THE ASSESSMENT OF CARDIOVASCULAR DISEASE RISK IN RELATION TO THE BUILT ENVIRONMENT AND RACE

by

Vanisha L. Brown

BS, Florida Agricultural and Mechanical University, 2000

MPH, Florida Agricultural and Mechanical University, 2002

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This dissertation was presented

by

Vanisha L. Brown

It was defended on

July 8, 2010

and approved by

Emma Barinas-Mitchell, PhD
Assistant Professor, Department of Epidemiology, Graduate School of Public Health
University of Pittsburgh

Kevin E. Kip, PhD
Associate Professor, Executive Director, Research Center, College of Nursing
University of South Florida

Suresh Mulukutla, MD
University of Pittsburgh Physicians, UPMC Cardiovascular Institute
University of Pittsburgh

Evelyn O. Talbott, DrPH
Professor, Department of Epidemiology, Graduate School of Public Health
University of Pittsburgh

Thomas J. Songer, PhD
Dissertation Advisor and Committee Chair
Assistant Professor, Department of Epidemiology, Graduate School of Public Health
University of Pittsburgh

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Vanisha L. Brown, PhD

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Cardiovascular disease (CVD) is a critical public health challenge, and the leading cause of death for both genders in the United States and worldwide. Much research has focused on addressing the health burden associated with CVD, and has identified a number of modifiable risk factors (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity).

One issue affecting CVD risk factors may be the built environment, which includes all things that are developed and altered by man. The built environment may impact health, yet, the underlying mechanisms by which it influences health remains unknown. The purpose of this study was to examine the association between the built environment and CVD risk, the degree to which these associations are influenced by race, and the extent to which assessments of the environment differ by the method applied.

Significant inverse relationships were found between the built environment and BMI, obesity, diabetes mellitus, hypertension, and physical inactivity. Physical activity was found to partially mediate the relationship between the built environment and BMI. In Whites, significant inverse relationships were found between the built environment and BMI, obesity, and physical inactivity. Again, physical activity was found to mediate the relationship between the built environment and BMI. No significant relationships were found between the built environment and measures of CVD risk in Blacks. Environmental assessments revealed fair agreement

between ratings from participants and independent evaluators, although agreement was better for more objective items. Agreement was also higher for racially mixed neighborhoods. Measurement of objective attributes revealed a significant difference in the mean distance between neighborhood ratings for participants and independent evaluators for the presence of sidewalks; and among participants, there was a significant difference in the mean distance to trees.

Information from this study is of considerable public health significance, as it emphasizes the need to consider race in future interventions and modifications to the built environment, and highlights some of the measurement issues surrounding the built environment. By investigating relationships between the built environment and other measures of CVD risk, additional insights on adequate and appropriate CVD interventions for all populations are gained.

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(Psalm 5:12)

1.0 INTRODUCTION

Cardiovascular disease (CVD) is a critical public health challenge, affecting a large proportion of the U.S. population (Labarthe, 1998). CVD is a broad term that is commonly used to categorize various types of diseases involving the cardiac and vascular systems, including, but not limited to, heart disease, hypertension, and stroke. According to the American Heart Association (AHA), one in three (37.1%) American adults have one or more types of CVD, with a higher prevalence found among men. Despite the higher prevalence in men, CVD is the leading cause of death for both genders in the United States and worldwide (*Braunwald's heart disease: A textbook of cardiovascular medicine, 8th ed*, 2007; Gaziano, Reddy, Paccaud, Horton, & Chaturvedi, 2006; Labarthe, 1998). Specifically, in the U.S., CVD was the underlying cause for 36.3% of all deaths in 2004 (American Heart Association & American Stroke Association, 2008; Centers for Disease Control and Prevention, 2008d). With regards to race/ethnicity, African Americans have a higher prevalence of CVD in comparison to Caucasian and Mexican Americans (American Heart Association & American Stroke Association, 2007, 2008).

Much research has been focused on how to best address this CVD epidemic. Epidemiologic studies have identified a number of risk factors for CVD. Non-modifiable risk factors include age, gender, ethnicity, and genetic composition. Modifiable risk factors include an unhealthy diet, high glucose levels, lipid abnormalities, tobacco use, obesity, and physical inactivity (AHA/ASA, 2007, 2008; *Braunwald's heart disease: A textbook of cardiovascular* *medicine, 8th ed*, 2007; Gaziano, Reddy, Paccaud, Horton, & Chaturvedi, 2006; WHO, 2008b). Other risk factors include measures of low socioeconomic status (SES), such as low educational attainment and income (Labarthe, 1998).

Several studies now outline the contribution of modifiable risk factors. For example, it has been recognized that sedentary lifestyles are associated with adverse health outcomes. In the mid-1990s, an expert panel of the National Institutes of Health (NIH) and reviewers of the Surgeon General's report identified that participation in regular physical activity reduces the risk of early mortality due to heart disease. Unfortunately, the Centers for Disease Control and Prevention (CDC) (2005) recently reported that a significant proportion of US adults remain physically inactive ("Trends in leisure-time physical inactivity by age, sex, and race/ethnicity--United States, 1994-2004," 2005). Physical inactivity is also a key contributing factor to the obesity epidemic in America.

Obesity is a major public health concern in the U.S., and its prevalence has significantly increased among all population subgroups (Baskin, Ard, Franklin, & Allison, 2005; Sowers, 2003). Obesity trends indicate an increase in prevalence from 15% to 32.2% over the last 30 years (Flegal, Carroll, Ogden, & Johnson, 2002; Ogden et al., 2006). It has been hypothesized that obesity is a result of a complex interaction between susceptibility genes, and an "obesogenic" environment that discourages physical activity, and promotes consumption of energy dense foods (Sowers, 2003; Whitaker, 2002). One other hypothesized contributing factor to the obesity epidemic is technology, where new technologies have led to an increase in sedentary behavior (Ainsworth, Haskell et al., 1993; Dietz, 1996). Developing strategies to increase participation in physical activity and subsequently combating obesity at the community level, is a public health priority (United States Department of Health and Human Services, 1996a).

Prior obesity research has examined biological, psychological, and behavioral factors. However, studying these factors individually has proven unsuccessful in explaining the rapid growth in obesity (Wadden, Womble, Stunkard, & Anderson, 2002). One current research effort is focusing on the influence of the built environment on obesity. According to the NIH (2004), "The built environment is defined as all buildings, spaces and products that are created, or modified, by people. It includes homes, schools, workplaces, parks/recreation areas, greenways, business areas and transportation systems" (p. 2).

Disciplines which are seemingly unrelated to the health sciences are now giving this area of research increased attention. These include architectural, urban and city, and regional planning disciplines, and consist of investigations on how the "physical" and "social" environments (e.g., availability of public and green spaces, playgrounds, walking paths, and neighborhood crime rate) may influence physical activity and dietary practices (National Institutes of Health, 2004).

This area of research, however, is in its infancy, and has not been linked in any systematic way with conventional biological and clinical measures of obesity or obesity-related cardiovascular risk. In addition, the relative predictive value of different methods of measuring the physical and social environments, including use of publicly-available data (e.g., census and geocoded data), resident self-report, and independent investigator observation, is unknown. Moreover, few studies have examined the relationships between the physical and social environments, and physical activity and cardiovascular risk by race/ethnicity. Importantly, there may be significant racial variations in how the physical and social environments influence health.

The current research project utilized the infrastructure of the **Heart** **S**trategies **C**oncentrating **O**n **R**isk **E**valuation (Heart SCORE) study to examine the relationship between the built environment and CVD risk in both Caucasian and African American populations. Heart SCORE is a community-based participatory research program in the greater Pittsburgh metropolitan area that has enrolled and is currently following 2,000 adults, ages 45 to 75 years, with nearly equal representation of African Americans and Caucasians. The primary goal of Heart SCORE is to identify and reduce disparities in cardiovascular risk, based on race and socioeconomic status (SES).

The current cross-sectional study, *The Assessment of Cardiovascular Disease Risk in Relation to the Built Environment and Race*, will investigate the manner in which physical and social environments are associated with CVD risk. Relationships between the physical and social environments and physical activity, obesity, and CVD risk will also be examined. This includes an assessment of the validity and utility of objective versus self-report measures of the environment, and comparisons of these relationships by race. The following literature review will consist of an overview of the basic epidemiology of cardiovascular disease, including an examination of six major risk factors for the disease (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity), a synopsis of the existing disparities in CVD health, and lastly, a description of the built environment and an evaluation of related measurement issues.

2.0 REVIEW OF LITERATURE

2.1 EPIDEMIOLOGY OF CARDIOVASCULAR DISEASE (CVD)

2.1.1 Introduction

Cardiovascular disease (CVD) is a significant public health concern due to its widespread occurrence in the US population. This issue is further complicated by the loss of independence, impaired quality of life, social and economic costs, and the accompanying mortality incurred by those affected (Labarthe, 1998). In the US and globally, the 20th century has seen a transition in the primary causes of morbidity and mortality from infectious disease and malnutrition to CVD and cancer. Currently, CVD is the leading cause of death of both men and women worldwide (*Braunwald's heart disease: A textbook of cardiovascular medicine, 8th ed*, 2007; Gaziano, Reddy, Paccaud, Horton, & Chaturvedi, 2006; Labarthe, 1998). Most investigators expect that CVD mortality will increase naturally in low- and middle-income countries over the next 15 years (Gaziano et al., 2006; Murray & Lopez, 1994).

2.1.2 Definition

CVD encompasses a group of major disorders of the heart and the arterial circulation supplying the heart, brain, and peripheral tissues. These disorders include:

- Coronary heart disease (CHD)
- Cerebrovascular disease
- Hypertension
- Peripheral arterial disease
- Rheumatic heart disease
- Congenital heart disease
- Heart failure
- Deep vein thrombosis and pulmonary embolism (American Heart Association, 2009; American Heart Association & American Stroke Association, 2007, 2008; Labarthe, 1998; World Health Organization, 2008b).

The term "cardiovascular disease" is often used synonymously with heart disease because both terms refer to diseases of the heart or arteries; however, CHD (ischemic heart disease [IHD] or coronary artery disease [CAD]) is more specific to the heart (Labarthe, 1998).

2.1.3 Risk Factors

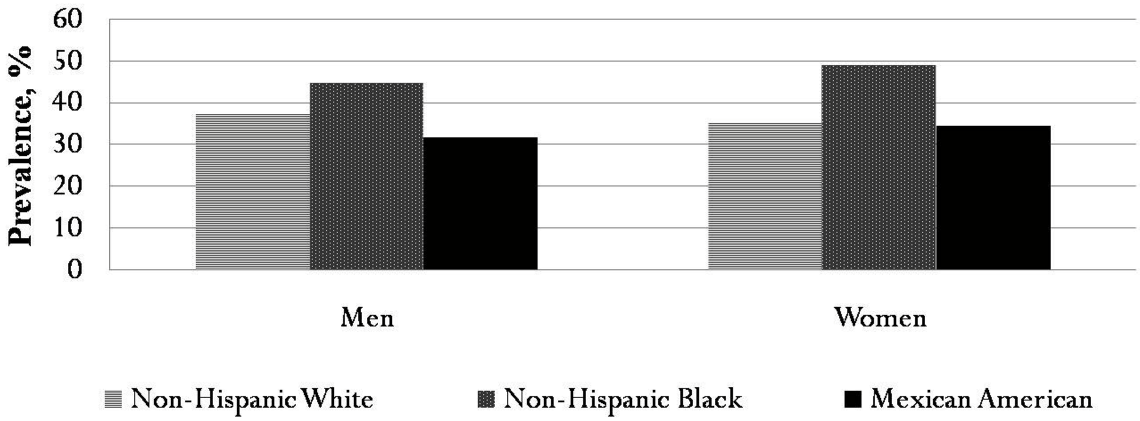
Risk factors for CVD are well established. Increasing age, male gender, racial/ethnic minority status, and genetic composition encompass those risk factors that are non-modifiable. Modifiable risk factors for CVD include an unhealthy diet composed of foods high in saturated fats and cholesterol, hypertension, high glucose levels, lipid abnormalities, obesity, tobacco use, and physical inactivity (American Heart Association & American Stroke Association, 2007, 2008; *Braunwald's heart disease: A textbook of cardiovascular medicine, 8th ed*, 2007; Gaziano et al., 2006; World Health Organization, 2008b). Measures of low SES, such as low educational attainment and income, are also risk factors for CVD (Labarthe, 1998).

2.1.4 CVD Physiology

CVD is a progressive disease that begins in childhood and advances throughout the adult years. The complex disease process underlying CVD is described by several key physiologic features. The initial stages of CVD begin with fatty streaks in the arteries, followed by the build up or collection of atherosclerotic plaques within the arteries. This build up can progress over time, block blood flow, and rupture, causing a thrombus, or a clot to form. If the thrombus is large enough, it can stop blood flow to the heart, causing myocardial infarction (Labarthe, 1998; T. Orchard, personal communication, March 17, 2005; I. Kamboh, personal communication, March 13-15, 2006).

2.1.5 Prevalence

There are approximately one in three (80.7 million or 37.1%) American adults with CVD, of which 38.2 million are estimated to be age 65 or older (American Heart Association & American Stroke Association, 2008). The prevalence of CVD is slightly higher in males compared to females (37.5% vs. 36.6%) (American Heart Association & American Stroke Association, 2007, 2008). When stratified by race/ethnicity and gender, Black males have the highest prevalence of CVD, followed by Whites, then Mexican American men (44.6%, 37.2%, and 31.6%, respectively). This pattern is also seen among Black, White, and Mexican American women (49.0%, 35.0%, and 34.4%, respectively) (Figure 1) (American Heart Association & American Stroke Association, 2007, 2008).



[1]

Figure 1. Prevalence of Total CVD by Gender and Race/Ethnicity in US Adults, 2005

2.1.6 Mortality

Cardiovascular disease is the leading cause of death of both men and women in the U. S. (Centers for Disease Control and Prevention, 2008d). Mortality data indicate CVD as the underlying cause of death, responsible for 35.3% of all deaths in 2005 (American Heart Association & American Stroke Association, 2008; Centers for Disease Control and Prevention, 2008b). In 2005, the overall mortality rate was 278.9 (per 100,000 population). When stratified by race/ethnicity and gender, the mortality rates (per 100,000 population) for Black males and

[1] Note. From the American Heart Association & American Stroke Association, *Heart disease and stroke statistics -- 2008 update at-a-glance*, http://www.americanheart.org/downloadable/heart/1200078608862HS_Stats%202008.final.pdf (June 2008).

females were considerably higher than the mortality rates for White males and females ([Blacks: males = 438.4; females = 319.7] [Whites: males = 324.7; females = 230.4]) (American Heart Association, 2009; American Heart Association & American Stroke Association, 2008).

2.1.7 Prevention Strategies

Extensive research on CVD has identified several key issues in the etiology of CVD. This knowledge has provided health professionals with the necessary tools needed to develop and implement CVD prevention activities.

Three complementary strategies have been identified to reduce the morbidity and mortality attributable to CVD. One method involves developing public health strategies to decrease CVD risk factors across all populations. These strategies include improved surveillance techniques, public education campaigns (e.g., national campaigns against cigarette smoking), and the establishment of affordable, population-wide, preventive interventions (*Braunwald's heart disease: A textbook of cardiovascular medicine, 8th ed*, 2007). Strategies also include an assessment of neighborhood environments, which are suspected of affecting individual health behaviors that subsequently lead to CVD.

The second method entails the identification of at-risk subgroups in populations who stand to benefit most from the specific, affordable, prevention measures. This requires the appropriate screening and targeting of interventions, such as the treatment of elevated cholesterol levels and hypertension. The third approach allows resources to be appropriately allocated to those with a clinical diagnosis of some form of CVD, whose treatments are considered expensive (*Braunwald's heart disease: A textbook of cardiovascular medicine, 8th ed*, 2007).

While there are several contributing factors to CVD, this review will primarily focus on six of the major risk factors. These consist of lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity. The synergistic nature of these risk factors will allow an effective assessment of the built environment on CVD health, and the probable mediating quality of physical activity.

2.2 LIPIDS

2.2.1 Definition

Blood lipids are one of the most well understood risk factors for CVD. Lipids comprise a group of lipophilic, fat-soluble, organic compounds or particles in the body that are generally oily in texture (I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006). The key lipids in the blood are free cholesterol, cholesterol esters, triglycerides, phospholipids, and apolipoproteins. The assembly of lipids and proteins forms lipoproteins that are carried through the bloodstream (I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006). Lipoproteins are complex macromolecules with a hydrophobic core, composed of triglycerides and cholesterol esters. The outer, hydrophilic region, consist of free cholesterol, apolipoprotein, and phospholipids. Clinically, lipoproteins are named by their location in a density gradient (g/mL) that is determined by the lipid and protein portion of each molecule (I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006). In order of increasing density, lipoproteins include:

1. Chylomicrons (0.98 g/mL) are composed primarily of triglycerides;
2. Very low-density lipoproteins (VLDL) (0.98 – 1.006 g/mL);
3. Intermediate-density lipoproteins (IDL) (1.006 – 1.019 g/mL);
4. Low-density lipoproteins (LDL) (1.019 – 1.063 g/mL); and
5. High-density lipoproteins (HDL) (1.063 – 1.21) are composed primarily of proteins (T. Orchard, personal communication, January 27, 2005; I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006).

Population studies have revealed that LDLs, IDLs, and small breakdown remnants of VLDLs and chylomicrons are associated with increasing atherosclerosis. Thus, LDLs are labeled as "bad" cholesterol, and are the focus of most lipid-lowering regimes (Kelley, Kelley, & Franklin, 2006; Smith, 2006). LDL cholesterol levels greater than or equal to 130 mg/dL have been widely categorized as a risk factor for heart disease and stroke (American Heart Association, 2009; American Heart Association & American Stroke Association, 2008). Because two-thirds of the total cholesterol in the blood stream is LDL cholesterol, high levels of total cholesterol, which is usually indicative of LDL cholesterol, are also associated with an increased risk of atherosclerosis (Smith, 2006).

In contrast, large amounts of HDL are associated with protection from atherosclerosis. HDL assists in the removal of LDL from the bloodstream due to their biochemical nature (composed of more protein and less fat), and small size, and are therefore labeled as healthy or "good" cholesterol (I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006). An HDL level greater than 40 mg/dL is considered desirable (Table 1), and aids in the prevention of CVD (American Heart Association & American Stroke Association, 2008; "Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on

Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001).

Table 1. Adult Treatment Panel III (ATP III) Classification of LDL, HDL, Total Cholesterol, and Triglycerides (mg/dL) [2]

Cholesterol Type	mg/dL	Classification
LDL	< 100	Optimal
	100 – 129	Near or above optimal
	130 – 159	Borderline high
	160 – 189	High
HDL	Men: < 40 Women: < 50	Low
	≥ 60	High (Optimal)
Total Cholesterol	< 200	Optimal
	200 – 239	Borderline high
	≥ 240	High
Triglycerides	< 150	Normal
	150 – 199	Borderline high
	200 – 499	High
	≥ 500	Very High

LDL = low-density lipoprotein; HDL = high-density lipoprotein.

Triglycerides are fats found in the body and those ingested by food. Structurally, triglycerides consist of a 3 carbon glycerol backbone molecule, bound to 3 fatty acid chains (strings of covalently bound carbon and hydrogen atoms). Triglycerides are stored in adipose fat cells, awaiting oxidation. When oxidized, the fatty acid chains will be reduced to carbon dioxide and water, while simultaneously producing energy. Elevated triglyceride levels are associated with an increased risk for myocardial infarction and stroke. Increases in these levels may be due to heredity, but can also due to abdominal obesity, insulin resistance, diabetes, and some medications. Behavioral modifications can play an important role in decreasing triglyceride

[2] Note. From "Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)," 2001, *JAMA, 285*, pp.2486-2497. Copyright 2001 by the American Medical Association. Adapted with permission of the author.

Note. From "Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002, *Circulation, 106*, pp.3143-3421. Copyright 2002 by the American Heart Association. Adapted with permission of the author.

levels, by decreasing weight, stabilizing blood-glucose levels, decreasing the intake of simple sugars, and increasing physical activity (Smith, 2006).

A lipid profile is often obtained in clinical practices to identify an individual's risk for CVD. As seen in Table 1, this profile quantifies total cholesterol, LDL cholesterol, HDL cholesterol, and triglyceride levels. Risk for atherosclerosis is interpreted on a lipid profile as the total cholesterol/HDL cholesterol ratio (TC/HDLC). A TC/HDLC ratio should be less than 4.5 to 1, for prevention of myocardial infarction (MI) (Smith, 2006).

2.2.2 Risk Factors

Elevated lipid and lipoprotein levels, specifically that of LDL cholesterol, increase an individual's risk for morbidity and mortality from CHD ("Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001; Kelley, Kelley, & Tran, 2004). Extreme elevations of LDL cholesterol usually aggregate in families, demonstrating the heritability associated with some conditions. However, LDL increases in individuals and populations can be due to nutrition as well. Diets consisting of saturated fatty acids, partially hydrogenated fats, and excess cholesterol intake (by too many egg yolks, meats, liver, or high levels of squid or shrimp) are also associated with elevated LDL cholesterol levels. LDL levels may also be increased by hypothyroidism or certain types of kidney failure (T. Orchard, personal communication, January 27, 2005; I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006).

Significant elevations in triglyceride levels are often associated with increased CHD. This is primarily due to genetic factors, but increases are also due to excess abdominal fat, excess simple sugar intake, estrogens, glucocorticoids, excess alcohol intake, and insulin resistance and diabetes (T. Orchard, personal communication, January 27, 2005; I. Kamboh, personal communication, March 13-15, 2006; Smith, 2006). The significance of serum triglycerides as a risk factor for CVD, however, is controversial. The findings of many epidemiological studies have indicated a univariate relationship between triglycerides and CHD risk, however, this relationship is attenuated and often becomes insignificant after adjusting for major CVD risk factors, such as low HDL cholesterol levels (< 40 mg/dL) (Patel et al., 2004; Rizzo & Berneis, 2006).

Low HDL cholesterol is usually caused by genetic factors, but can also be caused by smoking, abdominal obesity, inactivity, insulin resistance and diabetes, elevated serum triglycerides, very high carbohydrate intakes (> 60% of total energy intake), and androgen ingestion ("Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002). Levels of HDL cholesterol can be increased through smoking cessation, increased physical activity, maintained weight loss, mild to moderate alcohol consumption, reduction of elevated triglyceride levels, postmenopausal estrogen use, and moderate to high doses of niacin, fibric acid medications, statins, and bile acid binders (T. Orchard, personal communication, January 27, 2005; Smith, 2006).

2.2.3 Prevalence

a. Prevalence of Borderline High and High Total Blood Cholesterol

The Adult Treatment Panel III (ATP III) categorizes a desirable total cholesterol level as less than 200 mg/dL ("Executive Summary of The Third Report of The National Cholesterol

Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001). However, in 2005, the prevalence of total cholesterol greater than or equal to 200 mg/dL in U.S. adults was approximately 106.7 million (48.4%). After stratifying by race/ethnicity and gender, this estimate was highest in Mexican Americans, followed by Whites, then Blacks (men: 49.9%, 47.9%, and 44.8%, respectively; women: 50.0%, 49.7%, and 42.1%, respectively). The prevalence estimate for total cholesterol greater than or equal to 240 mg/dL was 37.2 million (16.8%). Among men, this estimate was highest for Whites, followed by Mexican Americans, then Blacks (16.1%, 16.0%, and 14.1%, respectively). This same pattern was observed among women (18.2%, 14.2%, and 12.5%, respectively) (American Heart Association & American Stroke Association, 2008).

b. Trends in Total Blood Cholesterol over Time

As seen in Figure 2, when examining trends in total serum cholesterol by race/ethnicity over the last few decades, there is a consistent pattern of decreased total cholesterol seen in all racial/ethnic groups. The most dramatic decrease is observed among non-Hispanic Blacks between NHANES (1988-1994) and NHANES (1999-2002) (American Heart Association & American Stroke Association, 2008). However, reasons for this decrease were not provided by the authors.

[3]

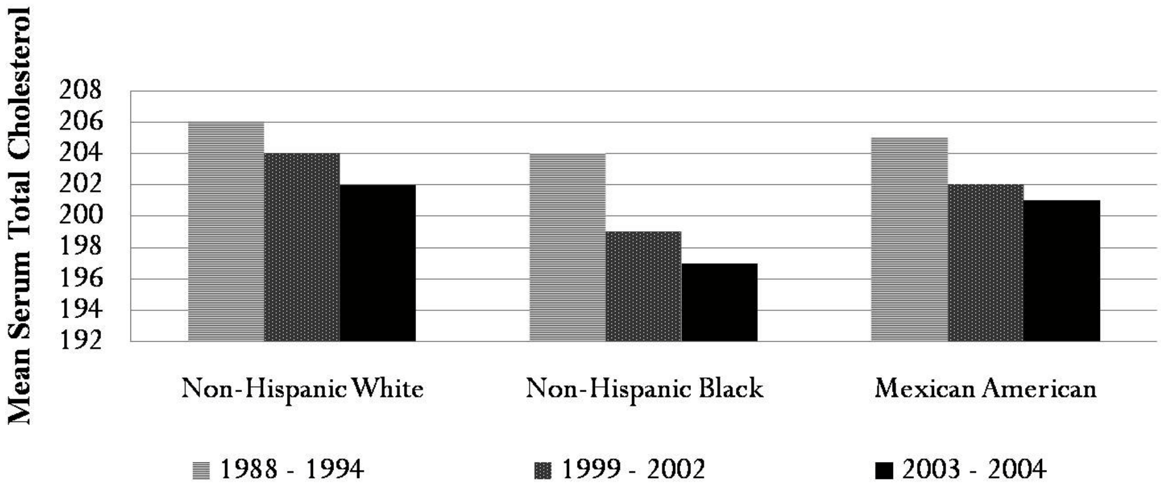


Figure 2. Trends in Adult Mean Total Serum Cholesterol by Race [NHANES (1988-1994), (1999-2002), and (2003-2004)]

c. Prevalence of Borderline High and High LDL and Low HDL Cholesterol

The optimal LDL cholesterol level is less than 100 mg/dL ("Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001). However, the 2005 prevalence estimate for LDL cholesterol (> 130 mg/dL) in American adults was 80.4 million (32.5%). Among men, this estimate was highest for Mexican Americans, followed by Blacks, then Whites (39.0%, 32.4%, and 31.7%, respectively).

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[3] Note. From American Heart Association & American Stroke Association, *High Blood Cholesterol and Other Lipids*, http://www.americanheart.org/downloadable/heart/1200078608862HS_Stats%202008.final.pdf (June 2008).

Among women, this estimate was highest for Whites, followed by Mexican Americans, then Blacks (33.8%, 30.7%, and 29.8%, respectively). Optimal HDL cholesterol levels are greater than or equal to 60 mg/dL, while low HDL cholesterol levels (less than 40 mg/dL for men and less than 50 mg/dL for women), are considered major risk factors for CHD. The prevalence of HDL cholesterol (< 40 mg/dL) was 44.6 million (16.7%). As seen in Table 2, after stratifying by race/ethnicity and gender, this estimate was highest in Mexican Americans, followed by Whites, then Blacks (men: 27.7%, 26.2%, and 15.5%, respectively; women: 13.0%, 8.8%, and 6.9%, respectively) (American Heart Association & American Stroke Association, 2008).

Table 2. Prevalence of Borderline High and High LDL and Low HDL Cholesterol by Race and Gender [4]

LDL (≥ 130 mg/dL)	**Race**	**Prevalence**
Males	Whites	31.7
	Blacks	32.4
	Mexican Americans	39.0
Females	Whites	33.8
	Blacks	29.8
	Mexican Americans	30.7
HDL (< 40 mg/dL)		
Males	Whites	26.2
	Blacks	15.5
	Mexican Americans	27.7
Females	Whites	8.8
	Blacks	6.9
	Mexican Americans	13.0

LDL = low-density lipoprotein; HDL = high-density lipoprotein.

2.2.4 Prevention

Prevention of CHD is targeted at the improvement of lipid and lipoprotein levels, including LDL cholesterol, and often focuses on a pharmacological and lifestyle modification approach that specifically includes physical activity ("Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001; Kelley et al., 2004). A popular activity among Americans, which is highly appropriate in this area, is walking, as it is inexpensive and available to most people (Kelley et al., 2004; United States Department of Health and Human Services, 1996b). This premise was further emphasized in a meta-analysis

[4] Note. From American Heart Association & American Stroke Association, *At-A-Glance Summary Tables*, http://www.americanheart.org/downloadable/heart/1200078608862HS_Stats%202008.final.pdf (June 2008).

by Kelley et al. (2004), in which the authors observed statistically significant, walking-induced decreases of 5% and 6% for LDL cholesterol (95% CI -9.9 - -1.2) and TC/HDL-C (95% CI -0.6 - -0.1), respectively. From a pharmacological perspective, a class of drugs, known as statins, is most commonly prescribed to lower blood cholesterol. These drugs work in the liver and prevent the production of cholesterol by inhibiting 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase. Statins elicit positive effects on all lipid levels; they moderately increase HDL levels, and lower triglycerides, but are most effective at lowering LDL levels. For example, statins are responsible for a 19-37% decrease in total cholesterol; a 25-50% decrease in LDL cholesterol levels; a 4-12% increase in HDL cholesterol levels; and a 14-29% decrease in triglyceride levels ("National Cholesterol Education Program. Second Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel II)," 1994; Yeshurun & Gotto, 1995). Examples of statins currently available in the U.S. include: Atorvastatin (Lipitor®), Fluvastatin (Lescol®), Lovastatin (Mevacor®, Altoprev™), Pravastatin (Pravachol®), Rosuvastatin Calcium (Crestor®), and Simvastatin (Zocor®) (American Heart Association, 2008a).

2.2.5 Summary

High blood cholesterol is a major modifiable risk factor for heart disease. It is estimated that a 10% reduction in total cholesterol levels may yield an approximate 30% reduction in the incidence of coronary heart disease (American Heart Association & American Stroke Association, 2008; J. D. Cohen, 1997; "State-specific cholesterol screening trends--United States, 1991-1999," 2000). As such, cholesterol screening is an important tool in decreasing the prevalence of elevated cholesterol levels and has several functions, such as:

1. Identifying individuals at risk for CVD;
2. Identifying individuals who may benefit from lower cholesterol levels by dietary modification, physical activity, weight control, or drug treatment; and
3. Increasing public awareness and emphasizing educational messages (Cleeman, 1997; "State-specific cholesterol screening trends--United States, 1991-1999," 2000).

2.3 HYPERTENSION

2.3.1 Introduction

Hypertension is another well understood risk factor for CVD. Hypertension results from elevated blood pressure, and is identified through blood pressure readings. “Blood pressure (BP) is the force in the arteries when the heart beats (systolic pressure) and when the heart is at rest (diastolic pressure),” (American Heart Association, 2008e), and is measured in millimeters of mercury (mm Hg). Hypertension, or high blood pressure, is defined as untreated, adult blood pressure greater than or equal to 140 mm Hg systolic pressure or greater than or equal to 90 mm Hg diastolic pressure, or taking antihypertensive medicine (Table 3) (American Heart Association, 2008e; American Heart Association & American Stroke Association, 2007, 2008; Chobanian et al., 2003). Significant behavioral risk factors for hypertension include excess body weight, excess dietary sodium intake, reduced physical activity, inadequate intake of fruits, vegetables, and potassium, and excess alcohol intake (Chobanian et al., 2003; Stamler et al., 1999; Whelton et al., 2002). Examples of identified physiological risk factors for hypertension include renal disease, sleep apnea, and coarctation of the aorta, a narrowing of the aorta that presents at birth. Non-modifiable risk factors include increasing age, racial/ethnic minority status, male gender, and family history of hypertension (AHA, 2008; Chobanian et al., 2003).

Table 3. JNC 7 Classification of Blood Pressure for Adults [5]

BP Classification	SBP mm Hg	DBP mm Hg
Normal	< 120	and < 80
Prehypertension	120 – 139	or 80 – 89
Stage 1 hypertension	140 – 159	or 90 – 99
Stage 2 hypertension	≥ 160	or ≥ 100

JNC 7 = Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; BP = blood pressure; SBP = systolic blood pressure; DBP = diastolic blood pressure.

2.3.2 Prevalence

Hypertension is an important medical and public health issue, as it is estimated that 73 million Americans are affected (1 in 3 U.S. adults) (American Heart Association & American Stroke Association, 2007, 2008; Burt et al., 1995; Chobanian et al., 2003; Hajjar & Kotchen, 2003). (American Heart Association & American Stroke Association, 2007, 2008; Bakris, 2007; Fields et al., 2004). The prevalence of hypertension increases with age, accounting for more than half of those aged 60 to 69 years, and approximately three-fourths of those aged 70 being affected (American Heart Association & American Stroke Association, 2007; Bakris, 2007; Burt et al., 1995; Ostchega, Dillon, Hughes, Carroll, & Yoon, 2007; Vasan et al., 2002).

Various assessments have been made regarding the prevalence, awareness, treatment, and control of hypertension among U.S. adults. However, this review will focus on the prevalence of the disease and subsequent trends over time, as well as a discussion of appropriate prevention methods.

[5] Note. From "Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure," by A.V. Chobanian, G.L. Bakris, H.R. Black, W.C. Cushman, et al., 2003, *Hypertension, 42*, p. 1211. Copyright 2003 by the American Heart Association, Inc. Adapted with permission of the author.

a. Overall Prevalence

Ong et al. (2007) analyzed hypertension prevalence among U.S. adults using the results from the National Health and Nutrition Examination Health Survey (NHANES) 1999-2004. NHANES is a cross-sectional health survey of a nationally representative sample of the noninstitutionalized civilian U.S. population. In a sample of 14,653 participants, the unadjusted, overall prevalence of hypertension was 29.3%. A multiple logistic regression analysis indicated that the following were significantly associated with hypertension: increasing age (aged 18 to 39 [reference]) (40 to 59 years: OR = 6.04; 95% CI 3.99 – 9.16) (≥ 60 years: OR = 27.35; 95% CI 18.88 – 39.61), increasing body mass index (BMI) (BMI < 25 kg/m^2 [reference]) (overweight: OR = 1.73; 95% CI 1.18 – 2.54) (obese: OR = 3.39; 95% CI 2.49 – 4.61), and having less than a high school education (more than high school [reference]) (OR = 1.41; 95% CI 1.01 – 1.97) (Ong, Cheung, Man, Lau, & Lam, 2007).

