COMPLIANCE TO AN ACCELEROMETER PROTOCOL IN OLDER ADULTS

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Accelerometers are reliable, valid, and versatile tools for measuring physical activity for research studies. However, compliance to protocols of accelerometer use by participants of research studies is crucial in order to ensure the most accurate measure of their physical activity. It is possible that aging effects on physical and cognitive health will limit the ability of an older adult to be compliant with wearing an accelerometer. Unfortunately, research investigations into the factors that predict compliance to accelerometer protocols in older adults are nonexistent.

We used data from the study entitled *Environmental Correlates of Physical Activity Among Older Adults: A Healthy Aging Network Research Collaboration* to investigate compliance to an accelerometer protocol in a cohort of 201 individuals 65 years of age and older in Allegheny county, Pennsylvania. We had two main hypotheses: (a) Compliance generally decreases with age among older adults and (b) the effect of age on compliance will be attenuated when controlling for demographic variables, cognitive and physical functioning, and walking behavior.

The results show that 89.90% (n=178) of participants had at least four valid days of accelerometer wear and therefore met the valid person criteria and 50.00% (n=99) of participants had seven valid days of accelerometer wear and therefore met the compliant person criteria based on the accelerometer protocol. The best multivariate logistic regression model to predict being a valid person included IADL ($p=0.002$) score and a constant ($p<.001$) while the best multivariate

logistic regression model to predict being a compliant person included Modified Guralnik Lower Body Score (p=0.008), White race (p=0.018), and a constant (p=0.036).

While we hypothesized that compliance would decrease with advancing age in older adults, this analysis found no significant relationship between age and compliance. The results of this analysis did, however, show that several characteristics were associated with compliance, which supports the idea that compliance to an accelerometer protocol is influenced by certain characteristics among older adults. This research has public health significance because participants with characteristics associated with lower compliance will be consistently excluded from analyses involving measures of physical activity with accelerometers until compliance is increased to acceptable levels.

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PREFACE

First I would like to acknowledge and thank all of the co-authors on this manuscript: Constance Mols Bayles, PhD, FACSM; Kathleen McTigue, MD, MPH, MS; William Satariano, PhD, MPH; Ravi Sharma, PhD; John Wilbur Wilson, PhD; Joseph Robare, MS, RD, LDN; and Anna Ercius, MPH. I would also like to acknowledge and thank everyone who assisted in the data collection process for the *Environmental Correlates of Physical Activity Among Older Adults: A Healthy Aging Network Research Collaboration* study in Allegheny county: Joseph Robare, Anna Ercius, Anna Pendley, Jennifer Sala, and Tracey Beason. I am so grateful for their help and support and willingness to be flexible throughout the data collection process. Although there are too many individuals to name, I would also like to acknowledge and thank all of the members of the Healthy Aging Research Network who were involved with the *Environmental Correlates of Physical Activity Among Older Adults: A Healthy Aging Network Research Collaboration* study.

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1.0 BACKGROUND

1.1 PHYSICAL ACTIVITY

1.1.1 Importance of Physical Activity in Older Adults

Over the past several decades, physical activity has emerged as an important factor in the promotion and maintenance of health throughout a person's lifespan. Research has revealed that an active lifestyle is linked with lower rates of all-cause mortality and mortality from cardiovascular disease in particular [1-7]. Furthermore, an active lifestyle has been shown to be protective against the development of hypertension [8-11] and obesity [12-15], and have positive health effects on individuals with type II diabetes mellitus [16-18] and cancer [19-21]. As a result, the Centers for Disease Control and Prevention, American College of Sports Medicine [22], National Institutes of Health [23], and the United States Department of Health and Human Services [24] have all promoted physical activity in an attempt to increase physical activity levels among Americans. Furthermore, physical activity has been included as a leading health indicator in Healthy People 2010 [25].

It is well known that physical activity is associated with the maintenance of health and functioning in older populations in particular [26]. Regular physical activity is beneficial to older adults for many reasons: Exercise helps maintain the ability to live independently; reduces the risk of falling and fracturing bones; reduces the risk of dying from coronary heart disease and of developing high blood pressure, colon cancer, and diabetes; helps those with chronic, disabling conditions improve their stamina and muscle strength; reduces symptoms of anxiety and depression and fosters improvements in mood and feelings of well-being; helps maintain healthy bones, muscles, and joints; and helps control joint swelling and pain associated with arthritis. Research has shown that reduced physical activity in older age partially contributes to the loss of strength and stamina that is associated with the aging process [27].

Compared with younger populations, older adults have the most to gain from physical activity because as a group they are at the highest risk for the diseases and health problems that physical activity can help prevent [28]. Unfortunately, despite the known health benefits, the frequency of physical activity declines with advancing age. Among adults 65 to 74 years of age, the prevalence of no leisure time physical activity is 51%, and the prevalence of no leisure time physical activity increases to 65% among adults 75 years of age and older [25]. As a group, older adults are the most sedentary age group in the entire population [29, 30]. Given the tremendous health benefits and the prevalence of a sedentary lifestyle, increasing physical activity in older adults is an important public health goal for the twenty-first century, especially in light of the substantial projected increase in the number of older Americans over the next several decades [31, 32].

1.1.2 Definition of Physical Activity

Physical activity is defined as “any bodily movement produced by skeletal muscle that results in energy expenditure” [33]. It is a complex phenomenon characterized by its frequency, intensity, duration, and surrounding environmental and social conditions [34]. Physical activity-associated energy expenditure (AEE) is only one component of an individual's total energy expenditure (TEE). TEE is comprised of the resting metabolic rate (RMR), diet-induced energy expenditure (DEE), and AEE. There are a wide range of activities that can contribute to AEE, including occupational and leisure-time physical activities, sports, household activities, personal care, and transportation. Variation in TEE is affected mostly by changes in AEE, as RMR and DEE vary only slightly within and between individuals [35]. The various health-related dimensions of physical activity, which include energy expenditure, aerobic intensity, weight bearing, flexibility, and strength, likely have implications in terms of the prevention of different diseases [36], and therefore make the measurement of physical activity more complicated [37]. As a result, epidemiological studies measuring physical activity should identify all body movements and obtain information on dose, which is the intensity, frequency, and duration of the movement. The variable of interest in epidemiological research is generally an overall physical activity score that is based on the frequency, intensity, and duration of all activities with the consolidation of, rather than distinction between, occupational, leisure, and household activity [38].

Metabolic energy turnover, abbreviated as METS, is often used as the expression of the intensity of physical activity. For an average adult, 1 MET equals an energy expenditure of 1 kcal per kilogram body mass per hour or the approximate oxygen consumption of 3.5 ml oxygen per kilogram body mass per minute. Duration of physical activity is commonly measured in minutes or hours. The optimal measure of the duration of physical activity should be sensitive to small bouts of movement. Frequency of physical activity is usually measured in times per day, per week, or per month [38]. Researchers commonly use these physical activity dimensions to estimate the energy expenditure of individuals, which is then used in the analysis of data from epidemiological studies [39].

1.1.3 Measurement of Physical Activity

Physical activity is a complex epidemiological exposure that has many dimensions, making it difficult to study. Accurate measurement of physical activity is essential in order to (a) identify causal associations between physical activity and various health and disease outcomes, (b) examine dose-response relationships between physical activity and various health and disease outcomes, (c) document changes and differences in physical activity within and between individuals over time, (d) formulate public health recommendations, (e) validate intervention programs, (f) compare physical activity levels between populations, and (g) measure physical activity in children and other groups of individuals who have a limited capacity for accurate self-appraisal. Valid and reliable methods of measuring physical activity decrease the chances of misclassification and increase the chances of better understanding its relationship with health and disease [38].

Over the past few decades, investigations into the relationship between physical activity and health have been gaining popularity. However, despite the increased attention paid to physical activity epidemiology, the lack of practical, valid, reliable, and sensitive instruments for measuring physical activity has been a limiting factor [38]. In the past, epidemiological studies relied mostly on questionnaires and interviews to examine patterns of physical activity in the population. Although the investigators were always aware of the limitations and many possible errors and biases associated with these methods, no other measurement techniques were available [40]. Fortunately, the number of valid and reliable methods of measuring physical activity has greatly expanded in recent years. In order for a method to be useful in measuring physical activity it must (a) measure what it is intended to measure, (b) consistently give similar results under similar circumstances, (c) have acceptable costs to the study investigator and participant, and (d) not alter behavior of the participant [41].

Today numerous methods exist for measuring physical activity in both laboratory and free-living conditions. These methods generally fall into three categories: (1) criterion methods, (2) subjective methods, and (3) objective methods. In general, criterion methods like behavioral observation, doubly labeled water, and indirect calorimetry are the most reliable and valid methods of measuring physical activity. These methods are commonly used to validate other physical activity measurement tools. Subjective methods of measuring physical activity are self-report techniques including physical activity records and logs, recall questionnaires, quantitative histories, and global self-reports. The primary objective methods of measuring physical activity include heart rate monitors, pedometers, and accelerometers [35]. Each method of measuring physical activity captures only a part of the entire activity behavior pattern of an individual [41] and no one method is suitable for every situation and every population [38]. As a result, a variety of methods are often employed to measure physical activity in epidemiological studies. In epidemiological studies, the optimal tool to measure physical activity requires a balance between the accuracy of an instrument and its utility in studying large groups of individuals.

1.2 CATEGORIES OF PHYSICAL ACTIVITY MEASUREMENT

1.2.1 Criterion Methods of Physical Activity Measurement

1.2.1.1 Behavioral observation

Behavioral observation was one of the first methods that was used to measure physical activity. This method involves a trained observer documenting the activities of a participant through observation [35]. The trained observer classifies the physical activity behaviors of the participant into discrete categories. The frequency, intensity, and duration of physical activity as well an estimate of energy expenditure can be determined through behavioral observation. Although behavioral observation can provide excellent quantitative and qualitative information about the physical activity being performed as well as the surrounding environment, it has several disadvantages that make its use in large epidemiological studies impractical: Intense training of observers is required, data collection is both time- and labor-intensive, and the presence of the observer may alter the activity patterns of the participant [42].

1.2.1.2 Doubly labeled water

The doubly labeled water method is a biochemical procedure that can estimate energy expenditure through biological markers that reflect the rate of metabolism in the body. The procedure involves the ingestion of two stable isotopes of water by the participant. After a one or two week period, the rate of loss of the two isotopes from the body is analyzed and energy expenditure is determined. While doubly labeled water is often the preferred method of measuring energy expenditure, it cannot be used to determine the frequency, intensity, or duration of physical activity. The doubly labeled water method is seldom used in large epidemiological studies because of its invasiveness, high cost, and inability to measure the different dimensions of physical activity [42]. It is, however, an extremely common method of validating other measures of physical activity [38].

1.2.1.3 Indirect calorimetry

Indirect calorimetry measures the frequency, duration, and intensity of activity, which results in an estimate of energy expenditure. In this method, either a metabolic chamber or a metabolic cart is used to determine the amount of oxygen an individual consumes and the amount of carbon dioxide an individual expires in order to estimate total energy expenditure [42]. While indirect calorimetry is a very accurate tool for estimating energy expenditure, it is costly, invasive, and is likely to affect the physical activity patterns of the participant [38]. As a result, indirect calorimetry is rarely used in large epidemiological studies, although it is often used as a method of validating other measures of physical activity [41].

1.2.2 Subjective Methods of Physical Activity Measurement

1.2.2.1 Self-report

Many epidemiological studies rely on self-reports of physical activity by the participant through survey procedures and questionnaires [35]. These methods are commonly used in epidemiological research because they can capture both quantitative and qualitative information, are inexpensive, are of low burden to the participant, and can be administered quickly [42]. However, self-report techniques rely on the subjective interpretation of the questions and the perceptions of the physical activity behaviors of the participants themselves [35]. Although self-report techniques are easy and inexpensive to administer compared to other types of physical activity measures [43], problems with accurate recall and over- or under-estimation of physical activity by the participant are severe limitations [44]. While self-report techniques can be used to classify a population into distinct categories based on levels physical activity, these methods are not appropriate to quantify energy expenditure at the individual level [45].

Self-report techniques are used to measure the frequency, intensity, and duration of activity as well as provide an estimate of energy expenditure. There are four main categories of self-report techniques used in epidemiological research: physical activity records and logs, recall questionnaires, quantitative histories, and global self-reports. All four of the main categories of self-report techniques are generally used in large epidemiological studies because they are inexpensive and are socially acceptable [42]. Physical activity records require participants to record individual bouts of activity as they occur during the day [46], while physical activity logs generally provide a list of specific activities and require participants to record the time spent in the listed activities [47]. The main limitations of physical activity records and logs are a high burden to participants, potential reactivity to participants, and potential unacceptability to participants.

Global self-report measures are typically brief one- to four-item instruments that ask participants to provide a generic classification of their usual activity patterns in a specific time period, usually for a specific activity domain such as leisure or occupation. These measures only attempt to characterize broad patterns of habitual physical activity behavior, usually over a relatively long period of time such as a year [42]. In epidemiological research, these measures are typically used to stratify a population into high and low physical activity level categories so that the rates of disease in each activity category can be compared [48].

Quantitative history questionnaires are detailed instruments that assess physical activity behaviors with 15 to 60 items. These items are used to determine the frequency, intensity, and duration of activity in various categories such as occupation, household, sports and conditioning, transportation, and recreational activities over a certain period of time such as the past day, week, month, or year. These instruments are generally administered by an interviewer because of their length and complexity. Quantitative history questionnaires are generally used in epidemiological studies to investigate a dose response relationship between historical physical activity levels and disease. The main disadvantages of these instruments are that they have higher administrative and participant burden [42]. Some well-known and widely-used quantitative history questionnaires are the Minnesota Leisure-Time Physical Activity Questionnaire [49], the Modifiable Activity Questionnaire [50], and the Paffenbarger Physical Activity Questionnaire [51].

Recall questionnaires are typically short and simple instruments that take between 5 and 15 minutes to complete and are used to quantify physical activity patterns over the recent past, such as the last week or the last month [42]. The main purpose of these instruments is to classify individuals into broad physical activity categories and provide some basic quantification of the major behavioral characteristics of the activities reported [52-54]. The Seven Day Physical Activity Recall is a commonly used recall questionnaire in epidemiological research [55].

1.2.3 Objective Methods of Physical Activity Measurement

1.2.3.1 Heart rate monitoring

Heart rate monitoring is a direct measure of the body's physiological response to physical activity, which can be used to estimate energy expenditure. Energy expenditure estimates using this method are based on the linear relationship between heart rate and oxygen consumption during moderate and vigorous activity [35]. Heart rate monitoring is a much less accurate estimate of energy expenditure during low-intensity activities, however, because the relationship between heart rate and oxygen consumption is generally nonlinear and is confounded by other factors such as stress, smoking, and caffeine intake [56]. The main advantages of heart rate monitors are that they have a good association with energy expenditure, are valid in laboratory and field settings, have low participant burden, describe the intensity, frequency, and duration of activity well, and are easy and quick to use for data collection purposes. On the other hand, the main disadvantages of heart rate monitors are that they are costly, may provide some discomfort to participants, and are useful only for estimating the energy expenditure associated with aerobic activities. In addition, there is currently uncertainty regarding the best way to use heart rate data to predict energy expenditure [42]. Although heart rate monitoring appears to have epidemiological validity for estimating energy expenditure [56], the large variability in heart rate data due to confounding factors make estimations of energy expenditure on the individual level unreliable [57].

1.2.3.2 Pedometers

A pedometer is a mechanical device worn on the hip that measures walking behavior by counting the number of steps taken by an individual. A pedometer counts steps by measuring the vertical displacement of a lever that rotates a counting device. Steps can then be converted to distance when the stride length of an individual is known. Pedometers are typically used to provide an estimate of the energy expenditure associated with the walking behavior of an individual. Pedometers have many advantages: They are low cost, are noninvasive, can be used in a variety of settings, are easy to manage and oversee use in large groups of individuals, may promote behavior change, and are an objective measure of walking behavior [42]. The main disadvantages of pedometers are that they are not appropriate for individuals who perform a large proportion of activities without vertical movement and that they cannot measure the intensity of walking [35].

1.2.3.3 Accelerometers

Accelerometers measure the frequency, intensity, and duration of physical activity [58]. They are composed of one or more piezoelectric acceleration sensors, which are small electric devices that measure acceleration to detect patterns of body movement [59]. Acceleration is the change in the speed of a body over an amount of time. In general, measuring acceleration is more desirable than measuring speed of movement because both speed and distance can be determined from acceleration by taking the integral of acceleration with respect to time [60]. Accelerometers are typically worn on the hip or wrist or are attached to the shoe. It is important to note that an accelerometer measures the acceleration of the body part to which it is attached, rather than the absolute acceleration of the individual [42].

As mentioned previously, the majority of accelerometers used today contain one or more piezoelectric acceleration sensors. A piezoelectric acceleration sensor is composed of a piezoelectric element and a seismic mass contained in an enclosure. When the sensor accelerates, the seismic mass causes the piezoelectric element to deform by bending, causing direct tension or compression. These conformational changes cause a displaced charge to build on one side of the sensor. This charge generates a variable output voltage signal, which is then filtered, amplified, and converted to an output measure called raw counts. Different analytical techniques are then applied to the raw counts to determine the physical activity counts for a given time frame, which is commonly one-minute in length. Physical activity counts are the final output of the accelerometer. These counts can then be used to predict physical activity-related energy expenditure in order to classify daily physical activity into intensity categories. As a result, the duration and frequency of light, moderate, and vigorous physical activity can be calculated at the individual level on a daily basis [60].

The main advantages of accelerometers are that they can be used in both laboratory and field settings, are non-invasive, provide indicators of the intensity, frequency, and duration of activity, provide minute-by-minute information, and allow for extended periods of recording [42]. The main disadvantages of most accelerometers are that they are reliable only in detecting dynamic events [60], they inaccurately assess a large range of activities such as upper-body movements and water-based activities, and that accurate monitor placement by participants, which is crucial for accurate data collection, during long unobserved periods of data collection cannot be guaranteed [42]. Currently, the most profound limitation of accelerometers is that there is no single equation that can accurately estimate energy expenditure based on one acceleration score for all activities because the relationship between acceleration and energy expenditure depends on the activity being performed [61]. As a result, it is likely that different equations will be necessary for different populations, including older adults, based on the most common physical activities in order to produce the most accurate estimate of energy expenditure from accelerometers.

