Acta Neurochirurgica, 150*(7), 713-714. doi:10.1007/s00701-008-1608-8

Ammermann, A. J., & Cavalli-Sforza, L. L. (1984). *The Neolithic transition and the genetics of populations in Europe*. Princeton, NJ: Princeton University Press.

Anderson, D. G. (1990). Stability and social change in chiefdom-level societies: An examination of Mississippian political evolution on the South Atlantic Slope. In M. Williams & G. Shapiro (Eds.), *Lamar archaeology: Mississippian chiefdoms in the deep south* (pp. 187-252). Tuscaloosa, AL: University of Alabama Press.

Angel, J. L. (1967). Porotic hyperostosis or osteoporosis symmetrica. In D. Brothwell & A.T. Sandison (Eds.), *Diseases in Antiquity* (pp. 373-389). Springfield, IL: Charles C. Thomas.

Antal, G. M., Lukehart, S. A., & Meheus, A. Z. (2002). The endemic treponematoses. *Microbes and Infection, 4,* 83-94.

Apley, A. G., & Solomon, L. (2000). *Concise system of orthopaedics and fractures*. London: Arnold.

Appleby, J. (2010). Ageing as fragmentation and dis-integration. In K. Rebay-Salisbury, M. L. S. Sørensen, & J. Hughes (Eds.), *Body parts and bodies whole: Changing relations and meanings* (pp. 46-53). Oxford: Oxbow Books.

Aranda-Jiménez, G., Montón-Subías, S., & Jiménez-Brobeil, S. (2009). Conflicting evidence? Weapons and skeletons in the Bronze Age of south-east Iberia. *Antiquity, 83*(322), 1038-1051. https://doi.org/10.1017/S0003598X00099336

Arifeen, S., Black, R. E., Antelman, G., Baqui, A., Caulfield, L., & Becker, S. (2001). Exclusive breastfeeding reduces acute respiratory infection and diarrhea deaths among infants in Dhaka slums. *Pediatrics, 108*(4), e67-e67. https://doi.org/10.1542/peds.108.4.e67

Armelagos, G. J., Goodman, A. H., Harper, K. N., & Blakey, M. L. (2009). Enamel hypoplasia and early mortality: Bioarcheological support for the Barker hypothesis. *Evolutionary Anthropology, 18*(6), 261-271. https://doi.org/10.1002/evan.20239

Armelagos, G. J., Sirak, K., Werkema, T., & Turner, B. L. (2014). Analysis of nutritional disease in prehistory: The search for scurvy in antiquity and today. *International Journal of Paleopathology, 5*, 9-17. https://doi.org/10.1016/j.ijpp.2013.09.007

Armit, I., Knüsel, C., Robb, J., & Schulting, R. (2007). Warfare and violence in prehistoric Europe: An introduction. In T. Pollard & I. Banks (Eds.) *War and sacrifice: Studies in the archaeology of conflict* (pp. 1-11). Leiden, The Netherlands: Brill.

Arnold, B. (1990). The past as propaganda: totalitarian archaeology in Nazi Germany. *Antiquity, 64*(244), 464-478. http://doi.org/10.1017/S0003598X00078376

Arnold, B. (1991). *The deposed princess of Vix: The need for an engendered European prehistory.* Paper presented at the archaeology of gender: Proceedings of the 22nd Annual Chacmool Conference.

Arnold, B. (1995). 'Honorary males' or women of substance? Gender, status, and power in Iron-Age Europe. *Journal of European Archaeology Archive, 3*(2), 153-168. http://doi.org/10.1179/096576695800703757

Arnold, E. R., & Greenfield, H. J. (2006). The origins of transhumant pastoralism in temperate southeastern Europe. In E. C. Robertson, J. D. Seibert, D. Fernandez, C., & M. U. Zender (Eds.), *Space and spatial analysis in archaeology* (pp. 243-251). Calgary, Canada: University of Calgary Press.

Artursson, M. (2010). Settlement structure and organisation. In T. K. Earle & K. Kristiansen (Eds.), *Organizing Bronze Age societies: the Mediterranean, Central Europe, and Scandinavia compared* (pp. 87-121). Cambridge: Cambridge University Press.

Aufderheide, A. C., & Rodríguez-Martín, C. (1998). *The Cambridge encyclopedia of human paleopathology*. Cambridge: Cambridge University Press.

Bader, T. (1978). *Epoca Bronzului în Nord-Vestul Transilvanei*. Bucharest, Romania: Bucharest Editura Ştiinţifică şi Enciclopedică.

BAKOTA (2020). An NSF REU site: The Bronze Age Körös Off-Tell Archaeology Project. Retrieved from http://bakota.net/

Bamforth, D. B. (1994). Indigenous people, indigenous violence: Precontact warfare on the North American Great Plains. *Man*, 95-115.

Bándi, G., & Nemeskéri, J. (1971). Die mittlere Bronzezeit Ungarns und ihre südöstlichen Beziehungen. *Alba Regia, 11*, 7-34.

Bankoff, A. (2004). The Early and Middle Bronze Age in the Balkans. In P. Bogucki & P. Crabtree (Eds.), *Ancient Europe 8000 B.C.-A.D. 1000: Encyclopedia of the barbarian world Vol. I and II.* New York, NY: Charles Scribner & Sons.

Bankoff, A., & Winter, F. A. (1990). The Late Aeneolithic in Southeastern Europe. *American Journal of Archaeology, 94*(2), 175-191. http://doi.org/10.2307/505948

Bankoff, A. H., Mitrovi, S., Arsić, R., Boger, R., Filipović, V., Huska, A., & Powell, W. (2011). Tin sources and settlement in the Bronze Age of south-eastern Europe: A pilot study from western Serbia. *Antiquity, 85*(327), Project Gallery.

Bankoff, H. A., & Winter, F. A. (1982). The Morava Valley project in Yugoslavia: Preliminary report, 1977–1980. *Journal of Field Archaeology, 9*(2), 149-164. http://doi.org/10.1179/009346982791504661

Bankoff, H. A., Winter, F. A., & Greenfield, H. J. (1980). Archaeological survey in the Lower Morava Valley, Yugoslavia. *Current Anthropology, 21*(2), 268-269. http://doi.org/10.1086/202446

Banner, J. (1931). A Marosvidék bronzkori zsugoritott temetkezéseinek sirmellékletei. *Dolgozatak Szeged, VII*, 1-53.

Banner, J. (1955). Research on the Hungarian Bronze Age since 1936 and the Bronze-Age settlement at Békés-Várdomb. In J. G. D. Clark (Ed.), *Proceedings of the Prehistory Society for 1955* (Vol. XXI, pp. 123-143). London: H.K. Lewis & Co.

Barić, D. (2011). Les provinces orientales de l’empire des Habsbourg. *Annuaire de l'École pratique des hautes études (EPHE), Section des sciences historiques et philologiques, 141*, 295-297.

Barlett, P. F. (1980). Adaptive strategies in peasant agricultural production. *Annual Review of Anthropology*, *9*, 545-573. http://doi.org/10.2307/2155747

Bátora, J. (1990). The latest knowledge on the burial rite of the people of the Nitra group. *Anthropologie XXVIII, 2-3*, 169-174.

Bátora, J. (2002). Contribution to the problem of "craftsmen" graves at the end of the Aeneolithic and in the Early Bronze Age in Central, Western and Eastern Europe. *Slovenska Archeologija*, *L-2*, 179-228.

BEAN (2017). BEAN – Bridging the European and Anatolian Neolithic: Demography, Migration, and Lifestyle at the Advent of Civilization. Retrieved from https://cordis.europa.eu/project/id/289966

Beck, M., Kalhor, M., Leunig, M., & Ganz, R. (2005). Hip morphology influences the pattern of damage to the acetabular cartilage. *The Journal of Bone and Joint Surgery. British volume*, *87-B*(7), 1012-1018. http://doi.org/10.1302/0301-620x.87b7.15203

Behrensmeyer, A. K. (1978). Taphonomic and ecologic information from bone weathering. *Paleobiology*, *4*(02), 150-162.

Beiswanger, B. B., Segreto, V. A., Mallatt, M. E., & Pfeiffer, H. J. (1989). The prevalence and incidence of dental calculus in adults. *The Journal of Clinical Dentistry*, *1*(3), 55-58.

Belcastro, G., Rastelli, E., Mariotti, V., Consiglio, C., Facchini, F., & Bonfiglioli, B. (2007). Continuity or discontinuity of the life-style in central Italy during the Roman Imperial Age-Early Middle Ages transition: Diet, health, and behavior. *American Journal of Physical Anthropology*, *132*(3), 381-394. http://doi.org/10.1002/ajpa.20530

Bello, S., & Andrews, P. (2009). The intrinsic pattern of preservation of human skeletons and its influence on the interpretation of human behaviours. In R. Gowland & C. Knüsel (Eds.), *Social archaeology of funerary remains* (pp. 1-13). Oxford: Oxbow.

Bengtsson, T., & Lindstrom, M. (2000). Childhood misery and disease in later life: The effects on mortality in old age of hazards experienced in early life, southern Sweden, 1760-1894. *Population Studies*, *54*(3), 263-277. http://doi.org/10.1080/713779096

Bereczki, Z., & Marcsik, A. (2005). Trephined skulls from ancient populations in Hungary. *Acta Medica Lituanica*, *12*(1), 65-69.

Bereczki, Z., Molnár, E., Marcsik, A., & Pálfi, G. (2015). Rare types of trephination from Hungary shed new light on possible cross-cultural connections in the Carpathian Basin. *International Journal of Osteoarchaeology*, *25*(3), 322-333. http://doi.org/10.1002/oa.2304

Bergerbrant, S. (2007). *Bronze Age identities: Costume, conflict and contact in northern Europe 1600-1300 BC*. Lindome, Sweden: Bricolear Press.

Bergström, J. (1999). Tobacco smoking and supragingival dental calculus. *Journal of Clinical Periodontology*, *26*(8), 541-547. http://doi.org/10.1034/j.1600-051X.1999.260808.x

Binford, L. R. (1965). Archaeological systematics and the study of culture process. *American Antiquity*, *2*(1), 203-210.

Binford, L. R. (1971). Mortuary practices: Their study and their potential. *Memoirs of the Society for American Archaeology, 25*, 6-29.

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., . . . Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet, 371*(9608), 243-260. https://doi.org/10.1016/S0140-6736(07)61690-0

Blakey, M. L. (1998). The New York African Burial Ground Project: An examination of enslaved lives, a construction of ancestral ties. *Transforming anthropology, 7*(1), 53-58. https://doi.org/10.1525/tran.1998.7.1.53

Boas, F. (1902). Rudolf Virchow's anthropological work. *Science, 16*(403), 441-445.

Bocherens, H., & Drucker, D. (2003). Trophic level isotopic enrichment of carbon and nitrogen in bone collagen: case studies from recent and ancient terrestrial ecosystems. *International Journal of Osteoarchaeology, 13*(1-2), 46-53. http://doi.org/10.1002/oa.662

Boel, L. W. T., & Ortner, D. J. (2013). Skeletal manifestations of skin ulcer in the lower leg. *International Journal of Osteoarchaeology, 23*(3), 303-309. http://doi.org/10.1002/oa.1248

Bogaard, A. (2005). 'Garden agriculture' and the nature of early farming in Europe and the near East. *World Archaeology, 37*(2), 177-196. http://doi.org/10.2307/40024228

Bogdanovic, I. D. (1996). The Early to Middle Bronze Age transition from the aspect of metal objects manufacture. In N. Tasić (Ed.), *The Yugoslav Danube basin and the neighbouring regions in the 2nd millennium BC*. Belgrade, Serbia: Serbian Academy of Science and Arts Institute for Balkan Studies.

Bogucki, P., & Grygiel, R. (1993). The first farmers of central Europe: A survey article. *Journal of Field Archaeology, 20*(4), 399-426. http://doi.org/10.2307/530071

Bökönyi, S. (1971). The development and history of domestic animals in Hungary: The Neolithic through the Middle Ages. *American Anthropologist, 73*(3), 640-674. http://doi.org/10.2307/671760

Bökönyi, S. (1972). Animal remains from the graves of the Bronze Age cemetery at Mokrin. In M. Girić (Ed.), *Mokrin, The Early Bronze Age necropolis* (Vol. II, pp. 91-96). Washington, D.C.: Smithsonian.

Bökönyi, S. (1980). The importance of horse domestication in economy and transport. In P. Sorbom (Ed.), *Transport technology and social change* (pp. 14-21). Stockholm, Sweden: Tekniska Museet Symposium Committee.

Boldsen, J. L., & Paine, R. R. (1995). The evolution of human longevity from the Mesolithic to the Middle Ages: An analysis based on skeletal data. In B. Jeune & J. W. Vaupel (Eds.), *Exceptional Longevity: From prehistory to the present. Odense University Press: Odense* (pp. 25-36). Odense, Denmark: Odense University Press.

Bóna, I. (1958). Chronologie der hortfunde vom Koszider-Typus. *Acta Archaeologica Hungaricae, 9,* 211-243.

Bóna, I. (1965). The peoples of southern origin of the Early Bronze Age in Hungary, I. The Pitvaros Group. *Alba Regia*, *4/5*, 17-63.

Bóna, I. (1975). *Die mittlere Bronzezeit Ungarns und ihre südöstlichen beziehungen*. Budapest, Hungary: Akadémiai Kiadó.

Bóna, I. (1994). Les cultures des tells de l'age du bronze en Hongrie. In I. Bóna & P. Raczky (Eds.), *Le Bel Age du Bronze en Hongrie* (pp. 9-39). Mont Beuvray, France: Centre Européen d'Archéologie du Mont-Beuvray.

Bonsall, C., Cook, G. T., Hedges, R. E. M., Higham, T. F. G., Pickard, C., & Radovanovic, I. (2004). Radiocarbon and stable isotope evidence of dietary change from the Mesolithic to the Middle Ages in the Iron Gates: New results from Lepenski Vir. *Radiocarbon, 46*(1), 293-300. https://doi.org/10.1017/S0033822200039606

Borić, D., & Price, T. D. (2013). Strontium isotopes document greater human mobility at the start of the Balkan Neolithic. *Proceedings of the National Academy of Sciences*, *110*(9), 3298-3303. http://doi.org/10.1073/pnas.1211474110

Borić, D., & Stefanović, S. (2015). Birth and death: Infant burials from Vlasac and Lepenski Vir. *Antiquity*, *78*(301), 526-546. http://doi.org/10.1017/S0003598X00113201

Boocock, P., Roberts, C. A., & Manchester, K. (1995). Maxillary sinusitis in medieval Chichester, England. *American Journal of Physical Anthropology, 98*(4), 483-495. https://doi.org/10.1002/ajpa.1330980408

Bradshaw, D. J., & Lynch, R. J. M. (2013). Diet and the microbial aetiology of dental caries: new paradigms. *International Dental Journal*, *63*(s2), 64-72. http://doi.org/10.1111/idj.12082

Brickley, M., & Ives, R. (2008). *The bioarchaeology of metabolic bone disease*. Oxford: Elsevier.

Bridges, P. S. (1994). Vertebral arthritis and physical activities in the prehistoric Southeastern United States. *American Journal of Physical Anthropology, 93*(1), 83-93. http://doi.org/10.1002/ajpa.1330930106

Britton, K., Müldner, G., & Bell, M. (2008). Stable isotope evidence for salt-marsh grazing in the Bronze Age Severn Estuary, UK: Implications for palaeodietary analysis at coastal sites. *Journal of Archaeological Science, 35*(8), 2111-2118. https://doi.org/10.1016/j.jas.2008.01.012

Broca, P. (1876). Sur les trépanations préhistoriques. *Bulletins et mémoires de la Société d'anthropologie de Paris*, 236-256.

Brogden, M. (2001). *Geronticide: Killing the elderly*. London: Jessica Kinglsey Publishers.

Brickley, M., & Ives, R. (2008). *The bioarchaeology of metabolic bone disease*. Oxford: Elsevier.

Brink, O., Vesterby, A., & Jensen, J. (1998). Pattern of injuries due to interpersonal violence. *Injury, 29*(9), 705-709. https://doi.org/10.1016/S0020-1383(98)00176-4

Brooks, S., & Suchey, J. M. (1990). Skeletal age determination based on the os pubis: A comparison of the Acsadi and Suchey-Brooks methods. *Human Evolution*, *5*, 227-238. http://doi.org/10.1007/BF02437238

Brothwell, D.R. (1981). *Digging up bones: The excavation, treatment, and study of human skeletal remains*. Ithaca, NY: Cornell University Press.

Brown, J. K. (1970). Economic organization and the position of women among the Iroquois. *Ethnohistory, 17*(3/4), 151-167. http://doi.org/10.2307/481207

Brukner, P., Bradshaw, C., Khan, K. M., White, S., & Crossley, K. (1996). Stress fractures: A review of 180 cases. *Clinical Journal of Sport Medicine*, *6*, 85-89.

Bruneteau, R. J., & Mulliken, J. B. (1992). Frontal plagiocephaly: Synostotic, compensational, or deformational. *Plastic and Reconstructive Surgery, 89*(1), 21-33.

Buckberry, J. L., & Chamberlain, A. T. (2002). Age estimation from the auricular surface of the ilium: A revised method. *American Journal of Physical Anthropology, 119*(3), 231-239. https://doi.org/10.1002/ajpa.10130

Buckley, H. R., & Dias, G. J. (2002). The distribution of skeletal lesions in treponemal disease: Is the Lymphatic system responsible? *International Journal of Osteoarchaeology, 12*, 178-188. https://doi.org/10.1002/oa.606

Budden, S., & Sofaer, J. (2009). Non-discursive knowledge and the construction of identity: Potters, potting, and performance at the Bronze Age tell of Szazhalombatta, Hungary. *Cambridge Archaeological Journal*, *19*, 203-220. https://doi.org/10.1017/S0959774309000274

Buhr, A. J., & Cooke, A. M. (1959). Fracture patterns. *The Lancet*, *273*(7072), 531-536. https://doi.org/10.1016/S0140-6736(59)92306-2

Buikstra, J., & Ubelaker, D. (Eds.). (1994). *Standards for data collection from human skeletal remains*. Fayetteville, AR: Arkansas Archaeological Survey.

Burton, J. H., & Price, T. D. (2000). The use and abuse of trace elements for paleodietary research. In S. H. Ambrose & M. A. Katzenberg (Eds.), *Biogeochemical approaches to paleodietary analysis* (pp. 159-171). New York, NY: Kluwer Academic/Plenum.

Byers, S. N. (2017). *Introduction to forensic anthropology, 5th edition*. New York, NY: Routledge.

Cardoso, H. F. (2007). Environmental effects on skeletal versus dental development: Using a documented subadult skeletal sample to test a basic assumption in human osteological research. *American Journal of Physical Anthropology, 132*(2), 223-233. http://doi.org/10.1002/ajpa.20482

Carman, J. (1999). Beyond the Western way of war: Ancient battlefields in comparative perspective. In J. Carman & A. F. Harding (Eds.), *Ancient warfare: Archaeological perspectives* (pp. 39-72). Phoenix Mill, UK: Sutton.

Cassman, V., & Odegaard, N. (2007). Storage and transport. In V. Cassman, N. Odegaard, & J. Powell (Eds.), *Human remains: Guide for museums and academic institutions* (pp. 103-128). Lanham, MD: AltaMira.