Factors such as large sample size and good quality control in variable measurement and data processing make the NHANES database an effective tool for investigating trends in the health status of a population. The Ong study analysis substantiates previous observations and expands upon prior research conclusions, indicating that the prevalence of hypertension has not increased significantly since 1999. The study used the age of the standard U.S. population for the age adjustment, which is much younger than the hypertensive population. However, it would have been more appropriate for the researchers to base their age adjustments on the average age of people with hypertension The use of the age distribution of participants with hypertension would provide a more accurate standard population (Ong et al., 2007).

b. Differences in Prevalence by Race/Ethnicity

Several population-based studies have described the prominent role of hypertension among Black non-Hispanics (nH) and its contribution to the disparity related to CVD, stroke, and end-stage renal disease (ESRD) prevalence and death between Black nH and White nH (Becker et al., 1993; Brancati, Kao, Folsom, Watson, & Szklo, 2000; Gillum, Mussolino, & Madans, 1998; Goldstein et al., 2001; Sowers, Ferdinand, Bakris, & Douglas, 2002). Ong et al. (2007) observed in the NHANES (1999-2004) data that Black nH were 61% more likely to have hypertension compared to White (OR = 1.61; 95% CI 1.30 – 1.99; $p < 0.001$) (Ong et al., 2007). The prevalence of hypertension in Black nH in the U.S. is among the highest in the world and is increasing (American Heart Association & American Stroke Association, 2007, 2008; Sowers, Epstein, & Frohlich, 2001; Sowers et al., 2002). In 2005, the overall prevalence of hypertension was 33.6%. However, after stratifying by race/ethnicity, the prevalence of hypertension was found to be highest among Black nH, followed by White nH, then Mexican Americans (Males: 42.6%, 32.5%, and 28.7%, respectively; females: 46.6%, 31.9%, and 31.4%, respectively) (American Heart Association & American Stroke Association, 2008).

Black nH also develop hypertension earlier in life, have higher than average blood pressures, and have disturbingly higher rates of hypertension-related death from stroke, heart disease, and ESRD compared to White nH. Hypertension is more aggressive in Black nH, resulting in more severe end-organ damage. These differences have been observed through several studies among the adult U.S. population. The underlying reasons for these disparities, however, remain unclear (American Heart Association & American Stroke Association, 2007, 2008; Sowers et al., 2001; Sowers et al., 2002).

Kramer et al. (2004) utilized the Multi-Ethnic Study of Atherosclerosis (MESA) to assess the relationship between race/ethnicity and hypertension among White nH, Black nH, Chinese, and Hispanic racial/ethnic groups. MESA is a population-based study designed to establish the characteristics of subclinical CVD and its progression. The study population included 6,814 men and women, aged 45 to 85 years, who were free of CVD upon entry into study. Participants were recruited from six areas within the U.S. (Baltimore, MD; Chicago, IL; Forsythe County, NC; Los Angeles County, CA; northern Manhattan, NY; and St. Paul, MN). Compared to White nH, the prevalence of hypertension was significantly higher among Black nH (60% vs. 38%; $p < 0.0001$). However, there were no significant differences in the prevalence of hypertension among Hispanic and Chinese participants, compared to White nH. After adjusting for age, BMI, Type 2 diabetes, and smoking, Black nH (OR = 2.21; 95% CI 1.91 – 5.26) and Chinese (OR = 1.30; 95% CI 1.07 – 1.56) racial/ethnic groups were significantly associated with hypertension compared to White nH (Kramer et al., 2004).

Although the MESA study was designed to measure the prevalence and progression of subclinical CVD in a population free of known CVD; the participants in this study were not representative of the U.S. population of individuals with hypertension which also consisted of those with known CVD. However, the MESA study cohort represents the patient population that is often targeted for the primary prevention of CVD. This study was also unique in that it included a diverse, multiracial population, that is usually not included in previous studies, to investigate racial/ethnic differences in hypertension and establish an avenue for continued research (Kramer et al., 2004).

Using data from the National Health and Nutrition Examination Survey [(NHANES) III] (1988 – 1994) and NHANES (1999 – 2002), Hertz et al. (2005) investigated racial differences in hypertension prevalence across two time periods. The study included 18,291 Black nH and White nH participants aged 20 years and older. There was a significant increase in hypertension prevalence among Black nH and White nH adults from NHANES III to NHANES 1999 – 2002 ($p < 0.001$). The greatest increase in prevalence, from 24.2 – 29.6%, was found among White nH women (22% change; $p < 0.001$). Significant increases in hypertension prevalence were also observed in Black nH men, from 33.9 – 38.6%, and Black nH women, from 37.6 – 44.0%, (13.9% change; $p = 0.02$ and 17.1% change; $p < 0.001$, respectively). There was also significant increase in the prevalence of hypertension for all participants aged 60 and older, from 71.5 – 81.0% for Black nH, and from 58.3 – 65.4% for White nH (13.2% change; $p < 0.001$ and 12.2% change; $p < 0.001$, respectively). However, according to the findings from the most recent NHANES survey, hypertension prevalence for Black nH in each age category significantly exceeded that of White nH (Hertz, Unger, Cornell, & Saunders, 2005).

c. Differences in Prevalence Over Time

In an effort to observe changes in the prevalence of hypertension, scientists have studied trends in time and populations to assess possible differences. In one analysis conducted by Ong et al. (2007), participants were categorized into three time periods: 1999 to 2000, 2001 to 2002, and 2003 to 2004, using data derived from the continuous NHANES program (1999-2004). This study showed that since 1999, the prevalence of hypertension has not significantly increased in different age, sex, race/ethnicity, and BMI groups ($p > 0.05$). However, in all three time periods, the prevalence of hypertension increased with increasing age and BMI ($p < 0.001$), with Black nH having the highest prevalence (Figure 3) (Ong et al., 2007).

[6]

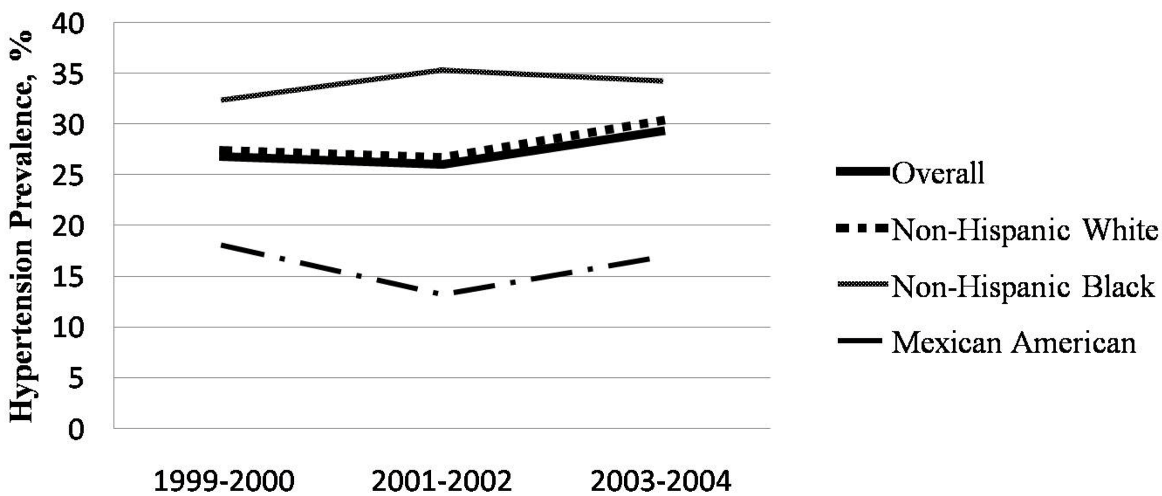


Figure 3. Prevalence of Hypertension in the US Population, 1999-2004 [NHANES (1999-2004)]

Utilizing the results of the Minnesota Heart Survey (MHS), Luepker et al. (2006), sought to ascertain populations trends in blood pressure and hypertension prevalence during the time periods of: 1980 to 1982, 1985 to 1987, 1990 to 1992, 1995 to 1997, and 2000 to 2002. The MHS is a population-based study of trends in CVD risk factors, morbidity, and mortality in noninstitutionalized adults, residing in the seven-county Minneapolis/St. Paul metropolitan area. The study included 21,773 randomly selected participants. The age-adjusted prevalence of hypertension among men decreased from 30.3% to 22.0% ($p < 0.01$ [linear]). A similar decrease

[6] Note. From “Prevalence, Awareness, Treatment, and Control of Hypertension Among United States Adults 1999-2004,” by K.L. Ong, M.Y. Cheung, Y.B. Man, C.P. Lau, and K.S.L. Lam, 2007, *Hypertension, 49*, p. 71. Copyright 2007 by the American Heart Association. Adapted with permission of the author.

among women was also observed: from 26.5% to 18.2% ($p < 0.001$ [linear]). (Luepker et al., 2006).

The results of the Luepker study are valuable due to the large size of the MHS population and the ability to evaluate trends over time using consistent, comprehensive sampling and measurement of population characteristics since 1980. However, the study participants encompass a population of individuals who are predominately White, of high SES, and are insured. Additionally, the state of Minnesota is recognized as being at the forefront of CVD prevention and treatment, therefore, limiting the generalizability of these findings to other populations (Luepker et al., 2006; McGovern et al., 1996).

2.3.3 Hypertension as a Risk Factor for CVD

The relationship between hypertension and risk of CVD events is continuous, consistent, and independent of other risk factors (Anderson, Wilson, Odell, & Kannel, 1991; Chobanian et al., 2003). The lifetime risk of developing hypertension is greater than 90% in those aged 55 and 65 years old (American Heart Association & American Stroke Association, 2007; Bakris, 2007; Burt et al., 1995; Ostchega et al., 2007; Vasan et al., 2002). BP values from 130/85 to 139/ 89 mm Hg are associated with a more than two-fold increase in relative risk for developing CVD compared to those with BP levels below 120/80 mm Hg (Chobanian et al., 2003; Vasan et al., 2001).

Hypertension is associated with a two to three times higher risk for developing congestive heart failure, and precedes the occurrence of congestive heart failure in 91% of cases. (American Heart Association & American Stroke Association, 2007; Levy, Larson, Vasan, Kannel, & Ho, 1996). Systolic hypertension represents the most common type of hypertension among those greater than 50 years of age (Ostchega et al., 2007). Continuous research suggests that SBP is a major risk factor for CVD related deaths (Anderson et al., 1991; Chobanian et al., 2003; Flack et al., 1995; Stamler, Stamler, & Neaton, 1993). Findings from clinical trials demonstrate that control of isolated systolic blood pressure (SBP) reduces total mortality, cardiovascular mortality, stroke, and congestive heart failure events. Observational studies have also implied that ischemic heart disease and stroke deaths increase gradually and linearly from SBP and DBP levels as low as 115 mm Hg and 75 mm Hg, respectively (Burt et al., 1995; Chobanian et al., 2003; S. S. Franklin, Gustin, W. 4th, Wong, N.D., Larson, M.G., Weber, M.A., Kannel, W.B., & Levy, D., 1997; S. S. Franklin et al., 2001; Kostis et al., 1997; Lewington, Clarke, Qizilbash, Peto, & Collins, 2002; "Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension. Final results of the Systolic Hypertension in the Elderly Program (SHEP). SHEP Cooperative Research Group," 1991; Staessen et al., 1999). For every 20 mm Hg systolic or 10 mm Hg diastolic increase, there is a doubling of mortality from ischemic heart disease and stroke (American Heart Association & American Stroke Association, 2007; Bakris, 2007; Chobanian et al., 2003). This trend is present among all age groups (American Heart Association & American Stroke Association, 2007; Franco, Peeters, Bonneux, & de Laet, 2005).

2.3.4 Summary

The literature suggests that prevalence estimates for hypertension are highest among Black nH. The prevalence is also higher among men compared to women until the age of 45. Between the ages of 45 to 54, the percentage of hypertensive males and females is similar, however, after the age of 54, a much higher percentage of females have hypertension compared to males (American Heart Association & American Stroke Association, 2007, 2008).

Hypertension is an important public health challenge affecting all people in the U.S. To combat these factors, a public health strategy, including lifestyle modifications targeting those aforementioned causal variables has been advocated (Chobanian et al., 2003; Hertz et al., 2005; Whelton et al., 2002). Population-level measures are also necessary to prevent the development of hypertension, and to improve awareness, treatment, and control of hypertension in the community, especially among high risk individuals and populations (Kearney, Whelton, Reynolds, Whelton, & He, 2004; Whelton et al., 2002).

2.4 OBESITY

2.4.1 Introduction

Obesity is a major public health challenge in the U.S. as its prevalence has significantly increased among adults of all age, gender, and racial/ethnic groups (Baskin, Ard, Franklin, & Allison, 2005; Sowers, 2003). Today, more than 30% of the U.S. population is defined as being obese (American Heart Association & American Stroke Association, 2008). Obesity is a major risk factor for CVD, and it is also linked to higher levels of high blood cholesterol, hypertension, and Type 2 diabetes (American Heart Association, 2008c; Poirier et al., 2006; Sowers, 2003). The obesity epidemic has been driven by several contributing factors, such as a decrease in physical activity, the increased intake of high fat and caloric foods, and the consumption of larger food portions (Sowers, 2003).

Obesity however, is a multifaceted condition. Evidence suggests that a genetic predisposition to obesity exist (Damcott, Sack, & Shuldiner, 2003). Alone, these genes are thought to exert only a modest effect, but some researchers currently believe that this predisposition is heightened due to an interaction of these susceptibility genes with an “obesogenic” environment. An obesogenic environment is one which discourages physical activity and promotes consumption of energy dense foods (Damcott et al., 2003; Sowers, 2003; Whitaker, 2002). Based on this theory, and other findings, the prevention and treatment is commonly viewed as difficult (Ogden, Yanovski, Carroll, & Flegal, 2007).

2.4.2 Definition

Obesity describes an excess in body weight with an abnormally high proportion of body fat. In the public health literature, obesity is defined on the basis of body mass index (BMI), a common measure expressing the relationship of weight to height. BMI is a mathematical formula in which body weight in kilograms is divided by the square of height in meters. Among adults, obesity corresponds to a BMI greater than or equal to 30 ("Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health," 1998; "Overweight and obesity threaten US health gains; communities can help address the problem, Surgeon General says [press release]," 2001; Sowers, 2003). The World Health Organization (WHO) classifies three different categories of obesity. These categories are: Obese Class I (BMI = 30 to 34.99 kg/m^2), Obese Class II (BMI = 35 to 39.99 kg/m^2), and Obese Class III (BMI greater than or equal to 40.00 kg/m^2) (Table 4) (World Health Organization, 2008a). In epidemiologic studies it is uncommon to see analyses of extreme obesity (BMI $\geq$ 40).

Table 4. World Health Organization (WHO) Body Mass Index (BMI) Classification [7]

Classification	BMI kg/m^2
Underweight	< 18.50
Normal	18.50 - 24.99
Overweight	≥ 25.00
Obese	≥ 30.00
Obese Class I	30.00 – 34.99
Obese Class II	35.00 - 39.99
Obese Class III	≥ 40.00

While obesity is defined by the BMI measure, several other measures of body size are also used in population studies to characterize excess weight (Colditz, Willett, Rotnitzky, & Manson, 1995; Dalton et al., 2003; "Geographical variation in the major risk factors of coronary heart disease in men and women aged 35-64 years. The WHO MONICA Project," 1988). Other measures, such as waist circumference (WC) and waist-hip ratio (WHR), are used because variations in body fat distribution and abdominal fat mass can differ considerably across populations. These variations are not identified by BMI indices. (Dalton et al., 2003; "Obesity: preventing and managing the global epidemic. Report of a WHO consultation," 2000). In addition, excess intra-abdominal fat is associated with the metabolic abnormalities believed to underlie an increased risk of obesity-related morbidities (M.L. Booth, Hunter, Gore, Bauman, & Owen, 2000; Dalton et al., 2003; Ho et al., 2001; Vanltallie, 1998; Visscher, Kromhout, & Seidell, 2002).

WC has been identified as an alternative to BMI (Dalton et al., 2003). Waist circumference, defined as, “A measure of the distance around the abdomen,” (National Heart, 1998), is a practical and accurate indicator of both intra-abdominal fat mass and total fat (M.L.

[7] Note. From World Health Organization, *BMI Classification*, http://www.who.int/bmi/index.jsp?introPage=intro_3.html (March2008).

Booth et al., 2000; Dalton et al., 2003; Han, McNeill, Seidell, & Lean, 1997; James, 1996; Lean, Han, & Morrison, 1995; Lemieux, Prud'homme, Bouchard, Tremblay, & Despres, 1996; Vanltallie, 1998). Although BMI and WC illustrate different types of adiposity, WC complements BMI in the examination of obesity- related CVD risk by providing an indicator of body fat distribution (M.L. Booth et al., 2000; Bray, 1989; Han, van Leer, Seidell, & Lean, 1995; Pouliot et al., 1994; Ross, Leger, Morris, de Guise, & Guardo, 1992; Zhu et al., 2004; Zhu et al., 2005; Zhu et al., 2002). In most adults with a BMI of 25 to 34.9 kg/m^2, for example, a WC measurement of greater than 102 cm (> 40 in) in men or greater than 88 cm (> 35 in) in women is indicative of an increased risk for the development of obesity-related risk factors for CVD (National Heart, 1998).

2.4.3 Prevalence

a. Overall Prevalence

The prevalence of obesity in the U.S. has increased considerably since 1980, and this trend is present in all subgroups of the population (Figure 4) (Baskin et al., 2005; Mokdad et al., 2003; Ogden et al., 2007).

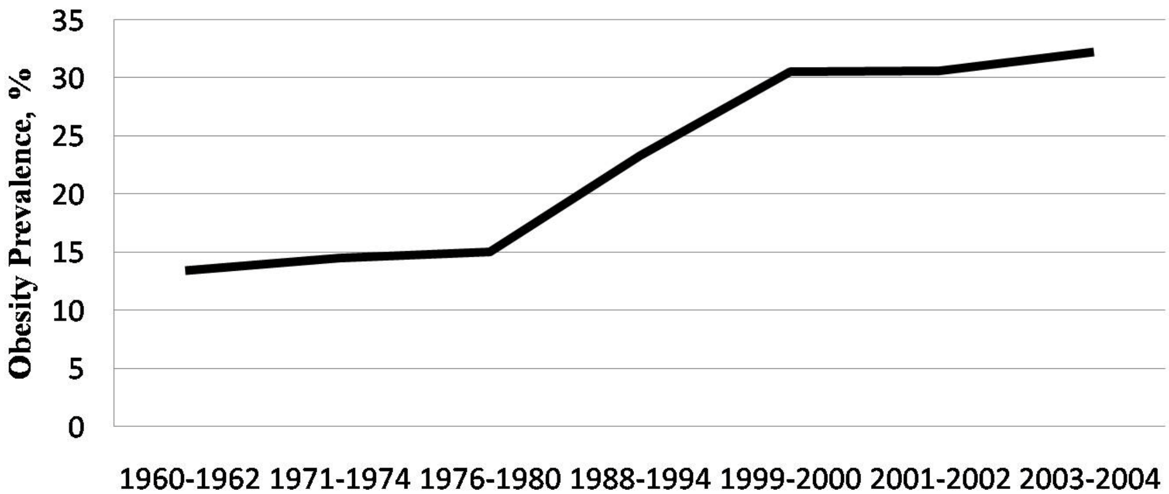


Figure 4. Trends in Obesity Prevalence, 1960-2004 (Derived From NHES/NHANES Data)

Prevalence estimates of obesity are typically obtained from surveys or population studies. (Ogden et al., 2007). Two widely-used national health surveys, the BRFSS and NHANES, are used to determine the prevalence of obesity in the U. S..

The BRFSS, conducted by the Centers for Disease Control and Prevention (CDC) and state health departments, is a cross-sectional telephone survey that assesses personal behaviors that increase the risk of the ten leading causes of death in the U.S. (Mokdad et al., 2003; Nelson, Holtzman, Waller, Leutzinger, & Condon, 1998; Remington et al., 1988). In 2001, the prevalence of obesity was estimated to be 20.9% (Mokdad et al., 2003).

[8] Note. From “Prevalence and Trends in Obesity Among US Adults, 1999-2000,” by K.M. Flegal, M.D. Carroll, C.L. Ogden, and C.L. Johnson, 2002, *JAMA, 288*, pp.1724-25. Copyright 2002 by the American Medical Association. Adapted with permission of the author.

Note. From “Prevalence of Overweight and Obesity in the United States, 1999-2004,” by C.L. Ogden, M.D. Carroll, L.R. Curtin, et al., 2006, *JAMA, 295*, p.1554. Copyright 2006 by the American Medical Association. Adapted with permission of the author.

A major strength of the BRFSS is the large sample sizes available to perform accurate statistical analyses. However, there are also several limitations to the BRFSS, namely, its cross-sectional study design. This design limits the ability to draw causal inference regarding issues underlying obesity. Also, the estimates may be biased due to the self-reported nature of the height and weight measurements obtained in the BRFSS. Given that all U.S. citizens do not have telephones, there also may be limited generalizability due to the use of a telephone survey (Mokdad et al., 2003).

In contrast, the National Health and Nutrition Examination Survey (NHANES) identifies heights and weights through clinical exams conducted in a nationally representative sample of the U.S. noninstitutionalized civilian population (Centers for Disease Control and Prevention, 1996, 2006; Flegal, Carroll, Ogden, & Johnson, 2002; Ogden et al., 2006). The NHANES sample in 2003 – 2004, included 4,431 adults aged 20 years and older. From this sample, it was estimated that the prevalence of obesity and extreme obesity (BMI $\geq$ 40) was 32.2% and 4.8%, respectively (Ogden et al., 2006).

A key strength of the NHANES is the use of standardized protocols and calibrated equipment to accurately measure height and weight. This NHANES design provides data that is more reflective of, or generalizable to, the current U.S. population. This design may also contribute to the variation in prevalence estimates between NHANES and BRFSS data. However, the cross-sectional nature of the NHANES design limits the ability of investigators to draw causal inference about factors underlying obesity (Ogden et al., 2006).

b. Differences in Prevalence by Race/Ethnicity

Although increased obesity prevalence exists among all age, gender, and racial/ethnic groups, there is a more profound impact of obesity on minority racial/ethnic groups (Baskin et al., 2005; Cossrow & Falkner, 2004). When compared to White non-Hispanic (nH) women, rates of obesity are higher in Black nH and Mexican American women (Figure 5) (Baskin et al., 2005). Obesity also occurs at younger ages in Black nH and Hispanic women, compared to White nH women, and earlier in Hispanic men compared to White nH or Black nH men. No major differences in obesity prevalence by race/ethnicity are observed for men (Baskin et al., 2005; McTigue, Garrett, & Popkin, 2002; Sowers, 2003).

[9]

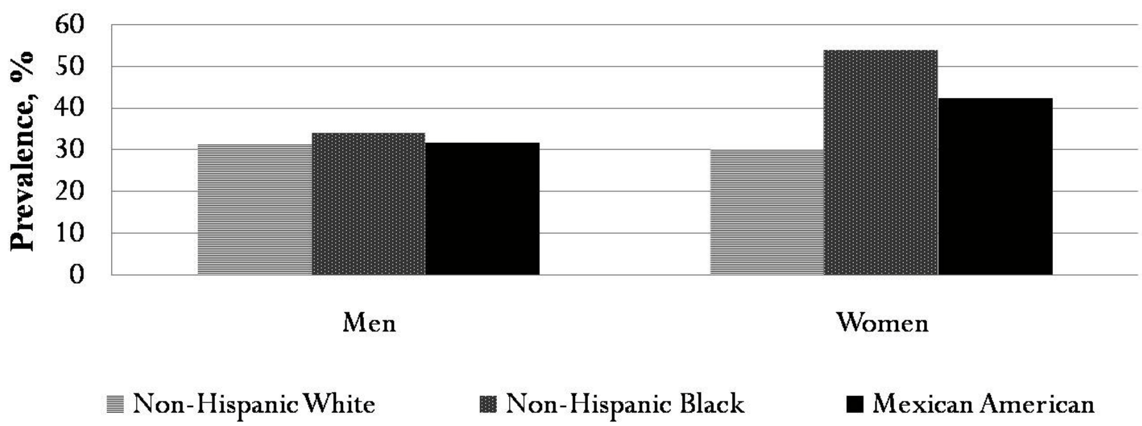


Figure 5. Prevalence of Obesity by Gender and Race/Ethnicity in US Adults, 2003-2004 [NHANES (2003-2004)]

Reasons for the racial/ethnic differences in obesity are not yet clear. Environmental variables (e.g., health-related behaviors and economic disadvantage) have been proposed as key

[9] Note. From "Prevalence of Overweight and Obesity in the United States, 1999-2004," by C.L. Ogden, M.D. Carroll, L.R. Curtin, et al., 2006, *JAMA, 295*, p.1554. Copyright 2006 by the American Medical Association. Adapted with permission of the author.

issues, but are not responsible for all of the existing disparity. A genetic component may also be responsible for the differences in prevalence and obesity-related comorbidities (Cossrow & Falkner, 2004). This evidence has been gathered from several studies examining these racial/ethnicity differences in obesity prevalence.

Using data derived from the 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII) (1994-1996 [CSFII]), Paeratakul et al. (2002) assessed the prevalence of obesity-related chronic diseases among U.S. adults by SES, gender, and race (Paeratakul, Lovejoy, Ryan, & Bray, 2002). The 1994-1996 CSFII is a self-report survey of noninstitutionalized U.S. adults conducted by the United States Department of Agriculture (USDA), which measures the types and amounts of foods consumed by individuals (Paeratakul et al., 2002; United States Department of Agriculture, 2007). The study included 9,643 participants who provided complete information for data analysis. The age adjusted prevalence of obesity by race was 16.5%, 29.0%, and 18.7%, respectively, for Whites, Blacks, and Hispanics (Paeratakul et al., 2002).

The Paeratakul study is unique in that the authors utilized a different survey instrument, as opposed to the BRFSS or NHANES, to assess obesity prevalence. However, the study was subject to recall and reporting bias due to the self-report nature of the instrument. In addition, the use of BMI as the only measure of obesity, did not take into account percent body fat and body fat distribution, which independently of BMI, are also associated with obesity-related comorbidities (Paeratakul et al., 2002).

Mensah et al. (2005) examined disparities in obesity rates using data from NHANES (1999 – 2002). The authors found no clear SES relationships. Among men, the highest prevalence of obesity was found among Mexican Americans who had completed a high school education (29.2%), followed by White nH who did not complete a high school education (28.4%). Among women, the prevalence was highest for Black nH with or without a high school education (47.1% and 47.7%, respectively) (Mensah, Mokdad, Ford, Greenlund, & Croft, 2005).

c. Differences in Prevalence Over Time

There has been a substantial increase in obesity prevalence among adults aged 20 years and older during the 1980 to 2002 time period (Ogden et al., 2006). This pattern also exists for children. Several studies that have examined current trends in obesity prevalence were reviewed.

Flegal et al. (2002) compared data from NHANES III (1988 – 1994) and NHANES (1999 – 2000) to assess trends in obesity prevalence among U.S. adults. Analyses for this study were done using 4,115 participants that were a part of the first two years of the continuous NHANES (1999 -2000). The NHANES III (1988 – 1994) age-adjusted prevalence was 22.9% compared to the 1999 – 2000 estimate of 30.5% ($p < 0.001$). A significant increase in extreme obesity was also observed, 2.9% versus 4.7% ($p = .002$). When stratified by race/ethnicity, an increase in obesity prevalence was also observed in Black nH men and women between the two time periods (Men: 21.1 – 28.1%; Women: 38.2 – 49.7) (Flegal et al., 2002).

Then using NHANES (2003 – 2004) data for comparison, Ogden et al. (2006) observed that between 1999 to 2000 and 2003 to 2004, the prevalence of obesity among men increased significantly from 27.5% to 31.1%. No significant increases were found in women for this time period. However, the prevalence of obesity among Black nH, from 1999 to 2000, was 39.8%, while in 2003 to 2004, the prevalence of obesity was 45.0% (Ogden et al., 2006).

To further assess changes over time, Sturm (2007) examined whether trends in obesity had changed since 2000, using BRFSS data. The author observed that the prevalence of obesity

(BMI ≥ 30) increased from 2001 to 2005 (20.7%, 21.6%, 22.6%, 23.6%, and 25.6%, respectively) (Sturm, 2007).

These studies emphasize the need for continued obesity research to understand the underlying reasons for these current trends (Baskin et al., 2005).

2.4.4 Obesity as a Risk Factor for CVD

As a result of extensive research, the American Heart Association (AHA) has identified obesity as a major risk factor for CHD (American Heart Association, 2008c; Eckel, 1997; Melanson, McInnis, Rippe, Blackburn, & Wilson, 2001). Obesity is also an independent risk factor for CVD, and is associated with other comorbidities, including Type 2 diabetes, glucose intolerance, dyslipidemia, impaired hemostasis, and hypertension (Melanson et al., 2001; Poirier & Eckel, 2000, 2002; Poirier et al., 2006). Research suggests that obese persons have multiple risk factors, and that these risk factors may act synergistically to increase the risk for CVD (Melanson et al., 2001; Poirier et al., 2006). Data also suggest that abdominal or central obesity is a significant contributor to CVD risk, as it is also related to other obesity-related disorders such as Type 2 diabetes, hypertension, and hypercholesterolemia (high blood cholesterol) (National Heart, 1998; Sowers, 2003; University of Illinois at Urbana-Champaign, 2006). Nonetheless, ongoing studies are underway to establish a comprehensive understanding of the relationship between obesity and CVD.

Using data from the Framingham Heart Study (FHS), Wilson et al. (2002) examined the role of overweight and obesity as determinants of cardiovascular risk (P. W. F. Wilson, D'Agostino, Sullivan, Parise, & Kannel, 2002). The FHS is a prospective study, designed to identify the common factors that contribute to CVD by monitoring its development over a long period of time (44 year follow-up) in a large group of participants who were free of CVD or had not suffered a heart attack or stroke at entry into the study (Framingham Heart Study, 2008; P. W. F. Wilson et al., 2002). This analysis included 5,209 White nH adults, aged 35 to 75 years. The authors observed that the age-adjusted relative risks (RR) and 95% confidence intervals (CI) for CVD were increased among obese participants ([men: RR = 1.46; 95% CI 1.20 – 1.77]; [women: RR = 1.64; 95% CI 1.37 – 1.98]) (P. W. F. Wilson et al., 2002).

A major strength of the Wilson study was its prospective design, in which temporal relationships between obesity and CVD could be examined. This enabled the researchers to measure the incidence of CVD and also calculate other risk estimates. However, since the Framingham cohort consisted of middle-class, middle-aged, White nH adults, the findings may not be generalizable to other populations (P. W. F. Wilson et al., 2002).

Mokdad et al. (2003) observed that obesity was significantly associated with other risk factors for CVD, including, diabetes, hypertension, and high cholesterol. The authors also observed that compared to normal weight individuals, those considered extremely obese (BMI ≥ 40), had odds ratios (OR) and 95% confidence intervals (CI) of: 7.37 (95% CI 6.39 – 8.50) for diabetes, 6.38 (95% CI 5.67 – 7.17) for hypertension, and 1.88 (95% CI 1.67 – 2.13) for high blood cholesterol levels (Mokdad et al., 2003).

The literature also indicates that disparities are present in regards to obesity and its relationship to other CVD comorbidities among minority racial/ethnic groups. Compared to non-Hispanic Whites, the prevalence of obesity-related cardiovascular diseases is greater among Black nH and Mexican Americans. However, the relationship between obesity and disease are not expressed the same in each race. For example, the prevalence of obesity-related diabetes is higher among Mexican Americans, while the prevalence of hypertension is greater among Black nH (Cossrow & Falkner, 2004).

2.4.5 Summary

A review of the literature on the subject of obesity has illustrated several key points:

1. There have been significant increases in obesity prevalence over the past 28 years.
2. Racial disparities exist, especially among Black non-Hispanic and Mexican American women, in which the prevalence of obesity is higher, compared to White non-Hispanic women. However, no major differences in obesity prevalence by race/ethnicity are observed for men (Baskin et al., 2005).
3. Obesity is a well-established and major risk factor for cardiovascular disease.

These factors reveal that obesity is indeed a public health challenge that requires thorough investigation and continued research. A decrease in obesity prevalence and the elimination of racial disparities will offer all Americans improved health and subsequent improved quality of life that can be passed on to future generations.

Areas of future research should concentrate on establishing an improved understanding of several factors, including:

1. The relationship between gene-environment interactions, obesity, and CVD;
2. Racial/ethnic differences in obesity in the development and progression of CVD;
3. The relationship between the built environment, obesity, and CVD risk; and
4. Effective prevention and treatment methods which are applicable to all populations (Poirier et al., 2006).

2.5 THE METABOLIC SYNDROME

2.5.1 Introduction

Several studies have shown a clustering of several CVD risk factors within individuals. This observation was initially termed as syndrome X by Reaven (Alberti, Zimmet, & Shaw, 2005; Reaven, 1988), but is now widely referred to as the metabolic syndrome. The metabolic syndrome is formally described as a disorder encompassing a group of metabolic abnormalities or risk factors for cardiovascular disease, related to a state of insulin resistance, resulting from the increasing prevalence of obesity (American Heart Association, 2008b; American Heart Association & American Stroke Association, 2008; Eckel, Grundy, & Zimmet, 2005; The Metabolic Syndrome Institute, 2008). These risk factors include:

- Abdominal obesity
- Atherogenic dyslipidemia
- Elevated blood pressure
- Insulin resistance or glucose intolerance
- Prothrombotic state
- Proinflammatory state (American Heart Association, 2008b; Eckel et al., 2005; Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004; "Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002).