1.3 MEASUREMENT OF PHYSICAL ACTIVITY IN OLDER ADULTS

Overall, there is a lack of valid and reliable methods available to measure physical activity in older adults because most of the measurement tools available today were designed to be used in a younger population [62]. In older adults, problems with memory and cognition can create a barrier to using self-report techniques [63, 64], which are the most commonly used tools to measure physical activity in epidemiological studies. Furthermore, the activities older adults tend to engage in most frequently are of light to moderate intensity such as leisurely walking, housework, and gardening. Unfortunately, these activities are often not assessed in self-report techniques that are age-neutral [64, 65]. Furthermore, even when these light to moderate intensity activities are assessed they tend to be difficult to measure reliably [65]. In addition, older adults may engage in physical activity on a somewhat irregular basis, which complicates their ability to accurately recall physical activities on a survey or questionnaire [63]. All of these factors make the measurement of physical activity in older adults more complex.

To address some of these issues, several surveys have been developed specifically for use in older adults. Examples of such surveys include the Community Healthy Activities Model Program for Seniors Questionnaire [64], the Yale Physical Activity Survey [66], the Physical Activity Scale for the Elderly [65], and modified versions of the Baecke questionnaire [54]. However, because these surveys still rely on memory, criterion and objective methods of measuring physical activity in older adults are generally considered superior to these subjective methods [67]. In general, the use of accelerometers for measuring physical activity in older adults in epidemiological studies has been relatively uncommon. However, some research suggests that accelerometers appear to be acceptable to older adults, as participants in one study did not find wearing an accelerometer to be inconvenient or uncomfortable [67].

1.4 COMPLIANCE TO ACCELEROMETER PROTOCOLS

In general, accelerometers are reliable, valid, and versatile tools for measuring physical activity for research studies [42, 68-74]. However, individuals participating in research studies must be compliant with wearing accelerometers as directed by the study protocol in order for accurate measures of physical activity to be obtained. Some research has suggested that a minimum number of days of monitoring is needed in order to produce an accurate assessment of the physical activity patterns of an individual [75-79]. As a result, participants in research studies who fail to meet the minimum number of valid days of accelerometer wear are excluded from any analysis related to physical activity because their level of physical activity cannot be calculated. It is possible that aging effects on physical and cognitive health may limit the ability of an older adult to be compliant with an accelerometer protocol. Unfortunately, research investigations into the factors that predict compliance to accelerometer protocols in older adults are nonexistent. It is important, therefore, to identify factors that predict compliance to accelerometer protocols in older adults to ensure that older adults with certain characteristics are not consistently excluded from analyses related to physical activity measured by an accelerometer in research studies due to lower compliance.

Many methods have been suggested for increasing compliance to accelerometer protocols for research studies. The most important recommendation for improving compliance appears to be education. Educating participants and providing them with education-level appropriate reading materials about how and when to wear the accelerometer is currently considered the most effective method of increasing compliance. Frequently contacting participants by phone to remind and encourage accelerometer wear, providing incentives for accelerometer return, having participants keep logs documenting accelerometer wear, and giving participants visual reminders to wear the accelerometer to put in the home are other strategies that have been recommended to improve compliance [80, 81].

Providing participants with a new accelerometer for every day of measurement has also been suggested to improve compliance, but this recommendation would be extremely expensive and burdensome to any research study. It has also been suggested that measuring a single day of activity over week or month intervals rather than monitoring for several consecutive days at a time may also improve compliance as well as control for seasonal variations in physical activity patterns [82]. In general, both investigator and participant based strategies to increase compliance are recommended for research studies using accelerometers to measure physical activity [81].

1.5 AGING EFFECTS MAY INFLUENCE COMPLIANCE TO ACCELEROMETER PROTOCOLS

It is generally agreed upon that certain physical and cognitive changes occur as a normal part of the aging process [83-98]. Physical changes such as declines in balance, strength, and walking speed, as well as cognitive changes such as declines in memory, all have the potential to impact the functional capacity of older adults [99-108]. Research has shown that physical and cognitive functioning are associated: Lower physical functioning tends to be associated with and even predictive of lower cognitive functioning and vice versa [87, 109-112]. Although some physical and cognitive changes are a normal part of the aging process, serious declines in physical or cognitive functioning should not be considered normal because these declines are usually associated with chronic diseases [113-115].

1.5.1 Cognitive changes associated with aging may influence compliance to accelerometer protocols in older adults

Although the etiology of the cognitive changes observed in older adults is still under debate [89, 116], it is likely that at least several distinct factors are involved including genetics, lifestyle, and the environment [89, 117, 118]. While some cognitive changes are considered normal and nonpathological in nature, some older adults may experience more drastic and debilitating declines in their cognitive functioning as a result of neuropathological conditions and diseases such as Alzheimer's disease [119]. Depending on the criteria used, it has been estimated that 16-38% of older adults experience mild cognitive impairment, which is cognitive decline that is greater than normal but not severe enough to be considered dementia [104, 120-123]. The prevalence of more serious conditions such as Alzheimer's disease are much lower but increase significantly with age [124-128].

Normal age-related cognitive declines tend to be minimal in areas such as short-term memory span tasks like repeating strings of words, letters, or numbers as well as implicit memory tasks, which refers to a situation in which the current behavior of an individual is affected by a stimulus that was encountered previously. On the other hand, age-related cognitive declines tend to be much greater in tasks involving free or cued recall as well as prospective memory, which refers to the ability of an individual to remember to carry out some task in the future [89]. In terms of measuring physical activity, declines in prospective memory could affect the ability of an older adult to remember to wear an accelerometer for a research study and could thus directly affect compliance to an accelerometer protocol. As a result, investigations into compliance to an accelerometer protocol in older adults should consider the cognitive functional status of participants and its potential impact on compliance.

1.5.2 Physical changes associated with aging may influence compliance to accelerometer protocols in older adults

Various aspects of physical functioning also have the potential to influence compliance to accelerometer protocols in older adults. For example, limitations in fine motor skills due to arthritis in the hands or other causes may make it difficult for an older adult to use an accelerometer properly because of limitations in dexterity. Therefore, limitations in fine motor skills may be directly related to the ability of an older adult to be complaint with an accelerometer protocol. Interestingly, among all adults, arthritis is the most commonly reported cause of disability in the United States [129]. In older adults, the age-adjusted prevalence of arthritis is 46.8% among individuals aged 65-74 years and 54.2% among individuals aged 75 years and older [130]. Based on the high prevalence of arthritis among older adults, the relationship between limitations in fine motor skills and compliance to accelerometer protocols should be examined.

Overall declines in physical functioning may also be related to compliance to accelerometer protocols: The declines in physical functioning that cause limitations in performing routine personal care and other daily activities may also limit the ability of an older adult to be compliant with a protocol of accelerometer use. As a result, declines in balance, walking speed, and strength as well as limitation with activities of daily living (ADL) and instrumental activities of daily living (IADL) should be examined in terms of their relationship with compliance to accelerometer protocols. Activities of daily living include bathing, dressing, using the toilet, transference, continence, and feeding [131], while instrumental activities of daily living include using the telephone, going to places beyond walking distance, grocery shopping, preparing meals, doing housework, doing laundry, taking medications, and managing money

[132]. The age-adjusted prevalence of limitation in ADL and IADL among older adults increases with advancing age: Among adults aged 65-74 years, the prevalence of limitation in ADL and IADL is 3.3% and 6.6% respectively while the prevalence increases to 9.6% and 18.6% respectively among adults aged 75 years and older [133].

1.6 OTHER FACTORS MAY INFLUENCE COMPLIANCE TO ACCELEROMETER PROTOCOLS IN OLDER ADULTS

1.6.1 Demographic factors

Numerous demographic factors may be associated with compliance to accelerometer protocols in older adults: Age, race, income, highest level of education completed, and whether an individual lives alone. As previously discussed, certain physical and cognitive changes are associated with the aging process and some of these changes may affect the ability of an older adult to be compliant with a protocol of accelerometer use. It is possible that compliance to accelerometer protocols in older adults will decrease with advancing age because of the cumulative physical and cognitive changes generally associated with the aging process. Race, income, and highest level of education completed may not be related to compliance to an accelerometer protocol per se, but rather may be a reflection of the appropriateness of the methods that were used to promote compliance or to describe appropriate use of the accelerometer to the study population. Also, it is possible that older adults who do not live alone may receive some social support for wearing the accelerometer and possibly reminders from those they live with to wear the accelerometer, which could potentially impact compliance.

1.6.2 Depressive symptoms

Depression is a serious illness and is not a normal part of the aging process. Individuals with depression often have difficulty functioning normally in daily life. While symptoms of depression are varied, one common symptom of depression may directly interfere with the ability of an older adult who is depressed to comply with an accelerometer protocol: Difficulty concentrating and remembering details. An older adult who is depressed may be more likely to forget to wear an accelerometer as instructed or forget how to properly wear the accelerometer. Furthermore, other common symptoms of depression such as persistent sad feelings, pessimism, feelings of hopelessness, loss of interest in activities and hobbies, and fatigue may indirectly interfere with the ability of an older adult who is depressed to comply with an accelerometer protocol compared with an older adult who is not depressed [134]. In addition, depressive symptoms have also been associated with poorer cognitive function [135, 136], which as discussed previously may have a direct impact on the ability of an older adult to be compliant with a protocol of accelerometer use.

1.6.3 Walking behavior

Accelerometers are basically a measure of walking behavior. As a result, older adults who walk on a regular basis may be more likely to comply with a protocol of accelerometer use because they may place more importance on wearing the accelerometer than older adults who do not walk on a regular basis, simply because they are performing the behavior being measured more frequently.

2.0 INTRODUCTION

2.1 NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY ACCELEROMETER DATA

2.1.1 Background

The National Health and Nutrition Examination Survey (NHANES) began using accelerometers to collect objective physical activity data on participants in 2003. NHANES is a major program of the National Center for Health Statistics, which is part of the Centers for Disease Control and Prevention. The NHANES survey is currently conducted on a continuous basis and has a shifting focus on health and nutrition measurements to meet the emerging needs of the population of the United States. A complex, multistage, probability sampling design is used by NHANES to obtain participants that are representative of the population of civilian, noninstitutionalized individuals in the United States. NHANES has two main components: the interview and the examination. About 7000 interviews are completed each year in the homes of participants with questions focusing on demographic, socioeconomic, dietary, and other health related issues. About 5000 examinations are completed each year in mobile examination centers (MEC). The examination includes mental and dental exams, physiological measurements, laboratory tests, and the use of accelerometers to measure physical activity.

As mentioned previously, accelerometers were added as a component of the NHANES examination in 2003. Ambulatory individuals 6 years of age and older who participated in the examination were eligible to participate in the accelerometer component. Participants were instructed to begin wearing the accelerometer the day after their examination and continue to wear the accelerometer during waking hours for seven consecutive days. The accelerometer used by NHANES is the Actigraph AM-7164 accelerometer manufactured by Actigraph of Fort Walton, Florida. The NHANES protocol states that the accelerometers sum and record the intensity of activity over one minute epochs for each participant [137].

2.1.2 Methods

We analyzed the accelerometer data from the 2003-2004 wave of NHANES as a preliminary investigation of compliance to an accelerometer protocol in a large data set. We focused the investigation on participants 65 years of age and older because we are interested in compliance to accelerometer protocols in older adults. The NHANES accelerometer data was processed exactly as described in the methods section of this dissertation: A valid day was defined as 10 or more hours of accelerometer wear in a 24 hours period, a valid person was defined as an individual with four or more days of valid accelerometer wear, and a compliant person was defined as an individual with seven days of valid accelerometer wear. The NHANES data was weighted to account for the complex survey design, nonresponse, and post-stratification. For the purposes of this analysis, the two-year MEC exam weight was used because the accelerometer data was collected as part of the examination.

2.1.3 Results

A total of 1143 individuals 65 years of age and older had valid accelerometer data in NHANES 2003-2004 and all of these individuals were included in this analysis. The mean age of participants in this subset of the NHANES population was 73.84 years and the median age was 73 years (SD=6.261). Figure 1 shows the age distribution of participants age 65 years and older who had valid accelerometer data in NHANES 2003-2004.

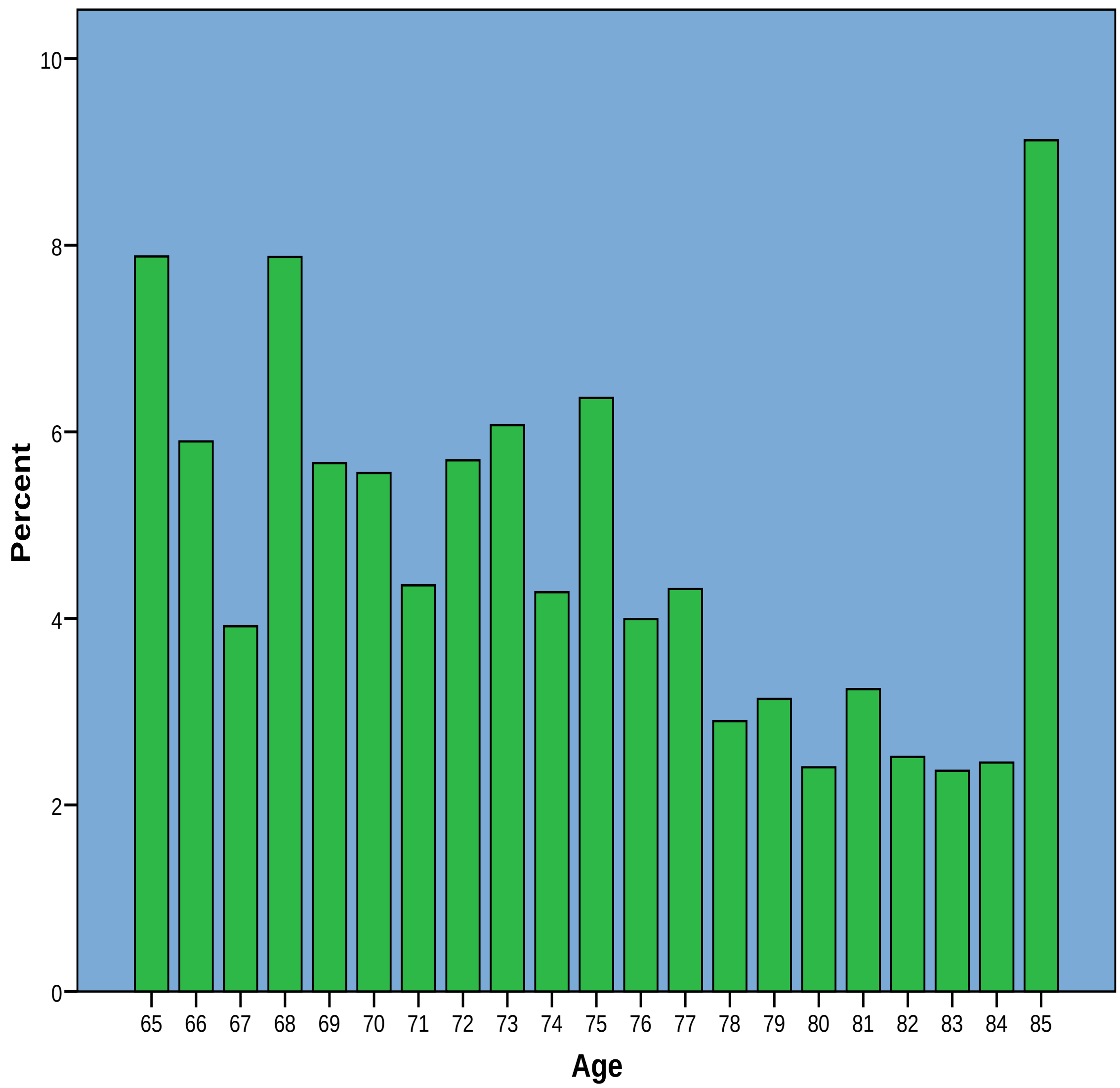


Figure 1 Age distribution of participants 65 years of age and older who had valid accelerometer data in NHANES 2003-2004.

2.1.3.1 Valid days

Figure 2 shows that the distribution of valid days of accelerometer wear in NHANES 2003-2004 was left-skewed. The mean number of valid days for participants 65 years of age and older was 5.71 and the median number of valid days was 7 (SD=1.85).

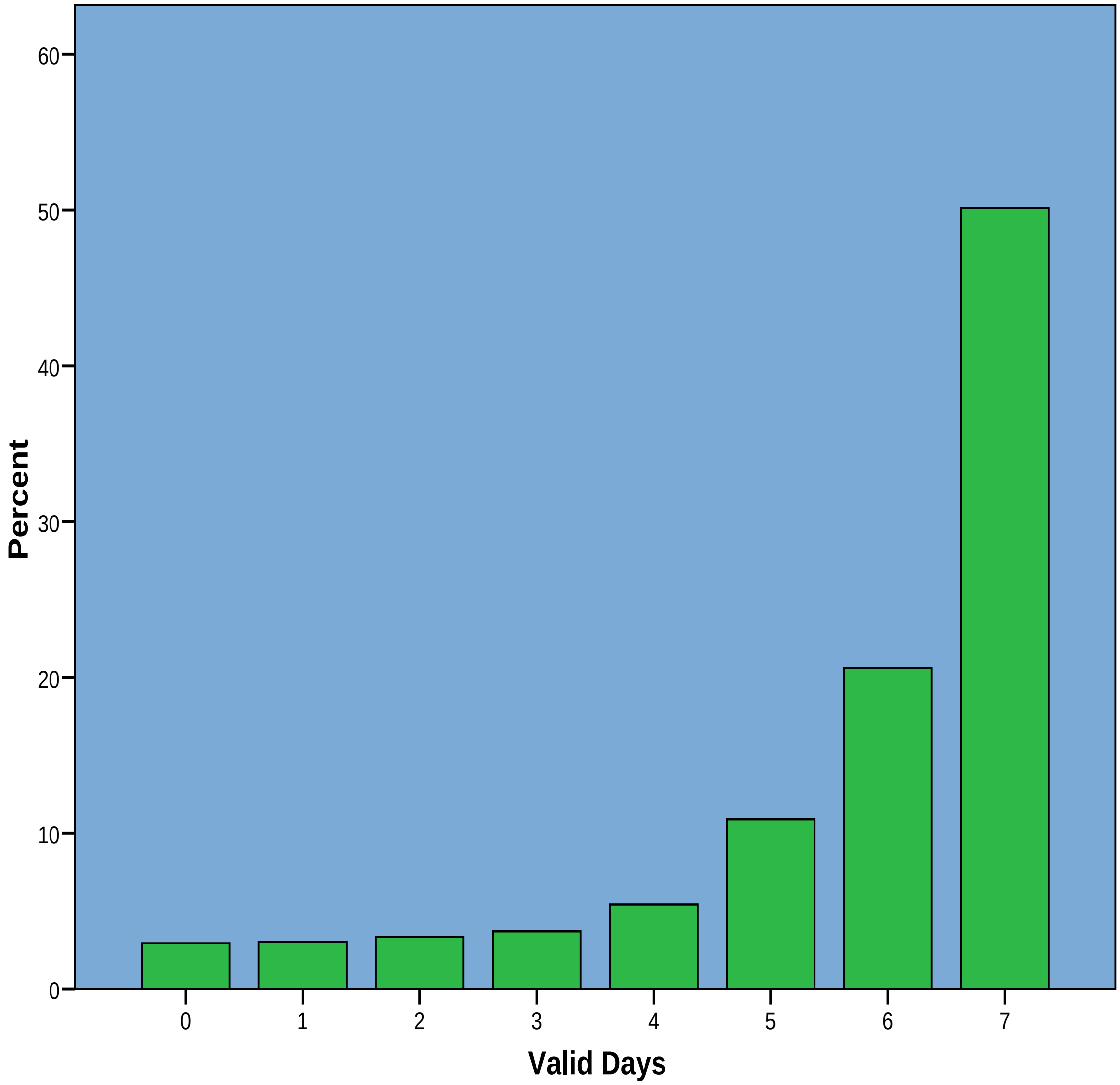


Figure 2 Distribution of valid days of accelerometer wear in participants 65 years of age and older in NHANES 2003-2004.