Čemere, Z. (Ed.) (2012). *Milorad Girić, Putovanje u Praistoriju*. Kikinda, Serbia: Istorijski Arhiv Kikinda.

Cerović, L., Kumović, M., & Smiljanić, M. (Eds.). (1997). *The Museum of Vojvodina: Permanent exhibition*. Novi Sad, Serbia: The Museum of Vojvodina.

Chaffin, D. B., & Park, K. S. (1973). A longitudinal study of low-back pain as associated with occupational weight lifting factors. *American Industrial Hygiene Association Journal, 34*(12), 513-525. http://doi.org/10.1080/0002889738506892

Chamberlain, A. (1994). *Human remains*. Berkeley, CA: The University of California Press.

Chamberlain, A. (2006). *Demography in archaeology*. Cambridge: Cambridge University Press.

Champion, T. (1982). Fortification, ranking and subsistence. In C. Renfrew & S. Shennan (Eds.), *Ranking, resource and exchange: Aspects of the archaeology of early European society* (pp. 61-66). Cambridge: Cambridge University Press.

Champion, T. (2009). The Later Bronze Age. In J. Hunter & I. Ralston (Eds.), *The archaeology of Britain: An introduction from earliest times to the twenty-first century, 2nd ed.* (pp. 144-166). London: Routledge.

Chang, A. C., Destouet, J. M., & Murphy, W. A. (1984). Musculoskeletal sporotrichosis. *Skeletal Radiology, 12*(1), 23-28. http://doi.org/10.1007/bf00373171

Chapman, J. (1994). Social power in early farming communities of Eastern Hungary - perspectives from the Upper Tisza region. *A Josa Andras Muzeum Evkonyve, 36*, 79-100.

Chapman, J. (1999). The origins of warfare in the prehistory of Central and Eastern Europe. In J. Chapman & A. F. Harding (Eds.), *Ancient warfare: Archaeological perspectives* (pp. 101-142). Phoenix Mill, UK: Sutton.

Chapman, J. (2005). Mortuary analysis: A matter of time? In G. F. M. Rakita, J. E. Buikstra, L. E. Beck, & S. R. Williams (Eds.), *Interacting with the dead: Perspectives on mortuary archaeology for the new millennium* (pp. 25-40). Gainesville, FL: University Press of Florida.

Chapman, R. (2008). Producing inequalities: regional sequences in later prehistoric southern Spain. *Journal of World Prehistory, 21*(3-4), 195. http://doi.org/10.1007/s10963-008-9014-y

Chapman, J. (2009). The Danube and settlement prehistory – 80 years on. *European Journal of Archaeology, 12*(1-3), 145-156. http://doi.org/10.1177/1461957109342798

Chapman, J., & Dolukhanov, P. M. (1992). The baby and the bathwater: Pulling the plug on migrations. *American Anthropologist, 94*(1), 169-174. https://doi.org/10.1525/aa.1992.94.1.02a00130

Chapple, I. L., Bouchard, P., Cagetti, M. G., Campus, G., Carra, M. C., Cocco, F., ... & Manton, D. J. (2017). Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. *Journal of Clinical Periodontology, 44*, S39-S51. https://doi.org/10.1111/jcpe.12685

Chen, A. L., & Koval, K. J. (2002). Elder abuse: the role of the orthopaedic surgeon in diagnosis and management. *Journal of the American Academy of Orthopaedic Surgeons*, *10*(1), 25-31.

Chernykh, E. N. (1992). *Ancient metallurgy in the USSR: The early metal age* (S. Wright, Trans.). Cambridge: Cambridge University Press.

Chhem, R. K., Saab, G., & Browthwell, D. R. (2008). Diagnostic paleoradiology for paleopathologists. In R. K. Chhem & D. R. Brothwell (Eds.), *Paleoradiology: Imaging mummies and fossils* (pp. 73-118). Berlin: Springer-Verlag.

Childe, V. G. (1925). *The dawn of European civilization*. London: K. Paul, Trench, Trubner & Co.

Childe, V. G. (1929). *The Danube in prehistory*. Oxford: Clarendon Press.

Childe, V. G. (1930). *The Bronze Age*. New York: The Macmillan Company.

Childe, V.G. (1954). Part 1: Prehistory. In E. Barker, G. Clark, & P. Vaucher (Eds.), *The European inheritance*, Vol.I (pp. 3–38). Oxford: Clarendon Press.

Chow, J. C. Y., Weiss, M. A., & Gu, Y. (2005). Anatomic variations of the hook of hamate and the relationship to carpal tunnel syndrome. *The Journal of Hand Surgery*, *30*(6), 1242-1247. doi:https://doi.org/10.1016/j.jhsa.2005.05.018

Christersson, L. A., Grossi, S. G., Dunford, R. G., Machtei, E. E., & Genco, R. J. (1992). Dental plaque and calculus: risk indicators for their formation. *Journal of Dental Research, 71*(7), 1425-1430. http://doi.org/10.1177/00220345920710071401

Chun, K. A., Stephanie, S., Choi, J. Y., Nam, J. H., & Suh, J. S. (2015). Enchondroma of the foot. *The Journal of Foot and Ankle Surgery*, *54*(5), 836-839. https://doi.org/10.1053/j.jfas.2015.01.002

Claessen, H. J. M. (2006). War and state formation: What is the connection? In O. Ton, H. Thrane, & V. Helle (Eds.), *Warfare and society: Archaeological and social anthropological perspectives* (pp. 217-226). Oakville, CT: Aarhus University Press.

Clarke, N., Carey, S., Srikandi, W., Hirsch, R., & Leppard, P. (1986). Periodontal disease in ancient populations. *American Journal of Physical Anthropology, 71*, 173-183. https://doi.org/10.1002/ajpa.1330710205

Clarke, N. G., & Hirsch, R. S. (1991). Physiological, pulpal, and periodontal factors influencing alveolar bone. In M.A. Kelley, & C.S. Larsen (Eds.), *Advances in dental anthropology* (pp. 241-266). New York, NY: Wiley-Liss.

Cleland, T. P., Schroeter, E. R., Feranec, R. S., & Vashishth, D. (2016). Peptide sequences from the first *Castoroides ohioensis* skull and the utility of old museum collections for palaeoproteomics. *Proceedings of the Royal Society B: Biological Sciences, 283*(1832), 20160593. http://doi.org/10.1098/rspb.2016.0593

Coale, A. J., & Demeny, P. (1983). *Regional model life tables and stable populations*. Princeton, NJ: Princeton University Press.

Cohen, M. N., & Armelagos, G. J. (Eds.). (1984). *Paleopathology at the origins of agriculture*. Orlando, FL: Academic Press.

Cole, G., & Waldron, T. (2019). Cribra orbitalia: Dissecting an ill-defined phenomenon. International Journal of Osteoarchaeology, 29(4), 613-621. https://doi.org/10.1002/oa.2757

Conde-Agudelo, A., Rosas-Bermudez, A., Castaño, F., & Norton, M. H. (2012). Effects of birth spacing on maternal, perinatal, infant, and child health: A systematic review of causal mechanisms. *Studies in Family Planning, 43*(2), 93-114. http://doi.org/10.1111/j.1728-4465.2012.00308.x

Conkey, M. W., & Spector, J. D. (1984). Archaeology and the study of gender. In M. B. Schiffer (Ed.), *Advances in archaeological method and theory* (pp. 1-38). San Diego, CA: Academic Press.

Corr, P. D. (2011). Musculoskeletal fungal infections. *Seminars in Musculoskeletal Radiology, 15*(05), 506-510. doi:10.1055/s-0031-1293496

Cox, G., & Sealy, J. (1997). Investigating identity and life histories: Isotopic analysis and historical documentation of slave skeletons found on the Cape Town foreshore, South Africa. *International Journal of Historical Archaeology, 1*(3), 207-224. http://doi.org/10.1023/a:1027349115474

Cresswell, T. R., & Smith, R. B. (1998). Bilateral anterior shoulder dislocations in bench pressing: An unusual cause. *British Journal of Sports Medicine, 32*(1), 71. http://doi.org/10.1136/bjsm.32.1.71

Crimmins, E. M., & Finch, C. E. (2006). Infection, inflammation, height, and longevity. *Proceedings of the National Academy of Sciences, 103*(2), 498. http://doi.org/10.1073/pnas.0501470103

Csányi, M. (2003a). The Tumulus Culture: Invaders from the West. In Z. Visy, M. Nagy, & Z.B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 161-163). Budapest, Hungary: Ministry of National Cultural Heritage.

Cśanyi, M. (2003b). Cemeteries of the Füzesabony culture. In Z. Visy, M. Nagy, & Z.B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 157-158). Budapest, Hungary: Ministry of National Cultural Heritage.

Csányi, M., & Tárnoki, J. (2003). The Middle Bronze Age Population of the Berettyó-Körös Region: The Gyulavarsánd Culture. In Z. Visy, M. Nagy, & Z.B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 158-160). Budapest, Hungary: Ministry of National Cultural Heritage.

Cucina, A., & Tiesler, V. (2003). Dental caries and antemortem tooth loss in the Northern Peten area, Mexico: A biocultural perspective on social status differences among the Classic Maya. *American Journal of Physical Anthropology, 122*(1), 1-10. http://doi.org/10.1002/ajpa.10267

Cvijić, J. (1922). *Balkansko Poluostrvo i južnoslovenske zemlje: Osnove antropologije* (Vol. I). Belgrade, Serbia.

Dagnelie, P. C., van Staveren, W. A., Vergote, F. J., Dingjan, P. G., van den Berg, H., & Hautvast, J. G. (1989). Increased risk of vitamin B-12 and iron deficiency in infants on macrobiotic diets. *The American Journal of Clinical Nutrition, 50*(4), 818-824. http://doi.org/10.1093/ajcn/50.4.818

Dean, M. C., & Cole, T. J. (2013). Human life history evolution explains dissociation between the timing of tooth eruption and peak rates of root growth. *PLoS ONE, 8*(1), 1-14. http://doi.org/10.1371/journal.pone.0054534

Decker, S. J., Davy-Jow, S. L., Ford, J. M., & Hilbelink, D. R. (2011). Virtual determination of sex: metric and nonmetric traits of the adult pelvis from 3D computed tomography models. *Journal of Forensic Sciences, 56*(5), 1107-1114. https://doi.org/10.1111/j.1556-4029.2011.01803.x

Demirjian, A. (1978). Dentition. In F. Falkner & J.M. Tanner (Eds.), *Human growth 2: Postnatal growth* (pp. 413-444). New York, NY: Plenum Press.

DeNiro, M. J. (1985). Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. *Nature, 317*, 806-809. https://doi.org/10.1038/317806a0

DeNiro, M. J., & Epstein, S. (1978). Influence of diet on the distribution of carbon isotopes in animals. *Geochimica et Cosmochimica Acta, 42*(5), 495-506. https://doi.org/10.1016/0016-7037(78)90199-0

Dhondt, E., Oudenhoven, L., Khan, S., Kroon, H. M., Hogendoorn, P. C., Nieborg, A., . . . De Schepper, A. (2006). Nora's lesion, a distinct radiological entity? *Skeletal Radiology, 35*(7), 497-502. http://doi.org/10.1007/s00256-005-0041-9

Di Rocco, C., Paternoster, G., Caldarelli, M., Massimi, L., & Tamburrini, G. (2012). Anterior plagiocephaly: Epidemiology, clinical findings, diagnosis, and classification. A review. *Child's Nervous System, 28*(9), 1413-1422. http://doi.org/10.1007/s00381-012-1845-2

Dias, G., & Tayles, N. (1997). 'Abscess cavity'—a misnomer. *International Journal of Osteoarchaeology, 7*(5), 548-554. http://doi.org/10.1002/(sici)1099-1212(199709/10)7:5<548::aid-oa369>3.0.co;2-i

Díaz-Andreu, M. (2007). *A world history of nineteenth-century archaeology: Nationalism, colonialism, and the past*. Oxford: Oxford University Press.

Dicks, J. L., & Banning, J. S. (1991). Evaluation of calculus accumulation in tube-fed, mentally handicapped patients: The effects of oral hygiene status. *Special Care in Dentistry, 11*(3), 104-106. http://doi.org/10.1111/j.1754-4505.1991.tb00827.x

Dietler, M. (1994). "Our ancestors the Gauls": Archaeology, ethnic nationalism, and the manipulation of Celtic identity in Modern Europe. *American Anthropologist, 96*(3), 584-605. http://doi.org/10.1525/aa.1994.96.3.02a00090

Djurić-Srejić, M., & Roberts, C. (2001). Palaeopathological evidence of infectious disease in skeletal populations from later medieval Serbia. *International Journal of Osteoarchaeology, 11*(5), 311-320. http://doi.org/10.1002/oa.570

Djurić, M., Janović, A., Milovanović, P., Djukić, K., Milenković, P., Drašković, M., & Roksandic, M. (2010). Adolescent health in medieval Serbia: Signs of infectious diseases and risk of trauma. *HOMO, 61*(2), 130-149. https://doi.org/10.1016/j.jchb.2010.02.003

Djurić, M. P., Roberts, C. A., Rakočević, Z. B., Djonić, D. D., & Lešić, A. R. (2006). Fractures in late medieval skeletal populations from Serbia. *American Journal of Physical Anthropology, 130*(2), 167-178. http://doi.org/10.1002/ajpa.20270

Dobberstein, R. C., Collins, M. J., Craig, O. E., Taylor, G., Penkman, K. E. H., & Ritz-Timme, S. (2009). Archaeological collagen: Why worry about collagen diagenesis? *Archaeological and Anthropological Sciences, 1*(1), 31-42. http://doi.org/10.1007/s12520-009-0002-7

Dobney, K., & Brothwell, D. (1987). A method for evaluating the amount of dental calculus on teeth from archaeological sites. *Journal of Archaeological Science, 14*, 343-351). https://doi.org/10.1016/0305-4403(87)90024-0

D'Orazio B. P. (1999). *Low Back Pain Handbook*. Boston, MA: Butterworth-Heinemann.

Douglas, M. (1978). Introduction to grid/group analysis. In M. Douglas (Ed.), *Essays in the sociology of perceptions* (pp. 1-8). New York, NY: Routledge.

Drennan, R. D. (2009). *Statistics for archaeologists: A common sense approach*, 2nd edition. New York, NY: Springer.

Duday, H. (2009). *The archaeology of the dead: Lectures in archaeothanatology*. Oxford: Oxbow.

Duffy, P. (2010). *Complexity and autonomy in Bronze Age Europe: Assessing cultural developments in Eastern Hungary.* (Ph.D. Dissertation), University of Michigan, Ann Arbor, MI.

Duffy, P. R., Parditka, G., Giblin, J. I., Paja, L., & Salisbury, R. B. (2014). Discovering mortuary practices in the Körös River Basin, Hungary. *Hungarian Archaeology E-Journal/Magyar Régészet Online Magazin, Autumn, 2014*, Terjedelem-5.

Dunnell, R. C., & Simek, J. F. (1995). Artifact size and plowzone processes. *Journal of Field Archaeology, 22*(3), 305-319. http://doi.org/10.1179/009346995791974242

Dvorniković, V. (1939). *Karakterologija Jugoslovena*. Kosmos: Beograd, Srbija.

Earle, T. K. (1987). Chiefdoms in archaeological and ethnohistoric perspective. *Annual Review of Anthropology, 16*, 279-308. https://doi.org/10.1146/annurev.an.16.100187.001431

Earle, T. (2002). *Bronze Age economics: The beginnings of political economies*. Oxford: Westview Press.

Earle, T. K., & Kolb, M. J. (2010). Regional settlement patterns. In T. K. Earle & K. Kristiansen (Eds.), *Organizing Bronze Age societies: The Mediterranean, Central Europe, and Scandinavia compared* (pp. 57-86). Cambridge: Cambridge University Press.

Earle, T. K., & Kristiansen, K. (Eds.). (2010a). *Organizing Bronze Age societies: The Mediterranean, Central Europe, and Scandinavia compared*. Cambridge: Cambridge University Press.

Earle, T. K., & Kristiansen, K. (2010b). Introduction: Theory and practice in the late prehistory of Europe. In T. K. Earle & K. Kristiansen (Eds.), *Organizing Bronze Age socieites: The Mediterranean, Central Europe, and Scandinavia compared* (pp. 1-33). Cambridge: Cambridge University Press.

Elder, G. H. (1975). Age differentiation and the life course. *Annual Review of Sociology, 1*(1), 165-190.

Erdal, Y., & Erdal, Ö. (2011). A review of trepanations in Anatolia with new cases. *International Journal of Osteoarchaeology, 21*(5), 505-534. https://doi.org/10.1002/oa.1154

Eshed, V., Gopher, A., & Hershkovitz, I. (2006). Tooth wear and dental pathology at the advent of agriculture: New evidence from the Levant. *American Journal of Physical Anthropology*, *130*(2), 145-159. http://doi.org/10.1002/ajpa.20362

Eshed, V., Gopher, A., Pinhasi, R., & Hershkovitz, I. (2010). Paleopathology and the origin of agriculture in the Levant. *American Journal of Physical Anthropology*, *143*(1), 121-133. http://doi.org/10.1002/ajpa.21301

Esrey, S. A., Potash, J. B., Roberts, L., & Shiff, C. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. Bulletin of the World Health Organization, 69(5), 609–621.

Evans, D. L. (1955). Fatigue fractures of the ulna. *The Journal of Bone and Joint Surgery. British volume*, *37-B*(4), 618-621. http://doi.org/10.1302/0301-620x.37b4.618

Faccia, K. J., & Williams, R. C. (2008). Schmorl's nodes: Clinical significance and implications for the bioarchaeological record. *International Journal of Osteoarchaeology*, *18*(1), 28-44. http://doi.org/10.1002/oa.924

Fahy, G. E., Deter, C., Pitfield, R., Miszkiewicz, J. J., & Mahoney, P. (2017). Bone deep: Variation in stable isotope ratios and histomorphometric measurements of bone remodelling within adult humans. *Journal of Archaeological Science*, *87*, 10-16. https://doi.org/10.1016/j.jas.2017.09.009

Falys, C. G., Schutkowski, H., & Weston, D. A. (2006). Auricular surface aging: worse than expected? A test of the revised method on a documented historic skeletal assemblage. *American Journal of Physical Anthropology*, *130*(4), 508-513. http://doi.org/10.1002/ajpa.20382

Farkas, G., & Lipták, P. (1971). Physical anthropological examination of a cemetery in Mokrin from the Early Bronze Age. In M. Girić (Ed.), *Mokrin, the Early Bronze Age Necropolis* (Vol. I, pp. 239-271). Washington, D.C.: Smithsonian.

Ferembach, D., Schwidetzky, I., & Stloukal, M. (1980). Recommendation for age and sex diagnoses of skeletons. *Journal of Human Evolution, 9*, 517-549.

Ferllini, R. (2012). Macroscopic and microscopic analysis of knife stab wounds on fleshed and clothed ribs. *Journal of Forensic Sciences, 57*(3), 683-690. http://doi.org/10.1111/j.1556-4029.2012.02087.x

Fibiger, L., & Knüsel, C. J. (2005). Prevalence rates of spondylolysis in British skeletal populations. *International Journal of Osteoarchaeology*, *15*(3), 164-174. http://doi.org/10.1002/oa.766

Fischl, K. P. (2003). The Settlements in the Maros Region. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 160-161). Budapest, Hungary: Ministry of National Cultural Heritage.