The physiological outcome of this clustering of risk factors in individuals, leads to the metabolic syndrome. The metabolic syndrome is, in turn, associated with an increased risk of

CVD (Eckel et al., 2005), and is therefore, an important risk factor from both a public health and medical perspective (Alberti et al., 2005; Eckel et al., 2005).

2.5.2 History

The metabolic syndrome is a concept that has been known and debated about for over 80 years (Alberti et al., 2005; Cameron, Shaw, & Zimmet, 2004; Kylin, 1923). In the 1920s, Kylin, a Swedish physician, first characterized the metabolic syndrome as the aggregation of hypertension, hyperglycemia, and gout (Eckel et al., 2005; Isomaa, 2001 ; Kylin, 1923). Then in 1947, Vague recognized that upper body adiposity (male-type obesity) was the most common phenotype frequently associated with metabolic anomalies related to Type 2 diabetes mellitus and CVD (Eckel et al., 2005; Vague, 1947). Later, Reaven described it as syndrome X (the occurrence of insulin resistance, hyperglycemia, hypertension, low HDL cholesterol, and raised VLDL-triglycerides) in 1988 (Alberti et al., 2005; Reaven, 1988). Other historical terms include the insulin resistance syndrome and the deadly quartet (DeFronzo & Ferrannini, 1991; Isomaa, 2001 ; Kaplan, 1989; Reaven, 1988). Evidence from continued research supports the validity of the metabolic syndrome concept, however, there is controversy regarding whether or not it is indeed a discrete syndrome (Meigs, 2000, 2002).

2.5.3 Definition

Although many theories have been proposed for the pathogenesis of the metabolic syndrome, a definitive cause for it has yet to be established (Eckel et al., 2005; Reaven, 2004). The etiology of the metabolic syndrome is likely to have multiple origins. Genetic factors and modifiable environmental factors such as obesity and sedentary lifestyles, coupled with poor diet, clearly interact in the pathogenesis of this syndrome (Bouchard, 1995; Lakka et al., 2002; Liese, Mayer-Davis, & Haffner, 1998; Meigs, 2002; Reaven, 1988). Critics of the metabolic syndrome concept emphasize that the contributing risk factors are quite common and may cluster in some subjects, independent of any underlying, unifying pathology or physiology. However, findings from population studies illustrate that these metabolic risk factors cluster to a greater extent than what would be predicted by chance alone (Meigs, 2002; Yarnell, Patterson, Bainton, & Sweetnam, 1998).

Two formal and widely used definitions (or clinical criteria) of the metabolic syndrome are now in use. These definitions were developed by the World Health Organization (WHO) and the National Cholesterol Education Program’s Adult Treatment Panel III (NCEP ATP III) and are shown in Table 5. These definitions/criteria have similar measures and foci, however, there are important differences between them (Grundy et al., 2004). For example, the WHO definition includes Type 2 diabetes as a contributing factor. However, this is often the subject of debate as many experts consider Type 2 diabetes to be a consequence, rather than a component, of the metabolic syndrome (Balkau & Charles, 1999; Meigs, 2002).

In addition, as stated by Grundy et al. (2004):

> The American Diabetes Association (ADA) recently established a cutpoint of ≥100 mg/dL, above which persons have either prediabetes (impaired fasting glucose) or diabetes (Genuth et al., 2003; Grundy et al., 2004). This new cutpoint should be applicable for identifying the lower boundary to define an elevated glucose as one criterion for the metabolic syndrome. (p. 435)

Another difference in the definitions involves blood pressure thresholds, which are higher according to the WHO criteria compared to the ATP III criteria. This difference results in lower prevalence estimates of hypertension among those with the metabolic syndrome, with greater severity (Meigs, 2002).

Table 5. ATP III and WHO Clinical Criteria for the Metabolic Syndrome [10]

	ATP III	WHO
<u>**Requirements**</u>	**All of the risk factors listed below**	**Insulin resistance plus any two of the Cardiovascular or Physical criteria**
Diabetic	Fasting glucose ≥110 mg/dL*****	Insulin resistance, identified by 1 of the following: ▪ Type 2 diabetes ▪ Impaired fasting glucose ▪ Impaired glucose tolerance ▪ Or for those with normal fasting glucose levels (< 110 mg/dL), glucose uptake below the lowest quartile for background population under investigation under hyperinsulinemic, euglycemic conditions
Cardiovascular	▪ Triglycerides ≥ 150 mg/dL ▪ HDL Cholesterol • Men: < 40 mg/dL • Women: < 50 mg/dL ▪ Blood Pressure ≥ 130 / ≥ 85 mm Hg	▪ Plasma triglycerides ≥ 150 mg/dL (≥1.7 mmol/L) ▪ HDL cholesterol • Men: < 35 mg/dL (< 0.9 mmol/L) • Women: < 39 mg/dL (1.0 mmol/L) ▪ Antihypertensive medication and/or high blood pressure (≥ 140 mm Hg systolic or ≥ 90 mm Hg diastolic) ▪ Urinary albumin excretion rate ≥ 20 µg/min or albumin:creatinine ratio ≥ 30 mg/g
Physical	▪ Abdominal Obesity, given as waist circumference • Men: > 102 cm (> 40 in) • Women: > 88 cm (> 35 in)	▪ BMI > 30 kg/m2 and/or ▪ Waist:Hip ratio • Men: > 0.9 • Women: > 0.85

ATP III = Adult Treatment Panel III; WHO = World Health Organization; HDL = high-density lipoprotein; BMI = body mass index.

[10] Note. From "Definition of Metabolic Syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association Conference on Scientific Issues Related to Definition," by S.M. Grundy, H.B. Brewer, Jr., J.I. Cleeman, S.C. Smith, Jr., and C. Lenfant, 2004, *Circulation, 109,* p. 435. Copyright 2004 by the American Heart Association. Adapted with permission of the author.

2.5.4 Prevalence

a. Overall Prevalence

Several studies have been conducted to examine the prevalence of the metabolic syndrome and its association with cardiovascular disease. Using the clinical criteria described by the ATP III, Ford et al. (2002) assessed the prevalence of the metabolic syndrome in the U.S. ("Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002). The study sample was derived from the Third National Health and Nutrition Examination Survey (NHANES III) (1988-1994) (Centers for Disease Control and Prevention, 1996; Ford, Giles, & Dietz, 2002; "Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94. Series 1: programs and collection procedures," 1994). The sample included 8,814 men and non-pregnant women aged 20 years and older. Metabolic syndrome prevalence was calculated by age, sex, race/ethnicity (White non-Hispanics [nH], Black nH, Mexican American, and Other). The overall age-adjusted prevalence of the syndrome was 23.7%. The authors applied these prevalence rates to the U.S. Census 2000 data and calculated that approximately 47 million U.S. residents have the metabolic syndrome (Ford et al., 2002).

Park et al. (2003) also utilized the ATP III criteria and NHANES III data to measure metabolic syndrome-associated factors and prevalence. The study included a representative U.S. sample of 12,363 Black nH, Mexican American, and White nH men and women aged 20 years and older who were not pregnant or lactating. The prevalence of the metabolic syndrome for men and women in this sample was 22.8% and 22.6%, respectively ($p = 0.86$). The authors also observed an increase in the prevalence of the syndrome in overweight ($25 \leq \text{BMI} < 30$) men and women. The authors estimated that approximately more than 20% of U.S. adults have the metabolic syndrome.

A limitation of both the Ford and Park studies is the use of data that was eight to nine years old at the time of publication (Ford et al., 2002; Park et al., 2003). Given the increasing rates of obesity, current rates of metabolic syndrome are likely to be larger.

b. Difference in Prevalence of Metabolic Syndrome by Race/Ethnicity

Racial and ethnic differences have been noted in the prevalence of metabolic syndrome. Ford et al. (2002) observed that the highest and lowest age-adjusted prevalence of the metabolic syndrome was found among Mexican Americans and White non-Hispanics (nH), respectively (31.9% and 23.8%) (Figure 6). Black nH women had about a 57% higher prevalence compared to Black nH men. Mexican American women had about a 26% higher prevalence compared to Mexican American men (Ford et al., 2002).

[11]

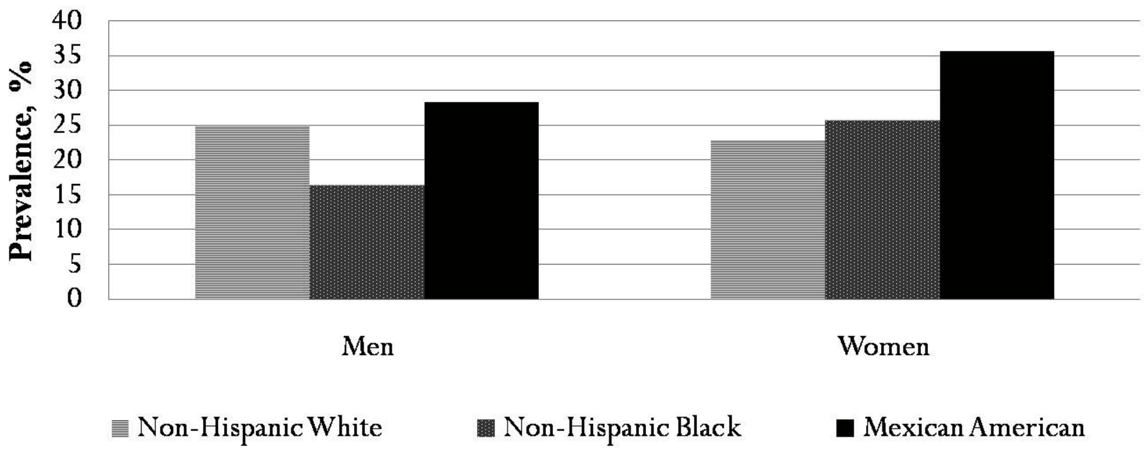


Figure 6. Prevalence of the Metabolic Syndrome by Gender and Race/Ethnicity in US Adults, [NHANES III (1988-1994)]

Similar results were found by Park et al. (2003), where in men, the prevalence of the metabolic syndrome was higher in Mexican Americans and White nH than in Black nH ($p < 0.001$ and $p = 0.006$, respectively). The prevalence of the metabolic syndrome was significantly higher (27.2%) in Mexican American women compared to that of Black nH and White nH women ($p < 0.001$ and $p = 0.002$, respectively) (Park et al., 2003).

The greatest strength of the Ford and Park studies is that they highlight the variations that exist between ethnic groups. However, the cross-sectional nature of both studies limits the ability to establish causal inference in the observed associations.

[11] Note. From "Prevalence of the Metabolic Syndrome Among US Adults: Findings From the Third National Health and Nutrition Examination Survey," by E.S. Ford, W.H. Giles, and W.H. Dietz, 2002, *JAMA, 287*, p. 358. Copyright 2002 by the American Medical Association. Adapted with permission of the author.

c. Difference in Prevalence by Definition of Metabolic Syndrome

As noted in the previous section, the use of two definitions for metabolic syndrome leads to differing estimates of metabolic syndrome. In general the WHO definition tends to give higher estimates of metabolic syndrome prevalence than the ATP III definition. Several studies have examined the impact of the definition of metabolic syndrome on prevalence findings. Ford and Giles (2003) used NHANES III data to compare the prevalence of the metabolic syndrome utilizing both definitions proposed by the WHO and ATP III (Centers for Disease Control and Prevention, 1996; Ford & Giles, 2003). Another study objective included an analysis of each criterion's ability to accurately identify those with the syndrome. The study included 8,608 participants aged 20 years and older. After adjusting for age, the estimated prevalence was 25.1% and 23.9%, using the WHO and ATP III criteria, respectively. Among all study participants, 82.2% were similarly classified after applying both definitions (Ford & Giles, 2003).

Lakka et al. (2002) evaluated how the relationship between the metabolic syndrome, cardiovascular and overall mortality differed by definition (Lakka et al., 2002). Participants were enrolled in the Kuopio Ischemic Heart Disease Risk Factor Study, a prospective population-based study, consisting of a random-age stratified sample of 2,682 men residing in eastern Finland. The participants were aged 42, 48, 54, or 60 years at baseline (between 1984 and 1989), and free of CVD, cancer, or diabetes. The prevalence of metabolic syndrome ranged from 8.8% (by the ATP definition) to 14.3% (by the WHO definition). Utilizing the ATP III definition, and adjusting for other conventional cardiovascular risk factors, those participants with the metabolic syndrome were 2.9 (95% CI 1.2-7.2) to 4.2 (95% CI 1.6-10.8) times more likely to die of CHD. When using the WHO definition, after adjusting for other conventional cardiovascular risk factors, participants were 2.9 (95% CI 1.2-6.8) to 3.3 (95% CI 1.4-7.7) times more likely to die of CHD. The metabolic syndrome, as defined by the WHO was associated with 2.6 (95% CI 1.4-5.1) to 3.0 (95% CI 1.5-5.7) times higher mortality from CVD. The syndrome was also associated with 1.9 (95% CI 1.2-3.0) to 2.1 (95% CI 1.3-3.3) times higher all-cause mortality. The authors observed that the use of the ATP III definition less consistently predicted CVD and all-cause mortality (Lakka et al., 2002).

Despite the inconsistency reported in the aforementioned results, there were several strengths associated with the Lakka study: 1) longitudinal study design; 2) reliable assessment of causes of death; 3) thorough examination of metabolic and cardiovascular risk factors; and 4) the exclusion criteria utilized at baseline. However, the study also had its limitations: 1) the exclusion of women, the elderly, and other races; and 2) the limited number of deaths from CHD, although the follow-up period was relatively extensive. These limitations significantly limit the generalizability of this study to other populations (Lakka et al., 2002).

d. Impact of the Metabolic Syndrome Definition on Prevalence of Metabolic Syndrome by Race and Ethnicity

Overall, differences in metabolic syndrome prevalence estimates are observed when stratified by race/ethnicity (Alberti et al., 2005; Cameron et al., 2004; Ford & Giles, 2003), independent of the definition of metabolic syndrome applied. However, the definitions proposed by the WHO and ATP III, give different results for different ethnic groups, specifically pertaining to obesity cutoffs (Alberti et al., 2005; "Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies," 2004). For example, Type 2 diabetes risk is observed at much lower levels of adiposity in Asian populations compared to European populations. Researchers have also found that when the ATP III definition was utilized, there were suspiciously lower prevalence statistics among Asian populations. This trend was also observed among Black nH and Mexican Americans, in which the prevalence of the syndrome was lower when the ATP III definition was applied (Ford & Giles, 2003). This emphasizes the need for developing ethnic-specific cutoffs or recommendations for obesity as well (Alberti et al., 2005; Tan, Ma, Wai, Chew, & Tai, 2004).

These different definitions have inevitably been responsible for inhibiting the standardized analysis of the epidemiology of the metabolic syndrome, as well as extensive confusion and lack of comparability between studies (Alberti et al., 2005; Meigs, 2002). This prompts researchers to continuously strive to develop a definition that will be applicable worldwide (Eckel et al., 2005; Meigs, 2002).

2.5.5 The Metabolic Syndrome as a Risk Factor for CVD

Persons with the metabolic syndrome are at increased risk for CVD and for subsequent increased mortality from both CVD and all causes (Eckel et al., 2005; Ford & Giles, 2003; Isomaa, 2001 ; Trevisan, Liu, Bahsas, & Menotti, 1998; Zimmet, Alberti, & Shaw, 2001). Due to the increased risk of morbidity and mortality associated with the syndrome, a comprehensive understanding of the scope of this syndrome is critical to both the allocation of health care and research resources (Ford & Giles, 2003). Several studies have been conducted to further examine this association.

Isomaa et al. (2001) evaluated the prevalence of, and the cardiovascular risk associated with, the metabolic syndrome in a high-risk Scandinavian population applying the WHO definition. The study sample included 4, 483 participants in the Botnia study, aged 35-70 years. The Botnia study is a large family study in Finland and Sweden that was established in 1990 to identify early metabolic anomalies in families with Type 2 diabetes (Groop et al., 1996; Isomaa, 2001). The authors observed the metabolic syndrome in approximately 80% of participants with

Type 2 diabetes, along with a history of CHD, MI, and stroke ($p < .001$). When evaluating all of the study participants, the metabolic syndrome was associated with an increased risk of CHD, MI, and stroke (2.96, 2.63, and 2.27, respectively; $p < .001$). This risk was greater than the risk associated with any of the individual CVD risk factor components. There was a significant increase in cardiovascular mortality in those with the metabolic syndrome (12.0 vs. 2.2%; $p < .001$) compared to those who without the syndrome. Based on these results, the authors found that the WHO definition, instead of the ATP III definition, is best suited for comparisons with other studies that use different criteria (Isomaa, 2001).

Wilson et al. (2005) applied a modified version of the ATP III definition to examine the effects of the metabolic syndrome on the risks for CVD, CHD, and Type 2 diabetes over an eight year follow-up period. The sample was primarily White and included 3,323 men and women, aged 22 to 81 years, who were free of CVD and Type 2 diabetes at entry into the study. The authors decided to use an impaired fasting glucose (IFG) criterion of 100 to 125 mg/dL, as suggested by other expert committees, instead of the greater than or equal to 110 mg/dL criterion recommended by the NCEP ATP III (Genuth, 2003; Genuth et al., 2003; Grundy et al., 2004; P. W. Wilson, D'Agostino, Parise, Sullivan, & Meigs, 2005). In men, the metabolic syndrome age-adjusted relative risks (RR) and 95% CI for CVD, hard CHD (MI and CHD death only), and total CHD were:

- CVD: RR = 2.88 (95% CI 1.99 – 4.16; $p < .0001$);
- Hard CHD: RR = 2.58 (95% CI 1.46 – 4.57; $p = .0011$);
- Total CHD: RR = 2.54 (95% CI 1.62 – 3.98; $p < .0001$)

For women, the metabolic syndrome age-adjusted relative risk and 95% confidence interval for CVD was RR = 2.25 (95% CI 1.31 – 3.88; $p = 0.0034$) (P. W. Wilson et al., 2005).

The design of the Wilson study allowed the authors to effectively assess risk through an eight-year follow-up period in which all participants were free of CVD and Type 2 diabetes at study entry. However, the overall prevalence of the metabolic syndrome in this population may be overestimated due the lower cut-point for the IFG criterion of 100 to 125 mg/dL. This modification would classify more participants as having metabolic syndrome according to the ATP III definition. Additionally, the use of a primarily suburban, White sample, limits the generalizability of the findings to other populations.

2.5.6 Summary

It is estimated that more than 20% of Americans have metabolic syndrome, with higher prevalence found among Mexican Americans. Therefore, as the prevalence of obesity and sedentary lifestyles continue to increase, it is likely that the prevalence of metabolic syndrome will also increase, thus presenting physicians and public health professionals with the challenge of identifying, treating, and helping to prevent the syndrome early in its course; although no specific treatments are currently available (Lakka et al., 2002). Therefore, abnormalities will have to be treated individually, which could present other unforeseen challenges. It is recommended that behavioral modifications along with clinical management of risk factors, such as obesity, physical inactivity, and atherogenic diets be the focus of any therapeutic regimen (Alberti et al., 2005; Eckel et al., 2005).

Of great importance is the fact that the metabolic syndrome is already recognized as a worldwide public health challenge. However, while the ATP III definition is the most widely utilized, there currently is no unified set of clinical criteria used to diagnose the syndrome. Thus, it is hard to estimate how many people truly have the metabolic syndrome, as different definitions produce different prevalence statistics. For example, the WHO definition tends to generally yield higher estimates of metabolic syndrome prevalence compared to the ATP definition. Thus, emphasizing the need for a standardized definition.

Table 6. Review of Studies

Authors	Definition	Results
Ford et al. (2002)	ATP III	▪ Age adjusted prevalence of metabolic syndrome = 23.7% ▪ Data suggested ~47 million Americans have the syndrome ▪ Mexican Americans had highest prevalence (31.9%), White nH had lowest prevalence (23.8 %) ▪ Mexican American and Black nH women had ~ a 26% & 57%, respectively, higher prevalence than their male counterparts
Park et al. (2003)	ATP III	▪ Prevalence of metabolic syndrome was 22.8% for men and 22.6% for women ($p = 0.86$) ▪ Estimated that ~ more than 20% of U.S. adults have the syndrome ▪ Prevalence higher in Mexican American & White nH men than in Black nH men ($p < 0.001$ & $p = 0.006$, respectively) ▪ Prevalence significantly higher (27.2%) among Mexican American women compared to Black nH and White nH women ($p < 0.001$ & $p = 0.002$, respectively)
Ford and Giles (2003)	WHO & ATP III	▪ Prevalence of syndrome using WHO criteria = 25.1 % ▪ Prevalence of syndrome using ATP III criteria = 23.9 % ▪ 82.2% of all study participants were similarly classified as having metabolic syndrome when both definitions were applied.
Lakka et al. (2002)	WHO & ATP III	▪ Prevalence of metabolic syndrome ranged from 8.8% (ATP III) to 14.3% (WHO), depending on the definition used ▪ ATP III: participants with metabolic syndrome were 2.9 (95% CI 1.2 – 7.2) to 4.2 (95% CI 1.6 – 10.8) times more likely to die of CHD ▪ WHO: participants with metabolic syndrome were 2.9 (95% CI 1.2 – 6.8) to 3.3 (95% CI 1.4 – 7.7) times more likely to die of CHD ▪ WHO: syndrome associated with 2.6 (95% CI 1.4 – 5.1) to 3.0 (95% CI 1.5 – 5.7) times ↑ mortality from CVD ▪ Syndrome associated with 1.9 (95% CI 1.2 – 3.0) to 2.1 (95% CI 1.3 – 3.3) times ↑ all cause mortality, though the authors note that ATP III criteria was less consistent in predicting all-cause mortality
Isomaa et al. (2001)	WHO	▪ Metabolic syndrome was seen in 80% of participants with Type 2 DM, along with history of CHD, MI, and stroke ($p < 0.001$) ▪ Syndrome associated with increased risk of CHD, MI, & stroke (2.96, 2.63, and 2.27, respectively; $p < 0.001$) ▪ Cardiovascular mortality increased among participants with metabolic syndrome (12.0 vs. 2.2%; $p < 0.001$)

Wilson et al (2005)	ATP III (modified)	▪ Modification included using an impaired fasting glucose (IFG- 100 to 125 mg/dL) instead of 110 mg/dL (ATP III criteria)
		▪ For men with metabolic syndrome, age adjusted relative risks (RR) & 95% CI were:
		    ▪ CVD: RR = 2.88 (95% CI 1.99 – 4.16; $p <0 .0001$)
		    ▪ Hard CHD: RR = 2.58 (95% CI 1.46 – 4.57; $p = 0.0011$)
		    ▪ Total CHD: RR = 2.54 (95% CI 1.62 – 3.98; $p < 0.0001$)
		▪ CVD among women with metabolic syndrome: RR = 2.25 (95% CI 1.31 – 3.88; $p = 0.0034$)

ATP III = Adult Treatment Panel III; WHO = World Health Organization; nH = non-Hispanic; CHD = coronary heart disease; CVD = cardiovascular disease; DM = diabetes mellitus; MI = myocardial infarction; CI = confidence interval.

2.6 DIABETES MELLITUS

2.6.1 Introduction

Diabetes mellitus (DM) is a serious public health problem at both national and international levels. It is the sixth leading cause of death in the U.S. (Centers for Disease Control and Prevention, 2009; Miser, 2007). DM encompasses a group of metabolic disorders characterized by insulin resistance, insufficient insulin secretion, or both. The major clinical manifestation of diabetes is a state of hyperglycemia or high blood glucose levels (American Diabetes Association, 2004; Miser, 2007). The cardinal symptoms, as historically described, include polyuria (increased urinary frequency), polydipsia (increased thirst), and polyphagia (increased appetite) (Engelgau et al., 2004; Hazlett, 2000).

The American Diabetes Association (ADA) has established three criteria for the diagnosis of diabetes mellitus (Table 7). The ADA has also established a set of criteria for those that do not meet the criteria to be diagnosed as having diabetes, but whose glucose levels are too high to be regarded as normal. This intermediary condition is known as having "pre-diabetes," which is diagnosed by impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) (American Diabetes Association, 2009).

Table 7. Criteria for the Diagnosis of Pre-Diabetes and Diabetes [12]

	Pre-Diabetes		Diabetes
1	*IFG:* Fasting plasma glucose (FPG) 100 – 125 mg/dL (5.6 – 6.9) mmol/L)	*IGT:* 2-hour postload glucose 140 – 199 mg/dL (7.8 – 11.1 mmol/L) during a 75-g oral glucose tolerance test (OGTT)	Fasting plasma glucose (FPG) ≥ 126 mg/dL (7.0 mmol/L)
2			Symptoms of hyperglycemia and a casual plasma glucose ≥ 200 mg/dL (11.1 mmol/L)
3			2-hour plasma glucose ≥ 200 mg/dL (11.1 mmol/L) during a 75-g oral glucose tolerance test (OGTT)

IFG = impaired fasting glucose; IGT = impaired glucose tolerance.

There are three recognized types of DM: 1) Type 1 diabetes (T1DM), which occurs predominantly in childhood; 2) Type 2 diabetes (T2DM), which occurs at any age, although most frequently after age 45; and 3) gestational diabetes (GDM), which occurs during pregnancy. (Engelgau et al., 2004). For this review, we will mainly focus on T2DM, which accounts for the majority of all DM diagnoses, and is also the primary type of diabetes seen in the Heart SCORE participants.

[12] Note. From "Diagnosis and Classification of Diabetes Mellitus," by the American Diabetes Association, 2009, *Diabetes Care, 32 Suppl 1*, pp. S62-67. Copyright 2009 by the American Diabetes Association. Adapted with permission of the author.

Note. From "The Management of Type 2 Diabetes Mellitus FOCUS on Quality," by W.F. Miser, 2007, *Primary Care*, *34*, pp.1-38. Copyright 2007 by Elsevier, Incorporated. Adapted with permission of the author.

2.6.2 Definition

T2DM, previously known as "non-insulin-dependent" or "adult-onset" diabetes, is a complex disease that is often triggered by insulin resistance, along with a relative deficiency of insulin secretion. T2DM is the most common form of DM, as it is responsible for an estimated 90-95% of all diagnosed cases of diabetes (American Diabetes Association, 2004; Engelgau et al., 2004).

The ADA (2004) has identified several key risk factors for T2DM. These include:

- Age ≥ 45 years
- Overweight (BMI ≥ 25 kg/m^2)
- Family history of diabetes (i.e., parents or siblings with diabetes)
- Habitual physical inactivity
- Race/ethnicity (e.g., African Americans, Hispanic-Americans, Native Americans, Asian Americans, and Pacific Islanders
- Previously identified impaired fasting glucose (IFG) or Impaired Glucose Tolerance (IGT)
- History of gestational diabetes mellitus (GDM) or delivery of a baby weighing > 9 lbs
- Hypertension (≥ 140/90 mmHg in adults)
- HDL cholesterol≤ 35 mg/dL (0.90 mmol/L) and/or triglyceride level ≥ 250 mg/dL (2.82 mmol/L)
- Polycystic ovary syndrome
- History of vascular disease. (p. S12)

While the exact etiology of T2DM is unknown, this disease is the result of interactions between genetic and environmental factors (Malecki, 2005; Malecki & Klupa, 2005). There is a rare form of T2DM that occurs in approximately 10% of the population, and is the consequence of rare single gene mutations that may occur in six genes (*hepatocyte nuclear factor-4a*, *-1a*, *-1b*, *glucokinase*, *insulin promoter factor-1a*, and *NEUROD1*). Mutations in these genes confer early onset disease, occurring in the second or third decade of life, without obesity, and result in severe impairment of insulin secretion (Malecki, 2005; Malecki & Klupa, 2005). Nonetheless, the large majority of T2DM is thought to be polygenic in nature, involving numerous genes, which also require the presence of another risk factor, such as obesity, to bring about the disease (Malecki, 2005; Malecki & Klupa, 2005; University of Virginia, 2007).

2.6.3 Prevalence

There is a worldwide increase in the number of people with diabetes as a result of population growth, aging, urbanization, and increasing prevalence of obesity and sedentary lifestyles (American Diabetes Association, 2004; Wild, Roglic, Green, Sicree, & King, 2004). The increasing prevalence is evident in both males and females of all ages in both developed and developing countries. In 2003, it was stated by the International Diabetes Federation (IDF) that there were approximately 194 million people with DM. The IDF also predicted that by the year 2025, this number would increase to 333 million. Similar predictions were also made the WHO (Duke, Colagiuri, & Colagiuri, 2009; International Diabetes Federation, 2005; Wild et al., 2004). In the U.S., diabetes prevalence estimates are presently derived from three national surveys: the Behavioral Risk Factor Surveillance System (BRFSS), the National Health Interview Survey (NHIS), and the National Health and Nutrition Examination Survey (NHANES). The BRFSS can identify state-specific prevalence estimates, while estimates of undiagnosed diabetes are provided by the NHANES (Engelgau et al., 2004).

a. Overall Prevalence

In 2007, the overall prevalence of DM in the U.S. was approximately 7.8% (23.6 million). This estimate includes 17.9 million diagnosed and 5.7 million undiagnosed Americans.

When stratified by age, it was estimated that the prevalence of DM among those aged 20 years and older was 10.7% (23.5 million), whereas, the prevalence among those aged 60 years and older was approximately 23.1% (12.2 million). When stratified by gender, the prevalence estimate for DM for all men aged 20 years and older was 11.2% (12 million), and 10.2% (11.5 million) for all women aged 20 years and older (Centers for Disease Control and Prevention, 2008e; National Institute of Diabetes and Digestive and Kidney Diseases, 2008).

b. Differences in Prevalence by Race/Ethnicity

There also exist significant racial/ethnic disparities in diabetic health, as T2DM is more prevalent among minority populations including, Black non-Hispanics (nH), Hispanic/Latino Americans, and Native Americans (Black, 2002; Carter, Pugh, & Monterrosa, 1996; Gaillard, Schuster, Bossetti, Green, & Osei, 1997; Harris, Eastman, Cowie, Flegal, & Eberhardt, 1999; McKinlay & Marceau, 2000; Miser, 2007; University of Virginia, 2007). In 2006, the American Heart Association (AHA) indicated that the prevalence of physician-diagnosed DM was 14.9% for Black nH men and 13.1% for Black nH women, 11.3% for Mexican American men and 14.2% for Mexican American women, compared to 5.8% for White nH men and 6.1% for White nH women (Figure 7). The prevalence of diagnosed diabetes in the Hispanic/Latino population was approximately 11.1% (American Heart Association, 2009). More recent reports by the CDC indicate that the prevalence of DM is approximately 9.8% (14.9 million) for all White nH aged 20 years and older, and 14.7% (3.7 million) for all Black nH aged 20 years or older (Centers for Disease Control and Prevention, 2008e).

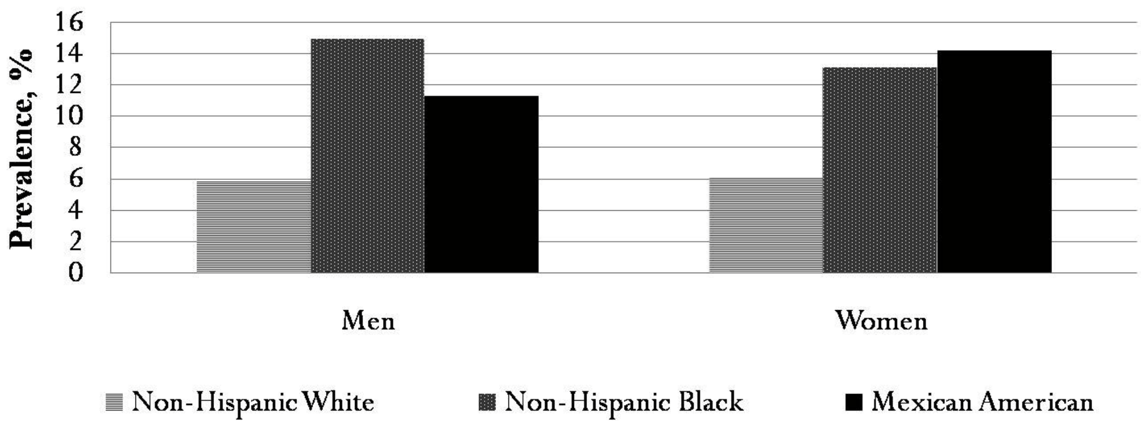


Figure 7. Prevalence of Diabetes by Gender and Race/Ethnicity in US Adults, 2005-2006 [NHANES (2005-2006)]

c. Differences in Prevalence Over Time

From 1980 through 2006, the U.S. has experienced an increase in the overall prevalence of diabetes from 2.5% to 5.8% (age adjusted: 2.8% to 5.6%) (Centers for Disease Control and Prevention, 2008c). The CDC also reported that the percentage of diagnosed diabetes had increased in every age group. When examined by age, individuals 65 to 74 years of age had the highest percentage of diagnosed DM (18.4%). This was followed by those aged 75 years and

[13] Note. From the American Heart Association, *Heart disease and stroke statistics -- 2009 update at-a-glance*, http://www.americanheart.org/downloadable/heart/1240250946756LS-1982%20Heart%20and%20Stroke%20Update.042009.pdf (February 2009).

older, aged 45 to 64 years, and those aged 45 years and younger (1.6%) (Centers for Disease Control and Prevention, 2008e).