2.1.3.2 Valid person

Section 3.5.1.3 of this dissertation provides the rationale for the definition of valid person.

Most of the participants in NHANES 2003-2004 aged 65 years and older met the valid person criteria (85%, n=972), which was defined as having at least four days of valid accelerometer wear. The remaining 15% of participants (n=171) had less than four days of valid accelerometer wear and therefore did not meet the valid person criteria. A two-tailed t-test (α=0.05) showed that the mean age of participants who met the valid person criteria (mean=73.64; SD=6.11) was significantly different from the mean age of participants who did not (mean=75.19, SD=7.04) ($p<0.001$). A univariate logistic regression model revealed that age was a statistically significant independent predictor of being a valid person ($p>0.001$): The odds of being a valid person decreased 3.8% with each year increase in age (95% CI=3.8%-3.9%). Table 1 shows the coefficients of the univariate logistic regression model of age as an independent predictor of being a valid person.

Table 1 Coefficients of the univariate logistic regression model of age as an independent predictor of being a valid person among participants aged 65 years and older in NHANES 2003-2004.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Age	-0.038	0.000	177971.0	1	>0.001	0.962	0.962 – 0.963
Constant	4.764	0.007	487785.9	1	>0.001	117.196	

2.1.3.3 Compliant person

Section 3.5.1.4 of this dissertation provides the rationale for the definition of compliant person.

Slightly less than half of the participants in NHANES 2003-2004 aged 65 years and older met the compliant person criteria (45.8%, n=523), which was defined as having seven days of valid accelerometer wear. The remaining 54.2% (n=620) of participants had less than seven days of valid accelerometer wear and therefore did not meet the compliant person criteria. A two-tailed t-test (α=0.05) showed that the mean age of participants who met the compliant person criteria (mean=73.23, SD=5.77) was significantly different from the mean age of participants who did not (mean=74.13, SD= 6.60) ($p>0.001$). A univariate logistic regression model revealed that age was a statistically significant independent predictor of being a compliant person ($p>0.001$): The odds of being a compliant person decreased 2.3% with each year increase in age (95% CI=2.3%-2.3%). Table 2 shows the coefficients of the univariate logistic regression model of age as an independent predictor of being a compliant person.

Table 2 Coefficients of the univariate logistic regression model of age as an independent predictor of being a compliant person among participants aged 65 years and older in NHANES 2003-2004.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Age	-0.024	0.000	142786.4	1	>0.001	0.977	0.977 – 0.977
Constant	1.749	0.005	144497.2	1	>0.001	5.748	

2.1.3.4 Trend analysis of number of valid days and age

To examine for a trend between the number of valid days of accelerometer wear and age, Figure 3 shows a plot of mean valid days by age in participants 65 years of age and older in NHANES 2003-2004 with 95% confidence intervals around each mean. In a visual examination of the data, it appears there is a slight increasing trend in mean valid days between the ages of 65 and 75 years. After the age of 75 years, there appears to be a general decreasing trend in mean valid days with increasing age.

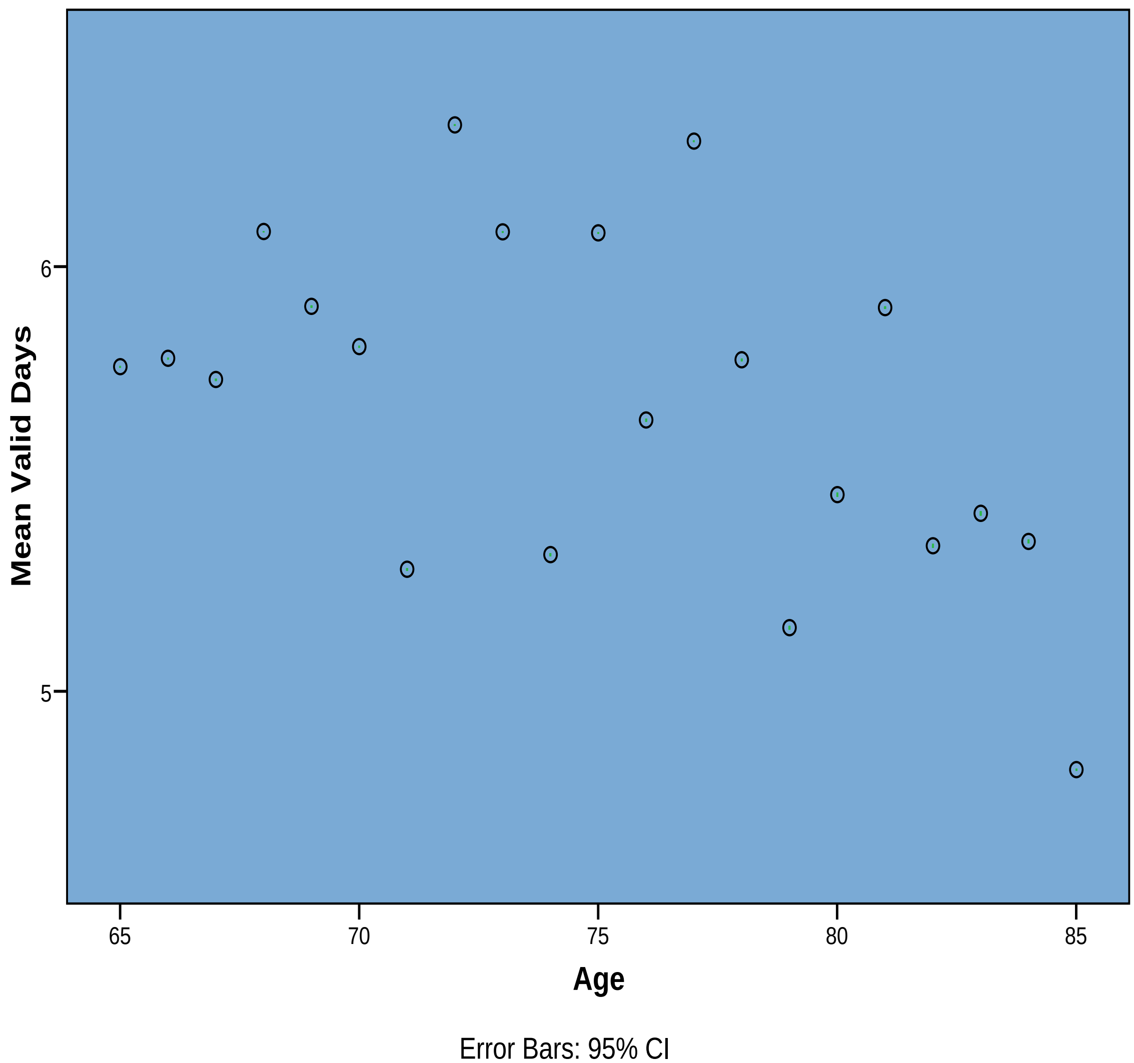


Figure 3 Plot of mean valid days by age in participants 65 years of age and older in NHANES 2003-2004.

Figure 4 shows the best fit regression line of age and valid days, which was a quadratic equation (r^2=.028). The quadratic regression line illustrates the curvilinear relationship between age and valid days: Valid days increase between the ages of 65 and approximately 72 years and then decrease as age increases above 72 years. Figure 5 contains the coefficients of the quadratic regression equation.

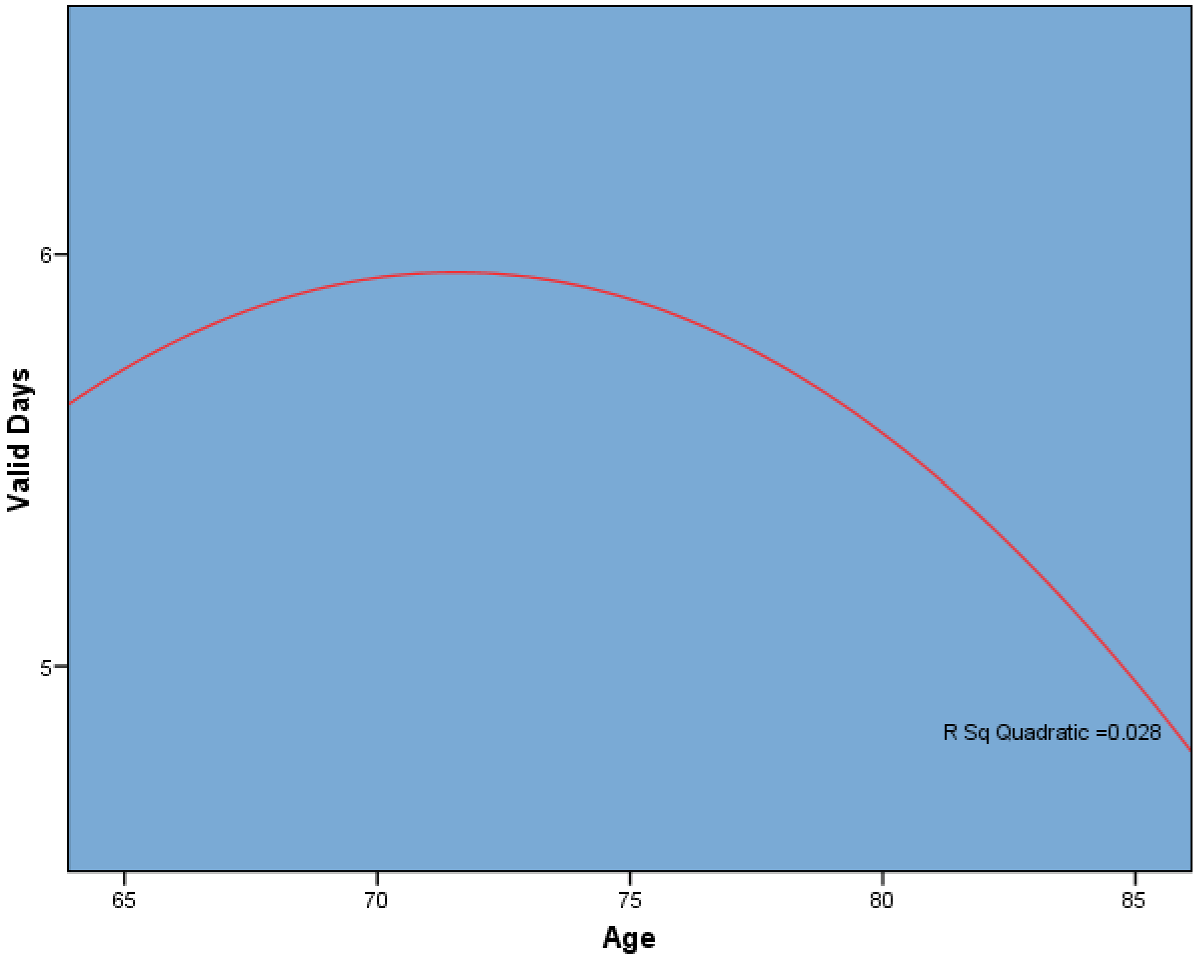


Figure 4 Quadratic regression line of age and valid days among participants age 65 years and older in NHANES 2003-2004.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Age	.782	.001	2.637	540.888	.000
Age ** 2	-.005	.000	-2.762	-566.620	.000
(Constant)	-22.011	.054		-408.559	.000

Figure 5 Coefficients of quadratic regression line of age and valid days among participants aged 65 years and older in NHANES 2003-2004.

2.2 DISSERTATION HYPOTHESES

This dissertation examines compliance to an accelerometer protocol in a cohort of individuals 65 years of age and older. Based on the analysis of the NHANES 2003-2004 accelerometer data among participants aged 65 years and older, our main hypotheses were that (a) compliance generally decreases with age among older adults and (b) the effect of age on compliance will be attenuated when controlling for demographic variables, cognitive and physical functioning, and walking behavior.

3.0 METHODS

3.1 DATA SOURCE

This examination of compliance to an accelerometer protocol among older adults is based on data collected as part of the study entitled *Environmental Correlates of Physical Activity Among Older Adults: A Healthy Aging Research Network Collaboration*. The study was funded by the Robert Wood Johnson Foundation and was a collaboration of several members of the Centers for Disease Control and Prevention's Healthy Aging Research Network: University of California, Berkeley (coordinating center); University of Illinois, Chicago; University of North Carolina, Chapel Hill; and the University of Pittsburgh. This dissertation is based on data from the cohort of 201 individuals in Allegheny county which were recruited for the study by the Center for Healthy Aging at the University of Pittsburgh. Table 3 shows the number of participants and senior centers from which participants were recruited by study location and for the entire study.

Table 3 Number of participants of the *Environmental Correlates of Physical Activity Among Older Adults* study and senior centers from which participants were recruited by study location and for entire study.

	Number of Participants	Number of Senior Centers
Alameda county, California	248	23
Cook county, Illinois	203	17
Durham and Wake counties, North Carolina	232	19
Allegheny county, Pennsylvania	201	18
Entire study	884	77

3.2 STUDY PROTOCOL

Despite the known health benefits of walking and other forms of physical activity, the frequency of physical activity declines with advancing age. It is important, therefore, to determine the reasons why some older people engage in walking and other forms of physical activity while others do not. There are three primary aims of the *Environmental Correlates of Physical Activity Among Older Adults* study:

1. Examine the relationship between elements of the built environment and levels of functional capacity on levels of walking and other forms of moderate activity among adults aged 65 years and older.

2. Determine how the level of functional capacity affects the strength of the association between built environment measures and levels of walking and other forms of moderate activity among older adults.

3. Examine how associations between self-perception of neighborhoods and neighborhood data obtained through Geographic Information Systems (GIS) vary according to the characteristics of the study population.

This study used a cross-sectional design to examine the relationship between elements of the built environment, functional capacity, and physical activity in older adults. Eligibility criteria for the study were age 65 or older, presence at residence for at least one year, not homebound, stable health, English speaking, and cognition sufficient to complete an in-person interview. After obtaining informed consent, each participant was administered a one-on-one interview by a trained interviewer lasting approximately one hour. The interview included questions about the neighborhood environment and physical activity as well as questions relating to demographic, behavioral, social, and environmental factors of interest. Participants were also instructed to wear an accelerometer for seven full days after the interview and keep a walking diary as measures of their physical activity.

As mentioned previously, older adults were recruited to participate in the study from senior centers in each of the following four areas of the United States: Alameda county, California; Cook county, Illinois; Durham and Wake counties, North Carolina; and Allegheny county, Pennsylvania. In each geographic area, all senior centers were stratified into five groups from lowest to highest housing density. Next, four senior centers within each of the five groups were randomly selected to participate in the study resulting in a total of 20 senior centers in each geographic area. If a senior center could not serve as a recruitment site for the study for any reason, another senior center within the same housing density was randomly selected as a replacement. In Allegheny county, Pennsylvania, data was collected between October 1, 2005 and March 31, 2007. Data collected at each site was double-entered into a database to check accuracy of entry and all data were cleaned and processed at the University of California, Berkeley.

3.3 ACCELEROMETER PROTOCOL

Accelerometers were used in the *Environmental Correlates of Physical Activity Among Older Adults* study to provide an objective measure of the physical activity of each participant over a seven day period. The accelerometers were given to participants upon the conclusion of the in-person interview. Participants were instructed to begin wearing the accelerometer the day after the interview as soon as they got out of bed in the morning and to continue wearing the accelerometer during waking hours for the next seven consecutive days. The trained interviewers informed the participants that the purpose of the accelerometer was to measure their physical activity patterns over the next seven days.

All participants were given an information sheet that described proper wear and care of the accelerometer (see Appendix A). The trained interviewers also fitted each participant with an accelerometer at the conclusion of the in-person interview to ensure the belt that held the accelerometer fit around the participant's waist securely. The trained interviewers also made sure participants understood all of the instructions on the information sheet regarding proper wear and care of the accelerometer. Each participant and the trained interviewer then selected and agreed on a date for the participant to return the accelerometer to the trained interviewer. The dates selected were at least eight days after the in-person interview to ensure the accelerometers could be worn by the participant for seven consecutive days. At some point during the second day each participant wore the accelerometer, a trained interviewer called the participant remind her to wear the accelerometer and also to answer any questions she may have had regarding wear and care of the accelerometer.

3.4 MEASURES OF INTEREST

There were many measures of interest for the purposes of this analysis on compliance to an accelerometer protocol among older adults that were collected during the prescreening process or the in-person interview in the *Environmental Correlates of Physical Activity Among Older Adults* study.

3.4.1 Measurement of Demographics

The demographic variables of interest that were collected in this study include age, gender, highest level of education completed, census race, income, and whether or not a participant lives alone.

Participants self-reported their age in years as well as their gender during the prescreening process. During the interview, participants self-reported the numerical value of the school grades they completed. For example, an individual who graduated from high school completed 12 grades and an individual who graduated from a traditional four-year college completed 16 grades. For the purposes of this analysis, participants were categorized into one of four categories based on the highest level of education they completed: Less than high school education, equivalent of a high school education, less than four years of education beyond high school, and equivalent of a four year college education or more.