Fletcher, A., Pearson, J., & Ambers, J. (2008). The manipulation of social and physical identity in the Pre-Pottery Neolithic. *Cambridge Archaeological Journal*, *18*(3), 309-325. http://doi.org/10.1017/S0959774308000383

Foggin, P. M., Farkas, O., Shiirev-Adiya, S., & Chinbat, B. (1997). Health status and risk factors of seminomadic pastoralists in Mongolia: A geographical approach. *Social Science & Medicine*, *44*(11), 1623-1647. https://doi.org/10.1016/S0277-9536(96)00273-0

Fox, J. A., Sanchez, A., Zajac, T. J., & Provencher, M. T. (2017). Understanding the Hill-Sachs Lesion in its role in patients with recurrent anterior shoulder instability. *Current Reviews in Musculoskeletal Medicine, 10*(4), 469-479. http://doi.org/10.1007/s12178-017-9437-0

French, C. (2010). The paleoenvironments of Bronze Age Europe. In T. K. Earle & K. Kristiansen (Eds.), *Organizing Bronze Age Societies* (pp. 34-56). Cambridge: Cambridge University Press.

Fried, M. H. (1967). *The evolution of political society*. Chicago: University of Chicago Press.

Friedman, J. (1974). Marxism, structuralism, and vulgar materialism. *Man, New Series, 9*(3), 444-469.

Frost, H. M. (1969). Tetracycline-based histological analysis of bone remodeling. *Calcified Tissue Research, 3*, 211-237.

Fuglestvedt, I. (2014). Declaration on behalf of an archaeology of sexe. *Journal of Archaeological Method and Theory, 21*(1), 46-75. http://doi.org/10.1007/s10816-012-9136-5

Garašanin, D. (1951). *Hronologija Vinčanske Grupe* (Ph.D. Dissertation), Državna založba Slovenije, Ljubljana, Slovenia.

Garašanin, M. (1973). *Praistorija na tlu Srbije.* Beograd, Srbija.

Gaulin, S. J. C., & Boster, J. S. (1992). Human marriage systems and sexual dimorphism in stature. *American Journal of Physical Anthropology, 89*(4), 467-475. http://doi.org/10.1002/ajpa.1330890408

Geere, J.-A. L., Hunter, P. R., & Jagals, P. (2010). Domestic water carrying and its implications for health: A review and mixed methods pilot study in Limpopo Province, South Africa. *Environmental Health: A Global Access Science Source, 9*(1), 52-52. http://doi.org/10.1186/1476-069X-9-52

Geller, D. S., Pope, J. B., Thornhill, B. A., & Dorfman, H. D. (2009). Cryptococcal pyarthrosis and sarcoidosis. *Skeletal Radiology, 38*(7), 721-727. http://doi.org/10.1007/s00256-009-0691-0

Gerling, C., Bánffy, E., Dani, J., Kohler, K., Kulcsar, G., Pike, A. W. G., . . . Heyd, V. (2012). Immigration and transhumance in the Early Bronze Age Carpathian Basin: The occupants of a kurgan. *Antiquity, 86*, 1097-1111. https://doi.org/10.1017/S0003598X00048274

Giblin, J. I. (2011). *Isotope analysis on the Great Hungarian Plain: An exploration of mobility and subsistence strategies from the Neolithic to the Copper Age.* (Ph.D. Dissertaion), The Ohio State University.

Giblin, J. I., Knudson, K. J., Bereczki, Z., Palfi, G., & Pap, I. (2013). Strontium isotope analysis and human mobility during the Neolithic and Copper Age: A case study from the Great Hungarian Plain. *Journal of Archaeological Science, 40*, 227-239. https://doi.org/10.1016/j.jas.2012.08.024

Giblin, J. I., & Yerkes, R. W. (2016). Diet, dispersal and social differentiation during the Copper Age in eastern Hungary. *Antiquity, 90*, 81-94. https://doi.org/10.15184/aqy.2016.3

Gilbert, B. M., & McKern, T. W. (1973). A method for aging the female os pubis. *American Journal of Physical Anthropology, 38*(1), 31-38. https://doi.org/10.1002/ajpa.1330380109

Gilman, A. (1981). The development of social stratification in Bronze Age Europe. *Current Anthropology, 22*(1), 1-23.

Gimbutas, M. (1963a). European Prehistory: Neolithic to the Iron Age. *Biennial Review of Anthropology, 3*, 69-106.

Gimbutas, M. (1963b). The Indo-Europeans: Archeological problems. *American Anthropologist, 65*(4), 815-836.

Gimbutas, M. (1965). *Bronze Age cultures in central and eastern Europe*. The Hague, The Netherlands: Mouton.

Gimbutas, M. (1977). The first wave of Eurasian steppe pastoralists into Copper Age Europe. *Journal of Indo-European Studies*, *5*, 277-338.

Girić, M. (1959). Гробови из раног бронзаног доба у Остојићеву. *Rad Vojvodjanskih Muzeja, 8*, 191-194.

Girić, M. (1971). *Mokrin, the Early Bronze Age Necropolis Vol. I*. Washington, D.C.: Smithsonian.

Girić, M. (Ed.). (1972). *Mokrin, the Early Bronze Age Necropolis Vol. II*. Washington, D.C.: Smithsonian.

Girić, M. (1987). Насеља моришке културе. *Rad Vojvodjanskih Muzeja, 30*, 71-83.

Girić, M. (2012 [1995]). Појава сахрањивања деце у питосима у средњем бронзаном добу у југоисточном делу Панонске низије. In ч. золтан (Ed.), *милорад гирић, путовање и праисторију: зборник стручних археолошких радова 1957-1998* (pp. 131-144). Kikinda, Serbia: историјски архив кикинда.

Glumac, P. D., & Todd, J. A. (1991). Eneolithic copper smelting slags from the Middle Danube Basin. *Achaeometry*, 155-164.

Gogaltan, F. (1996). About the Early Bronze Age in the Romanian Banat. In N. Tasić (Ed.), *The Yugoslav Danube basin and the neighbouring regions in the 2nd millennium B.C.* (pp. 43-68). Belgrade, Serbia: Serbian Academy of Science and Arts Institute for Balkan Studies.

González-Jaranay, M., Téllez, L., Roa-López, A., Gómez-Moreno, G., & Moreu, G. (2017). Periodontal status during pregnancy and postpartum. *PLoS ONE, 12*(5), e0178234. http://doi.org/10.1371/journal.pone.0178234

Gonzalez, P. N., Bernal, V., & Perez, S. I. (2009). Geometric morphometric approach to sex estimation of human pelvis. *Forensic Science International, 189*(1), 68-74. http://doi.org/10.1016/j.forsciint.2009.04.012

Goodman, A.H., Martin, D.L., Armelagos, G.J., & Clarke, G. (1984). Indications of stress from bone and teeth. In M.N. Cohen & G.J. Armelagos (Eds.) *Paleopathology at the origins of agriculture* (pp. 13-49). Orlando, FL: Academic Press.

Goodman, A. H., & Armelagos, G. J. (1985a). The chronological distribution of enamel hypoplasia in human permanent incisor and canine teeth. *Archives of Oral Biology*, *30*(6), 503-507. https://doi.org/10.1016/0003-9969(85)90097-4

Goodman, A. H., & Armelagos, G. J. (1985b). Factors affecting the distribution of enamel hypoplasias within the human permanent dentition. *American Journal of Physical Anthropology, 68*(4), 479-493. http://doi.org/10.1002/ajpa.1330680404

Goody, J. (1976). *Production and reproduction: A comparative study of the domestic domain*. Cambridge: Cambridge University Press.

Gottlieb, T., Atkins, B. L., & Shaw, D. R. (2002). Soft tissue, bone and joint infections. *Medical Journal of Australia, 176*(12), 609-615. http://doi.org/10.5694/j.1326-5377.2002.tb04595.x

Gowland, R. L. (2016a). That "tattered coat upon a stick", the ageing body: Evidence for elder marginalisation and abuse in Roman Britain. In L. Powell, W. Southwell-Wright, & R. Gowland (Eds.), *Care in the past: Archaeological and interdisciplinary perspectives* (pp. 71-90). Oxford: Oxbow.

Gowland, R. L. (2016b). Elder abuse: Evaluating the potentials and problems of diagnosis in the archaeological record. *International Journal of Osteoarchaeology, 26*(3), 514-523. http://doi.org/10.1002/oa.2442

Gray, J. P., & Wolfe, L. D. (1980). Height and sexual dimorphism of stature among human societies. *American Journal of Physical Anthropology, 53*(3), 441-456. http://doi.org/10.1002/ajpa.1330530314

Gray, S. J. (1996). Ecology of weaning among nomadic Turkana Pastoralists of Kenya: Maternal Thinking, maternal behavior, and human adaptive strategies. *Human Biology, 68*(3), 437-465.

Greenfield, H. J. (1986). *The paleoeconomy of the central Balkans (Serbia): Zooarchaeological perspective on the Late Neolithic and Bronze Age (ca. 4500-1000 B.C.)* (Vol. i). Oxford, UK: British Archaeological Reports, International Series 34 Vol. 1 & 2.

Greenfield, H. J., Chapman, J., Clason, A. T., Gilbert, A. S., Hesse, B., & Milisauskas, S. (1988). The origins of milk and wool production in the Old World: a zooarchaeological perspective from the Central Balkans [and comments]. *Current Anthropology*, 29(4), 573-593.

Greenfield, H. J. (1999). The origins of metallurgy: Distinguishing stone from metal cut-marks on bones from archaeological sites. *Journal of Archaeological Science, 26*, 797-808. https://doi.org/10.1006/jasc.1998.0348

Greenfield, H. J. (2010). The Secondary Products Revolution: the past, the present and the future. World Archaeology, 42(1), 29-54. https://doi.org/10.1080/00438240903429722

Grin, E. I. (1953). *Epidemiology and control of endemic syphilis: Report on a mass-treatment campaign in Bosnia*. Monograph series no. II. Geneva, Switzerland: World Health Organization.

Gruber, G., Giessauf, C., Leithner, A., Zacherl, M., Clar, H., Bodo, K., & Windhager, R. (2008). Bizarre parosteal osteochondromatous proliferation (Nora's lesion): A report of 3 cases and a review of the literature. *Canadian journal of surgery. Journal canadien de chirurgie, 51*(6), 486-489.

Gulyás, S., & Sümegi, P. (2011a). Riparian environment in shaping social and economic behavior during the first phase of the evolution of Late Neolithic tell complexes in SE Hungary (6th/5th millennia BC). *Journal of Archaeological Science*, *38*, 2683-2695. https://doi.org/10.1016/j.jas.2011.06.005

Gulyás, S., & Sümegi, P. (2011b). Farming and/or foraging? New environmental data to the life and economic transformation of Late Neolithic tell communities (Tisza Culture) in SE Hungary. *Journal of Archaeological Science, 38*, 3323-3339. https://doi.org/10.1016/j.jas.2011.07.019

Gupta, M. D. (1987). Selective discrimination against female children in rural Punjab, India. *Population and Development Review*, *13*(1), 77-100.

Gupta, M. D. (1995). Life course perspectives on women's autonomy and health outcomes. *American Anthropologist, 97*(3), 481-491.

Gutierrez, M. C., Brisse, S., Brosch, R., Fabre, M., Omaïs, B., Marmiesse, M., . . . Vincent, V. (2005). Ancient origin and gene mosaicism of the progenitor of mycobacterium tuberculosis. *PLOS Pathogens, 1*(1), e5. https://doi.org/10.1371/journal.ppat.0010005

Guttmann-Bond, E. B., & Kluiving, E. B. (2015). *Landscape archaeology between art and science: From a multi-to an interdisciplinary approach*. Amsterdam, The Netherlands: Amsterdam University Press.

Guy, H., Masset, C., & Baud, C.-A. (1997). Infant taphonomy. *International Journal of Osteoarchaeology*, *7*(3), 221-229. https://doi.org/10.1002/(sici)1099-1212(199705)7:3<221::aid-oa338>3.0.co;2-z

Gyucha, A., Duffy, P. R., & Frolking, T. A. (2011). The Körös Basin from the Neolithic to the Hapsburgs: Linking settlement distributions with pre-regulation hydrology through multiple data set overlay. *Geoarchaeology, 26*(3), 392-419. https://doi.org/10.1002/gea.20350

Gyucha, A., Duffy, P. R., & Parkinson, W. A. (2013). Prehistoric human-environmental interactions on the Great Hungarian Plain. *Anthropologie (Brno), 51*(2), 157-168.

Haglund, W. D., & Sorg, M. H. (1997). Method and theory of taphonomic research. In W. D. Haglund & M. H. Sorg (Eds.), *Forensic taphonomy: The postmortem fate of human remains* (pp. 13-26). Boca Raton, FL: CRC Press.

Halcrow, S., & Tayles, N. (2011). The bioarchaeological investigation of children and childhood. In S. Agarwal & B. A. Glencross (Eds.), *Social bioarchaeology* (pp. 333-360). West Sussex, UK: Blackwell.

Halfon, N., Larson, K., Lu, M., Tullis, E., & Russ, S. (2014). Lifecourse health development: Past, present and future. *Maternal and Child Health Journal, 18*(2), 344-365. https://doi.org/10.1007/s10995-013-1346-2

Hanks, B. (2008). Reconsidering warfare, status, and gender in the Eurasian Steppe Iron Age. In K. M. Linduff & K. S. Rubinson (Eds.), *Are all warriors male? Gender roles on the ancient Eurasian Steppe* (pp. 15-34). Plymouth, UK: AltaMira Press.

Hänsel, B., & Kalicz, N. (1986). Das bronzezeitliche Gräberfeld von Mezőcsát, Kom. Borsod, Nordostungarn. *Berichte der Römisch-Germanischen Kommission, 67*, 5-88.

Hansen, M., & Mulliken, J. B. (1994). Frontal plagiocephaly. Diagnosis and treatment. *Clinics in Plastic Surgery, 21*(4), 543-553.

Hansson, T., & Roos, B. (1983). The amount of bone mineral and Schmorl's nodes in lumbar vertebrae. *Spine*, *8*(3), 266-271. https://doi.org/10.1097/00007632-198304000-00006

Hårde, A. (2005). The emergence of warfare in the Early Bronze Age: The Nitra group in Slovakia and Moravia, 2200-1800 BC. In M. Parker Pearson & I. J. N. Thorpe (Eds.), *Warfare, violence and slavery in prehistory: Proceedings of a prehistoric society conference at Sheffield University* (pp. 87-105). Oxford: BAR International Series 1374.

Hårde, A. (2006). Funerary rituals and warfare in the Early Bronze Age Nitra Culture of Slovakia and Moravia. In T. Otto, H. Thrane, & H. Vandkilde (Eds.), *Warfare and society: archaeological and social anthropological perspectives* (pp. 341-384). Aarhus, Denmark: Aarhus University Press.

Harding, A.F. (1984). Aspects of social evolution in the Bronze Age. In J. Bintliff (Ed.) *European Social Evolution: Social Perspectives* (135-145). Chiltington, UK: Chanctonbury Press.

Harding, A. F. (1999). Warfare: A defining characteristic of Bronze Age Europe? In J. Chapman & A. F. Harding (Eds.), *Ancient warfare: archaeological perspectives* (pp. 157-173). Phoenix Mill, UK: Sutton.

Harding, A. F. (2000). *European societies in the Bronze Age*. Cambridge: Cambridge University Press.

Harding, A. F. (2006). What does the context of deposition and frequency of Bronze Age weaponry tell us about the function of weapons? In T. Otto, H. Thrane, & H. Vandkilde (Eds.), *Warfare and society: Archaeological and social anthropological perspectives* (pp. 505-514). Aarhus, Denmark: Aarhus University Press.

Harding, A. F. (2007). *Warriors and weapons in Bronze Age Europe*. Budapest, Hungary: Archaeolingua Alapítvány.

Hathi, P., Haque, S., Pant, L., Coffey, D., & Spears, D. (2017). Place and child health: The interaction of population density and sanitation in developing countries. *Demography*, *54*, 337-360. https://doi.org/10.1007/s13524-016-0538-y

Hassett, G., Hart, D. J., Manek, N. J., Doyle, D. V., & Spector, T. D. (2003). Risk factors for progression of lumbar spine disc degeneration: The Chingford Study. *Arthritis & Rheumatism, 48*(11), 3112-3117. https://doi.org/10.1002/art.11321

Hauspie, R., & Roelants, M. (2012). Adolescent growth. In N. Cameron & B. Bogin (Eds.), *Human growth and development*, *2nd edition* (pp. 57-79). London: Elsevier.

Hawkes, K., O'Connell, J. F., Jones, N. G. B., Alvarez, H., & Charnov, E. L. (1998). Grandmothering, menopause, and the evolution of human life histories. *Proceedings of the National Academy of Sciences, 95*(3), 1336-1339. https://doi.org/10.1073/pnas.95.3.1336

Hayward, A. D., Rickard, I. J., & Lummaa, V. (2013). Influence of early-life nutrition on mortality and reproductive success during a subsequent famine in a preindustrial population. *Proceedings of the National Academy of Sciences, 110*(34), 13886. https://doi.org/10.1073/pnas.1301817110

Hedges, R. E. M. (2003). On bone collagen—apatite-carbonate isotopic relationships. *International Journal of Osteoarchaeology, 13*(1-2), 66-79. https://doi.org/10.1002/oa.660

Hedges, R. E. M. (2006). Where does our protein carbon come from? *British Journal of Nutrition, 95*(06), 1031-1032. https://doi.org/10.1079/BJN20061782

Hedges, R. E. M., Clement, J. G., Thomas, C. D. L., & O'Connell, T. C. (2007). Collagen turnover in the adult femoral mid-shaft: Modeled from anthropogenic radiocarbon tracer measurements. *American Journal of Physical Anthropology, 133*(2), 808-816. https://doi.org/10.1002/ajpa.20598

Helbling, J. (2006). War and peace in societies without central power: Theories and perspectives. In T. Otto, H. Thrane, & H. Vandkilde (Eds.), *Warfare and society: Archaeological and social anthropological perspectives* (pp. 113-140). Oakville, CT: Aarhus University Press.

Hershkovitz, I., Bedford, L., Jellema, L. M., & Latimer, B. (1996). Injuries to the skeleton due to prolonged activity in hand-to-hand combat. *International Journal of Osteoarchaeology, 6*(2), 167-178. https://doi.org/10.1002/(sici)1099-1212(199603)6:2<167::aid-oa251>3.0.co;2-8

Hewitt, B. R. (2003). Mortality in tradition hunter-gatherer, pastoralist and agriculturalist communities: The validity of longevity studies based on mobility and subsistence strategies. *Nexus, 16*, 27-49.