2.6.4 Type 2 Diabetes as a Risk Factor for CVD

The diabetes epidemic is of great public health concern, as diabetes is strongly linked to CVD. The risks of developing CVD and coronary heart disease are increased 2- to 4-fold in those with DM, relative to matched controlled populations without DM (Bonow & Gheorghiade, 2004; Egede & Zheng, 2002; Wingard & Barret-Conner, 1995). Further, CVD is the leading cause of death in individuals with DM. Approximately 65% of the mortality among those with diabetes is the result of heart disease or stroke (American Heart Association, 2009; Egede & Zheng, 2002; Geiss, Herman, & Smith, 1995). In fact, CVD is responsible for 75% of the excess mortality among men, and 57% of the excess mortality among women (Bonow & Gheorghiade, 2004; Kleinman et al., 1988). Compared to those without diabetes, those with the disease develop CVD at much younger ages, and are more likely to die of cardiac related complications (Bonow & Gheorghiade, 2004; Wingard & Barret-Conner, 1995). Roughly 25% to 46% of DM-related mortality is caused by ischemic heart disease (IHD), while 6% to 22%, and 2% to 16% of this mortality is caused by other forms of heart disease and cerebrovascular disease, respectively (Bender et al., 1986; Bonow & Gheorghiade, 2004; Geiss et al., 1995; Kleinman et al., 1988; Moss, Klein, & Klein, 1991; Ochi, Melton, Palumbo, & Chu, 1985).

Various studies have indicated a diabetes-associated increase in mortality attributable to CAD even after controlling for risk factors such as, systolic blood pressure, cholesterol levels, weight, and cigarette smoking (Bonow & Gheorghiade, 2004; Butler, Ostrander, Carman, & Lamphiear, 1985; Kjaergaard, Hansen, Fog, Bulow, & Christensen, 1999). Furthermore, an analysis by Egede & Zheng (2002), found that the prevalence of CVD risk factors such as physical inactivity, hypertension, high cholesterol, and overweight and obesity, were significantly higher in adults with DM than adults without DM (Egede & Zheng, 2002).

2.6.5 Summary

Type 2 diabetes is a chronic disease that has made a global presence, which is due in part, to the obesity epidemic. T2DM is a highly prevalent condition and is strongly related to the occurrence of CVD (McKinlay & Marceau, 2000; Miser, 2007). Although its etiology is not well understood, researchers continue to examine the genetic and environmental components that contribute to the clinical manifestation of T2DM. In the presence of strong racial/ethnic differences that exist within T2DM, this research is essential to combating the disparities found among racial/ethnic minority populations, as well as developing appropriate prevention measures and treatment regimens. Management of T2DM involves the incorporation of education, nutritional assessment and therapy, increased physical activity, and oral medications, which increase insulin secretion, or glucose utilization. If these management techniques are unsuccessful in gaining glycemic control, then insulin treatment is required (Miser, 2007). As the prevalence of diabetes continues to increase, so does the financial burden associated with its chronic complications, resulting disability, loss of productivity, and subsequent premature death. Therefore, it is imperative that effective prevention techniques be developed to ensure a better quality of life for all people and future generations (Colagiuri, 2007; Engelgau et al., 2004).

2.7 PHYSICAL INACTIVITY

2.7.1 Introduction

Historical evidence indicates that sedentary behaviors are increasing in the population. However, as few studies attempt to measure inactivity, or address the morbidity and mortality attributable to inactivity, the effects of inactivity must often be deduced from studies that examine activity versus little or no activity (Dietz, 1996; Pettee, Ham, Macera, & Ainsworth, 2009). Since physical inactivity is a major risk factor for CVD, this review will primarily focus on prevalence statistics related to inactivity, as opposed to physical activity.

2.7.2 Definition

Physical activity is defined as, "Any bodily movement produced by skeletal muscles that results in an expenditure of energy," (Centers for Disease Control and Prevention, 2008f; United States Department of Health and Human Services, 1996b). Conversely, physical inactivity is defined as a "state in which bodily movement is minimal," and is characterized by the time spent in sedentary behaviors (Dietz, 1996; Pettee et al., 2009). Sedentary behaviors are commonly classified as either modifiable or necessary. Modifiable sedentary behaviors include television viewing or recreational computer use, whereas necessary sedentary behaviors include commuting or occupational tasks (Ainsworth, Haskell et al., 1993; Dietz, 1996).

2.7.3 Prevalence

Measurements of physical inactivity are included, indirectly, in national health surveys, such as the NHIS, NHANES, and the BRFSS (Cooper et al., 2000; Pratt, Macera, & Blanton, 1999; United States Department of Health and Human Services, 1996b). The NHIS includes several questions on participation in leisure-time physical activity: 1) frequency and duration of light-moderate activity; 2) frequency and duration of vigorous activity; and 3) frequency of strengthening activity. Physical inactivity is classified in the NHIS by the frequency in which participants report, “Never engaging in any light-moderate or vigorous leisure-time physical activity for as long as 10 minutes at a time,” (Schoenborn C.A. & Barnes, 2002). The BRFSS defines leisure-time physical inactivity based on participants who reply “no” to the following survey question: “During the past month, other than your regular job, did you participate in any physical activities or exercise, such as running, calisthenics, golf, gardening, or walking for exercise?” ("Trends in leisure-time physical inactivity by age, sex, and race/ethnicity--United States, 1994-2004," 2005). Finally, the NHANES III (1988 – 1994) used modified questions from the 1985 NHIS, in which participants were asked if they had engaged in any leisure-time physical activity in the past month, including exercises, sports, or physically active hobbies. Physical inactivity is defined in the NHANES by participants’ response as “no” leisure-time activities (Winkleby, Kraemer, Ahn, & Varady, 1998). Overall, the incorporation of these measurements has allowed researchers to monitor trends of inactivity in a representative sample of U.S. adults. Results of these surveys indicate similar and high prevalence patterns of inactivity: inactivity increases with age, is lower in men compared to women, is higher among those of lower SES, and is highest among Black and Hispanic groups (Cooper et al., 2000; Dubbert et al., 2002).

a. Overall Prevalence

Utilizing NHANES III (1988 – 1994) data, the American Heart Association (AHA) indicated that in 1996, approximately 28% of American adults reported no leisure-time physical activity within the past 30 days (American Heart Association, 2008d). Then, using the physical inactivity measure of the BRFSS, the Centers for Disease Control and Prevention (CDC) (2005), estimated that in 2004, the overall prevalence of leisure-time physical inactivity was 23.7%. The BRFSS is a cross-sectional, state-based, telephone survey of the noninstitutionalized, U.S., civilian population, aged 18 years and older ("Trends in leisure-time physical inactivity by age, sex, and race/ethnicity--United States, 1994-2004," 2005). Subsequently, data derived from the NHIS 2007, indicated that in 2006 the estimated, age-adjusted, overall prevalence of leisure-time physical inactivity was 39.5% (National Center for Health Statistics, 2007). The NHIS is a survey on the health of the noninstitutionalized, civilian, U.S. population (National Center for Health Statistics, 2008). The varying prevalence estimates seen above may have been due to differences in: 1) the way each survey was conducted; 2) how questions were phrased in each survey; 3) the time of year in which they were conducted; 4) the population sampling methods; 5) response rates; and 6) how physical inactivity was defined in each survey (HealthGoods, 2007).

b. Differences in Prevalence by Race/Ethnicity

Sundquist et al. (2001) utilized physical inactivity measures from the Third National Health and Nutrition Examination Survey (NHANES III) (1988-1994) to assess the association of ethnicity and inactivity (Centers for Disease Control and Prevention, 1996; Ford et al., 2002; "Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94.

Series 1: programs and collection procedures," 1994; Sundquist, Winkleby, & Pudaric, 2001). The study sample included 700 Black non-Hispanic (nH), 628 Mexican-American, and 2,192 White nH men and women aged 65 to 84 years. Compared to White nH women, Black nH women were significantly more likely to be inactive (OR = 2.62; 95% CI 1.82 - 3.76). Among Black nH men, there was also a significantly higher prevalence of inactivity compared to White nH men (OR = 1.88; 95% CI 1.19 - 2.97) (Sundquist et al., 2001).

Using inactivity measures from the NHANES III (1988-1994), Winkleby et al. (1998) tested the hypothesis that racial/ethnic differences in activity levels among women could be explained by differences in SES. The study sample included 5,266 Black nH, Mexican-American, and White nH women aged 25 to 64. The primary measure of SES was education level. Although the results did not substantiate the hypothesis, it was concluded that race/ethnicity was independently associated with activity levels. After adjusting for years of education, the authors found that compared to White nH women, significant higher levels of inactivity were observed among Black nH and Mexican-American women ($p < 0.001$). There was also a negative association between SES and physical inactivity ($p < 0.001$) (Winkleby et al., 1998).

A major strength of both the Sundquist and Winkleby studies was the use of NHANES III data, resulting in a wealth of information regarding CVD risk factors in addition to inactivity. However, self-reported data, such as physical activity participation, could have introduced recall bias into the studies, therefore, either overestimating or underestimating the results (Sundquist et al., 2001; Winkleby et al., 1998).

c. Differences in Prevalence Over Time

The Centers for Disease Control and Prevention (CDC) (2005) utilized BRFSS data to examine trends in leisure-time physical inactivity from 1994 to 2004. In this time frame, there was a significant decline in leisure-time physical inactivity (29.8% vs. 23.7%, $p < 0.001$). The largest decrease was observed among men aged 50 to 59 years (33.5% vs. 23.5%), and among women between the ages of 60 to 69 years (37.8% vs. 28.5%). Among men, the prevalence of leisure-time physical inactivity decreased significantly for each age group (p for trend < 0.001). This trend was also observed among women in every age group (p for trend < 0.001) The reasons behind this improvement were not given ("Trends in leisure-time physical inactivity by age, sex, and race/ethnicity--United States, 1994-2004," 2005).

The CDC study was unique, as it was the first examination of physical inactivity trends using BRFSS data from all 50 states and the District of Columbia (DC). The findings confirm previous research conducted using BRFSS data from 1990 to 1998 for 43 states and DC, and from 1996 to 2002 for 35 states and DC, which also found that there was an overall decrease in physical inactivity among all U.S. adults. However, there were several limitations to the study. First, since the BRFSS is a telephone survey that specifically relies on self-reported data, these data are subject to both recall and social desirability bias. Second, the study results are not generalizable to all populations, since all U.S. citizens do not have telephones. Finally, Rhode Island was excluded from the 1994 study analysis because they did not utilize the physical activity question. Although the results of this study indicate a positive trend in the decline of leisure-time physical inactivity, the results also indicate that a significant proportion of U.S. adults remain physically inactive ("Trends in leisure-time physical inactivity by age, sex, and race/ethnicity--United States, 1994-2004," 2005).

2.7.4 Physical Inactivity as a Risk Factor for CVD

Public health efforts have focused on ways of increasing participation in leisure-time physical activity among U.S. adults for many years. As a result of substantial epidemiological evidence, it is recognized that sedentary lifestyles are associated with health consequences, including hypertension, diabetes, osteoporosis, colon cancer, depression, obesity, and coronary heart disease (CHD) (Schoenborn C.A. & Barnes, 2002; Wannamethee & Shaper, 2001). Several longitudinal studies have suggested an inverse dose-response relationship between overall physical activity and CVD, where lower levels of activity are associated with higher CVD levels. These studies have also acknowledged that physical activity is associated with an estimated 40 to 50% reduction in CHD risk. Conversely, inactivity has been reported as an independent predictor of cardiovascular and all-cause mortality (Blair et al., 1989; Dubbert et al., 2002; Farrell et al., 1998; Wannamethee & Shaper, 2001; Wei et al., 1999). Due to the strength of these findings, increasing physical activity has become a goal of public health efforts including Healthy People 2010.

Oguma et al. (2004) conducted a meta-analysis to review and quantify the dose-response relationship between physical activity and CVD risk in women. The analysis included studies that contained: 1) data on women; 2) measured physical activity (exposure) as either a continuous variable or a categorical variable with 3 to 5 levels; 4) CVD (outcome); and presented relative risks and 95% confidence interval statistics. The 23 selected studies, based on a MEDLINE (National Library of Medicine) literature search, incorporated a range of 148 to 80,348 participants, aged 15 to 101 years, with 5 to 32 years of follow-up. The majority of studies (71%) were U.S.-based. The results of the meta-analysis indicate a dose-response relationship between physical activity and decreased CHD (RR = 1 [reference], 0.78, 0.53, and

0.61, respectively; p for trend < 0.0001). The authors also observed that compared to those who were extremely inactive (no walking during the average week), walking for one hour per week was associated with a reduction in overall CVD and all CHD (overall CVD: RR = 0.80; 95% CI 0.74 - 0.87) (all CHD: RR = 0.60; 95% CI 0.39 - 0.94) (Oguma & Shinoda-Tagawa, 2004).

In the Oguma study, the authors were unable to assess the components that contribute to physical activity volume (i.e., frequency, intensity, and time) since all studies relied on a single baseline assessment of physical activity. Short and long-term variations in physical activity that could modify the true effect of physical activity on disease also could not be determined. Therefore, misclassification of participant activity levels could have masked the true relationship between physical activity and CVD risk. Nonetheless, the Oguma study makes a strong contribution to CVD literature, because it was one of the few studies to separately investigate female activity patterns, which are very different from those of males (Oguma & Shinoda-Tagawa, 2004; Pate et al., 1995).

In the mid-1990s, an expert panel of the National Institutes of Health (NIH) and reviewers of the Surgeon General's report, indicated that participation in regular physical activity reduces the risk of early mortality due to heart disease, and positively modifies several key risk factors, including hypertension, blood lipids, and insulin resistance. Activity was also regarded as an important rehabilitation component for those who had previously suffered a myocardial infarction. It was determined that while moderate intensity activities (i.e., brisk walking and gardening) have significant health benefits, the underlying mechanisms for the protective effects of physical activity on CVD are still unclear (Anonymous, 1996; Dubbert et al., 2002; United States Department of Health and Human Services, 1996b; Wannamethee & Shaper, 2001).

The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) developed a set of guidelines for adult physical activity. For healthy adults under the age of 65, the ACSM and AHA recommend:

- Moderately intense cardio for 30 minutes a day, for five days a week; or
- Vigorously intense cardio for 20 minutes a day, for three days a week; and
- Eight to ten strength training exercises (8 to 12 repetitions of each twice a week) (American College of Sports Medicine, 2007).

For adults over age 65 (or adults between the ages of 50 and 64, with chronic conditions such as arthritis), the ACSM and AHA recommend that an activity plan be developed with a physician, or other health professional, before starting the following activities:

- Moderately intense aerobic exercise 30 minutes a day, five days a week; or
- Vigorously intense aerobic exercise 20 minutes a day, 3 days a week; and
- Eight to ten strength-training exercises (10-15 repetitions of each exercise, twice to three times per week) (American College of Sports Medicine, 2007).

It is also recommended by the ACSM and AHA that if you are at risk of falling, that you perform balance exercises (American College of Sports Medicine, 2007).

2.7.5 Summary

In conclusion, the research evidence suggests that physical inactivity is highly prevalent in the U.S., and is an established risk factor for CVD. The literature also indicates that a larger proportion of Black nH are inactive compared to White nH. In an effort to reduce this CVD risk, more public health initiatives are needed. Future endeavors in this area should focus on promoting moderate physical activities that are not necessarily strenuous or prolonged, but attainable by all populations (Wannamethee & Shaper, 2001).

2.8 MEASUREMENT OF THE BUILT ENVIRONMENT

2.8.1 Introduction

The increasing obesity epidemic in America is partially attributable to the increase in physical inactivity. Other contributing factors include the increased intake of high fat and caloric foods, and the consumption of larger food portions (Finkelstein, Ruhm, & Kosa, 2005; Sowers, 2003). Some researchers hypothesize that obesity is a result of an interaction between susceptibility genes, and an "obesogenic" environment that leads to lower physical activity and promotes consumption of energy dense foods (Sowers, 2003). Swinburn et al. (2001) define the obesogenicity of an environment as, "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" (Lake & Townshend, 2006; Swinburn & Egger, 2002).

Technological advances have also increased sedentary behaviors such as television viewing, recreational computer use, commuting, and occupational tasks (Ainsworth, Haskell et al., 1993; Dietz, 1996). For example, millions of Americans currently drive to and from work, as well as depend on vehicles to run most errands (Jackson & Kochtitzky, 2003). There has also been a decrease in the amount of time spent in physical activities while at home or at work (Finkelstein et al., 2005; Sturm, 2004).

Prior obesity research has examined biological, psychological, and behavioral factors, and their contributions to the increase in obesity. However, studying these factors individually has proven unsuccessful in explaining the rapid growth in obesity (Wadden et al., 2002). Additional research efforts are now focusing on the influence of the bulit environment on public health. Historically, the concept of the built environment encompassed factors such as transportation issues, the diminishing natural environment, air pollution, decreased sidewalks, and urban sprawl (Srinivasan, O'Fallon, & Dearry, 2003). However, current research recognizes that the built environment, including those places where individuals live and work, may consequently affect human health (Srinivasan et al., 2003; A. Wilson et al., 1998). However, it is important to point out that at this time, the direct causal relationship between the built environment and adverse health effects has been difficult to establish (Hodgson, 2002; Srinivasan et al., 2003).

2.8.2 Definition

What is the built environment? Identifying what the built environment is, can be a difficult task for research studies.

The most common definition in use today is that proposed by an NIH panel (2004):

> The built environment is defined as all buildings, spaces, and products that are created, or modified, by people. It includes homes, schools, workplaces, parks/recreation areas, greenways, business areas and transportation systems. It extends overhead in the form of electric transmission lines, underground in the form of waste disposal sites and subway trains, and across the country in the form of highways. It includes land-use planning and policies that impact our communities in urban, rural and suburban areas. (p. 2)

In order to examine the complexities underlying the built environment and its influence on public health, several disciplines, most not directly related to the health sciences, are now giving this area of research increased attention. These disciplines include the architectural, urban and city, and regional planning fields. They are involved in investigations on how the “physical” and “social” environments (e.g., availability of public and green spaces, playgrounds, walking paths, neighborhood crime rate, etc.) may influence physical activity and dietary practices (Lake & Townshend, 2006; National Institutes of Health, 2004).

Research focusing on the built environment and its relationship to physical activity and health is in its infancy, and has not yet been linked in any systematic way with conventional biological and clinical measures of obesity or obesity-related cardiovascular risk. In addition, the ability of different methods of measuring the physical and social environments, including the use of publicly-available data (e.g., census and geocoded data), resident self-report, and independent investigator observations, to predict levels of physical activity and subsequent obesity, is unknown.

2.8.3 Measurement of the Built Environment

An important issue in the assessment of the environment and health is the method applied to measure the influence of the environment. Several approaches to assessing neighborhood environments exist. One method involves quantifying the extent to which environments contain resources that facilitate or hamper physical activity (Sallis, Johnson, Calfas, Caparosa, & Nichols, 1997). This type of assessment looks to apply an objective measure of the environment. Another strategy involves using self-report measures, or subjective assessments of the environment, with the implicit assumption, again, that features of the environment can facilitate or hamper activity. A third approach is a composite of both objective and subjective measures. This chapter reviews several studies that have applied these methods and approaches to the measurement of the environment, and their results. In addition, strengths and limitations of the study designs will be discussed in detail.

2.8.4 Studies Using Self-Report Measures of Environmental Attributes

The studies reviewed in this section assess the relationship between the built environment and physical activity utilizing the participants' self – reported perceptions of their individual environments. As seen in Table 8, the majority of studies assessing the built environment utilize this approach. Using the 1996 Behavioral Risk Factor Surveillance System (BRFSS) data for Maryland, Montana, Ohio, Pennsylvania, and Virginia, for example, researchers from the CDC (1999) assessed the relationship between neighborhood safety and physical inactivity. The study included 12,767 adults who responded to the Social Context Module found in the 1996 survey, in which participants were asked, "How safe do you consider your neighborhood to be?" Responses were "extremely safe," "quite safe," or "not at all safe." To assess activity levels, participants were asked how often they engaged in physical activity or exercise during the preceding month. Higher levels of perceived neighborhood safety were associated with reduced levels of physical inactivity. This relationship was most significant among older adults (OR = 2.3; 95% C.I. 1.1 – 4.7) after stratification by age and sex, and controlling for race and education. In fact, among those aged 65 and older, participants were 38.6% less likely to be inactive if they perceived their neighborhood as being "extremely safe," yet were 63.1% more likely to be inactive if they perceived their neighborhood as being "not safe at all" (Centers for Disease Control and Prevention, 1999b).

The CDC study illustrates the potential value of providing safe alternatives for physical activity in neighborhoods in an effort to keep high risk populations, such as older adults, active. However, this study also highlights several methodological issues. First, the built environment was assessed on the basis of one environmental variable which assessed safety. This is a very limited perspective of the built environment. Second, the study's geographic exclusiveness limited the generalizability to the entire U.S. population. Third, results derived from self-reported data may have resulted in some level of bias in the estimates. Fourth, this represents a cross-sectional association, and it is not clear if temporality exists. Finally, the study findings may have also been influenced by unmeasured confounding factors such as social and demographic variables (Centers for Disease Control and Prevention, 1999b).

Another cross-sectional study by Suminski et al. (2005) examined the relationships between the neighborhood environment and walking. The study included 413 males and females aged 18 years and older. To measure walking behavior and other types of physical activity, a reliable and valid questionnaire was used (correlation coefficient r = 0.58; relationship with physical activity log correlation coefficient r = 0.71) (Dishman & Steinhardt, 1988; Suminski, Poston, Petosa, Stevens, & Katzenmoyer, 2005; H. L. Taylor et al., 1978). Physical activity patterns were assessed via two types of questions: lifestyle (e.g., dog walking, walking for transportation, etc.) and exercise (e.g., walking for exercise) engaged in during the seven days prior to the interview. There were three types of walking variables used in this study: walking for transportation, walking a dog, and walking for exercise (Suminski et al., 2005).

Utilizing a previously proposed protocol for evaluating neighborhood environmental features, the authors created a ten-item questionnaire to assess the environment (Humpel, Owen, Iverson, Leslie, & Bauman, 2004; Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003; Suminski et al., 2005). The survey included four environmental features recommended by Pikora et al. (Pikora et al., 2003). These measures were entitled: 1) “functional” (the construction/integrity of neighborhood sidewalks and streets); 2) “safety” (neighborhood traffic volume and speed, lighting, and crime); 3) “aesthetic” (neighborhood cleanliness and views of buildings and scenery); and 4) “destinations” (availability of places in and around the participant's neighborhood to which they could walk such as shops, parks, work, or schools) (Suminski et al., 2005). For each item, participants rated the condition of the environmental features, utilizing a 10-point scale ranging from 1= "the worst" to 10="the best." Average scores were calculated for each environmental feature and recoded into a 3-item categorical variable: low, middle, and high. Each tertile was established using the cut-points based on the distributions for each feature score (Suminski et al., 2005).

After controlling for age and education, the authors observed that women were 4.5 times more likely to walk for exercise ($p < 0.05$) if their neighborhood safety was average compared to below average. Female participants were also three times more likely to walk their dog if neighborhood safety was average in comparison to below average ($p < 0.05$). Those women who reported having an average number of available places in and around their neighborhood to which they could walk were 5.7 times more likely to walk for transportation in their neighborhood ($p < 0.01$). Male participants who reported that the functional and aesthetic features of their neighborhoods were average, versus below average, were approximately 80% less likely to walk for transportation in their neighborhoods ($p < 0.05$) (Suminski et al., 2005).

The Suminski study demonstrates how individual perceptions play a role in shaping individual health behavior. Another strength of this study was the use of an established, reliable, and valid tool for measuring neighborhood environmental characteristics. It also had a markedly improved assessment of the environment compared to other reports. However, the use of objective measures could further enhance the examination of the relationship between these individual perceptions of the built environment and walking behavior. These results emphasize the importance of conducting more longitudinal studies to determine whether or not changes in neighborhood safety, and awareness of neighborhood destinations, influence walking in U.S. adults.

Nevertheless, there were several limitations in the study. Reporting bias may have been introduced into the study, since the walking and perceived environment variables were derived from participant self-report. The cross-sectional design of the study also limits the interpretation of cause and effect in this relationship (Suminski et al., 2005).

A. C. King et al. (2000) examined the personal and environmental barriers to participation in physical activity among U.S. women aged 40 and older. This cross-sectional study was unique in that it included a representative sample of minority women, including African American, American Indian-Alaskan Native, and Hispanic women. A sample of Caucasian women was also interviewed, which served as the reference population. Physical activity was measured using questions derived from the National Health Interview Survey (NHIS) and the BRFSS. To assess perceptions of the physical environment, participants were asked to grade the presence of sidewalks, heavy traffic, hills, streetlights, unattended dogs, enjoyable scenery, frequency of observing others exercising, and high levels of crime. Participants were also asked about the safety of walking or jogging alone in their neighborhood during the day (1 = very unsafe to 5 = very safe) (A. C. King et al., 2000).

Participants who reported the presence of dogs in their neighborhoods were 20% more likely to be physically active compared to those who reported no dogs (OR = 1.20; 95% CI 1.01-1.42). Those who perceived enjoyable environmental scenery were 42% more likely to be active compared to those who did not have the same perception (OR = 1.42; 95% CI 1.12-1.79). Women who frequently saw others exercise in their environment were 26% more likely to participate in more activity compared to those who did not report seeing others exercise (OR = 1.26; 95% CI 1.06-1.50) (A. C. King et al., 2000).

When stratified by race/ethnicity, White and Hispanic women were respectively, 48% and 89% more likely to be active given the presence of hills (OR = 1.48, $p < 0.05$; OR = 1.89, $p < 0.01$, respectively). African American women were more likely to be active if they frequently observed others exercise in their neighborhood (OR = 2.08; $p < 0.001$). Finally, in American Indian/Alaskan Native women, feeling more self-conscious about physical appearance was associated with being more active (OR = 1.19; $p < 0.01$) (A. C. King et al., 2000).

The results of the King study regarding personal and environmental barriers to participation in physical activity give insight on environmental influences on people of various racial/ethnic categories, and the need for more research in this area. The physical activity measures utilized in this study, as well as the classification of participants as inactive or active, were derived from survey techniques previously used by other major population-based physical activity examinations in the U.S. (A. C. King et al., 2000; United States Department of Health and Human Services, 1996a). The study also had several limitations, including the evaluation of a limited amount of environmental influences (due to a few systematic investigations previously conducted before this research was completed) (Eyler et al., 1998; A. C. King et al., 2000; Sallis et al., 1997). Next, the authors could not adequately assess the reasons why some participants were inactive, because they only assessed whether or not a specific environmental variable was present, as opposed to the participant's perceptions that the environmental variable influenced their behavior. The study was also limited in its generalizability to other populations. For example, the study used a telephone survey, but not everyone in the U.S. has a telephone.

Finally, the telephone survey was only conducted in English, thus excluding those women who did not speak fluent English (A. C. King et al., 2000).

W. C. King et al. (2003) also conducted a cross-sectional analysis to examine whether the walking distance to specific destinations (including parks, trails, and various types of business and services) from a person's home, were associated with both walking and total physical activity levels. The authors also assessed the participant's perception of the suitability of their neighborhood surroundings for walking. The authors utilized a cohort of 229 older, Caucasian, women in Pittsburgh, Pennsylvania, who were participants in a 15-year follow-up evaluation to a randomized, controlled trial of a walking intervention (1982-1985). At the time of the original study, these women were between the ages of 50 to 65, postmenopausal, and otherwise healthy. This study analysis included 149 women (79% of the 1999 cohort) who completed the physical activity and environmental questionnaires, and wore activity monitors (W. C. King et al., 2003).

A modified version of the Paffenbarger Activity Questionnaire was used to capture walking and total leisure-time physical activity levels during the past year. The Yamax DigiWalker pedometer, a valid and reliable activity monitor, was used to objectively measure physical activity levels (Bassett et al., 1996; W. C. King et al., 2003). To assess perceptions of the convenience, safety, aesthetics, and overall quality of the neighborhood environment for walking, a 52-item questionnaire was developed. At the time of study, the validity of the environmental questionnaire was in the process of being examined. In addition, the authors utilized 14 questions that assessed the convenience of walking to different types of destinations in the neighborhood. To obtain a global neighborhood walkability rating, an additional question that assessed the overall quality of the neighborhood surroundings, specifically for walking (poor, fair, good, or excellent) was added. For this population, all destinations within 20-minutes were considered within walking distance. A convenience score, ranging from 0 to 11 was calculated by adding the number of commonly walked to destinations within walking distance. An approximate number of total walking trips per month was calculated by summing the number of walking trips to any of the 11 commonly walked to destinations per month (W. C. King et al., 2003).

A significant relationship was found between the participants' neighborhood walkability rating and objectively and subjectively measured physical activity levels. An increase in the neighborhood walkability rating was associated with higher pedometer readings, walking levels, and total physical activity levels ($p = 0.0008$, 0.0077, and 0.0016, respectively). The authors also observed that as the neighborhood walkability rating improved, the numbers of destinations within walking distance of the home increased ($p = 0.0005$) (W. C. King et al., 2003).

This study indicates the need to maintain environments in which older women (or older adults in general) can continue to be physically active. The study design was strengthened by the application of a thorough assessment of the neighborhood environment. Another strength of the study was the use of a homogenous sample of older, White women who lived in neighborhoods of middle to high SES, therefore, decreasing the number of confounding variables (e.g., age, race, or SES). However, the use of this cohort also limited the generalizability of the findings to other populations. The study also relied on self-reported data in which recall and reporting biases were inherent. The study's small sample size, may have limited the power to detect significant differences in some analyses. It is also possible that participants who had previously walked to destinations were able to give a more accurate account of the time it took to walk from their residences to specific destinations. Additionally, those who walked frequently may have been more knowledgeable of those destinations that were closest to their homes. Thus, an overestimation of the relationship between convenience of destinations and walking, could have been possible if either of these statements were true (W. C. King et al., 2003).

In a cross-sectional analysis by Wilbur et al. (2003), the authors sought to: 1) explain the physical activity patterns of urban-dwelling, Midwestern, African American women; 2) determine the personal and environmental (both social and physical) correlates of their activity; and 3) gather suggestions from these women regarding changes in their neighborhoods that would promote more physical activity. The study included 399 African-American women aged 20 to 50 years, who resided in Chicago neighborhoods. For data collection purposes, the authors utilized the *Women and Physical Activity Survey*, which was administered via face-to-face interviews. Using questions derived from the BRFSS to assess physical activity, the participants were then classified into three activity groups (Centers for Disease Control and Prevention, 2002; Wilbur, Chandler, Dancy, & Lee, 2003). These groups were: 1) "meet recommendations" (5 or more days per week of moderate activity for 30 minutes or 3 or more days a week of vigorous activity for 20 minutes); 2) "insufficiently active" (some physical activity, but not enough to meet recommendations); and 3) "inactive" (reported no moderate or vigorous physical activity) (Wilbur et al., 2003). For subsequent regression analyses, these three groups were combined and evaluated using two approaches: 1) "meets recommendations versus "does not" (combination of "insufficiently active" and "inactive"); and 2) "any activity" (combination of "meets recommendation" and "insufficiently active") versus "no activity" (inactive) (Wilbur et al., 2003).

To measure the correlates of activity, single items and three social environmental scales were used. The social issues scale included five statements, describing how some women feel when they see other women exercising. The social roles scale encompassed nine statements, listing common barriers to exercise. The sense of community scale included four statements concerning the neighborhood. For each scale, participants rated the correlates of physical activity, utilizing a 4-point scale ranging from 1= “strongly agree” to 4=“strongly disagree.” These responses were therefore averaged to a possible range of 1 to 4 for each scale, where higher scales suggested fewer social issues, fewer barriers from social roles, and a reduced sense of community. Participants were also asked open-ended questions regarding suggestions for changes in their neighborhoods or in the workplace that would promote more physical activity (Wilbur et al., 2003).

For the social issues, social roles, and sense of community scales, Cronbach's alphas were equal to 0.42, 0.74, and 0.73, respectively. Again, for the social issues, social roles, and sense of community scales, the intraclass correlations (ICCs) were 0.68, 0.67, and 0.91, respectively. The ICCs for the physical environment questions ranged from 0.26 to 1.00, and the ICC for the physical activity level questions was 0.32 (Wilbur et al., 2003).

When comparing any activity versus no activity, those women who reported knowing people who exercised were 2.71 times more likely to report some activity compared to those women who did not know anyone that exercised (95% CI 1.32 - 5.55). When comparing any versus no activity, those women who perceived their neighborhood as being extremely or somewhat safe were 2.43 times more likely to be active compared to women who perceived their neighborhood as being slightly, or not at all safe (95% CI 1.19 - 4.99) (Wilbur et al., 2003).

A strength of the Wilbur study was the use of an all African American, female population, as a higher prevalence of inactivity is found among this group. Additionally, the use of face-to-face interviews, which permitted the involvement of women who do not have access to telephones, was also a strength of this study. However, this may have also resulted in a limitation of the study, as social desirability bias may have been introduced. Another limitation of the study included the possible exclusion of women who may be limited in mobility or social interaction, by conducting face-to-face interviews in public arenas, such as community clinics and health fairs. The cross-sectional design of the study also limits the ability to draw causal inference in the relationship between the environment (social and physical) and physical activity. Finally, the use of a primarily urban, all-African-American sample, limits the generalizability of the findings to other populations (Wilbur et al., 2003).

Hooker et al. (2005) also conducted a cross-sectional analysis to evaluate the association between race, perceptions of social and safety-related environmental characteristics, recommended physical activity levels, and walking in White and Black inhabitants of a rural South Carolina county. The study included 1,270 adults aged 18 to 96 years. A questionnaire was used to evaluate perceptions of social and safety-related environmental supports, which consisted of questions regarding perceived trust of neighbors and the physical activity level of neighbors, as well as questions concerning perceived traffic volume, streetlight quality, issues with unattended dogs, safety of public recreational facilities, and overall neighborhood safety, respectively. These items were assessed using a Likert-type scale in which the smallest number represented the more favorable response. For this study, the neighborhood was defined as the "the area within one half-mile or a 10-minute walk" from the participant's residence (Hooker, Wilson, Griffin, & Ainsworth, 2005). The test-retest reliability of these variables ranged from $r = 0.42$ and $r = 0.73$ at the neighborhood level (Hooker et al., 2005; Kirtland et al., 2003).