Participants also self-reported their racial identity during the interview in one or more of the following categories: White, Black/African-American/Negro, American Indian/Alaskan Native, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian, Native Hawaiian, Guaminian/Chamorro, Samoan, Other Pacific Islander, or Other Race. For the purposes of this analysis, the self-reported racial identity of each participant was recoded into the race categories that were reported in the 2000 census: Asian, Asian only, African-American only, American Indian/Alaskan Native only, White only, or other race only. During the interview, participants also reported whether they are Latino or Hispanic.

Participants self-reported the income provided by themselves, their spouse, and any other person living in their household during the last year in one of two categories: less than $20,000 or $20,000 or more. These two income categories were used in this analysis. During the interview, participants also self-reported how many individuals currently live in their household. For the purposes of this analysis, a new variable was created as an indicator of whether individual lives alone.

3.4.2 Measurement of Depressive Symptoms

3.4.2.1 CES-D

The 10-item version of the Center for Epidemiologic Studies Depression (CES-D) scale was used to measure depressive symptoms. The CES-D is a short self-report scale which was designed to measure depressive symptoms in the general population. It has well-documented reliability, validity, sensitivity, and specificity in older adults [138-140], and is a common tool in epidemiological studies of depression. The CES-D 10-item scale, which is a shorter form version of the original CES-D scale, is preferred in older adults because of its shorter length

[141]. Each participant received a CES-D score between 0 and 30 based on their responses to the scale items, which asked how often they had certain feelings during the past week. CES-D scores were coded as missing if one or more items were missing or if a participant refused to answer one or more items on the 10-item scale. A participant was considered to show symptoms of depression if she received a score of 10 or greater [142].

3.4.3 Measurement of Cognitive Functioning

The cognitive functioning of participants was directly measured in this study using a modified Mini-Mental State Examination and Mental Alteration Test.

3.4.3.1 Mini-Mental State Examination

The Mini-Mental State Examination is a brief screening tool designed quantitatively to determine the severity of cognitive impairment and to track changes in cognitive impairment over time. It has well documented reliability, validity, sensitivity, and specificity for these purposes. The standard Mini-Mental State Examination is composed of 11 questions and takes approximately 5-10 minutes to administer, although the test is not timed. The first section of questions test the orientation, memory, and attention of an individual while the second section tests the ability of an individual to name, follow verbal and written commands, write a sentence spontaneously, and copy a complex polygon. Scores on the Mini-Mental State Examination range from 0-30 and a cutoff score of less than 24 is used to detect cognitive impairment [143, 144].

Seven questions from the standard Mini-Mental State Examination were used to assess cognitive functioning in this study. Scores ranged from 0 to 18, with a score of 18 indicating correct answers on all seven questions and a score of 0 indicating no correct answers. Each of the seven questions had varying possible point values. If a participant was unable or refused to complete any of the questions that composed the Mini-Mental State Examination in this study, her score was coded as missing.

3.4.3.2 Mental Alteration Test

The Mental Alteration Test was originally used to detect human immunodeficiency virus-related cognitive impairment but has also been shown to have utility in geriatric primary care and geriatric psychiatric settings for the detection of cognitive impairment. When compared to the Mini-Mental State Examination, the Mental Alteration Test has been shown to have good sensitivity and specificity for detecting cognitive impairment [145, 146]. The Mental Alteration Test requires individuals to switch between numbers and letters based on the following pattern: 1-A-2-B-3-C-4-D and so on. Scores on the standard Mental Alteration Test range from 0 to 52 based on the correct number of sequential number and letter alterations completed by an individual in 30 seconds. Each correct sequential number and each correct sequential letter alteration receives 1 point. To receive a score of 52, an individual must correctly alternate sequentially between numbers and all 26 letters of the alphabet. When compared with the standard Mini-Mental State Examination cutoff score used to detect cognitive impairment, a cutoff score of 15 or less on the Mental Alteration Test has been shown to result in the highest number of detected dementia cases and the lowest number of false positive cases [146].

In this study, the Mental Alteration Test was scored on a scale ranging from 0 to 26 based on the number of correct sequential number and letter alterations the participant completed in 30 seconds among the 26 letters of the alphabet. For each number and letter alteration, a participant received 1 point if both the number and letter were in correct sequence or a score of 0 if both the number and letter were non-sequential or if either the number or the letter were non-sequential. If a participant refused to do the test her score was coded as missing. If a participant was unable to do the test she received a score of zero meaning no correct alterations.

3.4.4 Measurement of Physical Functioning

3.4.4.1 Self-reported physical functioning

Self-reported physical functioning was assessed using a 12 question scale based on a similar 10 question scale developed by Sternfeld and colleagues [147]. The questions were taken from the Framingham Disability Study [148], Established Populations for Epidemiologic Studies of the Elderly [149], Nagle scale [150], and the Rosow and Bresleau scales [151]. All of these scales have well documented reliability and have been shown to be associated with direct measures of physical functioning [152]. The 12 question scale used in this study included questions about the degree of difficulty experienced doing certain activities in the past month such as pushing and pulling heavy objects, stooping, crouching, and kneeling, standing up from a seated position, walking up a flight of stairs, and walking two or three neighborhood blocks. Scores on this scale ranged from 0 to 12 for each participant. For each of the 12 functional tasks, a participant received a score of 0 if she had no difficulty with the task or a score of 1 if she reported any difficulty with the task. If a participant never did the activity on doctor's orders the value was coded as missing.

3.4.4.2 Difficulty writing and handling small objects

One item in the 12 question scale that was used to assess self-reported physical functioning was treated as an independent variable: difficulty writing and handling small objects.

A participant received a score of 0 if she reported no difficulty writing or handling small objects or a score of 1 if she reported any difficulty writing or handling small objects. If a participant reported never writing or handling small objects on doctor's orders the value was coded as missing.

3.4.4.3 Activities of Daily Living

Katz and colleagues developed the Activities of Daily Living (ADL) Scale as a measure of the biological and psychosocial function of older adults. The Katz ADL Scale measures the degree of independence an individual has in performing six activities: bathing, dressing, using the toilet, transference, continence, and feeding [131]. Difficulty with Activities of Daily Living (ADL) was assessed in this study using a 7 question scale. The questions addressed whether a participant needs help at the present time with seven activities: walking across a room, bathing or showering, personal grooming, dressing, eating, getting from a bed to a chair (transferring), and using the toilet. Scores on this scale ranged from 0 to 7 for each participant. For each of the 7 activities, a participant received a score of 0 if she reported that she does not need help with the activity at the present time or a score of 1 if she reported that she does need help with the activity at the present time. The scores for each of the 7 questions were summed for each participant to provide an ADL score.

3.4.4.4 Instrumental Activities of Daily Living

Lawton and Brody developed the Instrumental Activities of Daily Living (IADL) Scale to assess the functional capabilities of older adults. The Lawton and Brody IADL Scale measures the degree of independence an individual has in performing eight activities: using the telephone, going to places beyond walking distance, grocery shopping, preparing meals, doing housework, doing laundry, taking medications, and managing money [132]. Difficulty with three IADLs was assessed in this study: housekeeping, meal preparation, and grocery shopping. For each activity, participants indicated whether they currently limit or avoid the activity because of any health problem, ailment, or physical disability. For each of the 3 activities, a participant received a score of 0 if she reported that she does not currently limit or avoid the activity or a score of 1 if she reported that she does currently limit or avoid the activity. The scores for each of the 3 questions were summed for each participant to provide an IADL score.

3.4.4.5 Modified Guralnik Lower Body Score

Lower body physical functioning was directly measured in this study with tests of balance, performance of chair stands, and measurement of walking speed. These tests were originally used in the Established Populations for Epidemiologic Studies of the Elderly [149]. Scores on the tests of balance, performance of chair stands, and measurement of walking speed were added together to provide an overall Modified Guralnik Lower Body Score. Each participant received a score between 0 and 4 on each of the three tests based on her performance, with a higher score indicating a better performance. Scores on each of the three tests were summed to provide an overall Modified Guralnik Lower Body Score, which ranged from 0 to 12.

For the tests of balance, each participant was instructed first to place the heel of one foot next to the big toe of the other foot and hold the position for 10 seconds (semi-tandem stand). If the participant held the semi-tandem stand for less than 10 seconds, refused, or was unable to attempt the semi-tandem stand, the participant was then instructed to stand with her feet shoulder width apart and hold the position for 10 seconds (side-by-side stand). If the participant successfully held the semi-tandem stand position for 10 seconds, she was next instructed to place the heel of one foot directly in front of the big toe of the other foot and hold the position for 10 seconds (tandem stand). If the participant successfully held the tandem stand for 10 seconds, she was next instructed to stand on one leg for 10 seconds (one-legged stand). The scoring of the balance test was as follows: A participant received a score of 0 if she was unable to maintain the side-by-side stand for 10 seconds; a score of 1 if she was able to maintain the side-by-side stand for 10 seconds but unable to maintain the semi-tandem stand for 10 seconds; a score of 2 if she was able to maintain the semi-tandem stand for 10 seconds but was unable to maintain the tandem stand for 10 seconds; a score of 3 if she was able to maintain the tandem stand for 10 seconds but was unable to maintain the one-legged stand for 10 seconds; or a score of 4 if she was able to maintain the one-legged stand for 10 seconds.

For the chair stand test, each participant was placed in a seated position and was then instructed to stand up and sit down five times as fast as she could. A stopwatch was used to record the time it took the participant to perform the chair stands. The stopwatch was started when the participant was told to stand up from a seated position for the first time and was stopped when she sat down in the chair the fifth time. The scoring of the chair stand test was as follows: A participant received a score of 0 if she was unable to complete the test; a score of 1 if she was in the slowest quartile of study participants; a score of 2 if she was in the second quartile; a score of 3 if she was in the third quartile; or a score of 4 if she was in the fastest quartile of study participants.

Walking speed was determined by the number of lengths of a ten-foot rope each participant was able to walk in one minute. Each participant was instructed to walk at her normal pace back and forth along the length of the rope and at the end of one minute the number of lengths walked by the participant was recorded by the interviewer. This number was then converted into walking speed in feet per second. The scoring of the walking speed test was as follows: A participant received a score of 0 if she was unable to complete one minute of walking along the length of the rope; a score of 1 if she was in the slowest quartile; a score of 2 if she was in the second quartile; a score of 3 if she was in the third quartile; or a score of 4 if she was in the fastest quartile of study participants.

3.4.4.6 Jug lift

Upper body strength in this study was assessed by a jug lift test, which was also used in the Women's Health and Aging Study [153]. A camping water jug was filled with water so the total weight of the jug with the water was 10 pounds. Each participant was instructed to sit in a chair with the jug in her lap and then raise the jug as high as she could while remaining in a seated position. The jug lift was scored as follows: A participant received a score of 0 if she was unable to lift the jug; a score of 1 if she lifted the jug to chest-level; a score of 2 if she lifted the jug to eye-level; or a score of 3 if she lifted the jug above her head. If the participant refused to attempt to lift the jug, the value was coded as missing.

3.4.5 Walking behavior

Participants in this study self-reported the average number of minutes per week they spend walking at a brisk pace and walking at a leisurely pace. The time each participant spent walking at a brisk pace and at a leisurely pace were added together to provide the total number of minutes per week of walking. We decided to use total number of minutes per week of walking as a physical activity outcome variable rather than an overall physical activity score. We felt that total number of minutes per week of walking was more likely to be associated with compliance to an accelerometer protocol than an overall physical activity score because accelerometers are basically a measure of walking behavior and are a less accurate measure of other forms of activity. Furthermore, we decided not to use physical activity measured by the accelerometers as an outcome variable because these variables are only computed for participants who wore the accelerometer for at least 10 hours a day for a minimum of four days during the study. The purpose of this dissertation is to examine factors that are associated with compliance to an accelerometer protocol in older adults; as a result, it does not make sense to use a physical activity outcome variable which was only calculated for participants who were compliant with the accelerometer protocol.

3.5 ACCELEROMETER DATA REDUCTION

An Actigraph GTM1 accelerometer was used to collect the physical activity data in the *Environmental Correlates of Physical Activity Among Older Adults* study. The Actigraph GTM1 measures acceleration between the magnitudes of 0.05 and two times the force of gravity. This accelerometer is specifically designed and programmed to detect normal human motion and reject motion originating from other sources [154]. For the purposes of this study, the accelerometers were programmed to record activity counts in one-minute epochs and were worn on the waist of the participants.

3.5.1 Accelerometer Data Processing

SAS Statistical Software Version 9 was used to process the accelerometer data. The SAS programs used to process the data were the same as those used in the processing and analysis of the NHANES 2003-2004 data among participants aged 65 years and older. The original accelerometer data were downloaded directly from the accelerometer worn by each participant and contained the number of intensity counts for each minute that each participant wore the accelerometer. The first step in processing read the raw data into SAS in the form of one record per person-minute from the raw data files from the accelerometer for each participant. The second step in processing the accelerometer data was to edit invalid and unreliable intensity values and assign these values as missing data. The age of the participant was also added to each record during this process.

The third step in processing the accelerometer data was to summarize all of the valid accelerometer data into one record per person per day. In the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, all of the accelerometers were set to begin recording data the same day as in-person interview for each participant, usually around the expected time of completion of the interview. In terms of the accelerometer data processing, a "day" begins at midnight and ends at 11:59pm. Therefore, because the intention of the study was to collect seven full days of accelerometer data, any data collected before 11:59pm on the day of the participant's interview was discarded and any data collected after midnight of the seventh day of accelerometer recording was also discarded. Upon completion of this phase of the accelerometer data processing, the records for each participant for each day of accelerometer wear contained variables on the duration of accelerometer non-wear for each day as well as duration of activity bouts with moderate, vigorous, and moderate or vigorous intensity.

3.5.1.1 Accelerometer non-wear

The length of accelerometer non-wear for each day each participant wore the accelerometer was determined using the following algorithm:

A non-wear period starts with a minute with an intensity count of zero. Minutes with intensity counts equal to zero or up to two consecutive minutes with intensity counts between one and 100 are considered valid accelerometer non-wear minutes. A non-wear period is established when 60 minutes of consecutive non-wear minutes is reached. The non-wear period stops when any of the following conditions is met: One minute with an intensity count greater than 100, one minute with a missing intensity count, three consecutive minutes with intensity counts between one and 100, or the last minute of the day.

In general, identifying periods of accelerometer non-wear is difficult because periods of inactivity measured by an accelerometer can result for a variety of reasons. For example, continuous zero count readings by an accelerometer may occur due to participant removal of the accelerometer for a water-based activity such as showering or swimming, removal of the accelerometer by the participant for no reason at all, removal of the accelerometer during activities such as contact sports for safety reasons, long periods of sitting without movement while the participant is still wearing the accelerometer, or accelerometer malfunction [155]. As a result, it is often difficult to determine whether periods of accelerometer non-wear are due to participant inactivity or some other cause.

Sixty minutes of consecutive zeros was established as the minimum for an accelerometer non-wear period based on NHANES data as well as a study of the effects of four different accelerometer data reduction algorithms on outcome variables. Richard Troiano of the National Cancer Institute, who actively participated in the analysis of the NHANES accelerometer data, stated in a personal correspondence that 60 minutes of consecutive zeros was chosen as the non-wear period in NHANES data analysis because when a 20-minute cutoff was used, a large percentage of the study population had five or more wear/non-wear transitions in the day, which seemed unreasonable. In other words, using a shorter period for determining accelerometer non-wear suggested that a large number of participants were removing their accelerometer for an extended period of time five or more times a day.

It is rational to assume that participants may remove an accelerometer once or twice a day for a reasonable period of time to take a shower, participate in another water-based activity, or sleep. However, it seems unlikely that participants would remove an accelerometer five or more times a day as was suggested by the 20-minute cutoff for an accelerometer non-wear period in NHANES. It seems more likely the 20-minute cutoff not only identified times that participants removed the accelerometer but also identified times that participants were simply not moving such as when they were watching a television show or sitting and eating a meal. Although there is no evidence in the literature that suggests an age-specific cut point for non-wear is necessary, it is reasonable to assume that older adults may have longer periods of time without movement compared with younger members of the population because as a group older adults are more sedentary. As a result, it seems appropriate to use a longer time interval for determining accelerometer non-wear in older adults because they likely can remain still for long periods of time [155]. In conclusion, using the 60-minute cutoff for accelerometer non-wear seems to be the most reasonable for this investigation of compliance to an accelerometer protocol in older adults.

One study found that using a 60-minute cutoff for determining accelerometer non-wear along with a minimum of 10 hours of wear time per day to be considered a valid day of accelerometer wear resulted in the highest mean wear time for participants in minutes per day as well as the highest number of participants with at least four valid days of accelerometer wear. Of the four data reduction algorithms tested in the study, this algorithm also resulted in the largest sample size available for data analysis [155].

3.5.1.2 Valid days

The fourth step in processing the accelerometer data summarized all of the valid data into one record per person. The SAS program which processed the data also created variables for valid day and valid person. A valid day was defined as 10 hours or more of valid accelerometer wear in a 24 hour period. This definition of a valid day was also used in the reduction of the NHANES accelerometer data. As mentioned previously, the study examining the impact of four different accelerometer data reduction algorithms on select outcome variables found that using 10 hours as the minimum wear time for a valid day resulted in the largest sample size available for data analysis. Interestingly, in the same study, variations in the minimum wear time to be considered a valid day had the greatest effect on sample size compared to other data reduction decisions, such as the cutoff for the length of a non-wear period [155].

3.5.1.3 Valid person

For the purposes of this analysis, a valid person was defined as a participant with four or more days of valid accelerometer wear. This definition of a valid person was also used in the reduction of the NHANES accelerometer data. The main concern when selecting a minimum number of valid days of accelerometer wear to be considered a valid person is the validity of the physical activity data [155]. A number of studies have investigated the minimum number of days of accelerometer monitoring that is needed to accurately estimate the physical activity patterns of an individual for an entire week. It has been suggested that 3-4 days of monitoring is needed to reliably determine time spent in moderate and vigorous activity [76, 77], whereas at least 7 days of monitoring is needed to reliably determine physical inactivity [77]. Further, Trost found that 4-5 days of monitoring for children and 8-9 days of monitoring for adolescents is necessary to accurately measure activity patterns [79].

Unfortunately, none of these studies reported the mean amount of time participants wore the accelerometers. This complicates the decision making process regarding the minimum number of valid days of accelerometer wear to be considered a valid person because these decisions on the number of days of monitoring that are necessary to accurately measure physical activity patterns were not based on the number of hours per day participants actually wore the accelerometer. To further complicate the issue, there is some evidence that the minimum number of days of monitoring that is necessary varies according to the outcome variable of interest [77]. Additionally, there is no literature regarding the minimum number of days of accelerometer monitoring that is necessary for older adults in order to accurately measure their physical activity patterns. As a result, four valid days of accelerometer wear was chosen as the minimum to be considered a valid person for this analysis based on the existing literature and the NHANES accelerometer data reduction.