Hewlett, B. S. (1991). Demography and childcare in preindustrial societies. *Journal of Anthropological Research, 47*(1), 1-37. https://doi.org/10.1086/jar.47.1.3630579

Hill, H. A., & Sachs, M. D. (1940). The grooved defect of the humeral Head. *Radiology, 35*(6), 690-700. https://doi.org/10.1148/35.6.690

Hill, K., & Kaplan, H. (1999). Life history traits in humans: Theory and empirical studies. *Annual Review of Anthropology, 28*(1), 397-430. https://doi.org/10.1146/annurev.anthro.28.1.397

Hillson, S. W. (1979). Diet and dental Disease. *World Archaeology, 11*(2), 147-162. https://doi.org/10.2307/124357

Hillson, S. W. (2001). Recording dental caries in archaeological human remains. *International Journal of Osteoarchaeology, 11*(4), 249-289. https://doi.org/10.1002/oa.538

Hillson, S. W. (1996). *Dental Anthropology*. Cambridge: Cambridge University Press.

Hillson, S. W. (2008). Dental pathology. In M. A. Katzenberg & S. R. Saunders (Eds.), *Biological anthropology of the human skeleton* (pp. 301-340). Hoboken, NJ: John Wiley & Sons.

Hoekman-Sites, H. A., & Giblin, J. I. (2012). Prehistoric animal use on the Great Hungarian Plain: A synthesis of isotope and residue analyses from the Neolithic and Copper Age. *Journal of Anthropological Archaeology, 31*(4), 515-527. http://dx.doi.org/10.1016/j.jaa.2012.05.002

Holden, C., & Mace, R. (1999). Sexual dimorphism in stature and women's work: A phylogenetic cross-cultural analysis. *American Journal of Physical Anthropology, 110*(1), 27-45. https://doi.org/10.1002/(sici)1096-8644(199909)110:1<27::aid-ajpa3>3.0.co;2-g

Horowitz, D.L., Katzap, E., Horowitz, S., & Barilla-LaBarca, M. (2011). Approach to septic arthritis. *American Familiy Physician, 84*(6), 653-660.

Horváth, L. A., & Virág, Z. M. (2003). History of the Copper Age (4500/4400-2600/2500 B.C.). In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 125-127). Budapest, Hungary: Ministry of National Cultural Heritage.

Hsu, M.-C., Lue, K.-H., Lin, Z.-I., & Lu, K.-H. (2005). Stress fracture at the junction of the middle and distal third of the ulnar diaphysis in a spinner bowler: A case report and a review of the literature. *Knee Surgery, Sports Traumatology, Arthroscopy, 13*(6), 499-504. https://doi.org/10.1007/s00167-004-0560-2

Huang, J. I., Thayer, M. K., Paczas, M., Lacey, S. H., & Cooperman, D. R. (2019). Variations in hook of hamate morphology: A cadaveric analysis. *The Journal of Hand Surgery, 44*(7), 611.e611-611.e615. https://doi.org/10.1016/j.jhsa.2018.08.007

Hukelova, Z. (2016). *Comparative osteoarchaeological perspectives on health and lifestyle of Neolithic, Chalcolithic and Early Bronze Age populations from Slovakia, Moravia and Bohemia.* (Ph.D. Dissertation), The University of Edinburgh, Edinburgh, UK.

Hutton, C. W. (1987). Generalised osteoarthritis: An evolutionary problem?. *The Lancet, 329*(8548), 1463-1465. https://doi.org/10.1016/S0140-6736(87)92209-4

ICPDR. (2014). International Commission for the Protection of the Danube River (ICPDR) - Tisza Basin. Retrieved from http://www.icpdr.org/main/danube-basin/tisza-basin

Jackes, M. (2000). Building the bases for paleodemographic analysis: Adult age determination. In M. A. Katzenber & S. R. Saunders (Eds.), *Biological anthropology of the human skeleton* (pp. 417-466). New York, NY: Wiley-Liss.

Jain, K., Mruthyunjaya, & Ravishankar, R. (2011). Cryptococcal abscess and osteomyelitis of the proximal phalanx of the hand. *Indian Journal of Pathology and Microbiology, 54*(1), 216-218. https://doi.org/10.4103/0377-4929.77417

Jarcho, S. (1966). The development and present condition of human palaeopathology in the United States *Human palaeopathology* (pp. 3-30). New Haven, CT: Yale University Press

Jim, S., Jones, V., Ambrose, S. H., & Evershed, R. P. (2006). Quantifying dietary macronutrient sources of carbon for bone collagen biosynthesis using natural abundance stable carbon isotope analysis. *British Journal of Nutrition, 95*(06), 1055-1062. https://doi.org/10.1079/BJN20051685

Johnson, G. A. (1982). Organizational structure and scalar stress. In C. Renfrew, M. J. Rowlands, & B. A. Segraves (Eds.), *Theory and explanation in archaeology* (pp. 389-419). New York, NY: Academic Press.

Johnston, F. E. (1962). Growth of the long bones of infants and young children at Indian Knoll. *American Journal of Physical Anthropology, 20*(3), 249-254. https://doi.org/10.1002/ajpa.1330200309

Joyce, R. A. (2005). Archaeology of the body. *Annual Review of Anthropology, 34*(1), 139-158. https://doi.org/10.1146/annurev.anthro.33.070203.143729

Judd, M. A. (2002a). Comparison of long bone trauma recording methods. *Journal of Archaeological Science, 29*(11), 1255-1265. https://doi.org/10.1006/jasc.2001.0763

Judd, M. A. (2002b). Ancient injury recidivism: An example from the Kerma period of ancient Nubia. *International Journal of Osteoarchaeology, 12*(2), 89-106. https://doi.org/10.1002/oa.587

Judd, M. A. (2006). Continuity of interpersonal violence between Nubian communities. *American Journal of Physical Anthropology, 131*(3), 324-333. https://doi.org/10.1002/ajpa.20401

Judd, M. A. (2008). The parry problem. *Journal of Archaeological Science, 35*(6), 1658-1666. https://doi.org/10.1016/j.jas.2007.11.005

Judd, M. A., & Redfern, R. (2012). Trauma. In A. L. Grauer (Ed.), *A Companion to Paleopathology* (pp. 360-379). Chichester, UK: Wiley-Blackwell.

Judd, M. A., & Roberts, C. A. (1999). Fracture trauma in a medieval British farming village. *American Journal of Physical Anthropology, 109*(2), 229-243. https://doi.org/10.1002/(sici)1096-8644(199906)109:2<229::aid-ajpa7>3.0.co;2-y

Judd, M. A., Walker, J. L., Ventresca Miller, A., Razhev, D., Epimakhov, A. V., & Hanks, B. K. (2018). Life in the fast lane: Settled pastoralism in the Central Eurasian Steppe during the Middle Bronze Age. *American Journal of Human Biology, 30*(4), e23129. https://doi.org/10.1002/ajhb.23129

Kalicz, N. (1968). *Die Frühbronzezeit in Nordost-Ungarn*. Budapest, Hungary: Akadémiai Kiadó.

Karlberg, J. (1989). A biologically-oriented mathematical model (ICP) for human growth. *Acta Paediatrica*, *78*(s350), 70-94.

Katz, D., & Suchey, J. M. (1986). Age determination of the male os pubis. *American Journal of Physical Anthropology,* 69(4), 427-435. https://doi.org/10.1002/ajpa.1330690402

Katzenberg, M. A. (2008). Stable isotope analysis: A tool for studying past diet, demography, and life history. In M. A. Katzenberg & S. R. Saunders (Eds.), *Biological anthropology of the human skeleton, 2nd edition* (pp. 413-442). Hoboken, NJ: John Wiley & Sons.

Katzenberg, M. A., Goriunova, O., & Weber, A. (2009). Paleodiet reconstructions of Brone Age Siberians from the mortuary site of Khuzhir-Nuge XIV, Lake Baikal. *Journal of Archaeological Science, 36*, 663-674. https://doi.org/10.1016/j.jas.2008.10.012

Katzenberg, M. A., McKenzie, H. G., Losey, R. J., Goriunova, O. I., & Weber, A. (2012). Prehistoric dietary adaptations among hunter-fisher-gatherers from the Little Sea of Lake Baikal, Siberia, Russian Federation. *Journal of Archaeological Science, 39*(8), 2612-2626. http://dx.doi.org/10.1016/j.jas.2011.08.010

Keeley, L. (1996). *War before civilization*. Oxford: Oxford University Press.

Kellner, C. M., & Schoeninger, M. J. (2007). A simple carbon isotope model for reconstructing prehistoric human diet. *American Journal of Physical Anthropology, 133*(4), 1112-1127. https://doi.org/10.1002/ajpa.20618

Kelly, R. C. (2000). *Warless societies and the origin of war*. Ann Arbor, MI: University of Michigan Press.

Kemenczei, T. (1984). *Die Späthronzezeit Nordostungarns*. Budapest, Hungary: Akadémiai Kiadó.

Kemenczei, T. (2003). Bronze age metallurgy. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (Vol. 167-174). Budapest, Hungary: Ministry of National Cultural Heritage.

Kerr, N. W. (1998). Dental pain and suffering prior to the advent of modern dentistry. *British Dental Journal*, *184*(8), 397-399. https://doi.org/10.1038/sj.bdj.4809643

Kibii, J. M., Churchill, S. E., Schmid, P., Carlson, K. J., Reed, N. D., de Ruiter, D. J., & Berger, L. R. (2011). A Partial Pelvis of *Australopithecus sediba*. *Science, 333*(6048), 1407-1411. https://doi.org/10.1126/science.1202521

Kienlin, T. L. (2012). Patterns of change, or: perceptions decieved? Comments on the interpretation of Late Neolithic and Bronze Age settlement in the Carpathian Basin. In T. L. Kienlin & A. Zimmermann (Eds.), *Beyond Elites: Alternatives to hierarchical systems in modelling social formations* (pp. 251-310). Bonn, Germany: R. Habelt.

Kim, S.-I., Ha, K.-Y., Lee, J.-W., & Kim, Y.-H. (2018). Prevalence and related clinical factors of thoracic ossification of the ligamentum flavum—a computed tomography-based cross-sectional study. *The Spine Journal*, *18*(4), 551-557. https://doi.org/10.1016/j.spinee.2017.08.240

King, J. C. (2003). The risk of maternal nutritional depletion and poor outcomes increases in early or closely spaced pregnancies. *The Journal of nutrition, 133*(5), 1732S-1736S. https://doi.org/10.1093/jn/133.5.1732S

Kinsella, K., & Gist, Y. J. (1998). *International brief: Gender and aging*, United States Department of Commerce, Economics, and Statistics Administration, Washington, D.C.

Kinsella, K., & Suzman, R. (1992). Demographic dimensions of population aging in developing countries. *American Journal of Human Biology, 4*(1), 3-8. https://doi.org/10.1002/ajhb.1310040103

Kiss, V. (Ed.) (2003). *Hungarian archaeologty at the turn of the millennium*. Budapest, Hungary: Ministry of National Cultural Heritage, Teleki László Foundation.

Kiss, V. (2003a). Central European economies: Agriculturalists in Transdanubia. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 148-151). Budapest, Hungary: Ministry of National Cultural Heritage.

Kiss, V. (2003b). Potters in Transdanubia. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 150). Budapest, Hungary: Ministry of National Cultural Heritage.

Kissel, M., & Kim, N. C. (2018). The emergence of human warfare: Current perspectives. *American Journal of Physical Anthropology*, 168, 1-23. https://doi.org/10.1002/ajpa.23751

Klaassen, Z., Tubbs, R. S., Apaydin, N., Hage, R., Jordan, R., & Loukas, M. (2011). Vertebral spinal osteophytes. *Anatomical Science International*, *86*(1), 1-9. https://doi.org/10.1007/s12565-010-0080-8

Knüsel, C. (2005). The physical evidence of warfare - subtle stigmata? In M. Parker Pearson & I. J. N. Thorpe (Eds.), *Warfare, violence and slavery in prehistory: Proceedings of a prehistoric society conference at Sheffield University* (pp. 49-68). Oxford: BAR International Series 1374.

Knüsel, C. (2007). Activity-related skeletal change. In V. Fiorato, A. Boylston, & C. Knüsel (Eds.), *Blood red roses: The archaeology of a mass grave from the Battle of Towton AD 1461* (pp. 103-118). Oxford: Oxbow.

Knüsel, C., Outram, A., & Knight, S. (2007). A comparison of human and animal deposition at Velim-Skalka through an integrated approach. In A. Harding, R. Šumberová, C. Knüsel, & A. Outram (Eds.) *Velim: Violence and Death in Bronze Age Bohemia* (pp. 97-136). Prague, Czech Republic: Archeologický ústav AV CR.

Kohl, P. L. (1998). Nationalism and archaeology: On the constructions of nations and the reconstructions of the remote past. *Annual Review of Anthropology, 27,* 223-246.

Komar, D. A., & Buikstra, J. E. (2008). *Forensic anthropology: Contemporary theory and practice*. Oxford: Oxford University Press.

Komine-Aizawa, S., Aizawa, S., & Hayakawa, S. (2019). Periodontal diseases and adverse pregnancy outcomes. *Journal of Obstetrics and Gynaecology Research, 45*(1), 5-12. https://doi.org/10.1111/jog.13782

Konigsberg, L. W., & Hens, S. M. (1998). Use of ordinal categorical variables in skeletal assessment of sex from the cranium. *American Journal of Physical Anthropology, 107*(1), 97-112. https://doi.org/10.1002/(SICI)1096-8644(199809)107:1<97::AID-AJPA8>3.0.CO;2-A

Kosek, M., Bern, C., & Guerrant, R.L. (2003). The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. *Bulletin of the World Health Organization, 81*(3), 197-204.

Krall, E. A., Garvey, A. J., & Garcia, R. I. (1999). Alveolar bone loss and tooth loss in male cigar and pipe smokers. *The Journal of the American Dental Association, 130*(1), 57-64. https://doi.org/10.14219/jada.archive.1999.0029

Kristiansen, K. (1998). *Europe before history*. Cambridge: Cambridge University Press.

Kristiansen, K. (1999). The evolution of warrior aristocracies in later European prehistory and their long-term history. In J. Carman & A. F. Harding (Eds.), *Ancient warfare: Archaeological perspectives* (pp. 175-189). Stroud, UK: Sutton.

Kristiansen, K. (2001). Rulers and warriors: Symbolic transmission and social transformation in Bronze Age Europe. In J. Haas (Ed.), *From leaders to rulers. Fundamental issues in archaeology* (pp. 85-104). New York, NY: Kluwer Academic/Plenum Publishers.

Kristiansen, K. (2012). Bronze Age dialectics: Ritual economies and the consolidation of social divisions. In T.L. Kienlin & A. Zimmerman (Eds.) *Beyond Elites: Alternatives to Hierarchical Systems in Modelling Social Formations, Vol. 2* (pp. 381-392). Bonn, Germany: Verlag Dr. Rudolf Habelt GmbH.

Kuh, D., Hardy, R., Langenberg, C., Richards, M., & Wadsworth, M. E. J. (2002). Mortality in adults aged 26-54 years related to socioeconomic conditions in childhood and adulthood: Post war birth cohort study. *British Medical Journal, 325*(7372), 1076-1080. https://doi.org/10.1136/bmj.325.7372.1076

Kulcsár, G. (2003). The Early Bronze Age. In Z. B. Kiss (Ed.), In Z. Visy, M. Nagy, & Z.B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 141-142). Budapest, Hungary: Ministry of National Cultural Heritage.

Lam, Y. M., & Pearson, O. M. (2005). Bone density studies and the interpretation of the faunal record. *Evolutionary Anthropology*, *14*(3), 99-108. https://doi.org/10.1002/evan.20053

Lampl, M., & Johnston, F. E. (1996). Problems in the aging of skeletal juveniles: Perspectives from maturation assessments of living children. *American Journal of Physical Anthropology*, *101*(3), 345-355. https://doi.org/10.1002/(SICI)1096-8644(199611)101:3<345::AID-AJPA4>3.0.CO;2-Y

Lanata, C. F., Fischer-Walker, C. L., Olascoaga, A. C., Torres, C. X., Aryee, M. J., Black, R. E., . . . Unicef. (2013). Global causes of diarrheal disease mortality in children <5 years of age: A systematic review. *PLoS ONE*, *8*(9), e72788. https://doi.org/10.1371/journal.pone.0072788

Larsen, C. S. (1983). Behavioural implications of temporal change in cariogenesis. *Journal of Archaeological Science*, *10*(1), 1-8. https://doi.org/10.1016/0305-4403(83)90120-6

Larsen, C. S. (2015). *Bioarchaeology: Interpreting behavior from the human skeleton, 2nd edition*. Cambridge: Cambridge University Press.

Larsen, C. S., Shavitm R. & Griffin, M. C. (1991). Dental caries evidence for dietary change: An archaeological context. In M. A. Kelley & C. S. Larsen (Eds.), *Advances in dental anthropology* (pp. 179-202). New York, NY: Wiley-Liss.

László, A. (2009). The young Gordon Childe and Transylvanian archaeology: The archaeological correspondence between Childe and Ferenc László. *European Journal of Archaeology, 12*(1-3), 35-46. https://doi.org/10.1177/1461957109339700

Lawson, D. W., Alvergne, A., & Gibson, M. A. (2012). The life-history trade-off between fertility and child survival. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1748), 4755-4764. https://doi.org/10.1098/rspb.2012.1635

Le Huray, J. D., Schutkowski, H., & Richards, M. P. (2006). La Téne dietary variation in Central Europe: a stable isotope study of human skeletal remains from Bohemia. In J. Sofaer (Ed.), *Gender, bioarchaeology and human ontogeny*. Oxford: Oxbow Books.

Lee-Thorp, J. A. (2002). Two decades of progress towards understanding fossilization processes and isotopic signals in calcified tissue mineral. *Archaeometry*, *44*, 435-446. https://doi.org/10.1111/1475-4754.t01-1-00076

Lee, J., Feng, W., & Campbell, C. (1994). Infant and child mortality Among the Qing nobility: Implications for two types of positive check. *Population Studies, 48*(3), 395-411. https://doi.org/10.1080/0032472031000147936

Lefort, M., & Bennike, P. (2007). A case study of possible differential diagnoses of a medieval skeleton from Denmark: Leprosy, ergotism, treponematosis, sarcoidosis or smallpox? *International Journal of Osteoarchaeology, 17*(4), 337-349. https://doi.org/10.1002/oa.905

Legood, R., Scuffham, P., & Cryer, C. (2002). Are we blind to injuries in the visually impaired? A review of the literature. *Injury Prevention*, *8*(2), 155. https://doi.org/10.1136/ip.8.2.155

Lejarraga, H. (2012). Growth in infancy and childhood: A pediatric approach. In N. Cameron & B. Bogin (Eds.), *Human growth and development, 2nd edition* (pp. 23-56). London: Elsevier.

Lengyel, I. (1972). Laboratory analysis of the human bone finds from the Early Bronze Age Cemetery of Mokrin. In M. Girić (Ed.), *Mokrin, the Early Bronze Age necropolis* (Vol. II, pp. 75-90). Washington, D.C.: Smithsonian.

Lewis, J. E. (2008). Identifying sword marks on bone: Criteria for distinguishing between cut marks made by different classes of bladed weapons. *Journal of Archaeological Science, 35*(7), 2001-2008. https://doi.org/10.1016/j.jas.2008.01.016

Lewis, M. E. (2006). *The bioarchaeology of children: Perspectives from biological and forensic anthropology*. Cambridge: Cambridge University Press.