Using questions derived from the BRFSS to assess physical activity, participants were classified as either meeting the CDC's recommended level of physical activity, or not meeting the recommendation. Participants were asked if they walked for at least 10 minutes at a time for recreation, exercise, or transportation, or while at work. Those participants who replied "yes" were asked how many days per week, and how much time per day they walked. The participants were then classified as "walking 150 or more minutes per week " or "not walking at least 150 minutes per week" (Hooker et al., 2005).

There were no significant associations found among Black participants after stratifying by race. However, White participants who perceived their neighbors as being physically active were almost two times more likely to meet the CDC's physical activity recommendation, compared to those who did not have this perception (OR = 1.96; 95% CI 1.19 - 3.25; $p = 0.009$). Additionally, White participants who perceived their neighbors as being physically active were more than two times as likely to walk at least 150 minutes per week, compared to those who did not have this perception (OR = 2.51; 95% CI 1.54 - 4.08; $p < 0.001$). Also, White participants who perceived their neighborhoods as being safe from crime were almost two times more likely to walk at least 150 minutes per week, compared to those who did not think their neighborhoods were safe from crime (OR = 1.79; 95% CI 1.03 - 3.12; $p = 0.04$). Conversely, White participants who perceived their neighborhoods as having moderate traffic levels were 52% less likely to walk at least 150 minutes per week, compared to those who perceived heavy traffic in their neighborhoods (OR = 0.52; 95% CI 0.31 - 0.87; $p = 0.002$) (Hooker et al., 2005).

Some limitations of the Hooker study included the cross-sectional design that limited the ability to establish causal inference between perceptions of the neighborhood and physical activity and walking. Next, seasonality issues may have been present, as the questionnaire was administered during the winter months of January and February. Additionally, there were several variables that exhibited low to fair validity ($_{K}$ = -0.02 - 0.28), while other measures related to environmental determinants of physical activity, such as access, convenience, sidewalks, and aesthetics, were not utilized in this study (Burton, Turrell, Oldenburg, & Sallis, 2005; Giles-Corti & Donovan, 2002a; Hooker et al., 2005; Owen, Humpel, Leslie, Bauman, & Sallis, 2004). Since participants resided in a primarily rural area, the findings of this study may not be generalizable to all populations. The need for more quantitative research that primarily focuses on racial/ethnic influences on environmental perceptions is emphasized, as no significant relationships between perceptions of social and safety-related environmental characteristics, physical activity, and walking were found among Black participants. These findings also highlight the importance of establishing and implementing appropriate, activity-promoting interventions (Hooker et al., 2005).

A qualitative study by Sanderson, Littleton, and Pulley (2002), sought to investigate rural African American women's perceptions of physical activity, and possible environmental (both physical and social) circumstances that may be unique to them. Six focus groups were conducted among African American women aged 20 to 50 years, who resided in Wilcox County, a rural community in southwest Alabama, who were not currently exercising regularly (Sanderson, Littleton, & Pulley, 2002).

Most participants mentioned hot weather and the lack of safe places to walk as frequent barriers to engaging in regular physical activity. Additionally, a lack of adequate facilities was also thought of as a barrier to physical activity, as many women reported that there were no recreational or community centers with exercise equipment available. While walking was identified as a beneficial form of physical activity, the women reported that sidewalks, streetlights, and parks were scarce. Furthermore, facilities that were available were believed to be poorly equipped and inefficiently maintained (Sanderson et al., 2002).

On the other hand, rural, quiet areas, with little traffic, were said to promote regular physical activity. The local high school's swimming pool was accessible during the summer months, and does offer water aerobics course, however many participants were concerned with safety and proper supervision of the area. The presence of a physical therapy center was also noted as a facility suitable for physical activity, yet some considered the space too small, while others stated the fees to utilize the facility were too expensive (Sanderson et al., 2002).

Some suggestions to increase physical activity among this group of women, included the development of facilities and amenities to accommodate physical activities such as group exercise courses, the improvement of outdoor areas, such as the addition of sidewalks, and trails, ball fields, and playgrounds, to make walking safer and more pleasant (Sanderson et al., 2002).

In another qualitative analysis by Griffin et al. (2008), the authors sought to assess the perceptions of African Americans residing in a low-income, high crime neighborhood to: 1) identify potential barriers to physical activity; and 2) obtain suggestions for physical activity interventions for their neighborhood. The study included 27 African American adults aged 20 to 79 years, who were asked to participate in one of three focus groups conducted in their community. All participants were residents of, or were closely connected to the small, South Carolina community being evaluated (Griffin, Wilson, Wilcox, Buck, & Ainsworth, 2008).

The focus groups' discussion guide was comprised of questions that would give the investigators a better understanding of the participants' perceptions of influences affecting their participation in physical activity (i.e., interpersonal, social [family and neighbors], and environmental influences). There were also questions regarding recommendations for increasing the participants', their families, and their neighbors' overall physical activity (Griffin et al., 2008).

Several themes related to environmental barriers to physical activity were established throughout the focus groups. The safety-related category was divided into criminal and noncriminal activity. Criminal items were often derived from illustrations of past crimes or fear of certain types of crimes. According to Griffin et al. (2008), "These comments included specific references to drug trafficking, muggings, theft, prostitution, homicide, and desire for more action by the police to curtail these activities in their neighborhood" (Griffin et al., 2008, p. 185). Noncriminal items were related to safety and fear as opposed to crime specifically. This theme included statements regarding sidewalks, stray dogs, lighting, and traffic. The non-safety-related category encompassed themes specifically related to participants' concerns about access to environmental supports for physical activity, including: neighborhood aesthetics, lack of neighborhood trails, desire for more environmental infrastructure, and a desire for more facilities and programs.

As stated by Griffin et al. (2008):

> Community connectedness and/or social support included comments about wanting to increase the sense of connectedness with neighbors and how social support would help increase physical activity. Participants discussed bringing people from the neighborhood together; however, the purposes were different. For example, comments regarding community connectedness related to how to make the neighborhood safer or how to get people out of their houses and being more physically active in the neighborhood. (p. 186)

Other themes addressed in the focus groups were related to the participants' desire to have structured, activity-related programs located in their community (e.g., basketball or baseball).

Finally, the participants stated how they would like more police involvement in the neighborhood (Griffin et al., 2008).

The findings of the Griffin study are interesting, as they recognize the ideas and suggestions of community members for dealing with safety as a way to increase physical activity. However, there were several limitations to the study. The study's small sample size was not representative of the overall community. All of the study participants were African American, with the majority of them older than 50 years of age, therefore limiting the generalizability of the study results to other populations. Finally, some of the participants' responses to the focus group questions may have been influenced by a neighborhood shooting that took place a short time before the focus groups were conducted (Griffin et al., 2008).

International Studies

Several studies designed to investigate the relationship between physical-environmental attributes and walking for various reasons in the neighborhood were conducted in non-U.S. populations. Using a cross-sectional design, Humpel et al. (2004), examined whether the perceived attributes of local environments in Australia were associated with walking for four different purposes: general neighborhood walking, walking for exercise, walking for pleasure, and walking for transportation. The sample included 399 participants who resided in a regional, coastal Australian city and the surrounding neighborhoods. To measure neighborhood walking, an index of estimated minutes of walking per week for each walking type was calculated by multiplying the frequency of walking by the number of usual minutes. The study included 24 neighborhood environmental attribute questions, in which participants were instructed to select the most appropriate value on a 10-point scale (Humpel, Marshall, Leslie, Bauman, & Owen, 2004; Humpel, Owen, Iverson et al., 2004; Humpel, Owen, & Leslie, 2002; Humpel, Owen, Leslie et al., 2004; Saelens, Sallis, Black, & Chen, 2003). The four factors interpreted as influencing walking, as derived from the questionnaire, were accessibility, aesthetics, safety, and weather. Cronbach's alpha coefficient of internal consistency was calculated for each subscale. All scores were above the 0.70 recommended level (accessibility $\alpha = 0.88$; aesthetics $\alpha = 0.81$; safety $\alpha = 0.73$; and weather $\alpha = 0.77$). A total score for each environmental attribute was calculated by adding the selected scores for each factor, and then dividing by the number of items in each category. With all groups having a final score out of ten, equal comparisons were made across each category (Humpel, Owen, Iverson et al., 2004).

Humpel et al. (2004) used the following for data analyses:

> The scores of accessibility, aesthetics, safety, and weather were recoded into categorical variables with three levels: low (a less positive perception of the environment); moderate; and high (a highly positive perception of the environment). A high score for weather meant that the weather did not inhibit walking. (pp. 120-121)

Overall, higher proportions of neighborhood walkers were observed among participants with high perceptions for aesthetics (66.7%; $X^2 = 17.08$; $p < 0.001$). Participants with the most positive perceptions for all four environmental perception categories demonstrated significantly higher proportions of walking for exercise. Higher levels of walking for pleasure were reported by those individuals with the most positive perceptions for accessibility (45.2%; $X^2 = 7.28$; $p < 0.05$) (Humpel, Owen, Iverson et al., 2004).

The study findings illustrate the need for more innovative methods that specifically focus on the importance of local environmental characteristics that may increase physical activity behaviors, such as walking. However, because measures of walking and perceptions of environmental characteristics were based on self-reported data, reporting and/or recall bias may have been introduced into the study. Participants may have been subject to cognitive overlap when responding to questions regarding walking for different purposes. Using this multiple assessment of walking format, it is also possible that participants may have inadvertently overestimated their walking levels (Humpel, Owen, Iverson et al., 2004).

Ball et al. (2001) utilized a cross-sectional study design to explore relationships between environmental aesthetics, convenience, walking companions, and walking for exercise or recreation in Australia. The study population included 3,392 adults who completed the 1996 Physical Activity Survey for the state of New South Wales via telephone interview. Survey items assessed walking patterns over the past two weeks, such as frequency of walking for exercise and amount of time doing so. Walking for exercise variables were categorized into any or no walking in the past two weeks. Perceptions of environmental influences were also examined in a limited fashion. These items included measurement of local environment aesthetics, convenience to facilities, and the social environment (companionship) for walking. For all questions, a five-point Likert scale, ranging from 1 = "strongly agree" to 5 = "strongly disagree", was applied (Ball, Bauman, Leslie, & Owen, 2001).

Ball et al. (2001) assessed three perceptive attributes to measure participants' environment. Each characteristic was measured using the following statements:

1. Aesthetic nature
    a. "Your neighborhood is friendly;"
    b. "Your local area is attractive;" and
    c. "You find it pleasant walking near your home."

An aesthetics score ranging from 3 to 15, was derived by adding these items (Ball et al., 2001).

2. Convenience to facilities
    a. "Shops are in walking distance;"

b. "A park or beach is within walking distance;" and
c. "A cycle path is accessible."

3. Social environment (companionship) for walking
   a. "You have someone (or a pet) to walk with in the neighborhood."

For study analyses, the social environment variable was dichotomized (Ball et al., 2001).

Among those participants who reported more convenient environments, higher proportions of walkers were found (men: $X^2 = 19.1$; $p < 0.05$; women: $X^2 = 11.2$; $p < 0.05$). Higher proportions of walkers were also found among those who reported more aesthetically favorable environments (women: $X^2 = 30.7$; $p < 0.05$). Significantly higher proportions of male ($X^2 = 3.8$; $p = 0.05$) and female ($X^2 = 30.7$; $p < 0.05$) participants who stated having someone or a pet to walk with, reported walking within the past two weeks, compared to those who reported no companionship for walking (Ball et al., 2001).

In the Ball study, environmental characteristics such as aesthetics, convenience, and walking companions were important influences on walking among urban Australians. However, since walking for exercise was analyzed as a dichotomous variable, it is difficult to determine if there are differences in the factors influencing persons who walk minimally compared to those who sufficiently walk to gain health benefits. The authors only applied one measure of the social environment, limiting the ability to capture other avenues for social support for walking, such as encouragement (Ball et al., 2001).

The 2003 Health Survey for England (HSE) was used by Poortinga (2006) to cross-sectionally examine: 1) the associations of the perceptions of the local environment with obesity, self-rated health, and physical activity; and 2) whether physical activity mediates the association between the perceptions of the environment, and obesity and self-rated health. The study population included 14,836 English adults who lived in private households. Three physical activity measures were utilized. The first measure was overall physical activity, which indicated the number of days during the last four weeks that participants were moderately or vigorously active for at least 30 minutes (housework, home-based manual work, walking, occupational activity, and sports). The second activity measure was based on the variable indicating the number of days in the last four weeks participants had engaged in any sports activity that lasted at least 30 minutes. The third measure was derived from the variable indicating the number of days during the last four weeks participants had walked for at least 30 minutes. Weight and height measurements were taken by a nurse, and obesity was assessed using participant BMI, as defined by the World Health Organization (WHO) (Poortinga, 2006).

Individual perceptions of the local environment were obtained from respondents by assessing the friendliness of the neighborhood; access to amenities; presence of social nuisances ("teenagers hanging around" and "vandalism/graffiti/deliberated damage to property"); and type of area where participants lived (i.e., urban, suburban, or rural). The friendliness of the neighborhood and access to amenities items were measured using a transformation of the original four-point Likert scales (0 = "disagree" and 1 = "agree"). However, regarding access to amenities, participants were also asked, "How easy it is to get to 'a medium to large supermarket' and to 'a post office' using their usual type of transport." These responses were recoded as (1 = "very or fairly easy" and 0 = "very or fairly difficult"). The scales for the presence of social nuisances variable were recoded as (1 = "a fairly or very big problem" and 0 = "not a very big problem at all") (Poortinga, 2006).

Access to leisure facilities increased the likelihood of doing at least two sports activities per week by 17%. Those who perceived good access to a post office and leisure facilities were

42% and 10% more likely to achieve the Department of Health's recommended five active days per week (London Department of Health, 2004; Poortinga, 2006). There was a positive association between being obese and perceptions of social nuisances for teenagers hanging around and vandalism/graffiti/deliberate damage to property (OR = 1.25, 95% CI 1.09 – 1.43; OR = 1.17, 95% CI 1.01-1.34, respectively). There was also a negative association between access to leisure facilities and being obese (OR = 0.83, 95% CI 0.75-0.92) (Poortinga, 2006).

The results of the Poortinga study indicate that certain environmental characteristics may contribute to the risk of obesity. On the other hand, the potential for reporting bias was present, due to the use of self-reported data. The access to amenities variables may not have been the most reliable when measuring whether or not these amenities are within walking distance, because individuals utilize various methods of transportation. Finally, since activity was assessed by only three dichotomous variables (i.e., walking, sports, and overall physical activity), other activities that were not included in these categories could have been missed, therefore, limiting the ability to adequately ascertain the mediating effects of physical activity between the perceived environment, obesity, and health. Continued research, both subjectively and objectively, is needed to examine the specific mechanisms that tie the perceptions of the environment to obesity and overall health (Poortinga, 2006).

Table 8. Studies Utilizing Only Self-Report Measures of Environmental Attributes

Study	Attributes Assessed	Measures
CDC, 1999	▪ Safety	▪ 1996 BRFSS
Suminski et al., 2005	▪ Accessibility ▪ Aesthetics ▪ Neighborhood characteristics (Functional) ▪ Safety	▪ 2 questions on lifestyle activity & exercise ▪ 3 types of walking assessed • Transportation • Dog • Exercise
A.C. King et al., 2000	▪ Aesthetics ▪ Safety ▪ Social environment	▪ Survey on environmental features ▪ Questions derived from NHIS & BRFSS
W.C. King et al., 2003	▪ Accessibility ▪ Aesthetics ▪ Neighborhood characteristics ▪ Safety	▪ 52-item questionnaire ▪ Paffenbarger Activity Questionnaire (modified version) ▪ Yamax DigiWalker pedometer
Wilbur et al., 2003	▪ Social environment • Social issues • Social roles • Sense of Community ▪ Physical environment • Accessibility • Presence of sidewalks • Presence of unattended dogs • Street lighting • Safety • Traffic	▪ *Women and Physical Activity Survey* ▪ Questions derived from BRFSS
Hooker et al., 2005	▪ Safety ▪ Social environment	▪ Survey that evaluated the perceptions of social and safety-related environmental supports ▪ Questions derived from BRFSS
Sanderson et al., 2002	▪ Safety ▪ Neighborhood characteristics ▪ Accessibility	▪ Focus Group
Griffin et al., 2008	▪ Social environment ▪ Interpersonal influences ▪ Environmental influences	▪ Focus Group

Table 8 (continued)

Humpel et al., 2004	▪ Accessibility ▪ Aesthetics ▪ Safety ▪ Weather	▪ Survey that assessed perceptions of the neighborhood environment ▪ Survey that assessed walking for 4 different purposes • General • Exercise • Pleasure • Transportation
Ball et al., 2001	▪ Accessibility ▪ Aesthetics ▪ Social environment (companionship) for walking	▪ Cross-sectional survey of local environmental attributes ▪ 1996 Physical Activity Survey for the state of New South Wales, Australia • Walking vs. not walking for exercise in last 2 weeks
Poortinga, 2006	▪ Accessibility ▪ Friendliness ▪ Neighborhood characteristics ▪ Presence of social nuisances	▪ Questionnaire that assessed individual perceptions of the local environment ▪ Questionnaire that assessed overall PA, any activity, completion of a 30-minute walk, and BMI (as defined by WHO)

CDC = Centers for Disease Control and Prevention; BRFSS = Behavioral Risk Factor Surveillance System; NHIS = National Health Interview Survey; PA = physical activity; BMI = body mass index; WHO = World Health Organization.

2.8.5 Studies Using Objectively Assessed Environmental Attributes

Studies that have relied solely on self-report measures or subjective assessments of the environment are inherently susceptible to reporting and/or recall bias. The use of objective measures, however, such as Geographic Information Systems (GIS), allow researchers to make more systematic assessments of the environment (Porter, Kirtland, Neet, Williams, & Ainsworth, 2004). Geographic Information Systems is one of the most widely used methods for acquiring objectively measured data.

As stated by Kurland (2007):

> GIS is defined as a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems. GIS

> applications use both spatial information (maps) and databases to perform analytical studies. (K. Kurland, personal communication, August 28, 2007)

When measuring the environment, and its subsequent relationship to physical activity, GIS is an important tool, because it alleviates a number of methodological inaccuracies characteristic of self-reported environmental data, and increases the quantity and quality of environmental variables available to investigators (Bauman, Sallis, & Owen, 2002; Porter et al., 2004).

Other objective techniques used in conjunction with GIS include the global positioning system (GPS) and geocoding. The global positioning system is a satellite-based navigation system and precise positioning technology, consisting of a network of 24 satellites. The global positioning system was originally developed for use by the military, but was made available for civilian use (e.g., commercial or scientific) in the 1980s (Garmin, 2008; National Aeronautics and Space Administration, 2008; Southern California Integrated GPS Network, 1998). Geocoding is the "creation of attributes that describe the data" (Porter et al., 2004). This methodology was utilized by W.C. King et al. to evaluate neighborhood attributes and activity levels in the greater Pittsburgh, Pennsylvania area (Table 9).

W. C. King et al. (2005) examined the relationship between physical activity levels and objectively measured neighborhood characteristics (SES, urban form, and proximity to businesses and facilities) among older women. The study population included a cohort of 158 randomly selected, older, postmenopausal, Caucasian, and African-American women in Pittsburgh, Pennsylvania who were participants in the Woman on the Move through Activity and Nutrition (WOMAN) Study. All participants were either overweight or obese. To assess physical activity levels, each participant wore the Yamax Accusplit (Accusplit, Inc., San Jose, CA) pedometer, a valid and reliable physical activity monitor, for seven consecutive days on their dominant hip (Bassett et al., 1996; W. C. King et al., 2005). The number of steps taken was recorded in a daily activity diary, and average steps per day were calculated. The home address of each participant was geocoded using *ArcView 8.2* (Environmental Systems Research Institute, Inc., Redlands, CA, 2002). The geocoded addresses were then linked to census block groups. The median year in which homes were built was used as a proxy measure for urban form. A distance of 1500 meters (20-minute walk away) was considered within walking distance of businesses and facilities (W. C. King et al., 2005).

Positive associations were found between physical activity levels and living within walking distance of a golf course and post office ($p = 0.0081$ and 0.0082, respectively). After controlling for age, education, race/ethnicity, smoking status, and BMI, the investigators found that the percentage of residents living in poverty, residing within walking distance of a post office or golf course, and living in a neighborhood with houses built between 1950 and 1969 were all independently associated with more physical activity ($p = 0.0259$, 0.0357, 0.0104, and 0.0068, respectively) (W. C. King et al., 2005).

The findings from the King study are important, because they highlight the role of objectively measured neighborhood characteristics in older adult activity. However, this study had several limitations. The authors did not assess many environmental variables that may have influenced activity levels (i.e., aesthetics and safety). The study population also consisted of a largely, homogenous cohort of White (90.5%), postmenopausal, married, nonsmoking, educated, and overweight or obese women from Pittsburgh; therefore, limiting the generalizability to other populations. However, these demographics are similar to that of postmenopausal women in the U.S. (W. C. King et al., 2005).

Table 9. Studies Utilizing Only Objectively Assessed Environmental Attributes

Study	Attributes Assessed	Measures
W.C. King et al., 2005	▪ Accessibility ▪ SES ▪ Urban Form	▪ Objectively measured neighborhood characteristics ▪ Yamax Accusplit pedometer

SES = socioeconomic status.

2.8.6 Studies Using both Self-Report and Objectively Assessed Environmental Attributes

Assessing the interaction between perceived and actual built environment attributes and how they relate to physical activity is essential, as it is unknown whether environmental perceptions of the built environment have an independent, synergistic, or shared relationship with the actual environment regarding physical activity (McGinn, Evenson, Herring, Huston, & Rodriguez, 2007; Saelens, Sallis, & Frank, 2003). To acquire a thorough understanding of environmental effects on physical activity, a systematic investigation of subjective and objective measurement strategies is required (Kirtland et al., 2003; Sallis et al., 1997). However, previous research examining agreement between self-reported and objective environmental variables is limited (Table 10) (Troped et al., 2001).

Troped et al. (2001) investigated the associations between both perceived and objectively measured physical environmental variables and the use of a community rail-trail. This was a cross-sectional study in which the authors utilized a mail-administered survey of adults living in Arlington, Massachusetts. GIS data was also obtained for the town. The town of Arlington was used for this study, because it was one of three towns through which the Minutemen Bikeway passes. This is a rail-trail that is used for both recreational and transportation-related physical activity. The study included 419 Caucasian men and women aged 18 years and older. The authors developed the *Arlington Physical Activity and Bikeway Survey*, which included fifty-three questions used to assess the residents' physical activity patterns and factors possibly associated with the use of the trail (Troped et al., 2001).

A neighborhood environment scale measuring neighborhood features, perceived safety, and neighborhood character was used to assess perceptions of the physical environment. The neighborhood features variable was calculated as the sum of eight characteristics of the participants' neighborhoods such as presence of sidewalks, lack of hills, and lack of crime. Each attribute was measured with a dichotomous (yes or no) variable. Using a five-point Likert scale, perceived safety was evaluated by an item that measured how safe a participant felt walking in their neighborhood during the day. Neighborhood character was a three-category variable that required each participant to grade their neighborhood as either residential, mixed residential-commercial, or mostly commercial. The scores from the three components were added to calculate a neighborhood environment scale, with higher scores indicating an environment that better facilitates physical activity. One-week, intraclass test-retest reliability for this scale was 0.68 for 110 male and female college students (Sallis et al., 1997; Troped et al., 2001). Three additional variables measuring the perceived physical environment included self-reported distance to the Bikeway, a steep hill barrier, and a busy street barrier. Both environmental barrier items had a possible yes or no response (Troped et al., 2001).

The primary physical activity measure in this study was the use or nonuse of the Minuteman Bikeway. A Bikeway user was defined as a participant who reported any use of the Minutemen Bikeway during the previous four-week period. The data derived from GIS were used to create the three objective measures of the physical environment: road network (functional), distance to the Bikeway from participants' homes, a busy street barrier, and a steep hill barrier (Troped et al., 2001).

The environmental measures used by Troped et al. (2001) included the following, functional distance between two places (DeMers, 1997; Troped et al., 2001), GIS distance, GIS busy street barrier, and "shortest distance route" (Troped et al., 2001).

Those who reported not having to cross a busy street were approximately twice as likely to use the Bikeway as those who reported this barrier. Those participants who described their neighborhood as residential compared to those who described their neighborhood as mixed residential/commercial or commercial were about half as likely to use the Bikeway (OR = 0.56, 95% CI 0.36 - 0.86). In the GIS model, those participants who did not have to bike over a slope ≥10% for a continuous distance of 100m or more were almost twice as likely to be Bikeway users compared to those who had this objectively measured barrier (Troped et al., 2001).

The results of the Troped study illustrate the importance of understanding how environmental barriers such as travel distance and hilly terrain can potentially affect physical activity patterns or use of community facilities. These findings also offer preliminary support for the use of GIS as a tool that may provide a more sound understanding of how physical environmental factors influence physical activity participation (Troped et al., 2001). Nevertheless, there were several limitations found in the Troped study. First, the authors were unable to make direct comparisons with other research because the outcome variable was the use of a trail, rather than physical activity per se. Second, there was potential response bias in the study sample; given the data indicated age and gender differences between respondents and non-respondents. Third, study participants appeared to be more active (20% reported no activity) compared to Massachusetts adults overall (25% inactive according to the 1998 BRFSS), therefore introducing sampling bias into the study (Centers for Disease Control and Prevention, 1999a; Troped et al., 2001). Next, the study sample included a homogenous cohort of White and well-educated adults who lived in an area that is considered to be safe and well maintained; thus, limiting the generalizability to other populations. Finally, causal inference could not be made due to the cross-sectional study design (Troped et al., 2001).

Rutt and Coleman (2005) investigated the relationship between the built environment, physical activity, and BMI among a largely Hispanic population in El Paso, Texas. A total of 943 participants residing in El Paso County were randomly selected to participate in a phone survey. In this study, an individual's neighborhood was defined as the area encompassing a 2.5-mile radius from their home. BMI was derived from self-reported height and weight data. To capture the amount of physical activity during the last month, each participant was asked to report the number of times they participated in 14 different activities and the average amount of time spent engaging in each activity.

Using the Compendium of Physical Activities as a guide, physical activities were categorized into light, moderate, and vigorous categories based on their Metabolic Equivalent (MET) value (Ainsworth, Haskell et al., 1993; Rutt & Coleman, 2005). Fourteen items were used to assess perceived barriers to exercise, based on a five-point Likert-type scale (from 1 = "never prevents me" to 5 = "always prevents me"). *ArcView* GIS was used to measure sidewalk availability; the number of physical activity facilities (i.e., parks, gyms, schools, and biking/walking paths) within a 2.5-mile radius of residence; and the shortest distance from each residence to each facility. Street addresses, survey data, and GIS data were all linked and geocoded, and then used to create objective variables for this study (Rutt & Coleman, 2005).

Moderate intensity physical activity was negatively associated with BMI ($p = 0.05$). Younger age ($p = 0.0002$), and increased distance to physical activity facilities ($p = 0.04$), were found to be associated with increased time spent engaging in vigorous physical activity ($R^2 = 0.14$) (Rutt & Coleman, 2005).

This was the first study reviewed in this report in which the majority of participants were of Hispanic ethnicity. Thus, emphasizing the importance of examining the role the environment plays in promoting increased physical activity among racial/ethnic minorities.

The Rutt and Coleman study had several strengths, including 1) the use of a large, representative community sample; and 2) the use of objectively measured environmental variables. Limitations of the study included: 1) the use of aerial photographs to assess sidewalk availability (problems were encountered because of trees in the Rio Grande valley and due to security reasons, missing photographs around the Fort Bliss Army Base); 2) aerial photographs were taken five years before the survey data was collected; 3) physical activity, weight, and height variables were all self-reported; 4) no information on the perceived environment was gathered due to the use of preexisting survey data; and 5) the use of a telephone survey, given all persons who reside in the U.S. do not have telephones (Rutt & Coleman, 2005).

Kirtland et al. (2003) utilized a community survey to examine perceptions of environmental supports for physical activity. The authors then sought to validate those perceptions using GIS methods at the neighborhood and community level. The study included 408 Sumter County, South Carolina residents between the ages of 18 and 96 years. Using a simple random sampling design, test-retest methods were used to assess the reliability of the survey items in an independent sample. The 2001 BRFSS physical activity module was used to assess physical activity. According to Kirtland et al. (2003), the "neighborhood was defined as a

0.5-mile radius or 10 minute walk from the participant's residence" (p. 325). A Likert scale was used to measure neighborhood attributes, which included neighborhood characteristics, barriers to physical activity, social issues, and access (presence or absence) to environmental supports. Also, according to Kirtland et al. (2003), "community was defined as a 10-mile radius or 20 minute drive from the participant's residence" (p. 325). A three-point scale was used to assess community survey variables, which measured whether participants used, did not use, or did not have the environmental support for physical activity. Data collected from established databases, GPS units, telephone interviews, and in-person audits were stored in a GIS database and used to create the objective variables for environmental supports for physical activity (Kirtland et al., 2003).

For the neighborhood variables, the authors observed that agreement between neighborhood items and GIS objective measures was highest for access to sidewalks and public recreation facilities, safety/crime, equitable public spending on facilities, trust of neighbors, and streetlights (κ = 0.19 to 0.37). Conversely, when examining agreement by activity level (active, insufficiently active, and inactive), using pairwise comparisons and z–test statistics, it was observed that active and insufficiently active participants demonstrated higher agreement in their perceptions of access to public recreation facilities, compared to inactive participants (z = 2.66, p = 0.008; z = 2.61, p = 0.009, respectively). For the community survey variables, the highest agreement between community items and GIS objective measures was found for access to malls for physical activity (κ = 0.25). Alternatively, when examining agreement by activity level (active, insufficiently active, and inactive), using pairwise comparisons and z–test statistics, it was observed that insufficiently active participants had higher agreement in their perceptions of safety of recreation facilities compared to active or inactive respondents (z = 3.17, p = 0.001; z =

2.83, p = 0.005, respectively). Also, insufficiently active participants had higher agreement for access to trails compared to active participants (z = 2.91; p = 0.004) (Kirtland et al., 2003).

A recent study by Mujahid et al. (2008), evaluated the relationship between physical neighborhood environments and BMI. This analysis consisted of a subpopulation of 2,865 Caucasian, African American, and Hispanic MESA study participants, aged 45 to 84 years, who participated in the MESA neighborhood study, and whose residential addresses had previously been geocoded and were available at baseline (Mujahid et al., 2008).

All demographic and sociodemographic variables, such as age, race/ethnicity, gender, education, income, diet, and the length of time the participant lived in the neighborhood, were all obtained by questionnaire. The participants' diet was evaluated by a separate 120-item food frequency questionnaire adapted from the Insulin Resistance Atherosclerosis Study (Block, Woods, Potosky, & Clifford, 1990; Mayer-Davis et al., 1999; Mujahid et al., 2008). Two measures of diet were obtained, total caloric intake (kilocalories) and the Alternate Healthy Eating Index (AHEI) (McCullough et al., 2002; Mujahid et al., 2008). The AHEI is a composite of dietary patterns and eating behaviors based on previously established guidelines (McCullough et al., 2002; McCullough & Willett, 2006; Mujahid et al., 2008). Scores from AHEI range from 2.5 to 8.75. Higher scores suggest a higher quality diet, one which includes a higher intake of fruits and vegetables, soy, protein, white meat, cereal fiber, polyunsaturated fats, and multivitamins, and a lower intake of alcohol, saturated fats, and red meat. Physical activity was assessed by an activity questionnaire adapted from the Cross-Cultural Activity Participation Study. The physical activity variable evaluated intentional activity measured in MET hrs/day (Irwin et al., 2000; Mujahid et al., 2008).

For this study, the neighborhood was defined as the area surrounding one mile of the participant's residence (Mujahid, Diez Roux, Morenoff, & Raghunathan, 2007; Mujahid et al., 2008). Six neighborhood characteristics were assessed via the community survey completed by 5,988 non-MESA residents, identified by random digit dialing, who resided in the same neighborhoods (census tracts) as participating MESA participants (Mujahid et al., 2007; Mujahid et al., 2008). The neighborhood characteristics evaluated were: aesthetic quality, walking environment, availability of healthy food options, safety, violent crime, and social cohesion (Ball et al., 2001; M. L. Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Giles-Corti, Macintyre, Clarkson, Pikora, & Donovan, 2003; W. C. King et al., 2005; Mujahid et al., 2008; Sampson, Raudenbush, & Earls, 1997; Stahl et al., 2001). The respondents agreement was assessed using a five-point Likert scale (1 = "strongly agree" to 5 = "strongly disagree"), with exception of violent crime, which utilized a four-point scale (1 = "often" to 4 = "never"). All scales demonstrated good internal consistency (Cronbach's $\alpha = 0.75$, $\alpha = 0.73$, $\alpha = 0.78$, $\alpha = 0.77$, $\alpha = 0.83$, and $\alpha = 0.74$ for aesthetic quality, walking environment, availability for healthy food options, safety, violent crime, and social cohesion, respectively) and two-week test-retest reliabilities (intraclass correlation coefficient = 0.83, 0.60, 0.69, 0.88, 0.72, and 0.65, respectively) (Mujahid et al., 2007; Mujahid et al., 2008). Gender specific standardized scores were calculated in all analyses by subtracting the mean (physical environment means: women = 6.97 and men = 6.98), and dividing this value by the respective standard deviation (SD) (physical environment SD: women = 0.83 and men = 0.81). Higher scores indicated better physical environments. Since previous research had already identified concordance for the measured neighborhood variables with individuals living within the same area, census tract data was used as an alternative to neighborhoods (Mujahid et al., 2007; Mujahid et al., 2008).