3.5.1.4 Compliant person

The main focus of this dissertation is compliance to an accelerometer protocol. As a result, since the accelerometer protocol for the *Environmental Correlates of Physical Activity Among Older Adults* study instructed the participants to wear the accelerometer for seven days, a compliant person for the purposes of this analysis was defined as a participant who had seven valid days of accelerometer wear during the study period.

3.6 DATA ANALYSIS

Analysis of data was performed using SPSS Statistical Software Version 15. Descriptive statistics were used to describe the study population in terms of demographic variables, depressive symptoms, cognitive and physical functioning variables, walking behavior, valid days of accelerometer wear, valid persons, and compliant persons. A t-test was used to compare the mean age of participants who met the criteria for valid person and compliant person and those who did not.

Univariate logistic regression models were developed with valid person and compliant person as dichotomous dependent variables and each of the demographic variables, depressive symptoms, each of the cognitive and physical functioning variables, and walking behavior as independent predictors to determine whether any significant relationships exist. Variables with a univariate logistic regression model significance of $p=0.150$ or less were entered into a multivariate logistic regression model in a backward stepwise fashion to determine the best multivariate model to predict being a valid person and being a compliant person.

4.0 RESULTS

4.1 DEMOGRAPHICS

A total of 201 older adults from 18 senior centers in Allegheny county, Pennsylvania were recruited to participate in the *Environmental Correlates of Physical Activity Among Older Adults* study. Table 4 contains the demographic characteristics of the study participants in Allegheny county. The majority of the participants were female (78.6%, n=158). Most of the participants completed at least a high school education or more: 51.2% (n=103) completed the equivalent of a high school education, 15.9% (n=32) completed less than four years of education beyond high school, and 13.9% completed the equivalent of a four year college education or more. Only 18.9% (n=28) of participants completed the equivalent of less than a high school education.

The majority of the participants identified their race as White only (75.6%, n=152). Slightly over one-fifth of participants (22.4%, n=45) identified their race African-American only, and 1.5% (n=3) of participants identified their race as Asian only. None of the participants identified themselves as Latino or Hispanic. One participant (0.5%) refused to identify her race. Slightly less than half of participants (46.8%, n=94) reported an annual household income of less than $20,000 while 38.8% (n=78) of participants reported an annual household income of $20,000 or more. Eleven participants (5.5%) did not know their annual household income and

18 participants (9%) refused to provide their annual household income. Slightly over half of participants (51.2%, n=103) live alone.

Table 4 Demographic characteristics of participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

	Percentage (Frequency)
Gender	
Female	78.6% (n=158)
Male	21.4% (n=43)
Highest level of education	
Less than high school	18.9% (n=38)
High school	51.2% (n=103)
Less than four years beyond high school	15.9% (n=32)
Four-year college or more	13.9% (n=28)
Race	
White only	75.6% (n=152)
African-American only	22.4% (n=45)
Asian only	1.5% (n=3)
Refused	0.5% (n=1)
Latino or Hispanic	0.0% (n=0)
Annual household income	
Less than $20,000	46.8% (n=94)
$20,000 or more	38.8% (n=78)
Don't know	5.5% (n=11)
Refused	9.0% (n=18)
Lives alone	
Yes	51.2% (n=103)
No	48.8% (n=98)

The age of participants ranged from 65 to 90 years. The mean age of participants was 75.24 years (SD=6.25) and the median age was 75 years. Figure 6 shows the age distribution of participants.

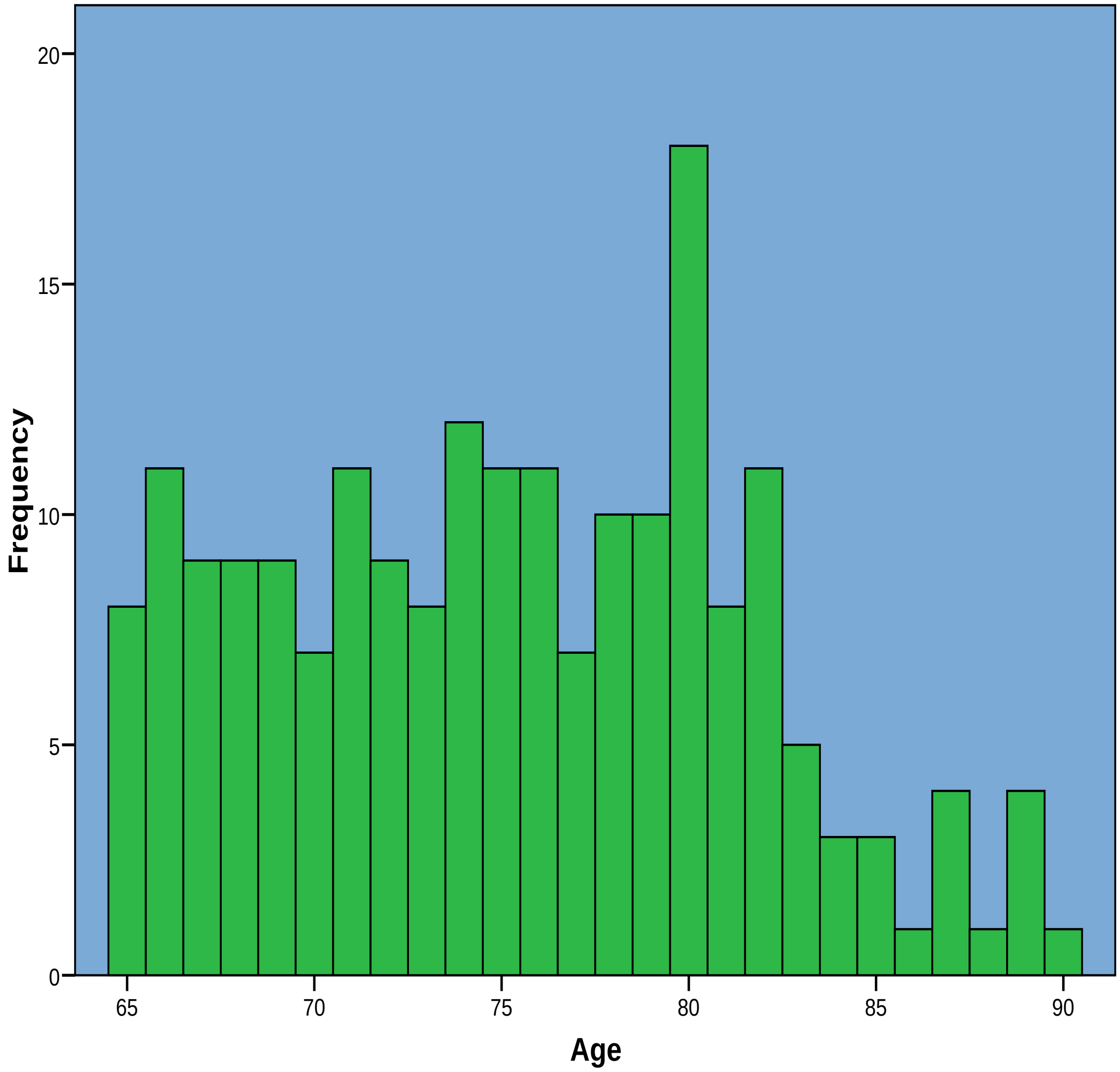


Figure 6 Age distribution of participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

Table 5 Depressive symptoms, cognitive and physical functioning, and minutes per week of walking among participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

Measure and Possible Range	Mean (Standard Deviation)	Median
CES-D [0-30]	6.15 (4.19)	6.00
Mini-Mental State Examination [0-18]	14.15 (3.35)	15.00
Mental Alteration Test [0-26]	10.50 (4.77)	11.00
Self-reported physical functioning [0-12]	4.47 (3.25)	4.00
Modified Guralnik Lower Body Score [0-12]	7.71 (2.81)	8.00
Minutes per week of walking [0-600]	118.78 (127.07)	73.00
	Percentage (Frequency)	
ADL score [0-7]		
0	93.5% (n=188)	
1	4.0% (n=8)	
2	1.5% (n=3)	
3	1.5% (n=2)	
IADL score [0-3]		
0	81.6% (n=164)	
1	14.4% (n=1)	
2	2.5% (n=5)	
3	1.5% (n=3)	
Jug lift		
Over-head level	68.7% (n=138)	
Eye level	14.4% (n=29)	
Mid-chest level	11.9% (n=24)	
Unable	3.0% (n=6)	
Refused	1.5% (n=3)	

4.2 DEPRESSIVE SYMPTOMS

4.2.1 CES-D

CES-D scores ranged from 0 to 23. The minimum possible score was 0 and the maximum was 30. The mean CES-D score was 6.15 (SD=4.19) and the median score was 6.00. Slightly over one-fifth of participants (21.9%, n=44) exhibited signs of depressive symptoms, which is a CES-D score of 10 or greater. CES-D scores for 2 participants (1.0%) were missing due to a missing value for one item each on the 10-item scale. Table 5 contains the mean, median, and range of possible CES-D scores.

4.3 COGNITIVE FUNCTIONING

4.3.1 Mini-Mental State Examination

Scores on the Mini-Mental State Examination ranged from 1 to 18. The minimum possible score was 0 and the maximum was 18. The mean score was 14.15 (SD=3.35) and the median score was 15.00. Twenty-five participants (12.4%) had perfect scores of 18 correct responses. Scores for 18 participants (9.0%) were missing due to refusal to answer one or more questions on the Mini-Mental State Examination. It was not possible to determine the prevalence of cognitive impairment based on Mini-Mental State Examination scores in this population because the scoring used in this study was different from the scoring used on the validated version of the Mini-Mental State Examination. Table 5 contains the mean, median, and range of possible Mini-Mental State Examination scores.

4.3.2 Mental Alteration Test

Scores on the Mental Alteration Test ranged from 0 to 22. The minimum possible score was 0 and the maximum was 26. The mean score was 10.50 (SD=4.77) and the median score was 11.00. The score for one participant (0.5%) was missing due to refusal to attempt the Mental Alteration Test. It was not possible to determine the prevalence of cognitive impairment based on Mental Alteration Test scores in this population because the scoring used in this study was different from the scoring used on the validated version of the Mental Alteration Test. Table 5 contains the mean, median, and range of possible Mental Alteration Test scores.

4.4 PHYSICAL FUNCTIONING

4.4.1 Self-Reported Physical Functioning

Participants reported difficultly on an average of 4.47 of 12 functional tasks (SD=3.25). The median number of tasks with which participants reported difficulty was 4.00. Ten percent (n=20) of participants reported no difficulty with all 12 functional tasks while 2.5% (n=5) of participants reported difficulty with all 12 functional tasks. The functional task with which the greatest percentage of participants reported difficulty was getting up from a stooping, crouching, or kneeling position (68.7%, n=138). The functional task with which the least percentage of participants reported difficultly was writing or handling small objects (14.9%, n=30). Table 5 contains the mean, median, and range of possible self-reported physical functioning scores. Figure 7 shows the distribution of the total number of functional tasks with which participants have any difficulty performing.

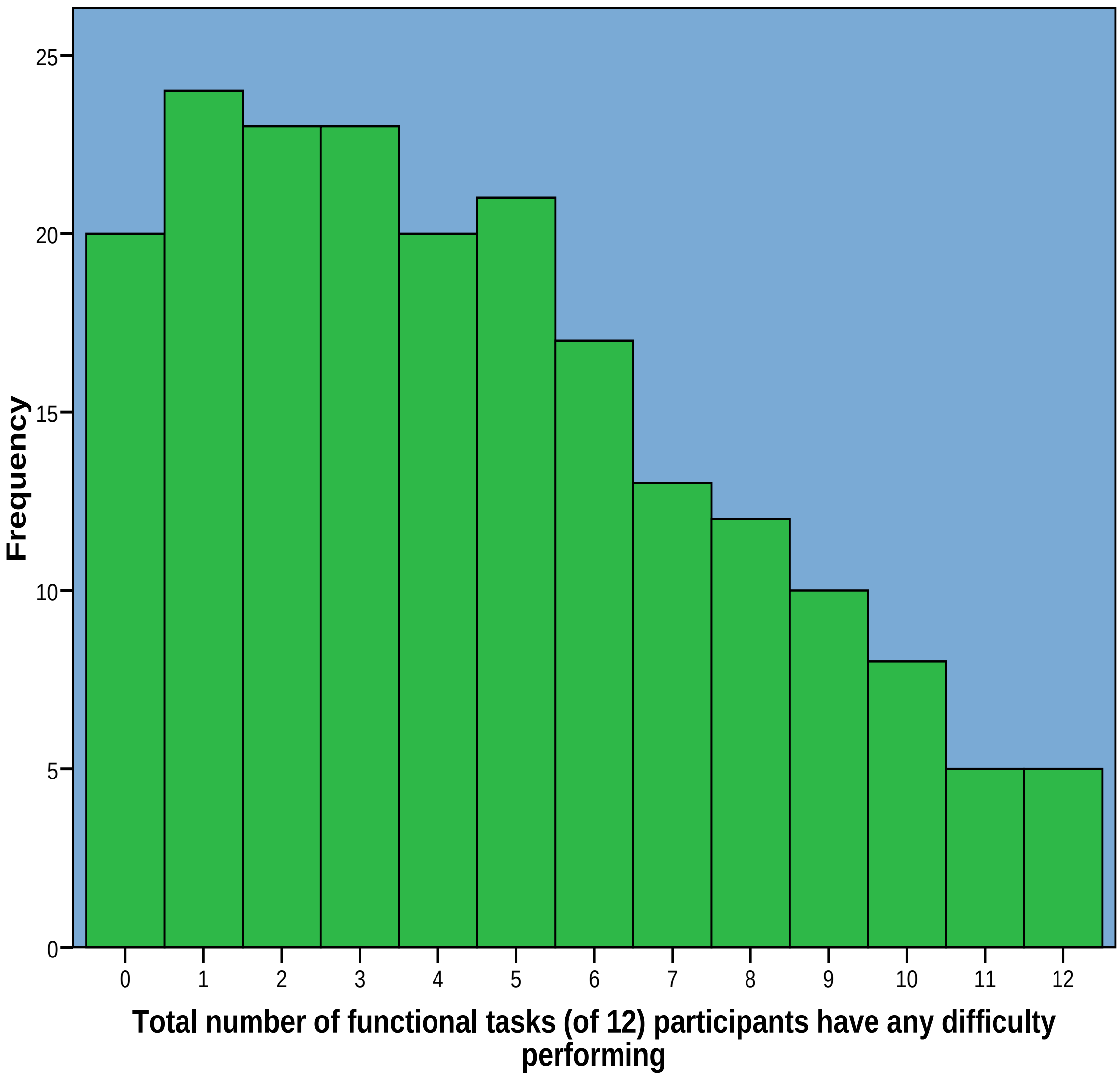


Figure 7 Distribution of the total number of functional tasks with which participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania have any difficulty performing.

4.4.2 Activities of Daily Living

Activities of Daily Living (ADL) scores ranged from 0 to 3. The minimum possible score was 0 and the maximum was 7. The majority of participants had a score of 0 (93.5%, n=188). Eight participants (4.0%) had a score of 1, 3 participants (1.5%) had a score of 2, and 2 participants (1.5%) had a score of 3. Table 5 contains the distribution of ADL scores.

4.4.3 Instrumental Activities of Daily Living

Instrumental Activities of Daily Living (IADL) scores ranged from 0 to 3. The minimum possible score was 0 and the maximum was 3. The majority of participants had a score of 0 (81.6%, n=164). Twenty nine participants (14.4%) had a score of 1, 5 participants (2.5%) had a score of 2, and 3 participants (1.5%) had a score of 3. Table 5 contains the distribution of IADL scores.

4.4.4 Modified Guralnik Lower Body Score

Modified Guralnik Lower Body Scores ranged from 0 to 12. The minimum possible score was 0 and the maximum was 12. The mean score was 7.71 (SD=2.81) and the median score was 8.00. Four participants (2.0%) had a score of 0 while 15 participants (7.5%) had a score of 12. Scores for 5 participants (2.5%) were missing because they refused to attempt one or more of the tests (chair stands, balance, and walking speed) that was necessary to complete in order to calculate the Modified Guralnik Lower Body Score. Table 5 contains the mean, median, and range of possible Modified Guralnik Lower Body Scores.

4.4.5 Jug Lift

Slightly over two-thirds (68.7%, n=138) of participants were able to lift the 10-pound jug over their heads. Twenty-nine participants (14.4%) were able to lift the jug to eye level, 24 participants (11.9%) were able to lift the jug to mid-chest level, and 6 participants (3.0%) were unable to lift the jug. Three participants (1.5%) refused to attempt the jug lift. Table 5 contains the distribution of jug lift scores.

4.5 WALKING BEHAVIOR

The mean total minutes of walking per week self-reported by participants was 118.78 (SD=127.07) and the median was 72.00. Thirty seven participants (19.3%) reported 0 minutes per week of walking while slightly more than one-quarter of participants (27.1%, n=52) reported 150 minutes per week of walking or more. The total number of minutes per week of walking was missing for 5 participants (2.5%). These participants reported walking in the interview but were unable to quantify their time spent walking in minutes per week. In addition, total minutes per week of walking for four participants (2.0%) were excluded because the values were more than 3 standard deviations (SD=248.74) greater than the original mean of 148.35 minutes per week of walking when these values were included. Table 5 contains the mean, median, and range of possible self-reported minutes per week of walking. Figure 8 shows the distribution of self-reported total minutes per week of walking among participants.