Lewis, M. E., & Gowland, R. (2007). Brief and precarious lives: Infant mortality in contrasting sites from medieval and post-medieval England (AD 850–1859). *American Journal of Physical Anthropology, 134*(1), 117-129. https://doi.org/10.1002/ajpa.20643

Li, M., Wang, Z., Du, J., Luo, Z., & Wang, Z. (2013). Thoracic myelopathy caused by ossification of the ligamentum flavum: A retrospective study in Chinese patients. *Clinical Spine Surgery, 26*(1), E35-E40. https://doi.org/10.1097/BSD.0b013e31827ada68

Lieff, S., Boggess, K. A., Murtha, A. P., Jared, H., Madianos, P. N., Moss, K., . . . Offenbacher, S. (2004). The oral conditions and pregnancy study: Periodontal status of a cohort of pregnant women. *Journal of Periodontology, 75*(1), 116-126. https://doi.org/10.1902/jop.2004.75.1.116

Lieverse, A. R. (1999). Diet and the aetiology of dental calculus. *International Journal of Osteoarchaeology, 9*(4), 219-232. https://doi.org/10.1002/(sici)1099-1212(199907/08)9:4<219::aid-oa475>3.0.co;2-v

Lieverse, A. R., Link, D. W., Bazaliiskiy, V. I., Goriunova, O. I., & Weber, A. W. (2007). Dental health indicators of hunter–gatherer adaptation and cultural change in Siberia's Cis-Baikal. *American Journal of Physical Anthropology, 134*(3), 323-339. https://doi.org/10.1002/ajpa.20672

Lieverse, A. R., Mack, B., Bazaliiskii, V. I., & Weber, A. W. (2016). Revisiting osteoarthritis in the Cis-Baikal: Understanding behavioral variability and adaptation among middle Holocene foragers. *Quaternary International, 405*, 160-171. https://doi.org/10.1016/j.quaint.2015.03.019

Lillie, M., Budd, C., & Potekhina, I. (2011). Stable isotope analysis of prehistoric populations from the cemeteries of the Middle and Lower Dnieper Basin, Ukraine. *Journal of Archaeological Science, 38*(1), 57-68. http://dx.doi.org/10.1016/j.jas.2010.08.010

Lingstrom, P., van Houte, J., & Kashket, S. (2000). Food starches and dental caries. *Critical Reviews in Oral Biology & Medicine, 11*(3), 366-380. https://doi.org/10.1177/10454411000110030601

Liversidge, H. M., & Molleson, T. (2004). Variation in crown and root formation and eruption of human deciduous teeth. *American Journal of Physical Anthropology, 123*(2), 172-180. https://doi.org/10.1002/ajpa.10318

Liversidge, H. M., Smith, B. H., & Maber, M. (2010). Bias and accuracy of age estimation using developing teeth in 946 children. *American Journal of Physical Anthropology*, *143*(4), 545-554. https://doi.org/10.1002/ajpa.21349

Löfqvist, L., Pinzke, S., Stål, M., & Lundqvist, P. (2009). Riding instructors, their musculoskeletal health and working conditions. *Journal of Agricultural Safety and Health*, *15*(3), 241-254. https://doi.org/10.13031/2013.27408

Loth, S. R., & Henneberg, M. (1996). Mandibular ramus flexure: A new morphologic indicator of sexual dimorphism in the human skeleton. *American Journal of Physical Anthropology*, *99*(3), 473-485. https://doi.org/10.1078/0018-442X-00039

Lovejoy, C. O., Meindl, R. S., Pryzbeck, T. R., & Mensforth, R. P. (1985). Chronological metamorphosis of the auricular surface of the ilium: a new method for the determination of adult skeletal age at death. *American Journal of Physical Anthropology*, *68*, 15-28. https://doi.org/10.1002/ajpa.1330680103

Lovell, N. C. (1994). Spinal arthritis and physical stress at Bronze Age Harappa. *American Journal of Physical Anthropology*, *93*(2), 149-164. https://doi.org/10.1002/ajpa.1330930202

Lovell, N. C. (1997). Trauma analysis in paleopathology. *American Journal of Physical Anthropology:*, *104*(S25), 139-170. https://doi.org/10.1002/(SICI)1096-8644(1997)25+<139::AID-AJPA6>3.0.CO;2-%23

Lukacs, J. R. (1989). Dental pathology: Methods for reconstructing dietary patterns. In M. İşcan & K. Kennedy (Eds.), *Reconstruction of life from the skeleton* (pp. 261-286). New York, NY: Alan R. Liss.

Lukacs, J. R. (2008). Fertility and agriculture accentuate sex differences in dental caries rates. *Current Anthropology*, *49*(5), 901-914. https://doi.org/10.1086/592111

Lukacs, J. R. (2011a). Sex differences in dental caries experience: Clinical evidence, complex etiology. *Clinical Oral Investigations*, *15*(5), 649-656. https://doi.org/10.1007/s00784-010-0445-3

Lukacs, J. R. (2011b). Gender differences in oral health in South Asia: Metadata imply multifactorial biological and cultural causes. *American Journal of Human Biology*, *23*(3), 398-411. https://doi.org/10.1002/ajhb.21164

Lukacs, J. R., & Largaespada, L. L. (2006). Explaining sex differences in dental caries prevalence: Saliva, hormones, and "life-history" etiologies. *American Journal of Human Biology*, *18*(4), 540-555. https://doi.org/10.1002/ajhb.20530

Lurie, H. I. (1963). Five unusual cases of sporotrichosis from South Africa showing lesions in muscles, bones, and viscera. *British Journal of Surgery*, *50*(224), 585-591.

Lynn, K. S., & Fairgrieve, S. I. (2009). Macroscopic analysis of axe and hatchet trauma in fleshed and defleshed mammalian long bones. *Journal of Forensic Sciences*, *54*(4), 786-792. https://doi.org/10.1111/j.1556-4029.2009.01061.x

Maat, G. J. R., & Mastwijk, R. W. (2000). Avulsion injuries of vertebral endplates. *International Journal of Osteoarchaeology, 10*(2), 142-152. https://doi.org/10.1002/(sici)1099-1212(200003/04)10:2<142::aid-oa519>3.0.co;2-l

Macintosh, A. A., Davies, T. G., Pinhasi, R., & Stock, J. T. (2015). Declining tibial curvature parallels ∼ 6150 years of decreasing mobility in central European agriculturalists. *American Journal of Physical Anthropology, 157*(2), 260-275. https://doi.org/10.1002/ajpa.22710

Macintosh, A. A., Pinhasi, R., & Stock, J. T. (2014). Lower limb skeletal biomechanics track long-term decline in mobility across ∼6150 years of agriculture in Central Europe. *Journal of Archaeological Science, 52,* 376-390. https://doi.org/10.1016/j.jas.2014.09.001

Mack, M. E., & Blakey, M. L. (2004). The New York African Burial Ground project: Past biases, current dilemmas, and future research opportunities. *Historical Archaeology*, *38,* 10-17.

Mader, J. T., Shirtliff, M., & Calhoun, J. H. (1997). Staging and staging application in osteomyelitis. *Clinical Infectious Diseases, 25*(6), 1303-1309. https://doi.org/10.1086/516149

Makuljević, N. (2013). The political reception of the Vienna School: Josef Strzygowski and Serbian art history. *The Journal of Art Historiography, 8,* 1-13.

Mandel, I. D. (1995). Calculus update: Prevalence, pathogenicity and prevention. *The Journal of the American Dental Association, 126*(5), 573-580. https://doi.org/10.14219/jada.archive.1995.0235

Manji, F., Fejerskov, O., Baelum, V., Luan, W. M., & Chen, X. (1991). The epidemiological features of dental caries in African and Chinese populations. In N. W. Johnson (Ed.), *Dental caries: Markers of high and low risk groups and individuals* (pp. 62-99). Cambridge: Cambridge University Press.

Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two-random variables is stochastically larger than the other. *The Annals of Mathematical Statistics, 18*(1), 50-60.

Marcsik, A., & Pap, I. (2000). Paleopathological research in Hungary. *Acta Biologica Szegediensis, 44*(1-4), 103-108.

Maresh, M. M. (1970). Measurements from roentgenograms, heart size, long bone lengths, bone, muscles and fat widths, skeletal maturation. In R. W. McCammon (Ed.) *Human Growth and Development* (pp. 157-200). Springfield, IL: Charles C. Thomas.

Margerison, B. J., & Knüsel, C. J. (2002). Paleodemographic comparison of a catastrophic and an attritional death assemblage. *American Journal of Physical Anthropology, 119*(2), 134-143. https://doi.org/10.1002/ajpa.10082

Marlowe, F. (2010). *The Hadza: hunter-gatherers of Tanzania* (Vol. 3). Berkeley, CA: University of California Press.

Márquez-Grant, N., Webster, H., Truesdell, J., & Fibiger, L. (2016). Physical anthropology and osteoarchaeology in Europe: History, Current Trends and Challenges. *International Journal of Osteoarchaeology, 26*(6), 1078-1088. https://doi.org/10.1002/oa.2520

Martin, D. L., Harrod, R. P., & Fields, M. (2010). Beaten down and worked to the bone: Bioarchaeological investigations of women and violence in the ancient Southwest. *Landscapes of Violence, 1*(1), 1-19.

Maschner, H. D., & Reedy-Maschner, K. L. (1998). Raid, retreat, defend (repeat): The archaeology and ethnohistory of warfare on the North Pacific Rim. *Journal of Anthropological Archaeology*, *17*(1), 19-51. https://doi.org/10.1006/jaar.1997.0315

Mason, A. H., Powell, W. G., Bankoff, H. A., Mathur, R., Bulatović, A., Filipović, V., & Ruiz, J. (2016). Tin isotope characterization of bronze artifacts of the central Balkans. *Journal of Archaeological Science, 69,* 110-117. https://doi.org/10.1016/j.jas.2016.04.012

Masson, M., Bereczki, Z., Molnár, E., Donoghue, H. D., Minnikin, D. E., Lee, O. Y. C., . . . Pálfi, G. (2015). 7000 year-old tuberculosis cases from Hungary – Osteological and biomolecular evidence. *Tuberculosis, 95,* S13-S17. https://doi.org/10.1016/j.tube.2015.02.007

Matsui, Y., Funakoshi, T., Kobayashi, H., Mitsuhashi, T., Kamishima, T., & Iwasaki, N. (2016). Bizarre parosteal osteochondromatous proliferation (Nora's lesion) affecting the distal end of the ulna: A case report. *BMC Musculoskeletal Disorders, 17*(1), 130. https://doi.org/10.1186/s12891-016-0981-3

Maxwell, S. E., & Delaney, H. D. (2004). *Designing experiments and analyzing data: A model comparison perspective, 2nd edition*. New York, NY: Psychology Press.

McEwen, C., Ditata, D., Lingg, C., Porini, A., Good, A., & Rankin, T. (1971). Ankylosing spondylitis and spondylitis accompanying ulcerative colitis, regional enteritis, psoriasis and reiter's disease. A comparative study. *Arthritis & Rheumatism, 14*(3), 291-318. https://doi.org/10.1002/art.1780140302

McIlvaine, B. K. (2015). Implications of reappraising the iron-deficiency anemia hypothesis. *International Journal of Osteoarchaeology, 25*(6), 997-1000. https://doi.org/10.1002/oa.2383

McKern, T. W., & Stewart, T. D. (1957). Skeletal age changes in young American males analysed from the standpoint of age identification. In Technical report EP 45 (pp. 89-97). Natick, MA: Quartermaster Research and Development Center, Environmental Protection Research Division.

McPherron, A., & Srejović, D. (Eds.). (1988). *Divostin and the Neolithic of central Serbia (No. 10)*. Pittsburgh, PA: University of Pittsburgh Press.

Medaris, L. A., Ponce, B., Hyde, Z., Delgado, D., Ennis, D., Lapidus, W., . . . Pappas, P. G. (2016). Cryptococcal osteomyelitis: A report of 5 cases and a review of the recent literature. *Mycoses, 59*(6), 334-342. https://doi.org/10.1111/myc.12476

Meindl, R. S., & Lovejoy, C. O. (1985). Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior sutures. *American Journal of Physical Anthropology, 68*(1), 57-66. https://doi.org/10.1002/ajpa.1330680106

Meisel, P., Reifenberger, J., Haase, R., Nauck, M., Bandt, C., & Kocher, T. (2008). Women are periodontally healthier than men, but why don't they have more teeth than men? *Menopause, 15*(2), 270-275. https://doi.org/10.1097/gme.0b013e31811ece0a

Merrett, D. C., & Pfeiffer, S. (2000). Maxillary sinusitis as an indicator of respiratory health in past populations. *American Journal of Physical Anthropology, 111*(3), 301-318. https://doi.org/10.1002/(sici)1096-8644(200003)111:3<301::aid-ajpa2>3.0.co;2-0

Meyer, C., Knipper, C., Nicklisch, N., Münster, A., Kürbis, O., Dresely, V., . . . Alt, K. W. (2018). Early Neolithic executions indicated by clustered cranial trauma in the mass grave of Halberstadt. *Nature Communications, 9*(1), 2472. https://doi.org/10.1038/s41467-018-04773-w

Meyer, C., Lohr, C., Gronenborn, D., & Alt, K. W. (2015). The massacre mass grave of Schöneck-Kilianstädten reveals new insights into collective violence in Early Neolithic Central Europe. *Proceedings of the National Academy of Sciences, 112*(36), 11217-11222. https://doi.org/10.1073/pnas.1504365112

Michelaki, K. (1999). *Household ceramic economies: Production and consumption of household ceramics among the Maros villagers of Bronze Age Hungary.* (Ph.D. Dissertation), University of Michigan, Ann Arbor, MI.

Michelaki, K. (2008). Making pots and potters in the Bronze Age Maros villages of Kiszombor-Új-Élet and Klárafalva-Hajdova. *Cambridge Archaeological Journal, 18*(03), 355-380. https://doi.org/10.1017/S0959774308000413

Mikić, Ž. (1998). O interdisciplinarnosti u srpskoj arheologiji sa posebnim osvrtom na fizičku antropologiju. *Гласник САД, 14,* 263-269.

Milašinović, L. (2008). *Grobovi moriške kulture nekropole bronzanog doba u Ostojićevu*. (Master's Thesis) Filozofski Fakultet, Univerzitet u Beogradu, Belgrade, Serbia.

Milašinović, L. (2009). Osvrt na moguću rekonstrukciju društvene strukture na moriškom sloju nekropole u ostojićevu. *Rad Muzeja Vojvodine, 51*, 65-70.

Miles, A. E. W. (1994). Non-union of the epiphysis of the acromion in the skeletal remains of a Scottish population of ca. 1700. *International Journal of Osteoarchaeology, 4*(2), 149-163. https://doi.org/10.1002/oa.1390040207

Milisauskas, S. (1992). Selevac: A Neolithic village in Yugoslavia by Ruth Tringham and Dušan Krstić [Book Review]. *American Journal of Archaeology, 96*(4), 765-766.

Miller, A. J., Brunelle, J. A., Carlos, J. P., Brown, L. J., & Löe, H. (1987). *Oral health of United States adults-The national survey of oral health in US employed adults and seniors: 1985–86*. Bethesda, MD: National Institute of Dental Research.

Miller, R. I., & Clarren, S. K. (2000). Long-term developmental outcomes in patients with deformational plagiocephaly. *Pediatrics, 105*(2), e26. https://doi.org/10.1542/peds.105.2.e26

Milner, G. R. (1999). Warfare in prehistoric and early historic Eastern North America. *Journal of Archaeological Research, 7*(2), 105-151.

Milner, G. R., Wood, J. W., & Boldsen, J. L. (2008). Advances in paleodemography. In M. A. Katzenberg & S. R. Saunders (Eds.), *Biological anthropology of the human skeleton, 2nd ed.* (pp. 561-600). New York, NY: Wiley-Liss.

Moini, M., Peyvandi, A. A., Rasouli, M. R., Khaji, A., Kakavand, M., Eghbal, P., . . . Molavi, B. (2011). Pattern of animal-related injuries in Iran. *Acta Medica Iranica*, *49*(3), 163-168.

Molleson, T., Cruse, K., & Mays, S. (1998). Some sexually dimorphic features of the human juvenile skull and their value in sex determination in immature skeletal remains. *Journal of Archaeological Science*, *25*(8), 719-728. https://doi.org/10.1006/jasc.1997.0215

Molleson, T. (2007). Bones of work at the origins of labour. In S. Hamilton & K. Wright (Eds.) *Archaeology and women: Ancient and modern issues* (pp. 185-198). Walnut Creek, CA: Left Coast Press.

Molnár, E. (2009). Malignant tumors in osteoarchaeological samples from Hungary. *Acta Biologica Szegediensis*, *53*(2), 117-124.

Molnar, S., & Molnar, I. (1985). Observations of dental diseases among prehistoric populations of Hungary. *American Journal of Physical Anthropology, 67*, 51-63. https://doi.org/10.1002/ajpa.1330670107

Moorrees, C. F., Fanning, E. A., & Hunt, E. E. (1963a). Formation and resorption of three deciduous teeth in children. *American Journal of Physical Anthropology*, *21*(2), 205-213. https://doi.org/10.1002/ajpa.1330210212

Moorrees, C. F., Fanning, E. A., & Hunt Jr, E. E. (1963b). Age variation of formation stages for ten permanent teeth. *Journal of Dental Research*, *42*(6), 1490-1502. https://doi.org/10.1177/00220345630420062701

Moral, E. (2016). Qu(e)erying sex and gender in archaeology: A critique of the "third" and other sexual categories. *Journal of Archaeological Method and Theory*, *23*(3), 788-809. https://doi.org/10.1007/s10816-016-9294-y

Morelli, E., Broadbent, J., Leichter, J., & Thomson, W. (2018). Pregnancy, parity and periodontal disease. *Australian Dental Journal*, *63*(3), 270-278. https://doi.org/10.1111/adj.12623

Morris, A. J., Steele, J., & White, D. A. (2001). The oral cleanliness and periodontal health of UK adults in 1998. *British Dental Journal*, *191*(4), 186-192. https://doi.org/10.1038/sj.bdj.4801135

Moumile, K., Merckx, J., Glorion, C., Pouliquen, J., Berche, P., & Ferroni, A. (2005). Bacterial aetiology of acute osteoarticular infections in children. *Acta Paediatrica*, *94*(4), 419-422. https://doi.org/10.1111/j.1651-2227.2005.tb01911.x

Mozsolics, A. (1957). *Archäologische Beiträge zur Geschichte der grossen Wanderung*. Budapest, Hungary: Akadémiai Kiadó.

Murphy Jr, W. A., Nedden, D. Z., Gostner, P., Knapp, R., Recheis, W., & Seidler, H. (2003). The iceman: discovery and imaging. *Radiology*, *226*(3), 614-629. https://doi.org/10.1148/radiol.2263020338

Nathan, M. A., Fratkin, E. M., & Roth, E. A. (1996). Sedentism and child health among rendille pastoralists of Northern Kenya. *Social Science & Medicine*, *43*(4), 503-515. https://doi.org/10.1016/0277-9536(95)00428-9

Nawrocki, S. P. (1995). Taphonomic processes in historic cemeteries. In A. L. Grauer (Ed.), *Bodies of evidence: Reconstructing history through skeletal analysis* (pp. 49-66). New York, NY: John Wiley.