The authors observed that all sociodemographic variables (with the exception of age), race/ethnicity, income, and education, were all associated with neighborhood environments. African Americans were found to live in neighborhoods with the poorest physical environments, followed by Hispanics, and then Caucasians. For both sexes, higher education levels were also associated with better neighborhood physical environments (Mujahid et al., 2008).

There were also significant associations with neighborhood physical environments and BMI. In fact, it was observed that participants who lived in neighborhoods with better physical environments had a lower mean BMI when compared to those who resided in the poorest physical environments (adjusted mean difference for women = -2.38; 95% CI -3.38 - -1.38; adjusted mean difference for men = -1.20; 95% CI -1.84 - -0.57). The authors also found evidence indicating that one's diet and physical activity level may mediate the association between neighborhood physical environments and BMI. When the authors controlled for age, race/ethnicity, income, education level, as well as total energy intake, AHEI, and physical activity, the mean change in BMI decreased from -1.06 to -0.69 in women, and from -0.73 to -0.44 in men (Mujahid et al., 2008).

Some strengths of this study include the large, racially diverse study population, and the accessibility to detailed neighborhood environment characteristics obtained from the non-MESA participants. On the other hand, a few limitations of this study include its cross-sectional and observational study design. This prevents the ability to determine causality in the relationship between neighborhood environments and obesity. Self-selection bias may have also been present, as it is hard to determine the reasons why certain people reside in certain neighborhoods. Additionally, the fact that participants may spend different amounts of time in their neighborhoods presents another limitation. The majority of the MESA participants in this population were retired, and reported spending 75% of the time in their respective neighborhoods (Mujahid et al., 2008).

A recent study by Li et al. (2009), sought to examine the relationship between neighborhood built environment characteristics, individual level eating and physical activity behaviors, and changes in body weight (Li et al., 2009).

The study population for this analysis was obtained from the Portland Neighborhood Environment and Health Study, a multilevel examination designed to explain how the built environment may influence levels of obesity and physical inactivity. The 1,145 participants were aged 50 to 75 years, and completed a baseline, and one year follow-up survey via a face-to-face interview. During both meetings, anthropometric measures of body weight (in pounds; 1 pound = 0.45 kg), height (in inches; 1 inch = 2.54 cm), and waist circumference (in inches; 1 inch = 2.54 cm) were obtained. Participants also completed survey questionnaires concerning demographic information, health status, dietary practices, and physical activity levels during these visits as well. Geographic databases and census data were obtained separately (Li et al., 2009).

Physical activity levels were determined utilizing questions derived from the BRFSS to evaluate the frequency (number of days), length (in minutes), and intensity of physical activity (Centers for Disease Control and Prevention, 2008a; Li et al., 2009). Changes in physical activity levels were calculated by subtracting baseline values from follow-up values (Li et al., 2009).

To assess the participants eating-out behavior, two questions were asked, "How often do you eat food from a place like McDonald's, Burger King, KFC, Pizza Hut, or some other fast-food restaurant?" and "How often do you go to buffet-type restaurants?" This assessment was scored on a 6-point Likert scale with 1 = never, 2 = < once a week, 3 = 1-2 times per week, 4 = 3-4 times per week, 5 = 5 times per week, and 6 = every day. A binary scoring method was created for this analysis. Participants were regarded as making frequent visits if they answered 3 or higher on either of the two questions, and were regarded as not making frequent visits if they answered 1 or 2 for both questions (Li et al., 2009).

To assess the density of fast food restaurants in the neighborhoods, commercial business establishment data was purchased from www.infousa.com. This data included names, addresses, and types of fast-food restaurants located with the study's geographic region. To obtain a density measure of how many fast-food restaurants were located in a one mile radius, the number of such restaurants was divided by the area (in square miles) for each of the neighborhoods (Li et al., 2009).

To determine the walkability of a neighborhood, a composite score was developed based on land-use mix, street connectivity, public transit stations, and green and open spaces (Li et al., 2009; Li et al., 2008). Each score was standardized, and summed, and the final scores were divided into percentiles (Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Li et al., 2009).

At baseline, the authors observed the lowest weight and waist circumference values in neighborhoods with high fast-food densities and high walkability ratings. Conversely, baseline values for weight and waist circumference were highest in neighborhoods with high fast-food restaurant densities with low walkability ratings (Li et al., 2009).

At the 1-year follow-up evaluation, the study population experienced an average weight increase of 1.72 kg and an average waist circumference increase by 1.76 cm. The authors also observed that over time, participants who made weekly visits to fast-food restaurants experienced a significant increase in weight and waist circumference (3.00 kg in weight, and

4.47 cm in waist circumference). In neighborhoods with high walkability ratings, participants saw a minimal increase in weight and waist circumference in those who did not increase their physical activity level. For those continuing to participate in moderate physical activity, a weight increase of 0.86 kg (1.07 for waist circumference) was experienced, compared to those continuing to participate in vigorous physical activity; 0.19 kg (0.41 for waist circumference).

Overall, the only variables that accurately predicted change in one's body weight and waist circumference were visits to fast-food restaurants, and vigorous physical activity. The presence of fast-food dense neighborhoods was associated with an increase of 1.40 kg (3.09 lbs) in weight ($p < 0.05$) and 2.06 cm (0.81 in) in waist circumference ($p < 0.05$) among participants who regularly visited such places. Furthermore, neighborhoods with high walkability ratings were associated with a decrease of 1.2 kg (2.56 lbs) in weight ($p < 0.05$) and 1.57 cm (0.62 in) in waist circumference ($p < 0.05$) in those who increased their vigorous physical activity level (Li et al., 2009).

A few limitations to the Li study include the utilization of two age cohorts, middle age (50) and older adults (70). This may present unforeseen problems, as older adults may have experienced more transitional moments, such as going from employment to retirement, which may encompass a drop in income. Secondly, another possible limitation is the presence of an ongoing community-based intervention, to increase health promotion. While the authors were unaware of such an event, this may have influenced their results. The authors did not take into account changes in the built environment that may have occurred during the 1-year follow-up. Lastly, the use of a primarily White and male sample limits the generalizability of the findings to other populations (Li et al., 2009).

International Studies

Several studies using subjective and objective measures to investigate the relationship between environmental attributes and physical activity were also conducted in non-US populations. Using a social-ecological construct, Duncan and Mummery (2005) assessed the relationship between self-reported and GIS-derived measures of the physical environment and physical activity in Australia. The Active Australia Physical Activity questionnaire was used to capture the participants' level of physical activity during the past week (Australian Institute of Health and Welfare, 2003; Duncan & Mummery, 2005). Participants were instructed to recall the amount of time spent in walking activities for leisure or recreation, for transport purposes, and any moderate or vigorous activities for a period of at least 10 minutes in the previous seven-day period. This instrument has exhibited moderate to very good test-retest reliabilities (Bull, Milligan, Rosenberg, & MacGowan, 2000; Duncan & Mummery, 2005).

To measure the perceived environment, participants were asked 15 questions regarding safety, aesthetics, accessibility, and opportunities for physical activity on a five-point Likert scale. The residential location of each participant was matched with those found in the Rockhampton City Council GIS database. Objective environmental measures, such as proximity and route connectivity to parklands, were taken from the respective geocoded locations. National guidelines were used to classify individuals as being sufficiently active or not (Australian Department of Health and Aged Care, 1999; Duncan & Mummery, 2005).

The results of the Duncan and Mummery study were unexpected. More than half (57.9%) of the study participants were classified as being sufficiently active to derive health benefits. Those participants who reported having an unclean neighborhood were 2.67 times more likely to achieve adequate physical activity levels compared to those who said their neighborhoods were indeed clean and tidy (95% C.I. 1.28-5.55). Participants with low route connectivity to the nearest parkland were 41% more likely to achieve sufficient levels of activity when compared to those who had acceptable route directness (95% C.I. 1.00-1.98). Those reporting that the neighborhood footpaths were in bad condition were 38% more likely to recreationally walk, compared to those who stated that the footpaths were in good condition (95% C.I. 1.00-1.91) (Duncan & Mummery, 2005).

In the Duncan and Mummery study, the authors sought to identify new correlates of the built environment to further investigate the neighborhood environment's influence on activity levels. At the time this research was conducted, no other studies had used GIS beyond determining proximity to recreational amenities and their impact on physical activity (Duncan & Mummery, 2005; Giles-Corti & Donovan, 2002a; Troped et al., 2001). Therefore, these study findings enhance the growing body of evidence that suggests community physical activity levels are influenced by both the built and self-reported environment. However, there were several study limitations. First, geocoding of the survey participants' residences was not performed until approximately 17 months after the initial survey was administered. In addition, participants that were surveyed, who resided outside of the city area of Rockhampton, were excluded from the geocoding process. Since their homes were disproportionally distanced from the area measured using GIS, inclusion of these residents would have skewed the sample data (Duncan & Mummery, 2005).

Using a population from Perth, Australia, Giles-Corti and Donovan (2002) examined associations between access to recreational facilities and participation in recreational physical activity, stratified by the SES of the residential area. Data pertaining to frequency and duration of physical activities carried out in the previous two weeks were used to measure physical activity. Access indicators were evaluated objectively, based on Hansen's accessibility model (Giles-Corti & Donovan, 2002b; Hansen, 1959). The authors utilized GIS to develop indices for the eight recreational facilities used by participants (i.e., golf courses, gym/health club/exercise centers, sport and recreational centers, swimming pools, tennis courts, public open space, beaches, and the river). The access indices were transformed into quartiles.

To measure neighborhood perceptions, 11 factors were assessed using a five-point scale (1 = "strongly agree" to 5 = "strongly disagree"), but only three main factors were used in the analyses: 1) neighborhood attractiveness, safety, and interest; 2) social support for walking locally; and 3) traffic and traffic hazards. Scales were developed from the variables in each factor (Cronbach's alpha ranging from 0.65 to 0.83) and recoded into quartiles (Giles-Corti & Donovan, 2002b).

Participants were more likely to walk for transport if: they were in the top quartile of access to attractive public open space (OR = 1.35; $p = 0.020$); they were in the top quartile for perceiving that their neighborhoods had a lot of traffic and busy roads (OR = 1.26; $p = 0.038$); they reported that there were sidewalks available in the neighborhood (OR = 1.65; $p = 0.011$); and they agreed that shops were in walking distance (OR = 3.00; $p = 0.000$). Participants were more likely to walk for recreation if they perceived that their neighborhoods were attractive, safe, and interesting (OR = 1.49; $p = 0.003$); and if their neighborhoods had a lot of traffic and busy roads (OR = 1.80; $p < 0.001$). Participants were more likely to walk as recommended if they were in the top quartile of access to attractive public open space (OR = 1.43; $p = 0.015$); perceived that their neighborhoods were attractive, safe, and interesting (OR = 1.50; $p = 0.017$); and perceived that their environment was supportive for walking (OR = 1.52; $p = 0.014$) (Giles-Corti & Donovan, 2002b).

The results of the Giles-Corti and Donovan study emphasize that regardless of SES level, designing supportive neighborhood environments has the potential to increase participation in either walking, or other activity. Nonetheless, there were several study limitations. The authors utilized a limited amount of environmental variables, in which many of those reported were based on self-report rather than objective assessments. Next, the study was confined to a specific area of Perth, and it is possible that utilizing a different study model may have been better than the one adopted by the authors. Since participants with reasons not to participate in recreational activity were excluded, all analyses were conducted using a population of young, healthy, sedentary workers and homemakers living in high and low SES areas; therefore introducing selection bias into the study, as well as limiting the generalizability of the study results to other populations (Giles-Corti & Donovan, 2002b).

Table 10. Studies Utilizing Both Self-Report and Objectively Assessed Environmental Attributes

Study	Attributes Assessed	Measures
Troped et al., 2001	▪ Neighborhood characteristics ▪ Safety ▪ Distance to the Bikeway ▪ Steep hill barrier ▪ Busy street barrier	▪ Neighborhood environment scale ▪ Arlington Physical Activity and Bikeway Survey
Rutt & Coleman, 2005	▪ Accessibility (within a 2.5 mile radius) ▪ Sidewalk availability ▪ Shortest distance from each residence to each facility	▪ 14-item questionnaire used to assess perceived barriers to exercise ▪ Questionnaire in which participants reported the number of times they participated in 14 different activities & duration ▪ Questionnaire in which participants reported how routinely they ate fruits & vegetables
Kirtland et al., 2003	▪ Barriers to PA ▪ Environmental support ▪ Neighborhood characteristics ▪ Social issues	▪ Community survey to examine perceptions of environmental supports for PA ▪ 2001 BRFSS Physical Activity Module
Mujahid et al., 2008	▪ Accessibility ▪ Aesthetics ▪ Safety ▪ Social cohesion ▪ Walking environment	▪ Questionnaire that assessed demographic and sociodemographic information ▪ 120-item food frequency questionnaire ▪ Activity questionnaire adapted from the Cross-Cultural Activity Participation Study ▪ Community Survey to assess environmental characteristics
Li et al., 2009	▪ Density of fast food restaurants ▪ Eating-out behavior ▪ Measures of obesity (weight and WC) ▪ Walkability	▪ Questionnaire that assessed demographic, health status, dietary practices, and PA level information ▪ Questions derived from BRFSS ▪ *www.infousa.com* to determine fast food density
Duncan & Mummery, 2005	▪ Accessibility ▪ Aesthetics ▪ Opportunities for physical activity ▪ Safety	▪ 15-item questionnaire ▪ Active Australia Physical Activity Questionnaire
Giles-Corti & Donovan, 2002	▪ Accessibility ▪ Aesthetics ▪ Interest ▪ Neighborhood characteristics ▪ Safety ▪ Social environment ▪ Traffic/traffic hazards	▪ Cross-sectional in-person survey ▪ Questionnaire that assessed frequency & duration of PAs carried out in the previous 2 weeks

PA = physical activity; BRFSS = Behavioral Risk Factor Surveillance System; WC = waist circumference.

2.9 THE BUILT ENVIRONMENT AND HEALTH

Research has suggested that the built environment impacts the health of a community, either negatively or positively. While prior investigations have demonstrated meaningful associations between the built environment and health, the underlying mechanisms by which the built environment actually influences health are still unknown. The following section reviews the implications of the built environment on the various aspects of human health, and highlights those areas in which there has been limited research.

There is a growing body of evidence that identifies an association between perceived aesthetic neighborhood characteristics, accessibility and convenience of facilities, and access to services with participation in regular physical activity (Humpel, Owen, Iverson et al., 2004; Humpel et al., 2002; Humpel, Owen, Leslie et al., 2004). The promotion and hindrance of physical activity is often determined by the condition of an individual's neighborhood and physical environment (A. C. King et al., 1995; Sallis et al., 1997; Sallis & Owen, 1997; Transportation Research Board, 2005). It is easier for individuals to participate in physical activity in environments that offer a wealth of resources appropriate for activity (i.e., sidewalks, parks, exercise classes, and health clubs). However, when these resources are not available or barriers exist (i.e., high crime rate or inclement weather), individuals are less likely to engage in physical activity (Sallis et al., 1997). Nonetheless, with regards to physical activity, it is unknown whether perceptions of the built environment have an independent, synergistic, or shared association with the existent environment (McGinn et al., 2007; Saelens, Sallis, & Frank, 2003).

Mediating factors such as sociodemographic characteristics, personal and cultural variables, safety and security, and time allocation for physical activity also contribute to the relationship between the built environment and physical activity (Transportation Research Board, 2005). Therefore, assessing the relationship between perceived and actual attributes of the built environment, and the effects on physical activity are essential (McGinn et al., 2007; Saelens, Sallis, & Frank, 2003).

Investigations of the built environment's influence on public health suggests that the greatest burden of disease lies within minorities and low-income communities (Bashir, 2002; Fullilove, 1998; Goran & Treuth, 2001; Kawachi, 1999; Srinivasan et al., 2003). Low SES communities tend to have environments that impede outdoor activities, and often lack healthy food options (K. M. Booth, Pinkston, & Poston, 2005; A. C. King et al., 2000; Srinivasan et al., 2003). Low income Blacks, the elderly, those with disabilities, and immigrants are also often victims of construction inequities and poor maintenance, which result in insufficient, poor quality housing, in overcrowded and population dense communities. Such environments are commonly plagued by health problems, including high rates of chronic diseases and obesity (Fullilove & Fullilove, 2000; Leaderer et al., 2002; Srinivasan et al., 2003). Findings from prior research have also consistently indicated an association between a deteriorated environment and higher crime rates, therefore, creating environments that are relatively unsafe for physical activities such as walking (Kuo & Sullivan, 2001; Srinivasan et al., 2003; R. B. Taylor & Harrell, 1996). Therefore, a thorough understanding of the association or interconnectedness between the built environment, socioeconomic inequality, and health risk is imperative to combat these disparities, and thus provide healthier communities for all people (Srinivasan et al., 2003).

Evidence suggests that the existence of chronic disease in the population can be alleviated via an active lifestyle, a healthy diet, and limited exposure to toxic environments (Perdue, Stone, & Gostin, 2003). Therefore, current research has investigated the effect of improved built environments on physical activity, and other health outcomes such as asthma, obesity, CVD, lung cancer, and diminished mental health. However, research in this area is limited, and has primarily focused on the relationship between the built environment and physical activity.

Thus, one area of research involves the influence of the built environment on mental health. Research has shown that the built environment can have direct and indirect effects on mental health. Direct effects of the built environment are seen through poorer environmental features which have been shown to increase psychological distress. For example, research efforts examining crowding have shown a positive association between the number of people in a room and psychological distress (Baum & Paulus, 1987; Evans, 2001, 2003; Evans, Lepore, & Allen, 2000; Evans, Lercher, Meis, Ising, & Kofler, 2001; Gove & Hughes, 1983; Lepore, Evans, & Schneider, 1991; Paulus, 1988; Wener & Keys, 1988). Some other direct effects of the built environment on mental health include housing type, noise, air quality, and light. For example, among low-income mothers, a positive association was found between living in high-rise residential communities and psychological distress (Evans, 2003; Evans, Wells, & Moch, 2003; Freeman, 1984; Gifford, (n.d.)). In children, a dose-response relationship between aircraft noise and elevated psychological distress has also been observed (Bullinger, Hygge, Evans, Meis, & von Mackensen, 1999; Evans, 2003; Haines, Stansfeld, Brentnall et al., 2001; Haines, Stansfeld, Job, Berglund, & Head, 2001a, 2001b; Lercher, Evans, Meis, & Kofler, 2002). Laboratory and field study analysis have revealed that exposure to malodorous pollutants (e.g., lead, solvents, and pesticides), can lead to negative mental health effects such as aggression, depression, anxiety, and sleep disorders (Cavalini, Koeter-Kemmerling, & Pulles, 1991; Evans, 2003; Rotton, 1983; Rotton & Cohn, 2002). Finally, clinical and experimental investigations have found that levels of illumination, specifically the amount of daylight exposure, can effect depression. For example, those consistently exposed to shorter hours of daylight were sadder, more fatigued, while some, were clinically depressed (Beauchemin & Hays, 1996; Evans, 2003; McColl & Veitch, 2001; Rosenthal et al., 1984).

The built environment can indirectly influence mental health through mediating pathways, such as sense of personal control. Research has shown that individuals who lack a sense of personal control over their environment are more likely to feel helpless. These feelings of helplessness may consequently increase their risk for mental health problems. In addition to personal control, social support, and restoration (i.e., places to escape stress) are two other pathways by which the built environment may indirectly influence mental health (Evans, 2003).

Research in this area has shown an association between increased mental health problems and neighborhoods with poor built environments. One possible explanation for this is that individuals who live in areas characterized by poor built environments are often socially deprived, which may increase their risk for mental health problems (Guite, Clark, & Ackrill, 2006). Conversely, some research has shown improved physical and mental health among individuals living in more green environments, possibly due to the promotion of increased social connection and interaction in these areas (Sugiyama, Leslie, Giles-Corti, & Owen, 2008). Another theory in regards to mental health and the built environment is the potential existence of more psychological stressors in areas with poor quality built environments. For example, residents of these areas may be exposed to more violence, which could subsequently increase their risk for mental health problems. Lastly, some researchers believe that individuals with poor mental health are more likely to move to areas characterized by poor quality built environments (Galea, Ahern, Rudenstine, Wallace, & Vlahov, 2005).

A review of the literature reveals the necessity for further longitudinal examination of how features of the built environment may contribute to mental health problems (Mair, Diez Roux, & Galea, 2008). However, the overall mechanism by which the built environment affects all facets of health remains unknown. Therefore, in order to establish targeted interventions aimed at reducing, and subsequently eliminating adverse health effects, more research in this area is imperative (Srinivasan et al., 2003).

2.9.1 Summary

While the area of research regarding the built environment and physical activity is growing quickly, the literature is still in the early stages of development. In addition, few reports have examined the link to obesity in this regard. To date, the results from these studies, which are mainly cross-sectional, provide a growing body of empirical evidence that highlight a positive association between the built environment and physical activity levels. However, the science is not currently advanced enough to infer causal relationships, or to determine specific characteristics of the built environment that are most closely associated with physical activity behavior (Transportation Research Board, 2005).

In the reviewed literature, when comparing the findings of subjective versus objective measures, a centralized theme was found. Utilizing either of the methodologies, investigators observed that convenience, accessibility, and aesthetics were all significantly associated with increasing physical activity. The same association was further demonstrated in studies using both subjective and objective measures, collectively. It is also important to mention that in some instances; the subjective reports indicated that knowing people who exercised or perceiving neighbors as active, were also factors that were associated with more activity as well.

Nonetheless, due to the varying definitions and assessment methods of both environmental and physical activity attributes, definitive conclusions regarding the relationship between the built environment and physical activity cannot be drawn. This absence only emphasizes the necessity for more longitudinal studies to accurately evaluate this association.

Though research on the relationship between the built environment and physical activity is in its early stages, several themes associated with evaluating the neighborhood environment have been identified. In an effort to increase daily activity and promotion of healthier lifestyles, research studies have provided insight on various methods of measuring the built or neighborhood environment. Investigators have shown that it is possible to assess individual perceptions of the environment and link them to actual environmental attributes. There is also an opportunity to observe concordance between the actual and perceived environment and the subsequent effects on physical activity.

Although the reviewed literature provides useful information, there were several limitations regarding the measures used. While all of these studies were based on the use of self-reported assessments, although few of the instruments have been validated, some element of both reporting and recall bias is inherent. This is especially relevant for perceptions of the neighborhood environment and reported amounts of activity participation. Second, as seen in Tables 8, 9, and 10, all of the studies reviewed in this chapter utilized different instruments for collecting both perceived environment and physical activity data. For example, the researchers of the CDC (1999) study used BRFSS data to capture both perceptions of neighborhood safety as well as physical activity data (Centers for Disease Control and Prevention, 1999b). Whereas, Duncan and Mummery (2005) developed their own 15-item questionnaire to measure environmental attributes, and used the Active Australia Physical activity Questionnaire to assess physical activity (Duncan & Mummery, 2005).

This chapter highlights the three methods utilized to quantify the contribution of the built environment on physical activity and/or inactivity. One method assessed this relationship using only self-report measures. In these studies, as well as those that utilized objective measures, the definition of the environment was inconsistent, due to the various types of attributes evaluated. All of the cited literature measured participants' perceptions of different neighborhood environments and related variables, but they did so in non-standardized fashions. Therefore, comparisons between the studies are limited, because:

1. There was no common set of environmental attributes, either built or natural, assessed, and there was no consistent method used to assess physical activity, all studies were therefore subject to information bias; and
2. Each study was conducted in a different geographic location; and
3. The cross-sectional nature of the studies limited the ability to examine self-selection bias (Transportation Research Board, 2005). For example, does the built environment influence the activity level of its inhabitants, or do those of a certain activity level choose specific environments?; and
4. These studies relied solely on individual perceptions, introducing reporting and/or recall bias, thereby limiting their reliability, due to the lack of complimentary objective measurements.

The second strategy analyzed within this chapter, utilized only objective measures to assess the effects of the built environment on physical activity and/or inactivity. The use of objective measures when evaluating individual and environmental characteristics has proven to be an effective technique. However, there are limitations in using this approach. For example, in regards to using GIS, input data may be incomplete, obsolete, or unavailable. In many regards, it is unavailable because not all environmental conditions have been geocoded. This is because this data is derived from resources that function at the federal, state, and local level, such as the U.S. Census Bureau, or neighborhood police departments, who may not update their respective information on an annual basis. The effects of human error are also inherent in using objective measurements, as individuals have to be thoroughly trained to use the various software and data analysis procedures. It is essential that investigators develop and use objective assessments that are appropriate for their specific research questions (Porter et al., 2004). This review includes only one study that utilized this method only. Therefore, this is an area where further research is needed. The results of the King (2005) study highlighted the need for more pedestrian-friendly environments that are conducive to increased physical activity. However, there are no other studies to confirm these findings at this time.

The last approach reviewed was the combination of both self-report and objective measures. This is most likely the most useful of the three methods, because it takes into account the participants' perceptions of their environment, as well as utilizing GIS to further measure their environment from a spatial perspective. As previously mentioned, a centralized theme was found in the results of these studies, indicating an association between the built environment and physical activity. Though, few reports by Mujahid (2008), Li (2009), and Rutt and Coleman (2005), for example, have extended this link to examine the subsequent impact on health. Nevertheless, a few minor inconsistencies were found. In those studies that assessed areas with high traffic volumes, the geographic location seemed to dictate whether or not this was a barrier to physical activity. For example, in the Troped (2001) study, high traffic areas were seen as a barrier to using the bike trail, while in the Giles-Corti and Donovan (2002) study, this same variable was associated with increased physical activity (Giles-Corti & Donovan, 2002b; Troped et al., 2001). In addition, the findings from the Duncan and Mummery (2005) study were the only factors in this chapter that deviated from the common theme. In fact, study participants who perceived their neighborhood as being unclean were 2.67 times more likely to achieve sufficient physical activity (Duncan & Mummery, 2005). These findings further delineate the complexity of the relationship between the environment and physical inactivity, and in turn, obesity.

When evaluating the inconsistencies in the literature regarding the relationship between the built environment and physical activity, several underlying reasons become apparent. First is the lack of a sound theoretical framework in which to guide the research methodology. This results, systematically, in chaotic research designs and incomplete data. The development of a sound theoretical framework is needed to provide the foundation for formulating testable hypotheses, proposing appropriate variables and relationships to study, developing standard measures, and aiding in the correct interpretation of study results (Transportation Research Board, 2005). Although no formal recommendations are currently available regarding the appropriate measurement of the relationship between the built environment and physical activity, the literature reveals that the built environment can influence activity decisions by providing opportunities for activity to occur. However, limited research and variable research methods emphasize the need for more research on the associations between environment and individual levels of physical activity (Duncan & Mummery, 2005; Giles-Corti & Donovan, 2002a; Jackson, 2003; Jackson & Kochtitzky, 2003). An area of future research may involve the establishment of a standardized set of environmental attributes based on those that are consistently examined in the literature, given appropriate reliability and validity are met. This could potentially shape the foundation for the development of improved comparable analyses. It also important to mention, that to date, few studies have examined the relationship between the built environment and physical activity by race/ethnicity. Thus, given the disparities that exist in CVD health, further investigation of this relationship by race/ethnicity is of great public health importance. Therefore, this research can facilitate the formation of effective interventions specifically aimed at increasing activity levels and promoting healthier lifestyles for all people.

Table 11. Review of Built Environment Measurement Studies

Study	Results
CDC, 1999	▪ ↑ Safety = ↓ inactivity ▪ ↓ Safety = ↑ inactivity among older adults (OR = 2.3; 95% CI 1.1 - 4.7)
Suminski et al., 2005	▪ Average safety = women 4.5 times more likely to walk for exercise ($p < 0.05$) ▪ Average safety = women 3 times more likely to walk dog ($p < 0.05$) ▪ Average # of neighborhood destinations = women 5.7 times more likely to walk for transportation ($p < 0.01$) ▪ Average functional & aesthetic neighborhood features = men 80% less likely to walk for transportation ($p < 0.05$)
A.C. King et al., 2000	▪ Presence of dogs = 20% more likely to be active (OR = 1.20; 95% CI 1.01 – 1.42) ▪ Enjoyable Scenery = 42% more likely to be active (OR = 1.42; 95% CI 1.12 – 1.79) ▪ Others exercising = 26% more likely to be active (OR = 1.26; 95% CI 1.06 – 1.50)
W.C. King et al., 2003	▪ ↑ Walkability rating = ↑ pedometer reading, walking, and total PA (p = 0.0008,0.0077, & 0.0016, respectively) ▪ ↑ Walkability rating w/ ↑ #s of destinations (p = 0.0005)
Wilbur et al., 2003	▪ Knowing people who exercised =↑ likelihood of being active (OR = 2.71; 95% CI 1.32 – 5.55) ▪ Extremely or somewhat safe neighborhood = ↑ likelihood of being active (OR = 2.43; 95% CI 1.19 – 4.99)
Hooker et al., 2005	▪ No significant associations found among Black participants ▪ Perceived neighbors as active = ~2 times more likely to meet CDC's PA recommendation (OR = 1.96; 95% CI 1.19 - 3.25; p = 0.009) ▪ Perceived neighbors as active = more than 2 times as likely to walk at least 150 min/week (OR = 2.51; 95% CI 1.54 - 4.08; $p < 0.001$) ▪ Perceived neighborhoods as being safe from crime = ~2 times more likely to walk at least 150 min/week (OR = 1.79; 95% CI 1.03 - 3.12; p = 0.04) ▪ Perceived neighborhoods as having moderate traffic = 52% less likely to walk at least 150 min/week (OR = 0.52; 95% CI 0.31 - 0.87; p = 0.002)
Sanderson, et al., 2002	▪ Identified focus group themes: • Barriers to PA = hot weather, lack of safe places to walk, lack of adequate facilities; scarce sidewalks, streetlights, & parks; poorly equipped, inefficiently maintained, & expensive facilities • Influences to PA = rural, quiet areas, with little traffic • Suggestions for ↑ in PA = development of facilities & amenities to accommodate PA (e.g., group exercise courses & addition of sidewalks, trails, ball fields, & playgrounds)

Table 11 (continued)

Griffin et al., 2008	▪ Identified focus group themes: • Safety-related: ▪ Criminal = references to drug trafficking, muggings, theft, prostitution, homicide, and desire for more police action ▪ Noncriminal = sidewalks, stray dogs, lighting, & traffic • Non-safety-related: ▪ Neighborhood aesthetics, lack of neighborhood trails, desire for more environmental infrastructure, & a desire for more facilities & programs ▪ Community connectedness and/or social support: ▪ ↑ sense of connectedness w/neighbors & social support = ↑ PA
Humpel et al., 2004	▪ ↑ aesthetics = ↑ walking (X^2 = 17.08; $p < 0.001$) ▪ ↑environmental perception (all 4 categories) = ↑ walking for exercise ▪ ↑ accessibility = ↑ walking for pleasure (X^2 = 7.28; $p < 0.05$)
Ball et al., 2001	▪ ↑ convenient environment = ↑ walking ([men: X^2 = 19.1; $p < 0.05$]; [women: X^2 = 11.2; $p < 0.05$]]) ▪ ↑ aesthetically favorable environments = ↑ walking (women: X^2 = 30.7; $p < 0.05$) ▪ Companionship =↑ walking ([men: X^2 = 3.8; $p = 0.05$]; [women: X^2 = 30.7; $p < 0.05$]])
Poortinga, 2006	▪ Leisure facility access =↑ likelihood of completing 2 sports activities per week by 17% ▪ ↑ access to post office & leisure facility = 42% & 10% more likely to complete 5 activities per week ▪ Social nuisances =↑ obesity by 25% (teenagers hanging around) & 17% (vandalism/graffiti/deliberate damage to property) (OR = 1.25, 95% CI 1.09 – 1.43; OR = 1.17, 95% CI 1.01 – 1.34, respectively) ▪ Access to leisure facility = ↓ obesity by 17% (OR = 0.83; 95% CI 0.75 – 0.92)
W.C. King et al., 2005	▪ Positive association btw. PA & living within walking distance of golf course & post office (p = 0.0081 and 0.0082, respectively) ▪ Independent associations btw. PA & living in poverty, residing within walking distance from post office or golf course, and homes built btw. 1950 - 1969 (p = 0.0259, 0.0357,0.0104, and 0.0068, respectively)
Troped et al., 2001	▪ No busy street barrier = twice as likely to use Bikeway ▪ Residing in a residential neighborhood = half as likely to use Bikeway (OR = 0.56; 95% CI 0.36 - 0.86) ▪ Did not have to bike over slope ≥ 10% for a ≥ 100m = twice as likely to use Bikeway

Table 11 (continued)

Study	Results
Rutt & Coleman, 2005	▪ Moderate intensity PA was negatively associated with BMI ($p = 0.05$) ▪ Younger age ($p = 0.0002$) & distance to PA facilities ($p = 0.04$) were associated with ↑ vigorous PA ($R^2 = 0.14$
Kirtland et al., 2003	▪ ↑ agreement for neighborhood variables & GIS measures = access to sidewalks and public recreation, safety/crime, equitable public spending, trust of neighbors, and streetlights ($_K = 0.19 - 0.37$) ▪ ↑ agreement for community variables & GIS measures = access to malls for PA ($_K = 0.25$)
Mujahid et al., 2008	▪ Living in neighborhoods with better physical environments = ↓ mean BMI (adjusted mean difference for women = -2.38; 95% CI -3.38 - -1.38; adjusted mean difference for men = -1.20; 95% CI -1.84 – -0.57) ▪ ↓ mean change in BMI (from -1.06 to -0.69 in women, & from -0.73 to -0.44 in men) after controlling for other covariates (e.g., age, race/ethnicity, income, education level, total energy intake, AHEI, & PA); indicating possible mediating characteristics of diet & PA to the association between the environment & BMI
Li et al., 2009	▪ Fast-food dense neighborhoods = ↑ of 1.40 kg (3.09 lbs) in weight ($p < 0.05$) & 2.06 cm (0.81 in) in WC ($p < 0.05$) among participants who regularly visited such places ▪ Neighborhoods with high walkability ratings = ↓ of 1.2 kg (2.56 lbs) in weight ($p < 0.05$) & 1.57 cm (0.62 in) in WC ($p < 0.05$) in those who ↑ their vigorous PA
Duncan & Mummery, 2005	▪ Unclean neighborhood = 2.67 times more likely to achieve adequate PA (95% CI 1.28 - 5.55) ▪ Low route connectivity to nearest parkland = 41% more likely to achieve sufficient PA (95% CI 1.00 - 1.98) ▪ Footpaths in bad condition = 38% more likely to walk recreationally (95% CI 1.00 - 1.91)
Giles-Corti & Donovan, 2002	▪ ↑ walking for transportation if : • Access to attractive places (OR = 1.35; $p = 0.020$) • ↑ heavy traffic & busy roads (OR =1.26; $p = 0.038$) • Sidewalks available (OR = 1.65; $p = 0.011$) • Shops in walking distance (OR = 3.00; $p = 0.000$) ▪ ↑ walking for recreation if: • Attractive, safe, & interesting neighborhood (OR = 1.49; $p = 0.003$) • ↑ traffic & busy road (OR = 1.80; $p = 0.000$) ▪ ↑ walking if: • ↑ access to attractive public open spaces (OR = 1.43; $p = 0.015$) • Attractive, safe, and interesting neighborhoods (OR = 1.50; $p = 0.017$) • Supportive walking environment (OR=1.52; $p = 0.014$)

CDC = Centers for Disease Control and Prevention; OR = odds ration; CI = confidence interval. X^2 = Chi-square; BMI = body mass index; GIS = geographic information systems; AHEI = Alternate Healthy Eating Index.