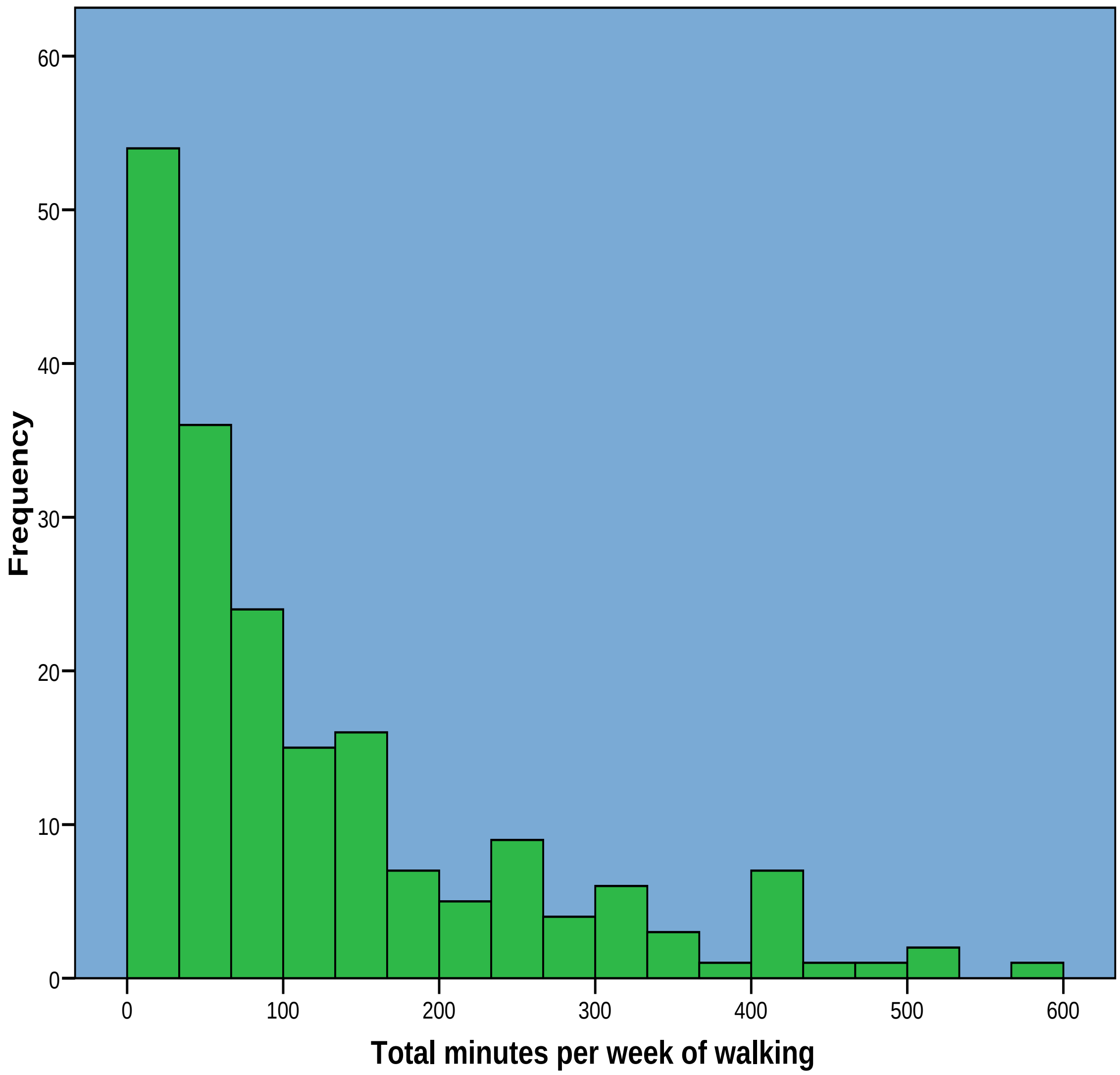


Figure 8 Distribution of self-reported total minutes per week of walking among participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

4.6 ACCELEROMETER MEASURES

4.6.1 Valid Days

Figure 9 shows that the distribution of valid days of accelerometer wear, which was defined as at least ten hours of valid accelerometer wear in a 24 hour period, was left skewed. The mean number of valid days was 5.75 (SD=1.69) and the median was 6.50 among the 198 participants who had valid accelerometer data. Three participants had missing accelerometer data due to accelerometer malfunction (1.5%).

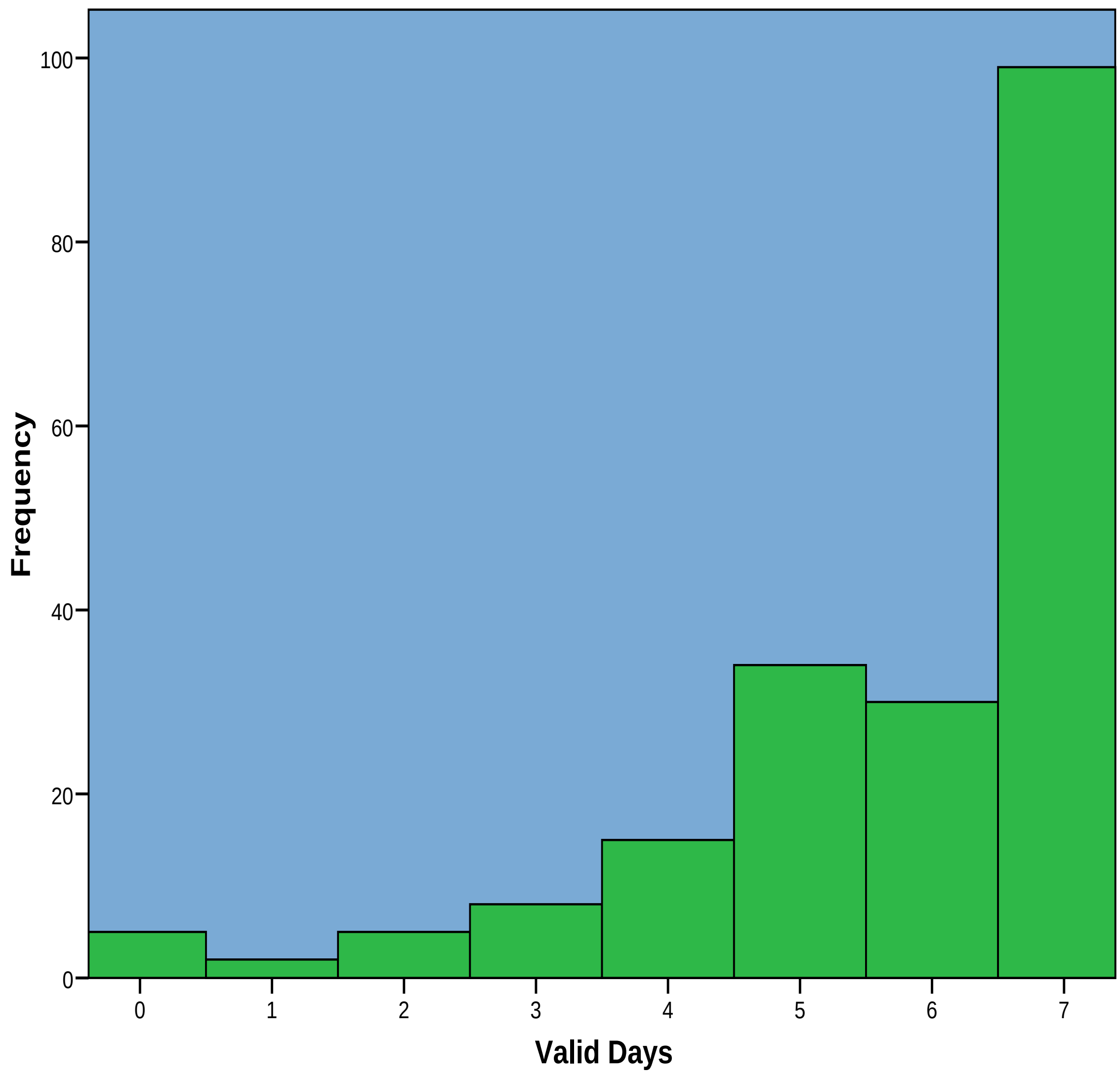


Figure 9 Distribution of number of valid days of accelerometer wear among participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

4.6.2 Valid Persons

Almost 90% of participants (89.9%, n=178) with valid accelerometer data had at least four valid days of accelerometer wear and therefore met the valid person criteria. A two-tailed t-test ($\alpha=0.05$) showed that the mean age of participants who met the valid person criteria (mean=75.27, SD=6.22) was not significantly different (p=0.500) from the mean age of participants who did not (mean=75.25, SD=6.70).

4.6.3 Compliant Persons

Exactly half (50.0%, n=99) of participants with valid accelerometer data had seven valid days of accelerometer wear and therefore met the compliant person criteria. A two-tailed t-test (α=0.05) showed that the mean age of participants who met the compliant person criteria (mean=75.45, SD=6.08) was not significantly different (p=0.675) from the mean age of participants who did not (mean=75.08, SD=6.45).

4.6.4 Univariate Analysis of Accelerometer Measures

4.6.4.1 Valid person

To investigate the relationship between being a valid person and the independent variables of interest described previously, univariate logistic regression models which included a constant were developed with valid person as the dichotomous dependent variable and each of the following as independent variables: Age (p=0.989), gender (p=0.888), highest level of education completed (p=0.356), White race (p=0.567), income category (p=0.686), whether a participant lives alone (p=0.080), CES-D score (p=0.730), Mini-Mental State Examination score (p=0.952), Mental Alteration Test score (p=0.314), self-reported difficulty with 12 functional tasks (p=0.711), whether a participant has any difficulty writing or handling small objects (p=0.526), ADL score (p=0.125), IADL score (p=0.001), Modified Guralnik Lower Body Score (p=0.077), jug lift score (p=0.755), and total number of minutes per week of walking (p=0.908).

IADL score (p=0.001), Modified Guralnik Lower Body Score (p=0.077), whether a participant lives alone (p=0.080), and ADL score (p=0.125) were selected to be entered into a multivariate logistic regression model with valid person as the dichotomous dependent variable because each of these predictor variables had a univariate logistic regression model significance of less than p=0.150. Tables 6-9 show the coefficients of the significant univariate predictors of being a valid person. The univariate logistic regression models show the following relationships: With each point increase in IADL score the odds of being a valid person decreased 63.1% (95% CI=33.0%-79.7%); with each point increase in Modified Guralnik Lower Body Score the odds of being a valid person increased 16.1% (95% CI=-1.6%-37.1%); participants who lived alone were 59.0% less likely to have met the valid person criteria than participants who did not live alone (95% CI=-11.4%-84.9%); for each point increase in ADL score the odds of being a valid person decreased 44.5% (95% CI=-17.8%-73.8%).

Table 6 Univariate logistic regression coefficients of IADL score as the independent predictor variable and valid person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
IADL	-0.998	0.305	10.702	1	0.001	0.369	0.203 – 0.670
Constant	2.573	0.292	77.795	1	>0.001	13.100	

Table 7 Univariate logistic regression coefficients of Modified Guralnik Lower Body Score as the independent predictor variable and valid person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Guralnik	0.149	0.085	3.118	1	0.077	1.161	0.984 – 1.371
Constant	1.124	0.627	3.210	1	0.073	3.078	

Table 8 Univariate logistic regression coefficients of whether a participant lives alone as the independent predictor variable and valid person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Live alone	-0.892	0.510	3.055	1	0.080	0.410	0.151 – 1.114
Constant	2.719	0.421	41.617	1	>0.001	15.167	

Table 9 Univariate logistic regression coefficients of ADL score as the independent predictor variable and valid person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
ADL	-0.588	0.384	2.350	1	0.125	0.555	0.262 – 1.178
Constant	2.275	-0.250	82.880	1	>0.001	9.725	

4.6.4.2 Compliant person

To investigate the relationship between being a compliant person and the independent variables of interest described previously, univariate logistic regression models which included a constant were developed with compliant person as the dichotomous dependent variable and each of the following as independent variables: Age (p=0.673), gender (p=0.888), highest level of education completed (p=0.196), White race (p=0.015), income category (p=0.015), whether a participant lives alone (p=0.320), CES-D score (p=0.256), Mini-Mental State Examination score (p=0.002), Mental Alteration Test score (p=0.034), self-reported difficulty with 12 functional tasks (p=0.965), whether a participant has any difficulty writing or handling small objects (p=1.000), ADL score (p=0.739), IADL score (p=0.054), Modified Guralnik Lower Body Score (p=0.006), jug lift score (p=0.204), and total number of minutes per week of walking (p=0.915).

Modified Guralnik Lower Body Score (p=0.006), Mini-Mental State Examination score (p=0.002), White race (p=0.015), income category (p=0.015), Mental Alteration Test score (p=0.034), and IADL score (p=0.054) were selected to be entered into a multivariate logistic regression model because each of these predictor variables had a univariate logistic regression model significance of less than p=0.150. Tables 10-15 show the coefficients of the significant univariate predictors of being a compliant person. The univariate logistic regression models show the following relationships: With each point increase in Modified Guralnik Lower Body Score the odds of being a compliant person increased 16.4% (95% CI=4.4%-29.7%); with each point increase in Mini-Mental State Examination score the odds of being a compliant person increased 17.7% (95% CI=6.3%-30.3%); participants who were non-White were 56.6% less likely to have met the compliant person criteria than participants who were White (95% CI=15.1%-77.8%); participants who had an income of less than $20,000 in the last year were 46.6% less likely to have met the compliant person criteria than participants who had an income of $20,000 or greater in the last year (95% CI=13.6%-74.9%); for each point increase in Mental Alteration Test score the odds of being a compliant person increased 6.7% (95% CI=0.5%-13.3%); for each point increase in IADL score the odds of being a compliant person decreased 41.6% (95% CI=-1.0%-66.2%).

Table 10 Univariate logistic regression coefficients of Modified Guralnik Lower Body Score as the independent predictor variable and compliant person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Guralnik	0.152	0.055	7.553	1	0.006	1.164	1.044 – 1.297
Constant	-1.211	0.456	7.060	1	0.008	0.298	

Table 11 Univariate logistic regression coefficients of Mini-Mental State Examination score as the independent predictor variable and compliant person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
MMSE	0.163	0.052	9.782	1	0.002	1.177	1.063 – 1.303
Constant	-2.293	0.765	8.978	1	0.003	0.101	

Table 12 Univariate logistic regression coefficients of White race (referent) as the independent predictor variable and compliant person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Non-White race	-0.835	0.342	5.943	1	0.015	0.434	0.222 – 0.849
Constant	0.202	0.165	1.505	1	0.220	1.224	

Table 13 Univariate logistic regression coefficients of income greater than $20,000 (referent) as the independent predictor variable and compliant person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Income less than $20,000	-0.764	0.316	5.863	1	0.015	0.466	0.251 – 0.864
Constant	0.483	0.236	4.181	1	0.041	1.621	

Table 14 Univariate logistic regression coefficients of Mental Alteration Test score as the independent predictor variable and compliant person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
MAT	0.065	0.031	4.495	1	0.034	1.067	1.005 – 1.133
Constant	-0.675	0.354	3.639	1	0.056	0.509	

Table 15 Univariate logistic regression coefficients of IADL score as the independent predictor variable and compliant person as the dichotomous dependent variable.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
IADL	-0.537	0.279	3.703	1	0.054	0.584	0.338 – 1.010
Constant	0.124	0.155	0.641	1	0.423	1.132	

4.6.5 Multivariate Analysis of Accelerometer Measures

4.6.5.1 Valid person

IADL score (p=0.001), Modified Guralnik Lower Body Score (p=0.077), whether a participant lives alone (p=0.080), and ADL score (p=0.125) were selected to be entered into a multivariate logistic regression model to predict being a valid person because each had a univariate logistic regression model significance of less than p=0.150. One-hundred ninety-three participants, which is 96% of the entire study population (N=201), had valid data for these four independent predictor variables as well as the dependent variable and were therefore included in the final multivariate logistic regression model to predict being a valid person. It should be noted that none of the independent predictor variables had correlations high enough to suggest a lack of independence ($-0.386 \geq r_s \leq 0.117$).

Using a backward likelihood-ratio elimination method, the best multivariate logistic regression model to predict being a valid person included IADL score (p=0.002) and a constant (p<.001): For each point increase in IADL score the odds of being a valid person decreased 62.0% (95% CI=30.7%-79.2%). Table 16 shows the coefficients of the best multivariate logistic regression model to predict being a valid person.

Table 16 Coefficients of best multivariate logistic regression model to predict being a valid person, which included IADL score and a constant.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
IADL	-0.968	0.307	9.949	1	0.002	0.380	0.208 – 0.693
Constant	2.579	0.295	76.289	1	>0.001	13.187	

To examine for a trend in the relationship between valid days of accelerometer wear and IADL score, Figure 10 shows a box plot of the median number of valid days by IADL score. A Jonckherre-Terpstra test confirmed that there is a significant decreasing trend in median number of valid days with increasing IADL score (p=0.015).