Nehlich, O., Borić, D., Stefanović, S., & Richards, M. P. (2010). Sulphur isotope evidence for freshwater fish consumption: A case study from the Danube Gorges, SE Europe. *Journal of Archaeological Science, 37*(5), 1131-1139. http://dx.doi.org/10.1016/j.jas.2009.12.013

Nelson, A. E., Smith, M. W., Golightly, Y. M., & Jordan, J. M. (2014). "Generalized osteoarthritis": A systematic review. *Seminars in Arthritis and Rheumatism, 43*(6), 713-720. https://doi.org/10.1016/j.semarthrit.2013.12.007

Nemeskéri, J. (1969). Stanovništvo Lepenskog Vira. In D. Srejović (Ed.), *Lepenski Vir: Nova praistorijska kultura u Podunavlju* (pp. 239-257). Beograd, Srbija: Srpska Knjizevna Zadruga.

Nerlich, A. G., Peschel, O., & Egarter-Vigl, E. (2009). New evidence for Ötzi's final trauma. *Intensive Care Medicine, 35*(6), 1138-1139. https://doi.org/10.1007/s00134-009-1409-4

Nestor, J. (1933). Der Stand der Vorgeschichtsforschung in Rumänien. *Bericht der Römisch-Germanischen Kommission 1932, 22*, 11-181.

Neustupný, E. (1973). Jednoduchá metoda archeologické analýzy. *Památky archeologické, 64*, 169-234.

Nicodemus, A. (2010). *Marshland economies: Bronze Age animal production strategies of the Maros culture*. (Predoctoral Paper), University of Michigan, Ann Arbor, MI.

Nicodemus, A. (2014). *Bronze Age economies of the Carpathian Basin: Trade, craft production, and agro-pastoral intensification.* (Ph.D. Dissertation), University of Michigan, Ann Arbor, MI.

Nikolova, L. (2000). *Technology, style and society (contributions to the innovations between the Alps and the Black Sea in prehistory)*. Oxford: British Archaeological Reports 854.

Norgan, N. G., Bogin, B., & Cameron, N. (2012). Nutrition and growth. In N. Cameron & B. Bogin (Eds.), *Human growth and development, 2nd edition* (pp. 123-152). London: Elsevier.

Norwood, S., McAuley, C., Vallina, V. L., Fernandez, L. G., McLarty, J. W., & Goodfried, G. (2000). Mechanisms and patterns of injuries related to large animals. *Journal of Trauma and Acute Care Surgery, 48*(4), 740-744. https://doi.org/10.1097/00005373-200004000-00025

Novak, M., & Šlaus, M. (2011). Vertebral pathologies in two early modern period (16th–19th century) populations from Croatia. *American Journal of Physical Anthropology, 145*(2), 270-281. https://doi.org/10.1002/ajpa.21491

Ochoa, T. J., Ecker, L., Barletta, F., Mispireta, M. L., Gil, A. I., Contreras, C., … & Cleary, T. G. (2009). Age-related susceptibility to infection with diarrheagenic Escherichia coli among infants from Periurban areas in Lima, Peru. *Clinical Infectious Diseases*, 49(11), 1694-1702. https://doi.org/10.1086/648069

Ogden, A. (2007). Advances in the palaeopathology of teeth and jaws. In R. Pinhasi & S. Mays (Eds.), *Advances in Human Palaeopathology* (pp. 283-307). Chichester, England: John Wiley & Sons.

O'Shea, J. M. (1991). A radiocarbon-based chronology for the Maros Group of southeast Hungary. *Antiquity, 65*, 97-102. https://doi.org/10.1017/S0003598X00081084

O'Shea, J. M. (1996). *Villagers of the Maros: A portrait of an Early Bronze Age society*. New York, NY: Plenum Press.

O'Shea, J. M. (1998). A perspective on the Early Bronze Age Villagers of the Eastern Carpathian Basin. *Cambridge Archaeological Journal, 8*(1), 95-111.

O'Shea, J. M. (2011). A river runs through it: landscape and the evolution of Bronze Age networks in the Carpathian Basin. *Journal of World Prehistory, 24*, 161-174. https://doi.org/10.1007/s10963-011-9046-6

O'Shea, J. M., Barker, A., Motta, L., & Szentmiklosi, A. (2011). Archaeological investigations at Pecica "Santul Mare" 2006-2009. *Analele Banatului, S.N., Arheologie – Istorie, XIX*, 67-78.

O'Shea, J. M., & Nicodemus, A. (2019). "…the nearest run thing" The genesis and collapse of a Bronze Age polity in the Maros valley of southeastern Europe. In A. Gyucha (Ed.), *Coming together: Comparative approaches to population aggregation and early urbanization* (pp. 61-80). Albany, NY: SUNY Press.

O'Shea, J. M., Parditka, G., Nicodemus, A., Kristiansen, K., Sjögren, K.-G., Paja, L., . . . Milašinović, L. (2019). Social formation and collapse in the Tisza-Maros region: dating the Maros Group and its Late Bronze Age successors. *Antiquity, 93*(369), 604-623. https://doi.org/10.15184/aqy.2019.40

Oas, S. E. (2010). *Maros macrobotanicals: An archaeobotanical analysis of Bronze Age agriculture in the Maros site of Santul Mic.* (BA Honors Thesis), University of Michigan, Ann Arbor, MI.

Oelze, V. M. (2012). *Mobility and diet in Neolithic, Bronze Age, and Iron Age Germany: Evidence from multiple isotope analysis.* (Ph.D. Dissertation), Leiden University, Leiden, The Netherlands.

Oelze, V. M., Nehlich, O., & Richards, M. P. (2011). 'There's no place like home' - no isotopic evidence for mobility at the Early Bronze Age cemetery of Singen, Germany. *Archaeometry, 54*, 752-778.

Ogden, A. (2007). Advances in the paleopathology of teeth and jaws. In S. Mays & R. Pinhasi (Eds.), *Advances in human paleopathology* (pp. 283-307). Chichester, UK: John Wiley & Sons.

Olivieri, I., D'Angelo, S., Palazzi, C., Padula, A., Mader, R., & Khan, M. A. (2009). Diffuse idiopathic skeletal hyperostosis: Differentiation from ankylosing spondylitis. *Current Rheumatology Reports, 11*(5), 321. https://doi.org/10.1007/s11926-009-0046-9

Ono, K., Yonenobu, K., Miyamoto, S., & Okada, K. (1999). Pathology of ossification of the posterior longitudinal ligament and ligamentum flavum. *Clinical Orthopaedics and Related Research, 359*, 18-26. https://doi.org/10.1097/00003086-199902000-00003

Ortner, D. J. (2003). *Identification of pathological conditions in human skeletal remains, 2nd edition.* San Diego, CA: Academic Press.

Ortner, D. J., Butler, W., Cafarella, J., & Milligan, L. (2001). Evidence of probable scurvy in subadults from archeological sites in North America. *American Journal of Physical Anthropology, 114*(4), 343-351. https://doi.org/10.1002/ajpa.1046

Osgood, R. (2001a). Central and Eastern Europe. In R. Osgood, S. Monks, & J. Toms (Eds.), *Bronze Age warfare* (pp. 65-88). Phoenix Mill, UK: Sutton.

Osgood, R. (2001b). Northern and Western Europe. In R. Osgood, S. Monks, & J. Toms (Eds.), *Bronze Age warfare* (pp. 9-36). Phoenix Mill, UK: Sutton.

Osgood, R., Monks, S., & Toms, J. (2001). *Bronze Age warfare*. Phoenix Mill, UK: Sutton.

Paine, R. R. (1989). Model life table fitting by maximum likelihood estimation: A procedure to reconstruct paleodemographic characteristics from skeletal age distributions. *American Journal of Physical Anthropology, 79*(1), 51-61. https://doi.org/10.1002/ajpa.1330790106

Paja, L. (2013). *Joint fusions in palaeopathology: Diagnosis and epidemiology.* (Ph.D. Dissertation), University of Szeged, Szeged, Hungary.

Palavestra, A. (2013). Čitanja Miloja M. Vasića u srpskoj arheologiji. *Етноантрополошки проблеми, 8*(3), 681-715.

Pappas, E. (2007). Boxing, wrestling, and martial arts related injuries treated in emergency departments in the United States, 2002-2005. *Journal of sports science & medicine, 6*(CSSI-2), 58-61.

Parker Pearson, M. (1999). *The Archaeology of Death and Burial*. College Station, TX: Texas A&M University Press.

Parker Pearson, M. (2005). Warfare, violence and slavery in later prehistory: An introduction. In M. Parker Pearson & I. J. N. Thorpe (Eds.), *Warfare, violence and slavery in prehistory: Proceedings of a prehistoric society conference at Sheffield University* (pp. 19-34). Oxford: BAR International Series 1374.

Parkinson, W. A. (2002). Integration, interaction, and tribal 'cycling': The transition to the Copper Age on the Great Hungarian Plain. In W. A. Parkinson (Ed.), *The Archaeology of Tribal Societies* (pp. 391-438). Ann Arbor, MI: International Monographs in Prehistory.

Parkinson, W. A. (2006). Tribal boundaries: Stylistic variability and social boundary maintenance during the transition to the Copper Age on the Great Hungarian Plain. *Journal of Anthropological Archaeology, 25*, 33–58. https://doi.org/10.1016/j.jaa.2005.06.002

Parkinson, W.A., & Duffy, P. (2007). Fortifications and enclosures in European prehistory: A cross-cultural perspective. *Journal of Archaeological Research, 15*(2), 97-141. https://doi.org/10.1007/s10814-007-9010-2

Parkinson, W. A., & Gyucha, A. (2012). Long-term social dynamics and the emergence of hereditary inequality: A prehistoric example from the Carpathian Basin. In T. L. Kienlin & A. Zimmermann (Eds.), *Beyond Elites: alternatives to hierarchical systems in modelling social formations* (pp. 243-249). Bonn, Germany: R. Habelt.

Parkinson, W. A., Yerkes, R. W., & Gyucha, A. (2010). Early Copper Age settlements in the Körös region of the Great Hungarian Plain. *Journal of Field Archaeology, 35*, 486-515. https://doi.org/10.1179/009346910X12707321520675

Parner, E., Heidmann, J. M., Kjaer, I., Væth, M., & Poulsen, S. (2002). Biological interpretation of the correlation of emergence times of permanent teeth. *Journal of Dental Research, 81*(7), 451-454. https://doi.org/10.1177/154405910208100703

Parvizi, J., Leunig, M., & Ganz, R. (2007). Femoroacetabular impingement. *Journal of the American Academy of Orthopaedic Surgeons, 15*(9), 561-570.

Peebles, C. S., & Kus, S. M. (1977). Archaeological correlates of ranked societies. *American Antiquity, 42*(3), 421-448. https://doi.org/10.2307/279066

Pelto, G. H., & Armar-Klemesu, M. (2011). Balancing nurturance, cost and time: Complementary feeding in Accra, Ghana. *Maternal & Child Nutrition, 7*(s3), 66-81. https://doi.org/10.1111/j.1740-8709.2011.00351.x

Pelto, G. H., Levitt, E., & Thairu, L. (2003). Improving feeding practices: Current patterns, common constraints, and the design of interventions. *Food and Nutrition Bulletin, 24*(1), 45-82. https://doi.org/10.1177/156482650302400104

Peregrine, P. N. (1999). Legitimation crises in prehistoric worlds. In P. N. Kardulias (Ed.), *World-systems theory in practice: Leadership, production, and exchange* (pp. 37-52). Lanham, MD: Rowan & Littlefield.

Phenice, T. W. (1969). A newly developed visual method of sexing the os pubis. *American Journal of Physical Anthropology, 30*(2), 297-301. https://doi.org/10.1002/ajpa.1330300214

Pike, I. L., Straight, B., Oesterle, M., Hilton, C., & Lanyasunya, A. (2010). Documenting the health consequences of endemic warfare in three pastoralist communities of northern Kenya: A conceptual framework. *Social Science and Medicine, 70*, 45-52. https://doi.org/10.1016/j.socscimed.2009.10.007

Pinhasi, R., Stefanović, S., Papathanasiou, A., & Stock, J. T. (2011). Variability in long bone growth patterns and limb proportions within and amongst Mesolithic and Neolithic populations from southeast Europe. In R. Pinhasi & J. T. Stock (Eds.), *Human Bioarchaeology of the Transition to Agriculture* (pp. 177-202). Oxford: John Wiley & Sons.

Pollard, A. M., Ditchfield, P., Piva, E., Wallis, S., Falys, C., & Ford, S. (2012). 'Sprouting like cockle amongst the wheat': The St. Brice's Day Massacre and the isotopic analysis of human bones from St. John's College, Oxford. *Oxford Journal of Archaeology, 31*(1), 83-102. https://doi.org/10.1111/j.1468-0092.2011.00380.x

Pompeani, K. (2018). *Reevaluating Early Bronze Age masculinities: Skeletal and mortuary analysis of transgenderism at Ostojićevo, Serbia*. Paper presented at the Annual Meeting of the Society for American Archaeology, Washington, D.C.

Popescu, D. (1944). *Die frühe und mittlere Bronzezeit in Siebenbürgen*. Bucharest, Romania: Propaganda Ministeriums.

Porčić, M., & Stefanović, S. (2009). Physical activity and social status in Early Bronze Age society: The Mokrin necropolis. *Journal of Anthropological Archaeology, 28*, 259-273. https://doi.org/10.1016/j.jaa.2009.06.001

Poroszlai, I. (2003). Tell Cultures of the Early and Middle Bronze Age. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 142-143). Budapest, Hungary: Ministry of National Cultural Heritage.

Porter, A., Montgomery, C. O., Montgomery, B. E., Eastin, C., Boyette, J., & Snead, G. (2019). Intimate partner violence-related fractures in the United States: an 8 year review. *Journal of Family Violence, 34*(7), 601-609. https://doi.org/10.1007/s10896-018-0007-z

Pósa, A., Maixner, F., Mende, B. G., Köhler, K., Osztás, A., Sola, C., . . . Zink, A. (2015). Tuberculosis in Late Neolithic-Early Copper Age human skeletal remains from Hungary. *Tuberculosis, 95*, S18-S22. https://doi.org/10.1016/j.tube.2015.02.011

Powell, W., Mathur, R., Bankoff, H. A., Mason, A., Bulatović, A., Filipović, V., & Godfrey, L. (2017). Digging deeper: Insights into metallurgical transitions in European prehistory through copper isotopes. *Journal of Archaeological Science, 88,* 37-46. https://doi.org/10.1016/j.jas.2017.06.012

Preradović, D. (2016). L'historique du Fonds photographique de plaques de verre noir et blanc du Musée national de Belgrade sur les monuments médiévaux. In R. Bertho, J.-P. Garric, & F. Queyrel (Eds.), *Patrimoine photographié, patrimoine photographique (Actes de colloques)*. Institut national d'histoire de l'art. Retrieved from http://journals.openedition.org/inha/3927.

Price, T. D., Knipper, C., Grupe, G., & Smrcka, V. (2004). Strontium Isotopes and prehistoric human migration: The Bell Beaker period in central Europe. *European Journal of Archaeology, 7*(1), 9-40. https://doi.org/10.1177/1461957104047992

Primas, M. (1997). Bronze Age economy and ideology: Central Europe in focus. *Journal of European Archaeology, 5*(1), 115-130. https://doi.org/10.1179/096576697800703593

Provencher, M. T., Frank, R. M., LeClere, L. E., Metzger, P. D., Ryu, J. J., Bernhardson, A., & Romeo, A. A. (2012). The Hill-Sachs lesion: Diagnosis, classification, and management. *Journal of the American Academy of Orthopaedic Surgeons, 20*(4), 242-252. https://doi.org/10.5435/jaaos-20-04-242

Pruvost, M., Schwarz, R., Correia, V. B., Champlot, S., Braguier, S., Morel, N., . . . Geigl, E.-M. (2007). Freshly excavated fossil bones are best for amplification of ancient DNA. *Proceedings of the National Academy of Sciences, 104*(3), 739. https://doi.org/10.1073/pnas.0610257104

Quinn, C. P., & Ciugudean, H. (2018). Settlement placement and socio-economic priorities: Dynamic landscapes in Bronze Age Transylvania. *Journal of Archaeological Science: Reports, 19*, 936-948. https://doi.org/10.1016/j.jasrep.2017.05.046

Raczky, P., Hertelendi, E., & Veres, M. (1994). La datation absolue des cultures des tell de l'age du bronze en Hongrie. In I. Bóna & P. Raczky (Eds.), *Le Bel Age du Bronze en Hongrie* (pp. 42-47). Mont-Beuvray, France: Centre Européen d'Archéologie du Mont-Beuvray.

Rader, W. T., & Peters, C. R. (1993). Hypertrophy of the acetabulo-cristal buttress in Homo sapiens. *American Journal of Physical Anthropology, 92*(2), 149-153. https://doi.org/10.1002/ajpa.1330920204

Radivojević, M., Rehren, T., Pernicka, E., Šljivar, D., Brauns, M., & Borić, D. (2010). On the origins of extractive metallurgy: New evidence from Europe. *Journal of Archaeological Science, 37*, 2775-2787. https://doi.org/10.1016/j.jas.2010.06.012

Radović, M., & Stefanović, S. (2013). The bioarchaeology of the Neolithic transition: Evidence of dental pathologies at Lepenski Vir (Serbia). *Documenta Praehistorica, 40*, 74-83.

Rebay-Salisbury, K., Sørensen, M. L. S., & Hughes, J. (Eds.). (2010). *Body parts and bodies whole: Changing relations and meanings*. Oxford: Oxbow.

Redfern, R. (2013). Violence as an aspect of the Durotriges female life course. In S. Ralph (Ed.), *The archaeology of violence: Interdisciplinary approaches* (pp. 63-97). Albany, NY: SUNY Press.

Redfern, R. C. (2008). A bioarchaeological analysis of violence in Iron Age females: A perspective from Dorset England (mid to late seventh century BC to the first century AD). In O. Davis, N. M. Sharples, & K. Waddington (Eds.), *Changing perspectives on the first millennium BC. Proceedings of the Iron Age research student seminar* (pp. 139-160). Oxford: Oxbow Books.

Rega, E. (1989). *A Bioarchaeological examination of the skeletal series from two Bronze Age mortuary sites in southeastern Hungary* (M.A. Thesis), University of Chicago, Chicago, IL.

Rega, E. (1995). *Biological correlates of social structure in the Early Bronze Age cemetery at Mokrin* (PhD Dissertation), University of Chicago, Chicago, IL.

Rega, E. (1997). Age, gender and biological reality in the Early Bronze Age cemetery at Mokrin. In J. Moore & E. Scott (Eds.), *Invisible people and processes* (pp. 229-247). London: Leicester University Press.

Rega, E. (2000). The Gendering of Children in the Early Bronze Age cemetery at Mokrin. In L. Hurcombe & M. McDonald (Eds.), *Gender and material culture in archaeological perspective* (pp. 238-249). New York, NY: Macmillan.

Renfrew, C. (1968). Wessex without Mycenae. *The Annual of the British School at Athens, 63*, 277-285. https://doi.org/10.1017/S0068245400014416

Renfrew, C. (1969a). Trade and culture process in European prehistory. *Current Anthropology, 10*(2/3), 151-169. https://doi.org/10.1086/201066

Renfrew, C. (1969b). The autonomy of the south-east European Copper Age. In J.G.D. Clark & J. Coles (Eds.), *Proceedings of the Prehistoric Society for 1969*, No. 2 (pp. 12-47). London: H.K. Lewis & Co.