2.10 LITERATURE REVIEW CONCLUSION

It is currently understood that CVD is the number one killer of both men and women worldwide. While CVD greatly affects most of the U.S. population, statistics clearly demonstrate racial disparities, with the highest prevalence amongst Black non-Hispanics in comparison to White non-Hispanics and Mexican Americans. Risk factors for CVD have been well established throughout the literature, with lipids abnormalities, hypertension, obesity, and physical inactivity being identified as independent risk factors for cardiovascular disease. Obesity, in particular, is highly prevalent within the U.S. population, and has had profound implications for CVD.

Although there has been a considerable decline in CVD mortality rates since 1950, CVD remains the leading cause of death among Americans, yet relative improvements in CVD risk differ by race (National Center for Health Statistics, 2007). Disparities in CVD health are present among many population subgroups; and when defined by race, ethnicity, gender, SES, educational level, and geography, constitute an important public health challenge in the U.S (Mensah, 2005). For example, more than one third of the differences in life expectancy between Blacks and Whites can be attributed to CVD (Mensah, 2005; Wong, Shapiro, Boscardin, & Ettner, 2002). These disparities are more evident in middle-to-older age adults, and are augmented by the earlier mortality experienced by Blacks from CVD (Jones et al., 2000).

The underlying reasons for the overall higher rates of CVD and the lack of recent improvement in these rates among African Americans are multifaceted. A potential biological explanation for these disparities is demonstrated by the presence of race-related differences in the prevalence of traditional CVD risk factors. For example, researchers have found that being of non-Hispanic Black race/ethnicity is significantly associated with a higher frequency of hypertension when compared to Whites (OR = 1.61; 95% CI 1.30 – 1.99) (Ong et al., 2007). In regards to physical activity, compared to White women, Black women are significantly more likely to be inactive (OR = 2.62; 95% CI 1.82 - 3.76). Among Black men, there is also a significantly higher prevalence of inactivity compared to White men (OR = 1.88; 95% CI 1.19 - 2.97) (Sundquist et al., 2001). Finally, rates of obesity are statistically higher in non-Hispanic Black and Mexican American women, when compared to non-Hispanic White women (53.9%, 42.3%, and 30.2%, respectively), a trend not seen in men (Baskin et al., 2005; Ogden et al., 2006).

Socioeconomic and environmental factors also contribute to disparities in CVD. Racial/ethnic differences in cardiac care have consistently been documented (Kaiser Family Foundation, 2002). Compared to Caucasians, African American Medicare recipients are less likely to be treated by physicians who are board certified, capable of providing high quality care to all patients, and able to gain patient access to high-quality subspecialists and diagnostic imaging (Bach, Pham, Schrag, Tate, & Hargraves, 2004). Furthermore, publicly insured minorities with prescription coverage benefits, are less likely to receive preventive care before or after a CVD diagnosis (Litaker & Koroukian, 2004). The above disparities in CVD by race are attenuated, yet persist, after adjustment for confounding factors, including SES.

CVD is a very complex disease that has made a significant impact on society. Risk factors for CVD are well-established; however, they appear to manifest themselves differently among population subgroups. The existing disparities in CVD health present significant challenges in the prevention and treatment of this disease. To combat the burden associated with CVD morbidity and mortality, the development of appropriate prevention measures is imperative, thus ensuring improved health and subsequent quality of life for all people and future generations.

One of the modifiable risk factors, and a common target for prevention, is obesity. Research suggests that the rising obesity epidemic is due in part to an obesogenic environment that discourages physical activity and promotes consumption of energy dense foods. To further understand this relationship, a new area of research is focusing on the built environment, its influence on public health, physical activity, as well as subsequent CVD risks. Previous research efforts in this area have focused on measuring the effects of the built environment on physical activity. Empirical evidence from this research has indicated an association between the built environment and physical activity levels. However, scientific advancements are needed to accurately infer causal relationships, and to determine specific characteristics of the built environment that are most closely associated with physical activity behavior. Furthermore, more recent investigations have examined the effect of improved built environments on physical activity. However, there is limited research in this area that focuses on the role of the built environment and its effect on other measures of CVD risks including lipid abnormalities, hypertension, obesity, the metabolic syndrome, and diabetes. Thus, continued research in this area is necessary (Srinivasan et al., 2003).

Yet, there are several areas in this field that are not well understood. While investigators have examined the effects of improved built environments on physical activity, the relationship between physical and social environments and physical activity is not well understood. In regards to assessment, the predictive value of different methods of measurement (i.e., subjective, objective, and independent investigator observation) is unclear. Furthermore, additional research is needed to determine the best methods for examining the relationship between the built environment and physical activity (e.g., subjective vs. objective measurement, types of environmental attributes to be assessed, and the instrument that best captures physical activity).

A more comprehensive understanding of this relationship has significant implications to decipher the disparity facing African Americans and the complexity of the CVD epidemic. Nonetheless, this area of research is in the early stages of development, therefore, definitive conclusions and adequate comparisons cannot be made.

The current research study, *The Assessment of Cardiovascular Disease Risk in Relation to the Built Environment and Race*, examines the manner in which the built environment, both physical and social, is associated physical activity and various measures of CVD risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity), and if these relationships differ by race.

Information from this study is of considerable public health significance, as it will provide valuable information for future research studies and public health programs aimed at health promotion and disease prevention. The current study examines existing racial disparities, and therefore, creates a foundation for our understanding of the role of race in this area. Incorporating the aforementioned novel assessment of the built environment, with the evaluation of these relationships by race, will offer insight on adequate and appropriate CVD interventions for all populations.

3.0 PURPOSE AND SPECIFIC AIMS OF STUDY

Purpose: To assess the manner in which the built environment (both physical and social) is associated with CVD risk, and how this relationship may be influenced by race.

Specific Aims and Hypotheses

Research suggests that the rising obesity epidemic is due in part to an obesogenic environment that discourages physical activity and promotes consumption of energy dense foods. To further understand this relationship, new research is focusing on the built environment, and its influence on public health, through physical activity. The following project investigates this link, and also examines the built environment and subsequent CVD risks.

The Assessment of Cardiovascular Disease Risk in Relation to the Built Environment and Race examines the manner in which the built environment, both physical and social, is associated with physical activity and various measures of CVD risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity), and if these relationships differ by race.

Capitalizing on the infrastructure of the Heart SCORE study and a selected subset of the study population, the **Specific Aims** of this study include:

1. **Evaluate the relationship between the built environment and measures of cardiovascular disease risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity).**

    H_0: There is no relationship between positive indicators of the built environment and measures of cardiovascular disease risk.

    H_1: There is an inverse relationship between positive indicators of the built environment and selected lipid measures (i.e., LDLs and triglycerides).

    H_1b: There is a positive relationship between positive indicators of the built environment and HDLs.

    H_2: There is an inverse relationship between positive indicators of the built environment and hypertension.

    H_3: There is an inverse relationship between positive indicators of the built environment and obesity.

    H_4: There is an inverse relationship between positive indicators of the built environment and the metabolic syndrome.

    H_5: There is an inverse relationship between positive indicators of the built environment and diabetes.

    H_6: There is an inverse relationship between positive indicators of the built environment and physical inactivity.

2. **Evaluate the extent to which the relationship between the built environment and measures of cardiovascular disease risk are mediated through physical activity.**

    H_0: Physical activity does not mediate relationships between the built environment and measures of cardiovascular disease risk.

    H_1: Physical activity is one mechanism (mediator) in which positive indicators of the built environment favorably influence measures of cardiovascular disease risk.

3. **Evaluate the extent to which the above relationships vary by race.**

   H_0: The above-defined relationships between the built environment and measures of cardiovascular disease risk are similar by race.

   H_1: The above-defined relationships between the built environment and measures of cardiovascular disease risk differ significantly by race.

4. **Evaluate the degree of concordance and discordance of three different methods of measuring indicators of the built environment. The three methods of assessing the environment include:**

   i. Heart SCORE participant self-report responses to an environmental questionnaire (these data were previously collected);

   ii. An independent investigator assessment of the environment utilizing the same environmental questionnaire completed by Heart SCORE participants; and

   iii. Objectively-collected data on the environment (e.g., census and geographic information systems [GIS]).

   This aim was exploratory, therefore, no specific hypotheses are proposed (refer to data analysis plan for methods of evaluation).

4.0 METHODS

4.1 HEART SCORE STUDY DESIGN AND POPULATION

4.1.1 Heart SCORE Study

A primary goal of the health promotion and disease prevention agenda established in *Healthy People 2010* is to eliminate health disparities among different segments of the population, including racial subgroups (United States Department of Health and Human Services, 2000). With respect to CVD, achievement of this goal requires a multi-faceted approach that includes, but is not limited to: 1) understanding racial differences in the biology and pathophysiology of CVD; 2) development, implementation, and evaluation of sustainable clinical interventions designed to reduce CVD risk; and 3) ensuring equal access to high-quality state-of-the-art health care (Kip et al., 2005).

Heart **S**trategies **C**oncentrating **O**n **R**isk **E**valuation (Heart SCORE) is a multi-faceted community-based participatory research program designed to address CVD by: 1) improving CVD risk stratification among African Americans; 2) identifying CVD disparities based on race and socioeconomic status; 3) evaluating biological mechanisms for population differences in CVD risk; and 4) implementing and evaluating a multidisciplinary community-based intervention program to decrease CVD risk in high-risk populations.

Heart SCORE is an ongoing prospective cohort study with 2,000 enrolled participants who are residents of western Pennsylvania. The study includes nearly equal representation of Caucasian and African American subjects. Within this cohort study, is an intervention study, in which participants were randomly assigned, with equal probability, to either a *usual care ("advice only") regimen* or a *multidisciplinary, culturally-sensitive behavioral modification intervention* to reduce CVD risk (Figure 8). Subjects included in the intervention study were selected on the basis of CVD risk assessed at study entry, with all participants initially classified into one of three mutually exclusive risk categories based on the Framingham risk score: 1) low (N=1,073), 2) intermediate/high (N=813) risk of CVD (Wilson P.W.F. et al., 1998), or 3) pre-existing CHD (N=114). The 813 intermediate/high risk subjects were randomly assigned into the intervention study stratified by race (Caucasian/non-Caucasian) and Framingham risk status (intermediate/high) (Figure 8) (Kip et al., 2005).

Subject eligibility criteria included age 45 to 75 years, residence in the greater Pittsburgh metropolitan area (~50 mile radius), ability to undergo baseline and annual follow-up visits, and absence of known comorbidities expected to limit life expectancy to less than five years. Recruitment occurred through community-based blood pressure and lipid screening programs, educational seminars at places of worship and community centers, targeted mailings by zip code, advertisements, referrals, and by direct promotion through community organizations. There was an emphasis on the recruitment of traditionally underserved and high-risk communities, which was achieved through partnerships with the Cardiovascular Institute at the University of Pittsburgh, Metro-Urban Institute Office of Applied Religion (MUI-OAR) of the Pittsburgh Theological Seminary, the Urban League of Pittsburgh, and other community-based and academic partners. All subjects provided written informed consent approved by the Institutional

Review Board (IRB) at the University of Pittsburgh. Additional details of the Heart SCORE study have been published (Kip et al., 2005).

4.1.2 Heart SCORE Data Collection

The Heart SCORE study protocol is outlined in Figure 8. At the baseline visit, detailed demographic and medical history was collected from all study participants. Physical examination included measurements of vital signs, anthropometric measures of height, weight, waist and hip circumference, and skin fold caliper measurement of the quadricep, tricep, iliac crest (females) and pectoral, abdomen, and thigh (males) to determine body fat distribution (American College of Sports Medicine, 2000; Kip et al., 2005).

Laboratory assessment of blood drawn in the fasting state included a battery of traditional and non-traditional CVD risk factors (e.g., glucose, total LDL and HDL cholesterol, triglycerides, high-sensitivity C-reactive protein [CRP], lipoprotein subfractions, lipoprotein [a], and urinary albumin levels). Laboratory tests were performed using standard techniques in the clinical laboratory of the University of Pittsburgh Medical Center, with the exception of the measurement of plasma lipids and lipoprotein subfractions. These subfractions were quantified by a commercial laboratory using a vertical auto profile (VAP, Atherotech, Birmingham, AL) (Kip et al., 2005).

Figure 8. Heart SCORE Study Design

Physical activity was measured by the Lipid Research Clinics (LRC) Questionnaire. The LRC physical activity questionnaire provides a comprehensive evaluation of the participant's regular energy expenditure. Participants were first asked to rank their level of physical activity in relation to their peers. The next question assessed the regularity with which participants took part in strenuous exercise or hard physical labor, and if they engaged in such activities at least three times a week (Ainsworth, Jacobs, & Leon, 1993). Other lifestyle characteristics including smoking history, use of alcohol, and family and social support, were measured by self-developed questionnaires (Kip et al., 2005).

Following the baseline examination, a summary of the subject's risk factor profile, based on the NCEP ATP-III ("Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001) and JNC7 (Chobanian et al., 2003) guidelines, were provided to their primary care physician. Subjects who did not have an established relationship with a healthcare provider were referred to family practitioners or general internists, including the Metro Family Practice, Inc. (MFPI, Wilkinsburg, PA), a 501(c)(3) comprehensive primary care organization that provides healthcare for uninsured patients (Kip et al., 2005).

4.1.3 Heart SCORE Methods Specific to this Study

Following an IRB-approved protocol, a self-report questionnaire of the participants' neighborhood environments was implemented into the study protocol. The instrument, entitled, The *Neighborhood Environment Scale,* was derived from the *Neighborhood Environment Walkability Survey (NEWS).* The *NEWS* is a 98-item questionnaire, designed to measure the perceptions of neighborhood design features, thought to be associated with physical activity (Active Living Research, 2006). In regards to the Heart SCORE Study, collection of this environment-specific data concluded after 955 participants completed the survey. However, follow-up data collection of all other Heart SCORE measures is ongoing.

4.1.4 Protection of Human Subjects (Reis et al., 2003)

1. Human Subjects Research:

Prior to initiation, the Heart SCORE study, as well as the current research study, were submitted and approved by the University of Pittsburgh Institutional Review Board (IRB).

2. Recruitment and Informed Consent:

The recruitment strategy of the Heart SCORE Study has been previously outlined. Participants responded to a recruitment letter, advertisement, or a disseminated public announcement, and phoned the study recruitment office. The study was explained by the recruiters, and interested subjects, who met eligibility criteria, were invited to a study visit. At that time, the study was described by a research coordinator and/or co-investigator. A written informed consent document was provided to each participant. Copies of the informed consent document were given to the subject, and placed in her/his research chart.

4.1.5 Heart SCORE Study Measures

1. Heart SCORE Data Collection and Measures:

This research study made extensive use of the data collected in the Heart SCORE dataset. Specifically, several key variables were identified from the existing Heart SCORE measures, including clinical and anthropometric data and data collected from the self-report environmental and physical activity questionnaires. **The current study also involved novel data collection methods aimed at characterizing and evaluating the built environment (both physical and social), as described below.** All demographic, anthropometric, behavioral, clinical, and biological variables were attained using the Heart SCORE study database (Kip, 2006). For the study, the following variables were analyzed to answer the above-defined research questions:

a. Demographics and Socioeconomic Status (SES): Demographic variables, such as age, gender, race, and ethnicity were obtained from Heart SCORE participants via self- report (Appendix A). Race and ethnicity were classified utilizing categories defined by the U.S. Census Bureau. Measures of SES were obtained by self-report items regarding educational attainment and annual household income (Appendix B).

b. Anthropometric Data: Measures of obesity and body composition of Heart SCORE participants were obtained by Heart SCORE study clinicians. These measurements included height, weight, and waist/hip circumference (Appendix C).

c. Measures of CVD Risk: Biological measures of CVD risk associated with physical inactivity and obesity were established by laboratory assessments of blood pressure, to assess the presence of hypertension, and a fasting blood sample, to obtain glucose concentrations in order to evaluate the metabolic syndrome, total cholesterol, LDL and HDL cholesterol, and triglyceride level (Appendices B, D, and E).

d. Physical Activity: Physical activity was measured in the Heart SCORE study by self-report, utilizing the Lipid Research Clinics (LRC) Questionnaire (Ainsworth, Jacobs et al., 1993) (Appendix F). This brief instrument has demonstrated high test-retest reliability (r = 0.85-0.88) and evidence of validity (Ainsworth, Jacobs et al., 1993; Jacobs, Ainsworth, Hartman, & Leon, 1993). However, for this study only item *#6* ("What is your current overall level of physical activity?") of the physical activity questionnaire was employed, as it was the only question that adequately captured the participants' perception of their current overall level of physical activity.

e. Individual Level Social Variable: Smoking status was categorized as *never, former, and current* (Appendix G).

f. Measures of the Built Environment: To assess subjective measures of the built environment, the self-report *Neighborhood Environment Scale* was utilized to evaluate residents' perception of their accessibility to services, and the functionality, safety, aesthetics, and overall "walkability" of their neighborhood environment (Appendix H) (Active Living Research, 2006).

4.2 STUDY DESIGN AND METHODS

4.2.1 Study Design

The objective of the current research study, *The Assessment of Cardiovascular Disease Risk in Relation to the Built Environment and Race,* was to examine the manner in which the built environment is associated with measures of CVD risk, including lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity. The research study is a cross-sectional analysis, embedded within the Heart SCORE cohort study, and satisfies the following specific aims:

1. **Evaluate the relationship between the built environment and measures of cardiovascular disease risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity).**
2. **Evaluate the extent to which the relationship between the built environment and measures of cardiovascular disease risk is mediated through physical activity.**
3. **Evaluate the extent to which the above relationships vary by race.**
4. **Evaluate the degree of concordance and discordance of three different methods of measuring indicators of the built environment.**

4.2.2 Data Collection

The data for Specific Aims 1-3 were collected as part of the Heart SCORE Study. However, as described below, to examine Specific Aim #4, data were collected via three methods: 1) Heart SCORE measures of the built environment; 2) Independent investigators' measures of the built environment; and 3) GIS methodology.

a. Independent Investigator Measures of the Built Environment: To satisfy specific aim 4, the investigator utilized a subset of the Heart SCORE Study population, and employed all questions in the *Neighborhood Environment Scale* that permitted evaluation by an external observer. The external evaluation involved observations of specified neighborhoods made by the independent investigator and trained interns, who subsequently completed relevant questions from the *Neighborhood Environment Scale*, in a manner parallel to that conducted by Heart SCORE participants. The neighborhoods examined included a mixture based on racial/ethnic composition (i.e., predominately White, predominately Black, and racially mixed). The racial/ethnic makeup of each neighborhood was derived from Census 2000 data. Predominately White neighborhoods had greater than 50% White composition. A similar procedure was used to define predominately Black neighborhoods. Racially mixed neighborhoods comprised the remainder, which were neither greater than 50% White or Black.

b. Use of Geographic Information Systems (GIS): In addition to self-report data, a large array of data was collected on the built environment from several resources including, the City of Pittsburgh Department of Finance, Pittsburgh Department of City Planning, Carnegie Mellon University's Center for Economic Development, BatchGeo, and the U.S. Census Bureau. This data was catalogued, managed, and analyzed using GIS.

Briefly, GIS is defined as a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems. GIS applications use both spatial information (maps) and databases to perform analytical studies. (K. Kurland, personal communication, August 28, 2007)

Although GIS is commonly used to create maps for visual representation of various data, it is also a research tool for analyzing spatial relationships, such as geographic topology. This tool is capable of capturing multiple layers of information simultaneously, and therefore, can combine physical coordinates (locations) with empirical data. For example, by collecting data on actual locations of sidewalks, city parks, schools, vacant lots, etc. in Pittsburgh, GIS was used to quantify the proximity and concentration of these locations to each participant's residence. This allowed an assessment of the accessibility, and representation of these elements, to the built environment.

This research study utilized *ArcGIS 9* (Environmental Systems Research Institute Inc., Redlands, California, 2009), a full-featured GIS software program. This program is the most commonly used, and allows the development of new geographic datasets, and the importation and exportation of empirical data. Therefore, data from the ongoing Heart SCORE study was incorporated with the geographic data from the built environment. Subsequent statistical analyses were conducted utilizing the SAS 9.2 system (SAS Institute, Cary, North Carolina, 2008).

4.3 DATA MANAGEMENT AND ANALYTICAL PLAN

To maintain participant anonymity, all relevant data was retrieved from the Heart SCORE data manager in a confidential manner.

Primary Research Site: All research activities and laboratory procedures were conducted at the University of Pittsburgh Medical Center's (UPMC) Cardiovascular Institute located in Pittsburgh, PA. All records pertaining to participant involvement in this study, as well as all information collected during the new data collection process, was stored in a locked file cabinet at the UPMC Cardiovascular Institute and the University of Pittsburgh's Graduate School of Public Health (GSPH). Participant identity on these records was indicated by an anonymous study ID number. This information was only accessible to the investigators and the research study staff. The dataset containing all existing Heart SCORE variables, as well as all information collected during the new data collection process, was password protected on a computer that also had a password protected account. All personal identifiers in the dataset, except participants' addresses, were removed before data analyses were conducted. However, the addresses were used only used for geocoding, the process of "taking a street address and converting it into latitude and longitude coordinates" (BatchGeo, 2010), and as a reference for the independent investigator observations. After the neighborhood observations and geocoding were completed, the addresses were removed from the original dataset for subsequent data analyses.

A. *Heart SCORE Study Data Collection and Measures:* The following variables were analyzed to answer the research questions:

1. **Demographics** (Appendix A)

   a. **Age:** Age in years is a continuous variable. For the current study, and per the Heart SCORE protocol, the participants' age ranged from 45 to 75 years old.

   b. **Gender:** Gender is a dichotomous variable.

   1 = Male

   2 = Female

   c. **Ethnicity:** Ethnicity is a dichotomous variable.

   1 = Hispanic/Latino

   2 = Non-Hispanic/Latino

   d. **Race:** Race is a nominal categorical variable with six categories.

   1 = American Indian/Alaska Native

   2 = Asian

   3 = Black/African American

   4 = Native Hawaiian/Pacific Islander

   5 = White/Caucasian

   6 = Other

2. **SES** (Appendix B)

   a**. Education**: Education is an ordinal categorical variable with five categories.

   1 = Less than high school

   2 = High school diploma

   3 = Some college

   4 = Bachelor's degree

   5 = Advanced degree

b. **Annual Income:** Annual income is an ordinal categorical variable with five categories.

1 = Less than $10,000

2 = $10,000 to less than $20,000

3 = $20,000 to less than $40,000

4 = $40,000 to less than $80,000

5 = $80,000 or more

3. Anthropometric Data (Appendix C)

a. **Height:** Height is a continuous variable measured in meters (m).

b**. Weight:** Weight is a continuous variable measured in kilograms (kg).

c. **Waist Circumference (WC):** WC is a continuous variable measured in centimeters (cm).

d**. Hip Circumference:** Hip circumference is a continuous variable measured in centimeters (cm).

e. **BMI:** BMI is an ordinal categorical variable, using the four categories defined by the WHO (World Health Organization, 2008a).

1 = Less than 18.50 = Underweight

2 = 18.50 to 24.99 = Normal

3 = Greater than or equal to 25.00 to 29.99 = Overweight

4 = Greater than or equal to 30.00 = Obese

ii. Additionally, BMI was transformed into a dichotomous variable, indicating Obesity status (yes/no).

1 = Yes = BMI greater than or equal to 30.00

0 = No = BMI less than 30.00

f. **Waist-Hip Ratio (WHR):** The WHR is a continuous variable that was calculated by dividing the waist circumference by hip circumference.

4. Measures of CVD Risk (Appendices B, D, and E)

a. **Blood Pressure Classification:** Blood Pressure Classification, derived from the JNC7 guidelines, is an ordinal categorical variable with four categories.

1 = Normal

2 = Prehypertensive

3 = Hypertensive Stage 1

4 = Hypertensive Stage 2

i. Blood Pressure Classification was transformed into a dichotomous variable, indicating the presence of hypertension (yes/no).

1 = Yes (summation of Hypertensive Stage 1 and 2 from above)

0 = No

b. **Glucose Concentration:** Fasting glucose concentration is a continuous variable measured in milligrams/deciliter (mg/dL). This variable was used to examine the presence of diabetes and the metabolic syndrome.

c. **Lipid Measures:** All lipid measures are continuous variables, measured in milligrams/deciliter (mg/dL), and were categorized based on the classifications defined by the ATP III ("Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III)," 2001; "Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002).

i. **LDL Cholesterol:** LDL cholesterol (mg/dL) was transformed into an ordinal categorical variable with four categories.

1 = Optimal

2 = Near or above optimal

3 = Borderline high

4 = High

ii. **HDL Cholesterol:** HDL cholesterol (mg/dL) was transformed into a dichotomous variable (with a differentiation made to establish accurate levels for men and women), indicating the presence of low HDL levels (yes/no).

1 = Yes

0 = No

iii. **Triglycerides:** Triglyceride levels (mg/dL) were transformed into an ordinal categorical variable with four categories.

1 = Normal

2 = Borderline High

3 = High

4 = Very High

d. **Metabolic Syndrome:** Metabolic Status, derived from the NCEP ATP-III guidelines, is an ordinal categorical variable.

1 = Normal

2 = Metabolic Syndrome

3 = History of Diabetes

i. The metabolic syndrome variable was transformed into a dichotomous variable, indicating the presence of metabolic syndrome (yes/no).

1 = Yes

0 = No

5. **Physical Activity/Inactivity** (Appendix F)

a. **Current level of Physical Activity (PA):** Current level of PA is an ordinal categorical variable with four categories.

1 = Sedentary

2 = Mild

3 = Moderate

4 = Strenuous

6. **Individual Level Social Variable** (Appendix G)

a**. Smoking Status:** Smoking status is an ordinal categorical variable with three categories.

1 = Current smoker

2 = Former smoker

3 = Never smoked

As Heart SCORE is a longitudinal study that requires annual follow-up, multiple data points were available for the above listed variables. However, for this study, only the biological and clinical measurements that corresponded to the time in which the environmental questionnaire data were collected were utilized.

7. **Measures of the Built Environment (*Neighborhood Environment Scale*)** (Appendix H)

The *Neighborhood Environment Scale* consisted of seven sections, evaluating different types of neighborhood characteristics (i.e., *streets in my neighborhood, places for walking and cycling, safety from traffic, safety from crime, access to services, neighborhood surroundings and sense of community*). These measures of the built environment used the following Likert scale:

1. Strongly Disagree
2. Somewhat Disagree
3. Somewhat Agree
4. Strongly Agree

Neighborhood Grade:

Briefly, the Heart SCORE Study personnel used a modified version of the *NEWS* to create the *Neighborhood Environment Scale* utilized in this study. Therefore, in order to accurately evaluate one's perception of their neighborhood, a neighborhood grade variable was derived using questions 1-52 of the *Neighborhood Environment Scale*. The investigator only used items 1-52 because these questions employed the exact same

Likert Scale (1 = "strongly disagree" to 4 = "strongly agree"). These 52 questions included the following neighborhood characteristics:

- Streets in my neighborhood
- Places for walking and cycling
- Safety from traffic
- Safety from crime
- Access to services
- Neighborhood surroundings
- Sense of community.

Items 53-72 were removed from the analyses, and included the following neighborhood characteristics:

- Sense of community (3 items)
- Overall neighborhood
- Barriers to exercise.

In those instances when items were negatively-keyed (i.e., when agreement or strong agreement supports a negative statement and/or question), a reverse coding scheme was applied so that all scores were in the positive direction. Once the same scoring scheme was applied, Cronbach's Coefficient Alpha, "a statistical measure of the internal consistency reliability of a test or survey" (Cronbach, 1951) was calculated to "assess the degree to which the items on the *Neighborhood Environment Scale* were all measuring the same underlying concept" (Cody & Smith, 2006). An overall alpha level of 0.90 was observed. Although this statistic is considered acceptable, several individual questions that did not correlate well with the total survey score, and would therefore negatively influence future analyses (Nunnally, 1978), were also found. Therefore, all questions whose correlation with the total survey score was less than 0.3, indicating a modest-to-low correlation, were removed. A total of 16 of the 52 items met this exclusion criterion. These 16 questions included the following neighborhood characteristics:

- Streets in my neighborhood
- Places for walking and cycling
- Safety from traffic
- Access to services
- Neighborhood surroundings
- Sense of community (1 item).

Cronbach's Coefficient Alpha was again calculated using the remaining 36 questions, and an alpha level of 0.92 was observed. As this was an acceptable statistic, this more parsimonious set of 36 items was used in the main analyses, and included the following neighborhood characteristics:

- Places for walking and cycling (4 items)
- Safety from traffic (4 items)
- Safety from crime (7 items)
- Access to services (2 items)
- Neighborhood surroundings (10 items)
- Sense of community (9 items).

To determine the amount of usable data present in the *Neighborhood Environment Scale*, a 60% rule was applied in which each participant had to answer at least 60% of the questions on the survey to be included in the study. Therefore, all participants who did not answer at least 22 of the 36 survey items were removed. Finally, to score the actual neighborhood grade, the environmental scores of each participant's *Neighborhood Environment Scale* were summed. To account for inherent missing data (i.e., among participants who answered at least 22 items, but not all 36 items), a weighted factor was applied to this total, wherein the sum of the environmental scores was divided by the percent of questions completed (weighted score = sum / percent of questions completed). For example, if a participant answered 34 items on the questionnaire, for a total environmental score of 250, the new weighted score would be 264.71 [250 / (34 /36)]. The new weighted score was then divided into four quartiles; the first quartile represented least favorable neighborhoods, and the last quartile represented most favorable neighborhoods. This ordinal categorical favorable was the primary measure of the built environment for all analyses.

8. *New Data Collection - Independent Investigator Measures of the Built Environment:*

As previously mentioned, the investigator utilized all questions in the *Neighborhood Environment Scale* that permitted evaluation by an external observer, and also had surrogate objective measures that could be captured by the use of GIS. Therefore, items related to *Sense of Community* were not addressed, and all corresponding statistical analyses were adjusted accordingly. Specifically, only 21 items from the *Neighborhood Environment Scale* were used in these analyses (Table 39). These 21 questions met all of the requirements listed above, and were identical (in question, scale, and scoring scheme) in both the surveys completed by the Heart SCORE participants, and in those completed by the independent evaluators. This allowed for the complete utilization of fully comparable instruments (Appendix I).

To evaluate how well questions in the *Neighborhood Environment Scale* correlated with assessments of the environment made by external observers, as well as objective GIS measures, independent observations of 40 neighborhoods of a randomly selected sample of participants from each neighborhood grade quartile, were rated by trained evaluators to assess the corresponding neighborhood characteristics that were measured in the *Neighborhood Environment Scale*.

The Principal Investigator and a team of 5 trained research assistants completed the following tasks:

1. Physically visited the neighborhood for each randomly selected address and independently rated neighborhood characteristics using the *Neighborhood Environment Scale*. The participants were not contacted as part of this neighborhood evaluation.
2. Externally assessed the physical nature, and walkability of the participants' neighborhood (i.e., the presence of sidewalks (yes/no); the physical characteristics of sidewalks; the perception of safety in the study participant's neighborhood; the presence and/or absence of parks, schools, vacant lots, trees, or other places of interest (e.g., churches, cemeteries, or shopping centers); as well as an overall assessment of the aesthetic nature of the participant's neighborhood) by taking a 20-minute walk around the participant's residence.

- A 20-minute walk was chosen for these assessments because it is equivalent to the average distance covered in a one-mile radius. The one-mile radius is a common measurement in the built environment literature (W. C. King et al., 2005; W. C. King et al., 2003; Li et al., 2009; Mujahid et al., 2008).

- Assessments were made by a total of 6 independent investigators who were paired into 3 teams of two. All of the trained evaluators were Black/African American, had a mean age of 28.5 ± 3, and were highly educated, with each having a Master's Degree or higher. There were two evaluators from the Pittsburgh metropolitan area, while the other four represented different parts of the U.S. including, Florida, Illinois, Texas, and Mississippi. Each team of independent evaluators completed one *Neighborhood Environment Scale* for each selected address upon completion of the 20-minute walk, for a maximum of 120 ratings of each neighborhood.