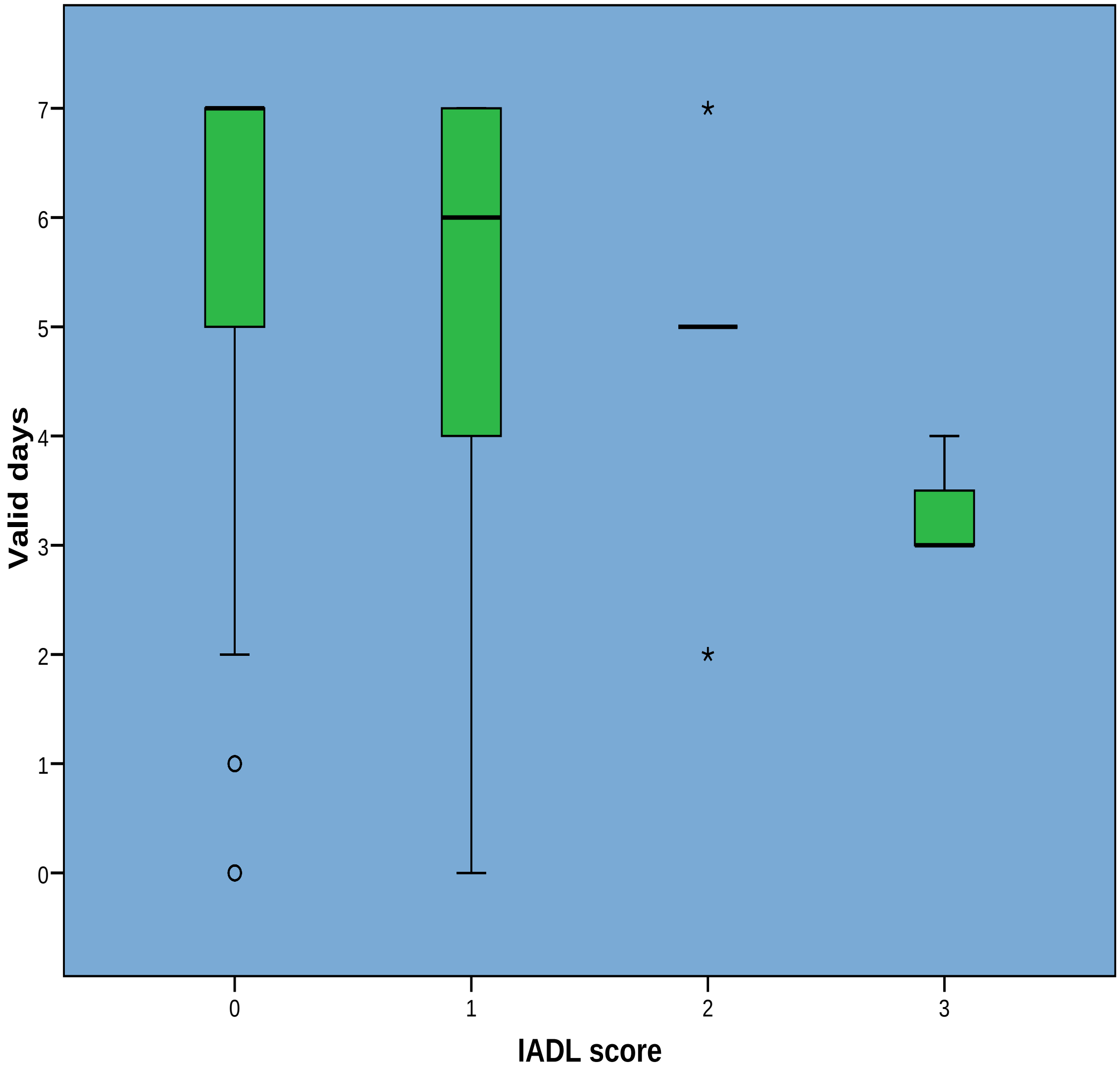


Figure 10 Box plot of median number of valid days by IADL score among participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

4.6.5.2 Compliant person

Mini-Mental State Examination score (p=0.002), Modified Guralnik Lower Body Score (p=0.006), White race (p=0.015), income category (p=0.015), Mental Alteration Test score (p=0.034), and IADL score (p=0.054) were selected to be entered into a multivariate logistic regression model to predict being a compliant person because each had a univariate logistic regression model significance of less than p=0.150. However, income category and Mini-Mental State Examination score were not entered into the final multivariate logistic regression model to predict being a compliant person because data was missing for 15.9% (n=23) and 10.0% (n=20) of participants respectively. One-hundred ninety-three participants, which is 96% of the entire study population (N=201), had valid data for the other four independent predictor variables, which were Modified Guralnik Lower Body Score, White race, Mental Alteration Test score, and IADL score, as well as the dependent variable and were therefore included in the final multivariate logistic regression model to predict being a compliant person. It should be noted that none of these four independent predictor variables had correlations high enough to suggest a lack of independence ($-0.386 \geq r_s \leq 0.386$).

Using a backward likelihood-ratio elimination method, the best multivariate logistic regression model to predict being compliant person among the four independent predictor variables entered into the model included Modified Guralnik Lower Body Score (p=0.008), White race (p=0.018) and a constant (p=0.036): For each point increase in Modified Guralnik Lower Body Score the odds of being a compliant person increased 16.4% with White race being held constant (95% CI=4.1%-30.1%); and participants who were non-White were 56.9% less likely to have met the compliant person criteria compared with participants who were White with Modified Guralnik Lower Body Score being held constant (95% CI=13.3%-78.6%). There was no significant interaction among the main effects of the model. Table 17 shows the coefficients of the best multivariate logistic regression model to predict being a compliant person among the four independent predictor variables that were entered into the model.

Table 17 Coefficients of best multivariate logistic regression model to predict being a compliant person, which included Modified Guralnik Lower Body Score, White race (referent), and a constant.

Predictor	Beta	SE	Wald	df	Significance	Odds Ratio	95% CI of Odds Ratio
Guralnik	0.152	0.057	5.988	1	0.008	1.164	1.041 – 1.301
Non-White race	-0.841	0.357	7.137	1	0.018	0.431	0.214 – 0.867
Constant	-0.998	0.477	4.384	1	0.036	0.368	

To examine for a trend in the relationship between valid days of accelerometer wear and Modified Guralnik Lower Body Score, Figure 11 shows a plot of mean valid days by Modified Guralnik Lower Body Score with 95% confidence intervals around each mean. In a visual examination of the data, it appears that there is a linear increase in mean valid days as Modified Guralnik Lower Body Score increases.

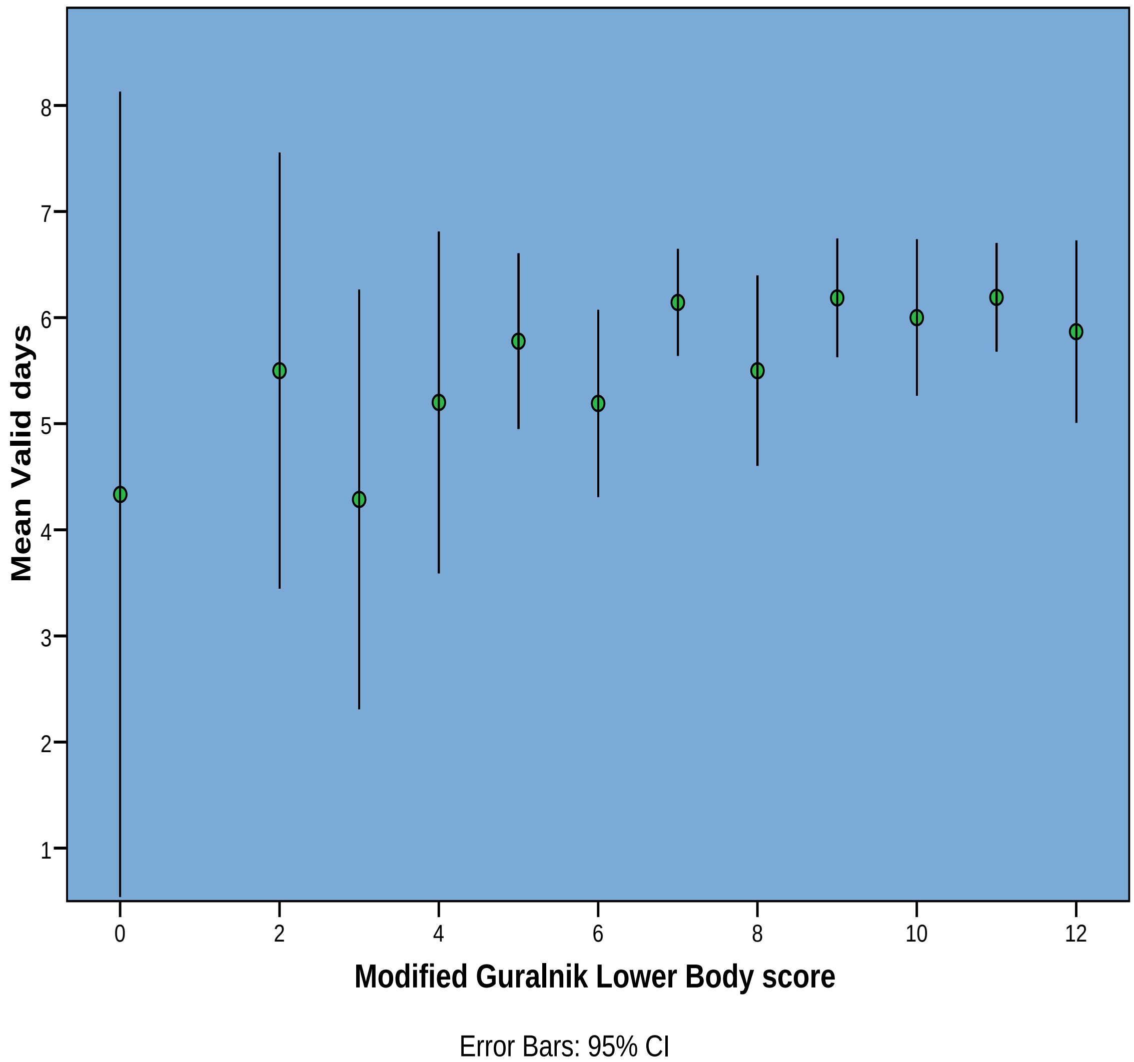


Figure 11 Plot of mean valid days by Modified Guralnik Lower Body Score with 95% confidence intervals around each mean among participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

Figure 12 shows the best fit regression line of Modified Guralnik Lower Body Score and valid days, which was a linear equation (r^2=.042). Figure 13 contains the coefficients of this linear regression equation.

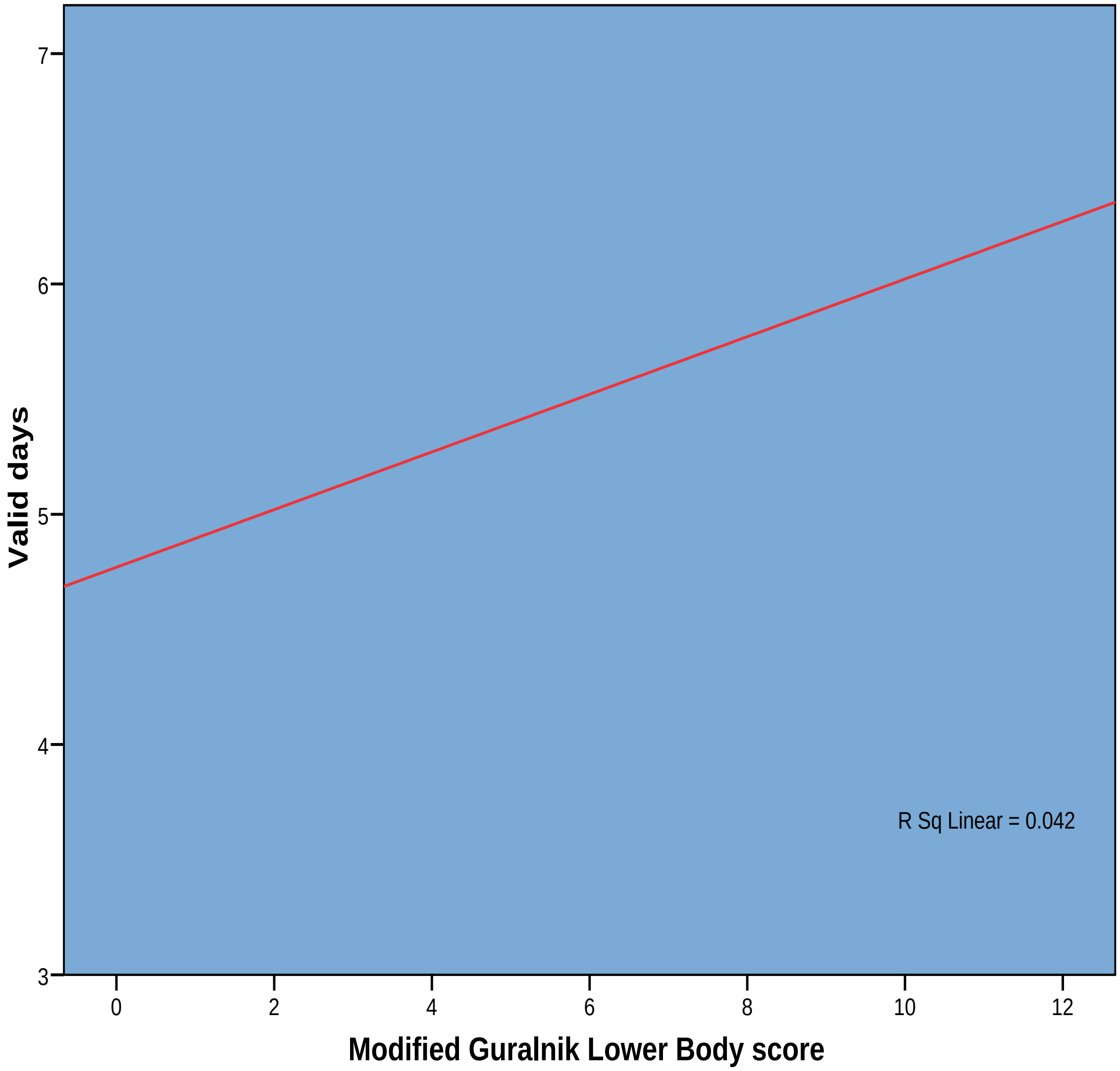


Figure 12 Linear regression line of Modified Guralnik Lower Body Score and valid days.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Modified Guralnik Lower Body score	.125	.043	.205	2.892	.004
(Constant)	4.770	.356		13.381	.000

Figure 13 Coefficients of the linear regression equation of Modified Guralnik Lower Body Score and valid days.

To examine for a trend in the relationship between valid days of accelerometer wear and White race status, a median test revealed that the median number of valid days among White participants (median=7) was significantly different than non-White participants (median=5) (p=0.021). Figure 14 shows a box plot of the median number of valid days for White and non-White participants.

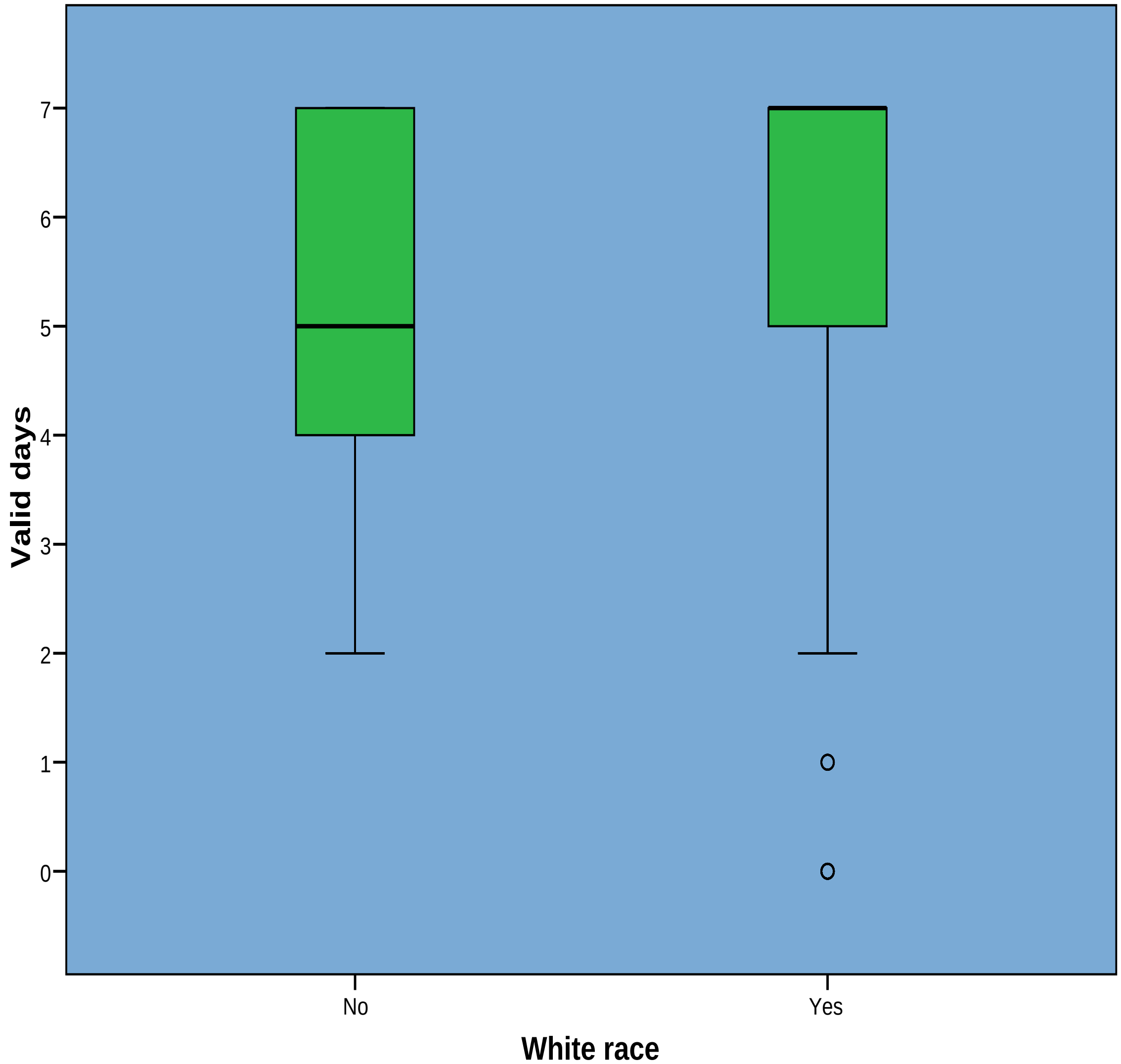


Figure 14 Box plot of median number of valid days by White race status among participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county, Pennsylvania.

5.0 DISCUSSION

5.1 INTERPRETATION OF THE FINDINGS

5.1.1 Demographics

Females comprised a greater percentage of this sample (78.61%) than in the actual population of older adults in Allegheny county, Pennsylvania: Based on the 2000 United States census, 60.95% of adults aged 65 years and older in Allegheny county were female. The self-reported racial identity of participants of the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county was fairly consistent with the 2000 United States census in Allegheny county, Pennsylvania, although there was a slightly higher percentage of African-Americans and a slightly lower percentage of White participants in the study compared with the actual population: 75.6% of study participants identified their race as White only compared with 84.3% in the census; 22.4% of study participants identified their race as African-American only compared with 12.4% in the census; 1.5% of study participants identified their race as Asian only compared with 1.7% in the census; and 0.0% of study participants identified themselves as Latino or Hispanic compared with 0.9% in the census [156].

According to a report by the Surgeon General of the United States, between 8% and 20% of community-dwelling older adults suffer from depressive symptoms [157]. Slightly over 20%

of participants in this study in Allegheny county exhibited signs of depressive symptoms, which was a score of 10 or greater on the CES-D 10-item scale. As was mentioned in the results section, it was not possible to determine the prevalence of cognitive impairment among participants in this study based on Mini-Mental State Examination and Mental Alteration Test scores because the scoring used in this study was different from the scoring used on the validated versions of the Mini-Mental State Examination and the Mental Alteration Test, respectively.

Overall, the participants in this study appeared to be a physically healthy group, which is not at all surprising since individuals with moderate or severe health limitations were excluded from the study during the prescreening process. Most of the participants did not have any ADL (93.5%) or IADL (81.6%) limitation and the majority had excellent upper body strength, as 68.7% of participants were able to lift the 10-pound jug over their heads. On average, the participants reported at least some difficulty on about one-third of the 12 functional tasks assessed. While there is no national average with which to compare, it seems reasonable that in a sample of older adults with an average age of 75.24 years at least some difficulty with a number of functional tasks is relatively prevalent. Modified Guralnik Lower Body Score was computed by dividing the raw scores of participants on the tests of leg strength, balance, and walking speed into quartiles. As a result, scores of participants within the study can be compared but it is not possible to compare the scores of these participants with scores of participants from other studies.