Renfrew, C. (1972). *The emergence of civilisation: The cyclades and the Aegean in the third millennium B.C.* London: Methuen & Co.

Renfrew, C. (1973). Monuments, mobilization and social organization in Neolithic Wessex. In C. Renfrew (Ed.), *The explanation of culture change: Models in prehistory* (pp. 539-558). Pittsburgh, PA: University of Pittsburgh Press.

Renfrew, C. (1974). Beyond a subsistence economy: The evolution of social organization in prehistoric Europe. *Bulletin of the American Schools of Oriental Research. Supplementary Studies, 20*, 69-95.

Renfrew, C. (1982). Socio-economic change in ranked societies. In C. Renfrew & S. Shennan (Eds.), *Ranking, resource and exchange: Aspects of the archaeology of early European society* (pp. 1-8). Cambridge: Cambridge University Press.

Renfrew, C., & Shennan, S. (Eds.). (1982). *Ranking, resource, and exchange: Aspects of the archaeology of early European society*. Cambridge: Cambridge University Press.

Resnick, D., & Niwayama, G. (1978). Intravertebral disk herniations: Cartilaginous (Schmorl's) nodes. *Radiology*, *126*(1), 57-65. https://doi.org/10.1148/126.1.57

Rice, P. C. (1981). Prehistoric venuses: Symbols of motherhood or womanhood? *Journal of Anthropological Research, 37*(4), 402-414. https://doi.org/10.1086/jar.37.4.3629836

Richard, S. A., Black, R. E., Gilman, R. H., Guerrant, R. L., Kang, G., Lanata, C. F., ... & Checkley, W. (2013). Diarrhea in early childhood: short-term association with weight and long-term association with length. *American Journal of Epidemiology, 178*(7), 1129-1138. https://doi.org/10.1093/aje/kwt094

Riebe, D. J. (2016). *Interaction and socio-cultural boundaries during the Late Neolithic on the Great Hungarian Plain.* (Ph.D. Dissertation), University of Illinois at Chicago, Chicago, IL.

Robbins, C. T., Felicetti, L. A., & Sponheimer, M. (2005). The effect of dietary protein quality on nitrogen isotope discrimination in mammals and birds. *Oecologia, 144*(4), 534-540. https://doi.org/10.1007/s00442-005-0021-8

Roberts, C., & Manchester, K. (2007). *The Archaeology of Disease*. Ithaca, NY: Cornell University Press.

Roberts, C. A. (2007). A bioarcheological study of maxillary sinusitis. *American Journal of Physical Anthropology*, *133*(2), 792-807. https://doi.org/10.1002/ajpa.20601

Rogers, J., & Waldron, T. (1995). *A field guide to joint disease in archaeology*. Chichester, UK: John Wiley & Sons.

Rogers, T. L. (2005). Determining the sex of human remains through cranial morphology. *Journal of Forensic Science, 50*(3), 1-8. https://doi.org/10.1520/JFS2003385

Rogers, T. L., & Saunders, S. R. (1994). Accuracy of sex determination using morphological traits of the human pelvis. *Journal of Forensic Sciences*, *39*(4), 1047-1056. https://doi.org/10.1520/JFS13683J

Robertson, A., Nutton, R. W., & Keating, J. F. (2006). Dislocation of the knee. *The Journal of Bone and Joint Surgery*, *88*(6), 706-711. https://doi.org/10.1302/0301-620X.88B6.17448

Roksandic, M., Djurić, M., Rakočević, Z., & Seguin, K. (2006). Interpersonal violence at Lepenski Vir Mesolithic/Neolithic complex of the Iron Gates Gorge (Serbia-Romania). *American Journal of Physical Anthropology*, *129*(3), 339-348. https://doi.org/10.1002/ajpa.20286

Rølla, G., Gaare, D., Langmyhr, F. J., & Helgeland, K. (1989). Silicon in calculus and its potential role in calculus formation. In J. M. ten Cate (Ed.), *Recent advances in the study of dental calculus: Proceedings of a workshop 6-9 November, 1988, Noordwijkerhout, the Netherlands* (pp. 97-103). Oxford: Oxford University Press.

Roper, D. C. (1976). Lateral displacement of artifacts due to plowing. *American Antiquity*, *41*(3), 372-375. https://doi.org/10.2307/279527

Roska, M. (1926-1928). Cercetări la Cetăţuia de la Otomani. *Anuarul Comisiei Monumentelor Istorice*, 192-205.

Roska, M. (1941). A Gyulavarsándi (Arad M.) Laposhalom Rétegtani Viszonyai. *Folia archaeologica, III-IV*, 45-61.

Russell, S. L., Ickovics, J. R., & Yaffee, R. A. (2008). Exploring potential pathways between parity and tooth loss among American women. *American Journal of Public Health, 98*(7), 1263-1270. https://doi.org/10.2105/ajph.2007.124735

Salvolini, E., Di Giorgio, R., Curatola, A., Mazzanti, L., & Fratto, G. (1998). Biochemical modifications of human whole saliva induced by pregnancy. *BJOG: An International Journal of Obstetrics & Gynaecology, 105*(6), 656-660. https://doi.org/10.1111/j.1471-0528.1998.tb10181.x

Sandor-Chicideanu, M., & Chicideanu, I. (1989). Zu den grăbsitten der Periam-Pecica Kultur *Dacia, XXXIII*, 5-38.

Saunders, S. R. (2008). Juvenile skeletons and growth-related studies. *Biological Anthropology of the Human Skeleton, Second Edition*, 115-147. Hoboken, NJ: John Wiley & Sons.

Saunders, S. R., & Hoppa, R. D. (1993). Growth deficit in survivors and Non-survivors: biological mortality bias in subadult skeletal samples. *American Journal of Physical Anthropology, 36*(S17), 127-151. https://doi.org/10.1002/ajpa.1330360608

Saxe, A. A. (1970). *Social dimensions of mortuary practices* (PhD Dissertation), University of Michigan, Ann Arbor, MI.

Scheie, A. A. (1994). Mechanisms of dental plaque formation. *Advances in Dental Research, 8*(2), 246-253. https://doi.org/10.1177/08959374940080021801

Schell, L. M., Knutson, K. L., & Bailey, S. (2012). Environmental effects on growth. In N. Cameron & B. Bogin (Eds.), *Human growth and development, 2nd edition* (pp. 245-286). London: Elsevier.

Scheuer, L., & Black, S. (2000). Development and ageing of the juvenile skeleton. In M. Cox & S. Mays (Eds.) *Human osteology in archaeology and forensic science* (pp. 9-21). London: Greenwich Medical Media.

Schmitt, H., Dubljanin, E., Schneider, S., & Schiltenwolf, M. (2004). Radiographic changes in the lumbar spine in former elite athletes. *Spine, 29*(22), 2554-2559. https://doi.org/10.1097/01.brs.0000145606.68189.69

Schmorl, G., & Junghanns, H. (1959). *The human spine in health and disease*. New York, NY: Grune and Stratton.

Schoeninger, M. J., & DeNiro, M. J. (1984). Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica Acta, 48*(4), 625-639. https://doi.org/10.1016/0016-7037(84)90091-7

Schofield, R., & Wrigley, E. A. (1979). Infant and child mortality in England in the late Tudor and early Stuart period. In C. Webster (Ed.), *Health, medicine and mortality in the sixteenth century* (pp. 61-96). Cambridge: Cambridge University Press.

Schultz, M. (1988). Paläopathologische diagnostik. In R. Knußmann (Ed.), *Anthropologie handbuch der vergleichenden biologie des menschen* (pp. 480-496). Stuttgart, Germany: Gustav Fischer Verlag.

Schwartz, J. H. (2007). *Skeleton keys: An introduction to human skeletal morphology, development, and analysis*. New York, NY: Oxford University Press.

Schwartz, J. H., Houghton, F., Macchiarelli, R., & Bondioli, L. (2010). Skeletal remains from Punic Carthage do not support systematic sacrifice of infants. *PloS one, 5*(2), e9177.

Schwidetzky, I. (1980). The influence of the Steppe people based on the physical anthropological data in special consideration to the Corded-Battle Axe Culture in the transformation of European and Anatolian Culture c. 4500-2500 B.C. and its Legacy, Part II. *The Journal of Indo-European Studies, 8*(3-4), 345-360.

Sciulli, P. W. (2007). Relative dental maturity and associated skeletal maturity in prehistoric Native Americans of the Ohio valley area. *American Journal of Physical Anthropology, 132*(4), 545-557. https://doi.org/10.1002/ajpa.20547

Scott, E. (2001). Killing the female? Archaeological narratives of infanticide. In B. Arnold & N. L. Wicker (Eds.), *Gender and the archaeology of death* (pp. 1-22). Walnut Creek, CA: AltaMira.

Service, E. R. (1962). *Primitive social organization*. New York, NY: Random House.

Shapiro, H. L. (1959). Symposium on the history of anthropology. *American Anthropologist, 61*(3), 371-379. https://doi.org/10.1525/aa.1959.61.3.02a00010

Shennan, S. (1975). The social organization at Branč. *Antiquity, 49*, 279-288. https://doi.org/10.1017/S0003598X00070319

Shennan, S. J. (1982). From minimal to moderate ranking. In C. Renfrew & S. J. Shennan (Eds.), *Ranking, resource and exchange: Aspects of the archaeology of early European society* (pp. 27-32). Cambridge: Cambridge University Press.

Shennan, S. J. (1993a). Settlement and social change in Central Europe, 3500-1500 BC. *Journal of World Prehistory, 7*, 121-161.

Shennan, S. J. (1993b). Commodities, transactions, and growth in the central-European early Bronze Age. *Journal of European Archaeology, 1*(2), 59-72. https://doi.org/10.1179/096576693800719347

Shennan, S. J. (1999). Cost, benefit and value in the organization of early European copper production. *Antiquity, 73*, 352-363. https://doi.org/10.1017/S0003598X0008830X

Sherratt, A. (1982a). Mobile resources: settlement and exchange in early agricultural Europe. In C. Renfrew & S. Shennan (Eds.), *Ranking, resource and exchange: Aspects of the archaeology of early European society* (pp. 13-26). Cambridge: Cambridge University Press.

Sherratt, A. (1982b). The development of Neolithic and Copper Age settlement in the Great Hungarian Plain part I: The regional setting. *Oxford Journal of Archaeology, 1*(3), 287-316. https://doi.org/10.1111/j.1468-0092.1982.tb00315.x

Sherratt, A. (1983). The secondary exploitation of animals in the Old World. *World Archaeology, 15*, 90-104. https://doi.org/10.1080/00438243.1983.9979887

Sherratt, A. (1993). What would a Bronze Age world system look like? Relationships between temperate Europe and the Mediterranean in later prehistory. *Journal of European Archaeology*, *1*, 59-71. https://doi.org/10.1179/096576693800719293

Sherratt, A. (1997). *Economy and society in prehistoric Europe: Changing perspectives*. Princeton, NJ: Princeton University Press.

Sherwood, S. C., Windingstad, J. D., Barker, A. W., O'Shea, J. M., & Sherwood, W. C. (2013). Evidence for Holocene aeolian activity at the close of the Middle Bronze Age in the eastern Carpathian Basin: geoarchaeological results from the Mureş River Valley, Romania. *Geoarchaeology*, *28*, 131-146. https://doi.org/10.1002/gea.21434

Shirtliff, M.E., & Mader, J. T. (2002). Acute septic arthritis. *Clinical Microbiology Reviews, 15*(4), 527-544. https://doi.org/10.1128/CMR.15.4.527-544.2002

Shnirelman, V. (1996). *Who gets the past? Competition for ancestors among non-Russian intellectuals in Russia*. Washington, D.C.: The Woodrow Wilson Center Press.

Siegel, S., & Castellan, N. J. (1988). *Non-parametric statistics for the behavioral sciences*. New York, NY: McGraw Hill.

Silver, J. R. (2002). Spinal injuries resulting from horse riding accidents. *Spinal Cord, 40*(6), 264-271. https://doi.org/10.1038/sj.sc.3101280

Skomal, S. N. (1980). The social organization of the Tiszapolgar Group at Basatanya. *The Journal of Indo-European Studies, 8*, 75-91.

Šljivić, B. (1935). Knochenfunde in einem prahistorischen Grab bei Trebenischte. *Zeitschrift fur Morphologie und Antropologie (Stuttgart), XXXVII*(2).

Smith, B. H. (1991). Standards of human tooth formation and dental age assessment. *Advances in dental anthropology*. New York, NY: Wiley-Liss.

Smith, M. E., Auchincloss, J. M., & Ali, M. S. (1985). Causes and consequences of hand injury. *The Journal of Hand Surgery: British & European Volume, 10*(3), 288-292. https://doi.org/10.1016/S0266-7681(85)80045-0

Smith, P. (n.d.). *Report on the faunal remains from Klárafalva-Hajdova and Kiszombor-Új-Élet*. University of Michigan, Museum of Anthropology, Ann Arbor, MI.

Sofaer Derevenski, J. (1997). Age and gender at the site of Tiszapolgar-Basatanya, Hungary. *Antiquity, 71*(274), 875-889. https://doi.org/10.1017/S0003598X00085793

Sofaer Derevenski, J. (2000). Sex differences in activity-related osseous change in the spine and the gendered division of labor at Ensay and Wharram Percy, UK. *American Journal of Physical Anthropology*, *111*(3), 333-354. https://doi.org/10.1002/(sici)1096-8644(200003)111:3<333::aid-ajpa4>3.0.co;2-k

Sofaer, J. R. (2006a). *The body as material culture: A theoretical osteoarchaeology* (Vol. 4). Cambridge: Cambridge University Press.

Sofaer, J.R. (2006b). Gender, bioarchaeology, and human ontogeny. In R. Gowland & C. Knüsel (Eds.), *Social archaeology of funerary remains* (pp. 155-156). Oxford: Oxbow.

Sofaer, J. (2006c). Pots, houses and metal: technological relations at the Bronze Age tell at Százhalombatta, Hungary. *Oxford Journal of Archaeology, 25*(2), 127-147. https://doi.org/10.1111/j.1468-0092.2006.00253.x

Sofaer, J. (2011). Human Ontogeny and Material Change at the Bronze Age Tell of Százhalombatta, Hungary. *Cambridge Archaeological Journal, 21*(2), 217. 1 https://doi.org/0.1017/S0959774311000242

Sørensen, M. L. S. (1997). Reading dress: The construction of social categories and identities in Bronze Age Europe. *Journal of European Archaeology, 5*(1), 93-114. https://doi.org/10.1179/096576697800703656

Sørensen, M.L.S. (2010). Households. In T. Earle & K. Kristiansen (Eds.), *Organising Bronze Age Societies: The Mediterranean, Central Europe, and Scandanavia compared* (pp. 122-154). Cambridge: Cambridge University Press.

Sørensen, M. L. S., & Rebay-Salisbury, K. (2009). Landscapes of the body: Burials of the Middle Bronze Age in Hungary. *European Journal of Archaeology, 11*, 49-74. https://doi.org/10.1177/1461957108101241

Spector, J., & Whelan, M. (1991). Incorporating gender into archaeology courses. In S. Morgan (Ed.), *Gender and anthropology: Critical reviews for research and teaching*. Washington, D.C.: American Anthropological Association.

Spekker, O., Pálfi, G., Kozocsay, G., Pósa, A., Bereczki, Z., & Molnár, E. (2012). New cases of probable skeletal tuberculosis from the Neolithic period in Hungary – A morphological study. *Acta Biologica Szegediensis, 56*(2), 115-123.

Spradley, M. K., & Jantz, R. L. (2011). Sex estimation in forensic anthropology: Skull versus postcranial elements. *Journal of Forensic Sciences, 56*(2), 289-296. https://doi.org/10.1111/j.1556-4029.2010.01635.x

Srejović, D. (1994). Kulture bakarnog i ranog bronzanog doba na tlu Srbije. In R. Samarȓić & J. Milićević (Eds.), *Istorija srpskog naroda: Vol. 1-2* (pp. 21-43). Beograd, Srbija: Srpska kȋiȇevna zadruga.

Steckel, R., Larsen, C., Sciulli, P., & Walker, P. (2005). *The global history of health project: Data collection codebook*. Columbus, OH.

Steckel, R. H. (2012). Social and economic effects on growth. In N. Cameron & B. Bogin (Eds.), *Human growth and development, 2nd edition* (pp. 225-244). London: Elsevier.

Steele, D. G., & Bramblett, C. A. (1988). *The anatomy and biology of the human skeleton*. College Station, TX: Texas A&M University Press.

Stefanović, S., & Jovanović, J. (2013). *Treponemal infections in the Danube Gorges (9500-5500 BC) - evidence from newborns*. Paper presented at the 150th anniversary of the discovery of the Mesolithic Shellmiddens, Muge, Portugal.

Stefanović, S., & Porčić, M. (2011). Between-group differences in the patterning of musculo-skeletal stress markers: Avoiding confounding factors by focusing on qualitative aspects of physical activity. *International Journal of Osteoarchaeology, 23*(1), 94-105. https://doi.org/10.002/oa.1243

Steinberg, J. M. (1996). Ploughzone sampling in Denmark: Isolating and interpreting site signatures from disturbed contexts. *Antiquity, 70*(268), 368-392. https://doi.org/10.1017/S0003598X00083332

Stevens-Lapsley, J. E., & Kohrt, W. M. (2010). Osteoarthritis in women: Effects of estrogen, obesity and physical activity. *Women's Health, 6*(4), 601-615. https://doi.org/10.2217/whe.10.38

Stevenson, D. K., Verter, J., Fanaroff, A. A., Oh, W., Ehrenkranz, R. A., Shankaran, S., . . . Papile, L. A. (2000). Sex differences in outcomes of very low birthweight infants: The newborn male disadvantage. *Archives of Disease in Childhood - Fetal and Neonatal Edition, 83*(3), F182. https://doi.org/10.1136/fn.83.3.F182

Stewart, T. D., & Kerley, E. R. (1979). *Essentials of forensic anthropology. Especially as developed in the United States*. Springfield, IL: Charles C. Thomas.

Stojanowski, C. M., Seidemann, R. M., & Doran, G. H. (2002). Differential skeletal preservation at Windover Pond: Causes and consequences. *American Journal of Physical Anthropology, 119*(1), 15-26. https://doi.org/10.1002/ajpa.10101

Stojić, M., & Jocić, M. (Eds.). (2006). *Niš: Cultural stratigraphy of prehistoric sites in the Niš region*. Beograd-Niš, Srbija: Arheološki Institut (Beograd) and Narodni Muzej Niš.

Stone, P. K. (2016). Biocultural perspectives on maternal mortality and obstetrical death from the past to the present. *American Journal of Physical Anthropology, 159*(S61), 150-171. https://doi.org/10.1002/ajpa.22906

Stuart-Macadam, P. (1985). Porotic hyperostosis: Representative of a childhood condition. *American Journal of Physical Anthropology, 66*(4), 391-398. https://doi.org/10.1002/ajpa.1330660407

Sugiyama, L. S. (2004). Illness, injury, and disability among Shiwiar forager-horticulturalists: Implications of health-risk buffering for the evolution of human life history. *American Journal of Physical Anthropology, 123*(4), 371-389. https://doi.org/10.1002/ajpa.10325

Sümegi, P., Kertész, R., & Rudner, E. (2003). Paleoenvrionmental history of Hungary. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 51-56). Budapest, Hungary: Ministry of National Cultural Heritage, Teleki László Foundation.