The Centers for Disease Control and Prevention and the American College of Sports Medicine recommend that all older adults accumulate at least 30 minutes of moderate activity on most or all days of the week [22]. In this sample, slightly more than one-quarter (27.1%, n=52) of participants reported at least 150 minutes per week of walking, which is an average of at least

30 minutes of walking five days of the week. Therefore, solely based on walking behavior, only about one-quarter of the participants in this study meet the physical activity recommendation set forth by the Centers for Disease Control and Prevention and the American College of Sports Medicine. This percentage may be slightly higher if other aerobic activities such as biking and aerobics were included. Nonetheless, this percentage is still higher than the percentage of adults aged 65-74 years and aged 75 years and older nationally who meet the physical activity recommendation, which is 16% and 12% respectively [25]. Walking was chosen as the sole measure of physical activity for this analysis because it is one of the most popular forms of physical activity among older adults [27].

5.1.2 Accelerometer Measures

The distribution of the number of valid days of accelerometer wear among participants in this study was very similar to the distribution of the number of valid days of accelerometer wear among adults aged 65 years and older in NHANES 2003-2004: The mean number of valid days in NHANES was 5.71 (SD=1.85) and the median was 7, while the mean number of valid days among older adults in this study was 5.75 (SD=1.69) and the median was 6.50. Also, the proportion of participants who met the valid person and compliant person criteria was also very similar among older adults in NHANES 2003-2004 and this study: 89.90% of participants in this study met the valid person criteria compared with 85.00% of older adults in NHANES, and 50.00% of participants in this study met the compliant person criteria compared with 45.8% of older adults in NHANES. The proportion of participants who met the criteria for valid person and compliant person from NHANES 2003-2004 and this study can be used to inform sample size decisions for future studies which will employ accelerometers to measure physical activity in older adults.

5.1.2.1 Main dissertation hypothesis

The main hypothesis of this dissertation is that compliance to an accelerometer protocol generally decreases with advancing age among older adults. In other words, as age increases, the number of valid days of accelerometer wear, as well as the odds of being a valid person and a compliant person, all decrease. One of the statistical tests of this hypothesis was t-tests comparing the mean age of participants who met the criteria for valid person and compliant person and those who did not. We expected that the mean age of participants who met the criteria for valid person and compliant person would be significantly lower than those who did not. The results, however, show that there was no statistically significant difference in age.

The power (two-tailed test, $\alpha=0.05$) of the two-tailed t-tests ($\alpha=0.05$) to detect a five year difference in the mean age of participants who met the criteria for valid person and compliant person and those who did not was high: 89% for the valid person analysis and 100% for the compliant person analysis. This power calculation was based on our decision that a difference in mean age of five years or more between participants who met the criteria for valid person and compliant person and those who did not would be clinically significant. As a result, these t-tests had a high probability of correctly failing to reject the null hypothesis, which in this case was that there was no difference in the mean age of participants who met the criteria for valid person and compliant person and those who did not. In other words, the probability that the null hypothesis was incorrectly accepted was very low: 11% for the valid person analysis and 0% for the compliant person analysis.

The analysis of the NHANES 2003-2004 data among older adults did, however, show a statistically significant difference in the mean age of participants who met the criteria for valid person and compliant person and those who did not: The mean age of participants who met the criteria for valid person (mean=73.65) and compliant person (mean=73.23) was significantly lower than those who did not (mean=75.19; mean=74.13) ($p>0.001$). The difference in mean age between participants who met valid person criteria and those who did not was 1.55 years and the difference in mean age between participants who met compliant person criteria and those who did not was 0.90 years. While these differences were statistically significant, the clinical significance of the differences is very minor. A larger difference in the mean age of participants who met the criteria for valid person and compliant person and those who did not, such as several years or more, would have much more relevance clinically because it would provide more concrete support for the hypothesis that compliance generally decreases with advancing age in older adults.

As mentioned previously, we decided a difference in mean age of five years or more would be clinically significant. Therefore, the small difference in mean age found among older adults in NHANES 2003-2004 who met the criteria for valid person and compliant person and those who did not, although statistically significant, is of minor clinical utility. It should be noted that the power (two-tailed test, $\alpha=0.05$) of the two-tailed t-tests ($\alpha=0.05$) to detect a five year difference in the mean age of participants who met the criteria for valid person and compliant person and those who did not in NHANES 2003-2004 was extremely high: 100% for both the valid person and the compliant person analysis. In other words, the probability that the null hypothesis was incorrectly accepted was 0% for both the valid person and the compliant person analysis.

5.1.2.2 Logistic regression analyses of valid person and compliant person

Based on the results of the univariate analysis, IADL score, Modified Guralnik Lower Body Score, whether a participant lives alone, and ADL score were the independent predictor variables selected to be entered into the multivariate logistic regression model with valid person as the dichotomous dependent variable. The results show that the best multivariate logistic regression model to predict being a valid person includes IADL score and a constant: For each point increase in IADL score, the odds of being a valid person decreased 62.0% (95% CI=30.7%-79.2%). In other words, a participant with an IADL score of 1 was 62.0% less likely to have met the valid person criteria compared with a participant with an IADL score of 0 (95% CI=30.7%-79.2%), and so on.

Based on the results of the univariate analysis, Modified Guralnik Lower Body Score, Mini-Mental State Examination score, White race, income category, Mental Alteration Test score, and IADL score were the independent predictor variables selected to be entered into the multivariate logistic regression model with compliant person as the dichotomous dependent variable. As described previously, income category and Mini-Mental State Examination score were not entered into the final multivariate logistic regression model because data for each of these variables was missing for a sizable percentage of the study participants. On one hand, excluding these variables from the final multivariate logistic regression model to predict being a compliant person may have masked important relationships. On the other hand, these variables may not be very useful in predicting being a compliant person because a significant percentage of participants did not know or refused to give their income or refused to answer one or more questions on the Mini-Mental State Examination.

The results show that the best multivariate logistic regression model to predict being a compliant person among the four independent predictor variables entered into the model, which were Modified Guralnik Lower Body Score, White race, Mental Alteration Test Score, and IADL score, includes Modified Guralnik Lower Body Score, White race, and a constant: For each point increase in Modified Guralnik Lower Body Score, the odds of being a compliant person increased 16.4% with White race being held constant (95% CI=4.1%-30.1%); and participants who were not White were 56.9% less likely to have met the compliant person criteria compared with participants who were White with Modified Guralnik Lower Body Score being held constant (95% CI=13.3%-78.6%). In other words, a participant who had a Modified Guralnik Lower Body Score of 8 was 16.4% less likely to have met the compliant person criteria than a participant who had a Modified Guralnik Lower Body Score of 9 with White race being held constant (95% CI=4.1%-30.1%). Also, a participant who was not White was 56.9% less likely to have met the compliant person criteria than a participant who was White with Modified Guralnik Lower Body Score being held constant (95% CI=13.3%-78.6%).

To our knowledge, this is the first analysis that examined the factors that are associated with compliance to an accelerometer protocol in older adults. Subsequently, the results presented in this dissertation should be used as a starting point for future investigations of this topic rather than providing any definitive answers. Many more investigations with diverse populations and measures of participant characteristics are necessary before any concrete conclusions regarding the factors that are associated with compliance to accelerometer protocols in older adults can be drawn. In addition, it is important to consider that some factors that may be associated with compliance to an accelerometer protocol in older adults were not measured in this study. Therefore, the results presented in this dissertation should be viewed in light of the characteristics of the participants that were measured in the *Environmental Correlates of Physical Activity Among Older Adults* study as well as the decisions that were made regarding which variables to include in the multivariate logistic regression models to predict being a valid person and being a compliant person.

5.2 PUBLIC HEALTH SIGNIFICANCE

Physical activity is a critical public health issue among older adults. The majority of older adults are sedentary [25] and as a group older adults are the most sedentary segment of the entire United States population [29, 30]. Furthermore, the prevalence of overweight and obesity in older adults is alarmingly high: Only 37% of females and 33% of males aged 60 years and older are a healthy weight [158]. Research has shown that an active lifestyle is associated with lower mortality from cardiovascular disease, which is the number one killer of older adults [1-7]. An active lifestyle has also been shown to be protective against the development of hypertension [8-11] and obesity [12-15], and have positive health effects on individuals with type II diabetes mellitus [16-18] and cancer [19-21]. Given the prevalence of inactivity and overweight and obesity in older adults, physical activity will continue to be a vitally important public health issue for years to come.

Physical activity is a complex epidemiological exposure that has many dimensions, making it difficult to study. As a result, accurately measuring physical activity is imperative in investigating its relationship with health and disease [38]. Accelerometers are reliable, valid, and versatile tools for measuring physical activity for research studies. However, compliance to protocols of accelerometer use by participants of research studies is crucial in order to ensure the most accurate measure of their physical activity. For now, researchers can use data on the proportion of participants who met the criteria for valid person and compliant person in the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county and NHANES 2003-2004 among older adults to inform decisions regarding the sample size needed for their research study.

Unfortunately, participants in research studies who fail to meet the minimum number of valid days of accelerometer wear are excluded from any analysis related to physical activity because their level of physical activity cannot be calculated. There are certainly randomly occurring reasons a participant may miss a day or two of accelerometer wear. However, characteristics which emerge that are consistently associated with lower compliance to accelerometer protocols need to be addressed because participants with these characteristics will be consistently excluded from analyses involving measures of physical activity with accelerometers until compliance is increased to acceptable levels.

Research related to the factors that are associated with compliance to accelerometer protocols in older adults should not be taken to imply that older adults with characteristics that have been associated with lower compliance should not be given accelerometers or should be excluded from research studies that utilize accelerometers to measure physical activity. Rather, it is likely that the strategies that were used to promote and increase compliance in the research studies that found these associations were not as effective among these participants. For example, the instructions given to participants regarding accelerometer use may have been culturally inappropriate for certain racial groups and as a result, compliance to the accelerometer protocol was lower. Additionally, the root cause of lower compliance in older adults with certain characteristics may be the accelerometers themselves; it is possible that the device will be physically difficult for older adults with certain limitations to use. As a result, accelerometers themselves may need to be physically altered in order to make them more user-friendly for older adults who have certain limitations.

5.3 FUTURE RESEARCH

Investigations into the factors that are associated with compliance to accelerometer protocols in older adults can be embedded in any study that uses accelerometers to measure physical activity, just as this analysis was embedded in the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county. As a result, a research study with the sole purpose of investigating this topic need never be undertaken, which makes all research regarding this topic extremely efficient. All research studies that use accelerometers to measure physical activity in older adults should report compliance rates, such as the proportion of participants who met the valid person and compliant person criteria. Reporting these characteristics of the research population is extremely important because participants in research studies who do not meet the minimum number of valid days of accelerometer wear are excluded from any analysis involving physical activity because their level of physical activity cannot be calculated.

More studies are needed related to the factors that are associated with compliance to accelerometer protocols in older adults to increase the breadth of evidence. To our knowledge this analysis was the first of its kind and similar analyses are needed before any concrete conclusions can be drawn. Future research on this topic should include more diverse populations, such as populations with greater variation in racial and ethnic identity of participants. As mentioned previously, the participants in the *Environmental Correlates of Physical Activity Among Older Adults* study in Allegheny county were a relatively healthy sample because individuals with moderate or severe limitations were excluded from the study during the prescreening process. As a result, in order to more thoroughly examine the effects of poorer health status on compliance to accelerometer protocols, research populations which include older adults with lower physical and cognitive functioning need to be utilized in order to investigate this topic more fully.

Once a more comprehensive set of investigations into the factors that are associated with compliance to accelerometer protocols in older adults has been undertaken, the next step in the research process should be to examine the reasons compliance is lower among older adults with certain characteristics. This is absolutely a crucial step in the research process and should not be ignored. To reinforce, research regarding the factors that are associated with compliance to accelerometer protocols in older adults should not be taken to mean that individuals who have certain characteristics that have been associated with lower compliance should not be given accelerometers or should be excluded from studies which use accelerometers to measure physical activity. Rather, the reasons participants in research studies with certain characteristics tend toward lower compliance need to be determined so that better methods to promote and improve compliance can be developed and employed.

Research to examine the reasons compliance tends to be lower among participants with certain characteristics should involve a large qualitative component. In-depth interviews and surveys can be given to older adults in research studies that use accelerometers to measure physical activity to thoroughly investigate this topic. Once the reasons participants with certain characteristics tend toward lower compliance are uncovered, research needs to go one step further and begin to investigate methods to promote and improve compliance in older adults who have these characteristics. It may be that the reading material given to participants explaining appropriate wear and care of the accelerometer needs to be altered in order to make the accelerometer more user-friendly or more culturally appropriate, or the accelerometer itself may need to be physically altered in order to make it easier to use among those who have poorer lower body functioning. All of these steps in the research process that have been described here are vital to ensure that accelerometers used in research studies among older adults can be employed to their fullest potential.

5.4 STRENGTHS AND LIMITATIONS OF THE STUDY AND THIS ANALYSIS

There are several strengths of the *Environmental Correlates of Physical Activity Among Older Adults* study and this analysis. One of the main strengths of the study is the wealth of data it provides. For an investigation of the factors that are associated with compliance to an accelerometer protocol in older adults, this study provides an abundance of variables from which to choose including demographic variables, activity-related variables, and physical and cognitive functioning variables. Along with this, a second strength of the study is that many objective measures were taken, including direct measures of physical and cognitive functioning. In general, objective measures are preferable to self-report measures because self-report measures are prone to bias in older adults due to problems with memory and cognition [63, 64].

A third strength of this study was the sampling design. The sampling design was mostly based on the primary goal of the study, which was to examine the relationship between elements of the built environment and levels of functional capacity on levels of walking and other forms of moderate activity among older adults. In the sampling design, all senior centers in Allegheny county were placed into one of five groups from highest to lowest housing density. Next, four senior centers within each of the five groups were randomly selected as recruitment sites for the study. Senior centers were grouped by housing density to ensure neighborhood variability among the study participants, assuming that the participants lived close to the senior center they attended. Twelve or thirteen individuals were attempted to be recruited from each senior center for the study. In terms of this analysis, the sampling design was beneficial because a fairly representative sample of the older adults in Allegheny county was obtained.

There are also several limitations of this study and this analysis. One of the main limitations of this analysis is that the population was relatively healthy, which made it difficult to examine the effects of poorer health status on compliance to an accelerometer protocol. There are two main reasons the participants who were recruited for the study were relatively healthy. First, individuals with moderate or severe limitations were excluded from the study during the prescreening process. Second, it was a relatively healthy population from which to recruit participants from to begin with because in general, older adults who attend senior centers are ambulatory and generally cognizant enough to get themselves to and from the center. As a result, older adults with more severe physical and cognitive limitations would likely not be present at the senior centers to be recruited for the study anyway. The fact that most of the participants in the study lacked more than a minor degree of physical and cognitive limitation made it difficult to examine the effects of poorer health on compliance to an accelerometer protocol. Therefore, the generalizability of the results of this analysis are limited to a relatively healthy population of older adults.

Another limitation of this study is that the Mini-Mental State Examination and Mental Alteration Test were altered from their validated form. While it was still possible to compare scores of the participants within the study, it was impossible to determine the proportion of participants who were cognitively impaired because the validated versions of the Mini-Mental State Examination and the Mental Alteration Test were not used. On the other hand, the validated version of the CES-D 10 was used so it was possible to determine the prevalence of depressive symptoms in the study population.

5.5 CONCLUSION

Physical activity is a critical public health issue among older adults. Accelerometers are reliable, valid, and versatile tools for measuring physical activity for research studies. However, compliance to protocols of accelerometer use by participants of research studies is crucial in order to ensure the most accurate measure of their physical activity. To our knowledge, this was the first investigation of the factors that are associated with compliance to an accelerometer protocol in older adults. The results of this analysis show that accelerometers are a promising tool for measuring physical activity in older adults because the majority of participants in this study as well as older adults in NHANES 2003-2004 had enough valid days of accelerometer wear to have their physical activity levels calculated.

However, because this was the first analysis of its kind, more research is needed regarding the factors that are associated with compliance to accelerometer protocols in older adults before any concrete conclusions are drawn. While we hypothesized that compliance would decrease with advancing age in older adults, this analysis found no significant relationship between age and compliance. The results of this analysis did, however, show that several characteristics were associated with compliance, which supports the idea that compliance is influenced by certain characteristics among older adults. In addition to continuing to examine the factors that are associated with compliance to accelerometer protocols in older adults, future research should also investigate the reasons certain characteristics are associated with lower compliance as well as methods to promote and improve compliance in older adults who have these characteristics. All of these steps will ensure that accelerometers used in research studies to measure physical activity among older adults can be employed to their fullest potential.

APPENDIX A

ACCELEROMETER INSTRUCTION SHEET

What you need to know about wearing the activity monitor

- **DOs:**

✓ **Do** remember to wear the monitor everyday for the next week.

✓ **Do** remove the monitor right before going to bed. Leave it on a table or dresser where you will be sure to see it first thing the next morning.

✓ **Do** put your monitor on each morning after you have showered or when you get out of bed.

✓ **Do** be sure the monitor fits snuggly around your waist. It is okay to wear it under your clothing as well as on the outside.

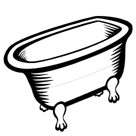
✓ **Do** be sure the monitor is on your right side, **aligned with your underarm**. NOT at the front or back of your waist.

✓ **Do** be sure the monitor is placed with the **black button upward** and the black button side away from the body.

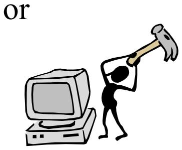
✓ You will receive a phone call in the next few days to see if you have any questions or problems with the monitor.

✓ **Do** wear the monitor through the same day of the next week. So if you received the monitor on Monday, the earliest you would return it would be next Tuesday.

- **DON'Ts:**



⃠ **Don't** let the monitor get wet. You should not wear it when you are bathing, showering, or swimming. Be sure to put it back on when you are out of the water.

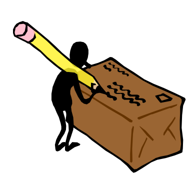


⃠ **Don't** drop the monitor or knock it against hard objects.

⃠ **Don't** forget to wear the monitor everyday. If you forget to put it on for any part of the day put it on as soon as you remember.

- **What to do if you have questions:**

✦ Call the Center for Healthy Aging (412) 624-3217. If no one answers, please leave your name, phone number, and a message so someone can call you back. We won't be available to return weekend calls until Monday.



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