(SWGANTH), S. W. G. f. F. A. (2011). Trauma analysis. Retrieved from http://swganth.startlogic.com/Trauma%20Rev0.pdf

Switzer, J. A., & Michienzi, A. E. (2012). Elder abuse: an update on prevalence, identification, and reporting for the orthopaedic surgeon. *Journal of the American Academy of Orthopaedic Surgeons, 20*(12), 788-794. https://doi.org/10.5435/JAAOS-20-12-788

Szathmári, I. (2003). The florescence of the Middle Bronze Age in the Tisza Region: The Füzesabony Culture. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 156-157). Budapest, Hungary: Ministry of National Cultural Heritage.

Tafuri, M. A., Craig, O. E., & Canci, A. (2009). Stable isotope evidence for the consumption of millet and other plants in Bronze Age Italy. *American Journal of Physical Anthropology, 139*(2), 146-153. https://doi.org/10.1002/ajpa.20955

Tasić, N. (1972). The Mokrin necropolis and its position in the development of the Early Bronze Age in Vojvodina. In M. Girić (Ed.), *Mokrin, the Early Bronze Age necropolis* (Vol. II, pp. 9-28). Washington D.C.: Smithsonian.

Tasić, N. (1983). *Југословенско подунавље од индоевропске сеобе до продора Скита*. Beograd-Vršac: Balkanološki institut SANU.

Tasić, N. (2003-2004). Historical picture of development of Bronze Age cultures in Vojvodina. *Starinar, 53-54*, 23-34.

Tasić, N. (2005). Bronze and Iron Age sites in Srem and the straigraphy of Gomolava. *Balcanica, 36*, 7-17.

Tasić, N. (Ed.) (1996). *The Yugoslav Danube basin and the neighbouring regions in the 2nd millennium B.C.* Belgrade-Vršac, Serbia: Serbian Academy for Sciences and Arts, Institute for Balkan Studies.

Ten Cate, A. R. (1989). *Oral histology: Development, structure, and function*. St. Louis, MO: Elsevier.

Todd, T. W. (1920). Age changes in the pubic bone. I. The male white pubis. *American Journal of Physical Anthropology, 3*(3), 285-334. https://doi.org/10.1002/ajpa.1330030301

Todd, T. W. (1921). Age changes in the pubic bone. *American Journal of Physical Anthropology, 4*(1), 1-70. https://doi.org/10.1002/ajpa.1330030301

Torda, A.J., Gottlieb, T., & BradburyR. (1995). Pyogenic Vertebral Osteomyelitis: Analysis of 20 Cases and Review. *Clinical Infectious Diseases*, 20(2), 320-328. https://doi.org/10.1177/2309499900501300305

Treherne, P. (1995). The warrior's beauty: the masculine body and self-identity in Bronze-Age Europe. *Journal of European archaeology*, *3*(1), 105-144. https://doi.org/10.1179/096576695800688269

Trigger, B. G. (1984). Alternative archaeologies: Nationalist, colonialist, imperialist. *Man*, *19*(3), 355-370. https://doi.org/10.2307/2802176

Trigham, R., & Krstić, D. (Eds.). (1990). *Selevac, a Neolithic village in Yugoslavia (No. 15)*. Los Angeles, CA: Cotsen Institute of Archaeology.

Tringham, R. (1983). V. Gordon Childe 25 Years after: His relevance for the archaeology of the eighties. *Journal of Field Archaeology*, *10*(1), 85-100. https://doi.org/0.1179/009346983791504381

Tringham, R. (2000). Southeastern Europe in the transition to agriculture in Europe: Bridge, buffer, or mosaic. In T. D. Price (Ed.), *Europe's first farmers* (pp. 19-56). Cambridge: Cambridge University Press.

Tung, T. A. (2007). Trauma and violence in the Wari empire of the Peruvian Andes: Warfare, raids, and ritual fights. *American Journal of Physical Anthropology*, *133*(3), 941-956. https://doi.org/10.1002/ajpa.20565

Turner II, C. G. (1979). Dental anthropological indications of agriculture among the Jomon people of central Japan. X. Peopling of the Pacific. *American Journal of Physical Anthropology, 51*(4), 619-635. https://doi.org/10.1002/ajpa.1330510413

Tyrrell, A. R., Reilly, T., & Troup, J. D. (1985). Circadian variation in stature and the effects of spinal loading. *Spine, 10*(2), 161-164. https://doi.org/10.1097/00007632-198503000-00011

Ubelaker, D. H. (1989). *Human skeletal remains, excavation, analysis, interpretation*. Washington, D.C.: Taraxacum.

Ubelaker, D. H., & Pap, I. (1996). Health profiles of a Bronze Age population from northeastern Hungary. *Annales Historico Naturales-Musei Nationalis Hungarici, Hungarian National History Museum, 88*, 271-296.

Ubelaker, D. H., & Pap, I. (1998). Skeletal evidence for health and disease in the Iron Age of northeastern Hungary. *International Journal of Osteoarchaeology, 8*(4), 231-251. https://doi.org/10.1002/(SICI)1099-1212(199807/08)8:4<231::AID-OA423>3.0.CO;2-B

Ubelaker, D. H., & Pap, I. (2008). Human skeletal biology from the Árpádian Age of northeastern Hungary. *Anthropologie, 46*(1), 25-36.

Ubelaker, D. H., & Pap, I. (2009). Skeletal evidence for morbidity and mortality in Copper Age samples from northeastern Hungary. *International Journal of Osteoarchaeology, 19*(1), 23-35. https://doi.org/10.1002/oa.969

Ubelaker, D. H., Pap, I., & Graver, S. (2006). Morbidity and mortality in the Neolithic of northeastern Hungary. *Anthropologie (Brno), 44*(3), 241-258.

Ulizzi, L., & Zonta, L. A. (2002). Sex differential patterns in perinatal deaths in Italy. *Human Biology, 74*(6), 879-888. https://doi.org/10.1353/hub.2003.0012

UNICEF & WHO. (2009). Diarrhoea: Why children are still dying and what can be done. Retrieved from http://whqlibdoc.who.int/publications/2009/9789241598415_eng.pdf

Uzelac, J. (1995). Bronze Age of the South Yugoslavian Banat - history and present state of research. In N. Tasić (Ed.), *The Yugoslav Danube Basin and the Neighbouring Regions in the 2nd Millennium B.C.* (pp. 23-42). Belgrade–Vršac, Serbia: Balkanološki institut SANU.

Uzsoki, A. (1963). Bronzkori temető Mosonszentmiklós-Jánosházapusztán. *Arrabona, 5*, 5-89.

Vallois, H. V. (1960). Vital statistics in prehistoric populations as determined from archaeological data. In R.F. Heizer & S.F. Cook (Eds), *The Application of Quantitative methods in archaeology* (pp. 186-222). Chicago: Quadrangle Books.

Van der Merwe, A. E., Işcan, M. Y., & L'Abbè, E. N. (2006). The pattern of vertebral osteophyte development in a South African population. *International Journal of Osteoarchaeology, 16*(5), 459-464. https://doi.org/10.1002/oa.841

van Dijk, C. N., van Sterkenburg, M. N., Wiegerinck, J. I., Karlsson, J., & Maffulli, N. (2011). Terminology for Achilles tendon related disorders. *Knee Surgery, Sports Traumatology, Arthroscopy, 19*(5), 835-841. https://doi.org/10.1007/s00167-010-1374-z van Klinken, G. J. (1999). Bone collagen quality indicators for palaeodietary and radiocarbon measurements. *Journal of Archaeological Science, 26*(6), 687-695. http://doi.org/10.1006/jasc.1998.0385

Vandkilde, H. (2006). Archaeology and war: Presentations of warriors and peasants in archaeological interpretations. In T. Otto, H. Thrane, & H. Vandkilde (Eds.), *Warfare and society: Aarchaeological and social anthropological perspectives* (pp. 57-74). Aarhus, Denmark: Aarhus University Press.

Vékony, G. (2003). The history of archaeological fieldwork in Hungary. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 15-22). Budapest, Hungary: Ministry of National Cultural Heritage.

Ventresca Miller, A., Hanks, B. K., Judd, M., Epimakhov, A., & Razhev, D. (2017). Weaning practices among pastoralists: new evidence of infant feeding patterns from Bronze Age Eurasia. *American Journal of Physical Anthropology*, *162*(3), 409-422. https://doi.org/10.1002/ajpa.23126

Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., & Sachdev, H. S. (2008). Maternal and child undernutrition: consequences for adult health and human capital. *The Lancet*, *371*(9609), 340-357. https://doi.org/10.1016/S0140-6736(07)61692-4

Vicze, M. (2003). Dunaújváros–Dunadûlõ: Burials of the Vatya Culture. In Z. Visy, M. Nagy, & Z. B. Kiss (Eds.), *Hungarian archaeology at the turn of the millennium* (pp. 155-156). Budapest, Hungary: Ministry of National Cultural Heritage.

Vikatou, I., Hoogland, M.P., & Waters-Rist, A.L. (2017). Osteochondritis Dissecans of skeletal elements of the foot in a 19th century rural farming community from The Netherlands. *International Journal of Paleopathology, 19*, 53-63. https://doi.org/10.1016/j.ijpp.2017.09.005

Villotte, S., Stefanovic, S., & Knüsel, C. J. (2014). External auditory exostoses and aquatic activities during the Mesolithic and the Neolithic in Europe: Results from a large prehistoric sample. *Anthropologie (Czech Republic), 52*(1), 73-90.

Volk, C. G., & Ubelaker, D. H. (2002). A test of the Phenice method for the estimation of sex. *Journal of Forensic Science*, *47*(1), 19-24.

Von Endt, D. W., & Ortner, D. J. (1984). Experimental effects of bone size and temperature on bone diagenesis. *Journal of Archaeological Science*, *11*(3), 247-253. https://doi.org/10.1016/0305-4403(84)90005-0

Vretemark, M. (2010). Subsistence strategies. In T. K. Earle & K. Kristiansen (Eds.), *Organizing Bronze Age societies* (pp. 155-184). Oxford: Oxford University Press.

Wagner, A. L., Murtagh, F. R., Arrington, J. A., & Stallworth, D. (2000). Relationship of Schmorl's nodes to vertebral body endplate fractures and acute endplate disk extrusions. *American Journal of Neuroradiology*, *21*(2), 276-281.

Waldron, T. (1987). The relative survival of the human skeleton: Implications for paleopathology. In A. Boddington, A. N. Garland, & R. C. Janaway (Eds.), *Death, decay, and reconstruction: Approaches to archaeology and forensic science* (pp. 55-64). Manchester, UK: Manchester University Press.

Waldron, T. (2009). *Palaeopathology*. Cambridge: Cambridge University Press.

Walker, P. L. (1995). Problems of preservation and sexism in sexing: Some lessons from historical collections for palaeodemographers. In S.R. Saunders & A. Herring (Eds.), *Grave reflections: Portraying the past through cemetery studies* (pp. 31-48). Toronto: Canadian Scholar's Press.

Walker, P. L., Johnson, J. R., & Lambert, P. M. (1988). Age and sex biases in the preservation of human skeletal remains. *American Journal of Physical Anthropology, 76*(2), 183-188. https://doi.org/10.1002/ajpa.1330760206

Walker, P. L., Bathurst, R. R., Richman, R., Gjerdrum, T., & Andrushko, V. A. (2009). The causes of porotic hyperostosis and cribra orbitalia: A reappraisal of the iron-deficiency-anemia hypothesis. *American Journal of Physical Anthropology, 139*(2), 109-125. https://doi.org/10.1002/ajpa.21031

Walrath, D. E., Turner, P., & Bruzek, J. (2004). Reliability test of the visual assessment of cranial traits for sex determination. *American Journal of Physical Anthropology, 125*(2), 132-137. https://doi.org/10.1002/ajpa.10373

Wang, Z., Li, X.-D., Li, M.-Q., & Wang, Q.-P. (2008). Changes in basic metabolic elements associated with the degeneration and ossification of ligamenta flava. *The Journal of Spinal Cord Medicine, 31*(3), 279-284. https://doi.org/10.1080/10790268.2008.11760723

Watson, J. T., Fields, M., & Martin, D. L. (2010). Introduction of agriculture and its effects on women's oral health. *American Journal of Human Biology, 22*(1), 92-102. https://doi.org/10.1002/ajhb.20958

Weiss, K. M. (1975). Demographic disturbance and the use of life tables in anthropology. *Memoirs of the Society for American Archaeology, 30*, 46-56. https://doi.org/10.1017/S0081130000003786

Weiss, K. M., & Wobst, H. M. (1973). Demographic models for anthropology. *Memoirs of the Society for American Archaeology, 27*, i-ix, 1-186.

Weston, V.C., Jones, A.C., Bradbury, N., Fawthrop, F., Doherty, M. (1999). Clinical features and outcome of septic arthritis in a single UK Health District 1982–1991. *Annals of the Rheumatic Diseases, 58*(4), 214-219. http://dx.doi.org/10.1136/ard.58.4.214

Wheeler, S.M. (2012). Nutritional and disease stress of juveniles from the Dakhleh Oasis, Egypt. *International Journal of Osteoarchaeology, 22*(2), 219-234. https://doi.org/10.1002/oa.1201

White, D. J. (1997). Dental calculus: recent insights into occurrence, formation, prevention, removal and oral health effects of supragingival and subgingival deposits. *European Journal of Oral Sciences, 105*(5), 508-522. https://doi.org/10.1111/j.1600-0722.1997.tb00238.x

White, T. D., & Folkens, P. A. (2005). *The human bone manual*. Oxford: Elsevier Science.

Wilcox, R. (2012). *Introduction to robust estimation and hypothesis testing, 3rd edition*. Waltham, MA.

Willey, G. R., & Phillips, P. (1958). *Method and theory in American archaeology*. Chicago, IL: University of Chicago Press.

Willey, P., & Emerson, T. E. (1993). The osteology and archaeology of the Crow Creek massacre. *Plains Anthropologist*, *38*(145), 227-269. https://doi.org/10.1080/2052546.1993.11931655

Willey, P., Galloway, A., & Snyder, L. (1997). Bone mineral density and survival of elements and element portions in the bones of the Crow Creek massacre victims. *American Journal of Physical Anthropology*, *104*(4), 513-528. https://doi.org/10.1002/(sici)1096-8644(199712)104:4<513::aid-ajpa6>3.0.co;2-s

Williams, B. A., & Rogers, T. L. (2006). Evaluating the accuracy and precision of cranial morphological traits for sex determination. *Journal of Forensic Sciences*, *51*(4), 729-735. 1 https://doi.org/0.1111/j.1556-4029.2006.00177.x

Wilson, M., & Daly, M. (1985). Competitiveness, risk taking, and violence: the young male syndrome. *Ethology and Sociobiology*, *6*(1), 59-73. https://doi.org/10.1016/0162-3095(85)90041-X

Wilson, R. J. P., Hermann, N. P., & Mantz, L. M. (2010). Evaluation of stature estimation from the Database for Forensic Anthropology. *Journal of Forensic Sciences*, *55*, 684-689. https://doi.org/10.1111/j.1556-4029.2010.01343.x

Wimmer, G., & Pihlstrom, B. L. (2008). A critical assessment of adverse pregnancy outcome and periodontal disease. *Journal of Clinical Periodontology*, *35*(s8), 380-397. https://doi.org/10.1111/j.1600-051X.2008.01284.x

Winkvist, A., Rasmussen, K. M., & Habicht, J. P. (1992). A new definition of maternal depletion syndrome. *American Journal of Public Health*, *82*(5), 691-694. https://doi.org/10.2105/ajph.82.5.691

Winterhalder, B., Lu, F., & Tucker, B. (1999). Risk-sensitive adaptive tactics: Models and evidence from subsistence studies in biology and anthropology. *Journal of Archaeological Research*, *7*(4), 301-348. https://doi.org/1059-0161/99/1200-0301516.00/

Woertler, K., & Waldt, S. (2006). MR imaging in sports-related glenohumeral instability. *European Radiology*, *16*(12), 2622-2636. https://doi.org/10.1007/s00330-006-0258-6

Wood, J. W. (1992). The osteological paradox: Problems of inferring prehistoric health from skeletal samples. *Current Anthropology*, *33*, 343-370. https://doi.org/10.1086/204084

Wu, V., Huff, H., & Bhandari, M. (2010). Pattern of physical injury associated with intimate partner violence in women presenting to the emergency department: a systematic review and meta-analysis. *Trauma, Violence, & Abuse*, *11*(2), 71-82. https://doi.org/10.1177/1524838010367503

Yaussy, S. L., & DeWitte, S. N. (2018). Patterns of frailty in non-adults from medieval London. *International Journal of Paleopathology*, *22*, 1-7. https://doi.org/10.1016/j.ijpp.2018.03.008

Yerkes, R. W., Sarris, A., Frolking, T. A., Parkinson, W. A., Gyucha, A., Hardy, M., & Catanoso, L. (2007). Geophysical and geochemical investigations at two Early Copper Age settlements in the Körös River Valley, southeastern Hungary. *Geoarchaeology*, *22*, 845-871. https://doi.org/10.1002/gea.20198

Zhou, H.-X., Lu, L., Chu, T., Wang, T., Cao, D., Li, F., . . . Feng, S. (2015). Skeletal cryptococcosis from 1977 to 2013. *Frontiers in Microbiology*, *5*(740). https://doi.org/10.3389/fmicb.2014.00740

Zimmerli, W. (2010). Vertebral osteomyelitis. *New England Journal of Medicine, 362*(11), 1022-1029. https://doi.org/10.1056/NEJMcp0910753

Zoffmann, Z. K. (2000). Anthropological sketch of the prehistoric population of the Carpathian Basin. *Acta Biologica Szegediensis, 44*(1-4), 75-79.

Zotović, M. (1985). *Arheološki i etnički problemi bronzanog i gvozdenog doba Zapadne Srbije*. Beograd, Srbija: Zavičajni Muzej Titovo Užice, Savez Arheoloških društava Jugoslavije.

Zuckerman, M. K., Garofalo, E. M., Frohlich, B., & Ortner, D. J. (2014). Anemia or scurvy: A pilot study on differential diagnosis of porous and hyperostotic lesions using differential cranial vault thickness in subadult humans. *International Journal of Paleopathology, 5*, 27-33. https://doi.org/10.1016/j.ijpp.2014.02.001

Zukowski, L. A., Falsetti, A. B., & Tillman, M. D. (2012). The influence of sex, age and BMI on the degeneration of the lumbar spine. *Journal of Anatomy, 220*(1), 57-66. https://doi.org/10.1111/j.1469-7580.2011.01444.x

Zvelebil, M. (1986). Mesolithic societies and the transition to farming: Problems of time, scale, and organisation. In M. Zvelebil (Ed.), *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming* (pp. 167-188). Cambridge: Cambridge University Press.

Zvelebil, M., & Rowley-Conwy, P. (1986). Foragers and farmers in Atlantic Europe. In M. Zvelebil (Ed.), *Hunters in Transition* (pp. 67-93). Cambridge: Cambridge University Press.