9. Statistical Power

The Heart SCORE dataset consists of 2,000 participants. However, this research project was based on the 955 participants who completed the *Neighborhood Environment Scale*. This questionnaire was offered to all participants who remained in the study at the time that this ancillary questionnaire was added. However, only the data from the first 955 participants who completed the survey was utilized in the current study. Therefore, *a priori*, power calculations were conducted based on these 955 participants.

The power and sample size calculations in Table 12 are derived from effect sizes of "small," "medium," and "large," as defined by Cohen (1988). To calculate the proposed sample sizes for each specific aim, the corresponding effect size indexes for simple linear and multiple linear regression were used (J. Cohen, 1988). All calculations were conducted in PASS, 2008 (NCSS, Kaysville, Utah) and G*Power 3.1, 2009 (Heinrich-Heine-University – Institute for Experimental Psychology, Germany). As seen below, the sample size of 955 participants provided 90% power to detect "medium" effect sizes for all specific aims, and approached the required sample size for being able to detect "small" effect sizes. Similarly, because detection of "medium" effect sizes at 90% power ranged from 154 to 210, the sample size of 955 participants was sufficient to conduct stratified analyses by race.

Table 12. Sample Size Calculations

Specific Aim	Effect Size	90% Power (2-sided alpha of 0.01)	80% Power (2-sided alpha of 0.01)
Effect size estimates for simple linear regression are derived from the Pearson product–moment correlation coefficient, r			
1A	Small: 0.10	1478	1160
	Medium: 0.30	**154**	122
	Large: 0.50	50	40
Effect size estimates for multiple linear regression are derived from the F-test, f^2			
1B	Small: 0.02	1480	1226
	Medium: 0.15	**210**	176
	Large: 0.35	100	84
Effect size estimates for simple linear regression are derived from the Pearson product–moment correlation coefficient, r			
2 3C	Small: 0.10	1478	1160
	Medium: 0.30	**154**	122
	Large: 0.50	50	40
Effect size estimates for simple linear regression are derived from the Pearson product–moment correlation coefficient, r			
3A	Small: 0.10	1478	1160
	Medium: 0.30	**154**	122
	Large: 0.50	50	40
Effect size estimates for multiple linear regression are derived from the F-test, f^2			
3B	Small: 0.02	1480	1226
	Medium: 0.15	**210**	176
	Large: 0.35	100	84

10. Statistical Methods

The data for the research project were analyzed using SAS version 9.2 (SAS Institute, Cary, North Carolina, 2008) and *ArcGIS 9* (Environmental Systems Research Institute [ESRI] Inc., Redlands CA, 2009) software. The investigator first assessed the normality of the distribution of the continuous variables (e.g., age, WHR, BMII, and lipid measures). In fact, the distribution of these variables was found to be approximately normal.

Two-sided statistical testing was used for all analyses with a p-value of 0.01 used to denote statistical significance. This level of significance was selected instead of the conventional value of 0.05 to account for the large number of statistical hypotheses that were evaluated and hence increased opportunity for type I error.

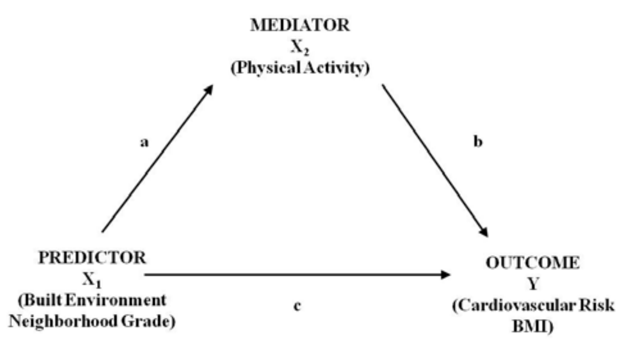
Since all analyses were observational in nature, assessment and control of confounding was critical. Without adequate consideration and methodological strategies to account for possible confounding, biased estimates and erroneous conclusions may have resulted. To identify potential covariates (confounders) to be controlled for in the analyses, the typical approach used was to fit an initial basic model (i.e., indicator of built environment and measure of cardiovascular disease risk) with individual covariates added singly in separate models. Those variables found to contribute significantly to the prediction of the selected measure of cardiovascular disease risk were then controlled for in the remaining multivariate models.

Specific Aim #1: Evaluate the relationships between measurements of the built environment, and measures of cardiovascular disease risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity).

- The measurement of the built environment served as the primary independent variable, while measures of cardiovascular disease risk were the dependent variables.
- If the measure of specific cardiovascular disease risk was a continuous variable, then conventional linear regression models were constructed. If the null hypothesis was rejected, using the p-value corresponding to the F statistic, it was then concluded that there was a relationship between the built environment and each measure of cardiovascular disease risk. The direction of this relationship was determined by whether or not the parameter estimate of beta was either positive or negative.
- If the measure of cardiovascular disease risk was a dichotomous or ordinal variable, then binary or ordinal logistic regression models were constructed. If the null hypothesis was rejected, using the p-value corresponding to the Chi-square statistic, it was then concluded that there was a relationship between the built environment and each measure of cardiovascular disease risk. The direction of this relationship was determined by whether or not the parameter estimate of the beta coefficient was either positive or negative. In addition, adjusted odds ratios and confidence intervals were estimated to aid in interpretation.

Specific Aim #2: Evaluate the extent to which relationships between the built environment and measures of cardiovascular disease risk are mediated through physical activity. For this analysis, the measurement of the built environment served as the independent variable, measures of cardiovascular disease risk as dependent variables, and the measure of physical activity as a potential mediating variable.

- The significant relationships observed between the built environment and cardiovascular disease risk identified in Aim #1 served as the basis for the mediational analyses, as there is little to no value in assessing mediation without a strong independent to dependent variable relationship. The goal of the mediational analyses was to estimate the extent to which physical activity mediates relationships between the built environment and cardiovascular disease risk.
- The general analytic approach for conducting this type of analysis is depicted in the diagram below.



- To illustrate, assume the measure of the built environment is the neighborhood grade of the participant's neighborhood. This environmental condition (X_1) is assumed to have both a direct and indirect path to the cardiovascular disease risk outcome of body mass index (BMI) (Y). "c," is the direct path, and "a → b" is the indirect path, passing through the mediating variable X_2 (extent of physical activity). The general statistical approach used to assess mediating effects was to add the potential mediating variable of physical activity to each significant built environment $\rightarrow$ cardiovascular disease risk model. If the $X_2 \rightarrow Y$ relationship was strong, yet the $X_1 \rightarrow Y$ relationship was substantially attenuated, this was considered an indication that variable X_2 (physical activity) was a mediator of the relationship, $X_1 \rightarrow Y$ (i.e., $X_1 \rightarrow X_2 \rightarrow Y$). There also existed the possibility that X_1 and X_2 were so strongly correlated that they could not survive in the model together, but in this case, the significance levels of both X_1 and X_2 were attenuated when they were evaluated simultaneously. These paths were expressed as standardized beta coefficients in regression modeling, including path analytic methods (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001) and sequential regression techniques (Baron & Kenny, 1986). Similarly, the Sobel test (Baron & Kenny, 1986) was used to formally evaluate the statistical significance of physical activity as a potential mediating variable.

Specific Aim #3: Evaluate the extent to which the above relationships vary by race.

- Analyses described in Aims 1 and 2 were conducted separately by race (Black and White groups). The coefficients of the variables derived from these models were examined and compared. This provided a general assessment as to whether race modified relationships between the built environment, physical activity, and measures of cardiovascular disease risk. Second, to formally test for effect modification, interaction terms (race x neighborhood grade) were included in all multivariable models. The corresponding value of the interaction term was examined to assess whether it was below the fixed alpha of 0.01.

Specific Aim #4: Evaluate the degree of concordance and discordance of three different methods of measuring indicators of the built environment. The three methods of assessing the environment include:

i. Heart SCORE participant self-report responses to an environmental questionnaire (these data were previously collected);

ii. An independent investigator assessment of the environment utilizing the same environmental questionnaire completed by Heart SCORE participants; and

iii. Objectively-collected data on the environment (e.g., census and geographic information systems [GIS]).

To satisfy this aim, two principal types of analyses were conducted: 1) To examine the extent to which the three different methods for measuring indicators of the built environment (as defined above) were concordant versus discordant; and 2) To examine whether race of the respondent influenced the degree of concordance.

As stated above, the *Neighborhood Environment Scale* used a 4-point Likert scale. Therefore, Fleiss' kappa statistic, "a statistical measure for assessing the reliability of the agreement between a fixed number of raters, thereby giving categorical ratings to a fixed number of items" (Chen, Zaebst, & Seel, 2005; Fleiss, 1971, 1981), was calculated to assess concordance and discordance for selected questionnaire items between actual Heart SCORE participants and the independent evaluators. This quantified the extent to which an external evaluator is able to judge a person's built environment without being an actual resident in the neighborhood.

For the second type of analysis, Fleiss' kappa statistic was again used to assess agreement, by race, for individual items from the *Neighborhood Environment Scale*.

In addition, the racial/ethnic composition or neighborhood type (i.e., predominately White, predominately Black, and racially mixed) of the actual Heart SCORE participants' neighborhoods was identified. Each participant's zip code was entered into the *Population Finder* found on www.census.gov. A fact sheet was then generated, which provided Census 2000 demographic profile highlights for each individual zip code area. The demographic information provided included the percentage of White and Black residents found in each area or neighborhood corresponding to that specific zip code (United States Census Bureau, 2010). Therefore, the neighborhood type variable was created by assessing whether or not there was a higher percentage of a particular racial/ethnic group found in that area. For example, when area code 15215 (zip code that encompasses the O'Hara Township) was entered, the fact sheet indicated that this area consists of approximately 96% Whites and 1.5% Blacks. This area was therefore categorized as predominately White.

Next, agreement analyses were conducted separately by neighborhood type. Ratings from individuals who resided in each of the different types of neighborhoods were compared to the separate external evaluators' ratings, to identify whether the degree of concordance differed by neighborhood type. Since all of the independent evaluators were Black/African American, the approach above was utilized as a proxy measure for assessment by race.

In the final analyses, several variables that could be captured objectively using geospatial data to directly examine the concordance with objective GIS measures of the environment were selected. Using spatial analysis tools, such as geocoding, proximity analysis, and spatial joining, the distance between each participant's residence and the closest corresponding objective feature of interest (e.g., sidewalks, walking trails/parks, and vacant lots) was calculated. For example, this permitted the accurate identification of the closest park to each participant's residence. This allowed the investigator to then calculate the exact distance between each residence and the nearest walking trail/park to that residence. Although the neighborhood ratings and the GIS measurements are not on the same scale, a comparison between the two groups of neighborhood ratings (agree vs. disagree) and the actual average distance to the objective measure was investigated by use of the t-test procedure. These analyses were conducted in order to assess whether there were any differences in the mean distance between the groups. In addition, these analyses were conducted using our participants' ratings (agree vs. disagree) and independent evaluators' ratings (agree vs. disagree) separately to test if there was a significant difference between the groups.

5.0 RESULTS

5.1 STUDY POPULATION (SPECIFIC AIMS 1-3)

The data for this evaluation originated from the Heart SCORE Study, a longitudinal assessment of cardiovascular disease in the Pittsburgh region. The data set for the current study consisted of 955 out of the total 2,000 participants who completed the *Neighborhood Environment Scale* which was later added to the Heart Score study protocol. We included 902 of these Heart SCORE participants (94.5%) who met the following inclusion criteria: 1) Black or White race; 2) residents of the Metropolitan Pittsburgh area whose *Neighborhood Environment Scale* was based on a Pittsburgh address; and 3) responses to greater than or equal to 60% of the 36 items on the *Neighborhood Environment Scale*. Post hoc power analyses indicated that a sample size of 902 was more than adequate to provide 90% power to detect "medium" effect sizes for all specific aims (1-3), and approached the required sample size for being able to detect "small" effect sizes. This sample size was also sufficient to conduct stratified analyses by race.

Table 13 contains a detailed description of the study population. The mean age at the time of completion of the *Neighborhood Environment Scale* was 62 $\pm$ 8 years, 66% were female, 57% were of White race, and 64% were married. In context of the general adult population of Western Pennsylvania, this sample was relatively healthy for the age range of 45 to 74, as indicated by the prevalence of risk factors. Only 6% of participants identified themselves as current smokers, and the majority reported at least a moderate level of physical activity. Additionally, the prevalence of cardiovascular risk factors and comorbidities was relatively low: diabetes (12.0%), hypertension (32.9%), low HDL (27.4%), high or very high triglycerides (8.5%). The majority of participants had near optimal or above optimal LDL levels, as well as HDL levels above the gender-specific low range, and normal triglycerides. Taking into consideration a population whose average age was approximately 62 at the completion of the *Neighborhood Environment Scale*, the prevalence of diabetes and hypertension found in this cohort is lower than the national age-specific prevalence statistics for individuals of this age (diabetes: 23.1%; hypertension: 39.5%) (Centers for Disease Control and Prevention, 2008e; National Heart, 2010; National Institute of Diabetes and Digestive and Kidney Diseases, 2008).

As previously mentioned, a neighborhood grade variable was created from the weighted environmental score, and divided into quartiles (1= least favorable neighborhood to 4 = most favorable neighborhood). This ordinal categorical variable was used as the primary measure of the built environment for all analyses. The results presented here involve an assessment of the association between the built environment and ten measures of cardiovascular disease risk: WHR, BMI, obesity, diabetes, metabolic syndrome, hypertension, physical inactivity, HDL, LDL, and triglyceride levels.

Table 13. Study Population Characteristics (N = 902)

Characteristic	Mean ± SD
Age (y) at time of NES	61.7 ± 7.5
WHR	0.90 ± 0.09
BMI	29.8 ± 5.9
	Prevalence
Gender (%)	
Male	34.2
Female	65.9
Race/Ethnicity (%)	
Black/African American	42.7
White/Caucasian	57.3
Neighborhood Grade (%)	
Least Favorable	24.8
Mildly Favorable	25.1
Moderately Favorable	25.1
Most Favorable	25.1
Married (%)	
Yes	64.2
No	35.8
Work Status (%)	
Full-Time	47.4
Part-Time	14.5
Long-Term Sick Leave	0.3
Homemaker	4.5
Retired	26.9
Disabled	2.7
Unemployed/Looking for Work	1.8
Temporarily Laid Off	0.2
Other	1.8
Education (%)	
None or Some Grade School	0.1
Some High School	1.7
High School Diploma	15.0
Some College, No Degree	17.9
Vocational or Technical School	5.3
Associate (2 yr) Degree	9.6
Bachelor's Degree	23.0
Master's Degree	19.7
Doctoral Degree	6.2
Other Advanced Degree	1.6
Annual Income (%)	
Less Than $10,000	4.8
$10,000 - < $20,000	10.3
$20,000 - < $40,000	28.3
$40,000 - < $80,000	35.1
$80,000 or More	21.5

Table 13 (continued)

Insurance Type (%)	
Medicare	12.9
Medicaid	0.4
Other Public	1.5
Private	79.0
None/Self Pay	6.2
Smoking Status (%)	
Current	6.0
Former	42.8
Never	51.2
PA Level (%)	
Sedentary	6.9
Mild	29.7
Moderate	53.9
Strenuous	9.6
Obese (%)	
Yes	42.4
No	57.6
Diabetes (%)	
Yes	12.0
No	88.0
Metabolic Status (%)	
Normal	67.7
Metabolic Syndrome	21.1
History of Diabetes	11.2
Hypertension (%)	
Yes	32.9
No	67.1
LDL (%)	
Optimal	28.3
Near/Above Optimal	34.1
Borderline High	24.2
High	13.5
Low HDL (%)	
Yes	27.4
No	72.7
Triglycerides (%)	
Normal	78.5
Borderline High	13.0
High	8.3
Very High	0.23

SD = standard deviation; WHR = waist-hip ratio; BMI = body mass index;
PA = physical activity; LDL = low-density lipoprotein; HDL = high-density lipoprotein.

Table 14 presents a detailed description of the distribution of the measures of CVD risk across each level of neighborhood grade that was examined in this study. The data indicates that as neighborhood grade increases, there was a significant decrease in the proportion of high WHR measurements ($p = 0.0081$), obesity ($p < 0.0001$), sedentary behaviors ($p = 0.0002$), presence of the metabolic syndrome ($p = 0.0069$), and hypertension ($p = 0.0009$). There was also a borderline significant trend for a decrease in the presence of diabetes as the neighborhood grade increases ($p = 0.0151$). However, there were no relationships between the lipid measures (i.e., LDLs, HDLs, and triglycerides) and levels of neighborhood grade.

Table 14. Study Population Clinical Characteristics

Outcome	N	Neighborhood Grade (%)				p-trend
		Least Favorable (n = 224)	Mildly Favorable (n = 226)	Moderately Favorable (n = 226)	Most Favorable (n = 226)	
High WHR						0.0081
Yes	633	164 (25.9)	164 (25.9)	159 (25.1)	146 (23.1)	
No	229	47 (20.5)	51 (22.3)	59 (25.8)	72 (31.4)	
BMI						<0.0001**
Underweight	9	2 (22.2)	2 (22.2)	4 (44.4)	1 (11.1)	
Normal	161	31 (19.3)	30 (18.6)	43 (26.7)	57 (35.4)	
Overweight	330	63 (19.1)	88 (26.7)	97 (29.4)	82 (24.9)	
Obese	368	119 (32.3)	95 (25.8)	77 (20.9)	77 (20.9)	
PA Level						0.0002
Sedentary	62	27 (43.6)	14 (22.6)	13 (21.0)	8 (12.9)	
Mild	266	71 (26.7)	76 (28.6)	63 (23.7)	56 (21.1)	
Moderate	483	101 (20.9)	118 (24.4)	130 (26.9)	134 (27.7)	
Strenuous	86	23 (26.7)	17 (19.8)	20 (23.3)	26 (30.2)	
Diabetes						0.0151
Yes	103	37 (35.9)	26 (25.2)	16 (15.5)	24 (23.3)	
No	757	174 (23.0)	187 (24.7)	204 (27.0)	192 (25.4)	
Metabolic Status						0.0069
Normal	584	127 (21.8)	151 (25.9)	154 (26.4)	152 (26.0)	
Metabolic Syndrome	182	50 (27.5)	40 (22.0)	50 (27.5)	42 (23.1)	
History of Diabetes	97	36 (37.1)	25 (25.8)	13 (13.4)	23 (23.7)	
Hypertension						0.0009
Yes	286	88 (30.8)	74 (25.9)	66 (23.1)	58 (20.3)	
No	583	127 (21.8)	141 (24.2)	155 (26.6)	160 (27.4)	
LDL						0.3506
Optimal	225	47 (20.9)	60 (26.7)	58 (25.8)	60 (26.7)	
Near/Above Optimal	271	67 (24.7)	72 (26.6)	67 (24.7)	65 (24.0)	
Borderline High	192	45 (25.0)	38 (19.8)	61 (31.8)	45 (23.4)	
High	107	30 (28.0)	28 (26.2)	22 (20.6)	27 (25.2)	
Low HDL						0.0752
Yes	236	62 (26.3)	64 (27.1)	64 (27.1)	46 (19.5)	
No	627	152 (24.2)	149 (23.8)	155 (24.7)	171 (27.3)	
Triglycerides						0.5568**
Normal	675	174 (25.8)	164 (24.3)	167 (24.7)	170 (25.2)	
Borderline High	112	21 (18.8)	36 (32.1)	26 (23.2)	29 (25.9)	
High	71	18 (25.4)	12 (16.9)	25 (35.2)	16 (22.5)	
Very High	2	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	

WHR = waist-hip ratio; BMI = body mass index; PA = physical activity; LDL = low-density lipoprotein; HDL = high-density lipoprotein. * Due to missing data, numbers may not equal the total N (902); ** Monte Carlo estimate for Fisher's Exact Test.

5.2 SPECIFIC AIM 1: EVALUATE THE RELATIONSHIP BETWEEN THE BUILT ENVIRONMENT AND MEASURES OF CARDIOVASCULAR DISEASE RISK (I.E., LIPID ABNORMALITIES, HYPERTENSION, OBESITY, THE METABOLIC SYNDROME, DIABETES, AND PHYSICAL INACTIVITY)

5.2.1 Univariate Regression Analysis Results

Univariate regression analyses were conducted to identify potential covariates (confounders) to be adjusted for in the multivariate analyses, and to examine the unadjusted relationships between the built environment and measures of cardiovascular disease risk. These results confirmed significant univariate associations between neighborhood grade and 5 of the 10 measures of cardiovascular risk: BMI, obesity, diabetes, hypertension, and physical inactivity. An inverse relationship was found between those residing in moderately and most favorable neighborhoods and BMI, when compared to those residing in least favorable neighborhoods ($p < 0.0001$ and $p < 0.0001$, respectively) (Table 15). These results were also observed when examining the relationship between neighborhood grade and obesity (moderately favorable: OR = 0.43, $p < 0.0001$; most favorable: OR = 0.44, $p < 0.0001$) (Table 16). Compared to those residing in least favorable neighborhoods, the odds of having diabetes were approximately 63% lower in those residing in moderately favorable neighborhoods (OR = 0.37; $p = 0.0016$) (Table 17). However, this relationship did not appear to follow an ordered trend (i.e., more favorable neighborhoods being associated with lower prevalence of diabetes). Conversely, the odds of having hypertension were approximately 48% lower in those residing in most favorable neighborhoods compared to those living in least favorable neighborhoods (OR = 0.52; p = 0.0017) (Table 18). Moreover, compared to those residing in least favorable neighborhoods, the odds of being inactive were approximately 47% lower in those residing in most favorable neighborhoods (OR = 0.53; p = 0.0005) (Table 19).

Table 15. Factors Associated with Body Mass Index (BMI) in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	-1.24	0.0267	-0.08
Moderately Favorable	Least Favorable	-2.54	<0.0001	-0.15
Most Favorable	Least Favorable	-2.67	<0.0001	-0.16
Race				
Black	White	2.94	<0.0001	0.25
Education Level				
High School or Less	Bachelor's Degree	0.84	0.1882	0.04
Some College	Bachelor's Degree	1.69	0.0017	0.11
More than Bachelor's Degree	Bachelor's Degree	0.11	0.8434	0.01
Physical Activity Level				
Sedentary	Moderate	4.76	<0.0001	0.20
Mild	Moderate	1.98	<0.0001	0.15
Strenuous	Moderate	-1.00	0.1372	-0.05

BMI (continuous).
r_{xy} = partial correlation coefficient.

Table 16. Factors Associated with Obesity in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.45	0.0209	0.64	(0.39- 1.05)
Moderately Favorable	Least Favorable	-0.84	<0.0001	0.43	(0.26 - 0.72)
Most Favorable	Least Favorable	-0.81	<0.0001	0.44	(0.27 - 0.74)
Race					
Black	White	0.94	<0.0001	2.55	(1.77- 3.67)
Education Level					
High School or Less	Bachelor's Degree	0.61	0.0070	1.83	(1.03 - 3.27)
Some College	Bachelor's Degree	0.63	0.0009	1.88	(1.15 - 3.06)
More than Bachelor's Degree	Bachelor's Degree	0.17	0.4046	1.18	(0.71 - 1.98)
Physical Activity Level					
Sedentary	Moderate	1.20	<0.0001	3.32	(1.57 - 7.00)
Mild	Moderate	0.43	0.0072	1.53	(1.02 - 2.30)
Strenuous	Moderate	-0.10	0.6851	0.91	(0.48 - 1.71)

Obese (dichotomous).
OR = odds ratio. OR for being obese is presented here.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for obese * neighborhood grade: (1 degree of freedom) = 21.02; $p < 0.0001$.
p-value for trend for neighborhood grade: $p < 0.0001$.

Table 17. Factors Associated with Diabetes in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		0.05	0.0007	1.05	(1.01 - 1.09)
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.42	0.1247	0.65	(0.32 - 1.33)
Moderately Favorable	Least Favorable	-1.00	0.0016	0.37	(0.16 - 0.83)
Most Favorable	Least Favorable	-0.53	0.0598	0.59	(0.28 - 1.22)
Race					
Black	White	0.97	<0.0001	2.65	(1.51 - 4.64)
Education Level					
High School or Less	Bachelor's Degree	0.75	0.0391	2.11	(0.83 - 5.34)
Some College	Bachelor's Degree	0.85	0.0067	2.35	(1.04 - 5.28)
More than Bachelor's Degree	Bachelor's Degree	0.35	0.3157	1.41	(0.58 - 3.43)
Insurance Type					
Medicare	Private	0.76	0.0048	2.14	(1.07 - 4.27)
Other Public	Private	0.93	0.1653	2.53	(0.45 - 14.23)
None/Self Pay	Private	0.10	0.8306	1.10	(0.34 - 3.53)

Diabetes (dichotomous).
OR = odds ratio. OR for being diabetic is presented here.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for diabetes * neighborhood grade: (1 degree of freedom) = 5.91; p = 0.0151.
p-value for trend for neighborhood grade = 0.0156.
Too few subjects with Medicaid to be assessed.

Table 18. Factors Associated with Hypertension in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		0.05	<0.0001	1.05	(1.02 - 1.08)
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.28	0.1639	0.76	(0.45 - 1.27)
Moderately Favorable	Least Favorable	-0.49	0.016	0.62	(0.37 - 1.03)
Most Favorable	Least Favorable	-0.65	0.0017	0.52	(0.31 - 0.89)
Race					
Black	White	0.63	<0.0001	1.89	(1.30- 2.75)
Education Level					
High School or Less	Bachelor's Degree	0.60	0.0087	1.83	(1.01 - 3.31
Some College	Bachelor's Degree	0.32	0.1024	1.38	(0.83 - 2.30)
More than Bachelor's Degree	Bachelor's Degree	-0.11	0.5933	0.89	(0.52 - 1.54)

Hypertension (dichotomous).
OR = odds ratio. OR for being hypertensive is presented here.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for hypertension * neighborhood grade: (1 degree of freedom) = 11.06; p = 0.0009.
p-value for trend for neighborhood grade = 0.0009.

Table 19. Factors Associated with Physical Inactivity in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		-0.02	0.0065	0.98	(0.96 - 1.00)
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.16	0.3763	0.85	(0.54 - 1.36)
Moderately Favorable	Least Favorable	-0.39	0.0320	0.68	(0.43 - 1.08)
Most Favorable	Least Favorable	-0.64	0.0005	0.53	(0.33 - 0.85)
Gender					
Male	Female	-0.41	0.0026	0.66	(0.47 - 0.94)

Physical activity level (ordinal categorical).
OR = odds ratio. OR for being sedentary/inactive.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for physical activity level * neighborhood grade: (1 degree of freedom) = 14.33; p = 0.0002.
p-value for trend for neighborhood grade = 0.0002.

Univariate analyses also identified several other variables that were associated with measures of cardiovascular disease risk not discussed above, independent of neighborhood grade. These variables were examined individually as potential confounders (Appendix K).

5.2.2 Multivariate Regression Analysis Results

For multivariate linear and logistic regression modeling, forward selection methods were utilized to identify other key variables that, together, contributed significantly to the prediction of the measures of cardiovascular disease risk. After the forward selection process, neighborhood grade was included in all multivariate models, and all models were adjusted for age and gender.

In both linear and logistic models, after adjusting for all relevant covariates, the results confirmed significant associations between neighborhood grade and obesity and physical inactivity. An inverse relationship was again found between those residing in moderately favorable neighborhoods and obesity, when compared to those residing in least favorable neighborhoods (OR = 0.57; p = 0.0069) (Table 20). Moreover, compared to those residing in least favorable neighborhoods, the odds of being inactive were approximately 44% lower in those residing in most favorable neighborhoods (OR = 0.56; p = 0.0016) (Table 21).

Table 20. Multivariate Model of Factors Associated with Obesity

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.32	0.1162	0.73	(0.43 - 1.23)
Moderately Favorable	Least Favorable	-0.56	0.0069	0.57	(0.33 - 0.97)
Most Favorable	Least Favorable	-0.45	0.0349	0.64	(0.37 - 1.10)
Race					
Black	White	0.85	<0.0001	2.33	(1.58- 3.44)
Physical Activity Level					
Sedentary	Moderate	1.00	0.0009	2.73	(1.26 - 5.92)
Mild	Moderate	0.40	0.0153	1.49	(0.98 - 2.29)
Strenuous	Moderate	-0.23	0.3644	0.79	(0.41 - 1.54)

Obese (dichotomous).
OR = odds ratio. OR for being obese is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, race, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 13.34; p = 0.1007.
p-value for trend for neighborhood grade = 0.0184.

Table 21. Multivariate Model of Factors Associated with Physical Inactivity

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		-0.02	0.0158	0.98	(0.96 - 1.00)
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.13	0.4548	0.87	(0.55 - 1.39)
Moderately Favorable	Least Favorable	-0.35	0.0560	0.71	(0.44 - 1.13)
Most Favorable	Least Favorable	-0.58	0.0016	0.56	(0.35 - 0.90)
Gender					
Male	Female	-0.36	0.0080	0.69	(0.49 - 0.99)

Physical activity level (ordinal categorical).
OR = odds ratio. OR for being sedentary/inactive.
CI = confidence interval.
*Model adjusted for: age and gender.
p-value for trend for neighborhood grade = 0.0008.

Multivariate analyses also identified several other variables that together, were associated with measures of cardiovascular disease risk not discussed above, independent of neighborhood grade (Appendix L).

5.3 SPECIFIC AIM 2: EVALUATE THE EXTENT TO WHICH THE RELATIONSHIP BETWEEN THE BUILT ENVIRONMENT AND MEASURES OF CARDIOVASCULAR DISEASE RISK ARE MEDIATED THROUGH PHYSICAL ACTIVITY

Prior to conducting the mediational analyses, the following conditions had to be met regarding univariate relationships between the variables of interest:

1) An association between the independent variable (neighborhood grade) and the dependent variable (i.e., measures of cardiovascular disease risk).
2) An association between the potential mediator (physical activity) and the dependent variable (i.e., measures of cardiovascular disease risk).

Therefore, BMI and obesity were the only measures of cardiovascular risk that met the criteria to serve as dependent variables in mediational analyses. However, since both BMI and obesity are two highly correlated variables, BMI was selected to serve as the dependent variable, as it is a continuous variable which permits greater assessment of variation in relation to neighborhood grade. Additionally, neighborhood grade served as the independent variable, while physical activity served as the potential mediator for this analysis.

As mentioned previously, this analysis required the examination of three regression equations to assess the relationships between neighborhood grade (independent variable) and physical activity (potential mediator), neighborhood grade and BMI (dependent variable), and lastly, physical activity and BMI, while adjusting for neighborhood grade. If statistically significant relationships are observed in each condition, then partial mediation is said to occur when the absolute value of the regression coefficients for the independent variable (neighborhood grade) is smaller in the third equation than in the second, but does not equal zero.

Tables 22-24 present the findings of the mediation analyses. First, Table 22 demonstrates an association between neighborhood grade and physical activity. Table 23 reveals a statistically significant relationship between neighborhood grade and BMI. Lastly, Table 24 illustrates an association between physical activity and BMI after adjusting for neighborhood grade. As seen in Tables 23 and 24, the results indicate that physical activity is one mechanism in which the positive indicators of the built environment favorably influence BMI, thereby suggesting that physical activity partially mediates the relationship between the built environment and BMI. The results of the Sobel Test (Table 25) further substantiate this finding (Sobel Z-statistic = -3.28; p = 0.0010).

Table 22. Relationship between Neighborhood Grade and Physical Inactivity in Univariate Analysis (When Testing for Mediation)

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.16	0.3763	0.85	(0.54 - 1.36)
Moderately Favorable	Least Favorable	-0.39	0.0320	0.68	(0.43 - 1.08)
Most Favorable	Least Favorable	-0.64	0.0005	0.53	(0.33 - 0.85)

Physical activity level (ordinal categorical).
OR = odds ratio. OR for being sedentary/inactive.
CI = confidence interval.

Table 23. Relationship between Neighborhood Grade and Body Mass Index (BMI) in Univariate Analysis (When Testing for Mediation)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	**-1.24**	0.0267	-0.08
Moderately Favorable	Least Favorable	**-2.54**	<0.0001	-0.15
Most Favorable	Least Favorable	**-2.67**	<0.0001	-0.16

BMI (continuous).
r_{xy} = partial correlation coefficient.

Table 24. Multivariate Model Assessing Relationship between Physical Activity, Neighborhood Grade, and Body Mass Index (BMI) (When Testing for Mediation)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Physical Activity Level		-1.77	<0.0001	-0.23
Neighborhood Grade				
Mildly Favorable	Least Favorable	**-1.16**	0.0328	-0.07
Moderately Favorable	Least Favorable	**-2.30**	<0.0001	-0.14
Most Favorable	Least Favorable	**-2.26**	<0.0001	-0.14

BMI (continuous).
r_{xy} = partial correlation coefficient.

Table 25. Summary Statistics of Mediation Analysis for Total Study Population

Type of Statistics	Value
1. Sobel Z-statistic	-3.28
2. p-value of Sobel	0.0010*

2. The p-value of Sobel: shows whether there is a significant independent effect associated with the postulated mediator.
* $p < 0.01$.

5.4 SPECIFIC AIM 3: EVALUATE THE EXTENT TO WHICH THE ABOVE RELATIONSHIPS VARY BY RACE

The goal of this analysis was to determine whether the above-defined relationships between the built environment, physical activity, and cardiovascular disease outcomes were modified by race. Two approaches were utilized to evaluate the potential presence of effect modification by race: 1) analyses described in Aims 1 and 2 were conducted separately by race (Black and White groups); and 2) in all multivariable models, interaction terms (race × neighborhood grade) were included to formally test for effect modification.

5.4.1 Study Population Stratified by Race

Table 26 contains a detailed description of the study population stratified by race. For Black participants, the mean age at the time of completion of the *Neighborhood Environment Scale* was 61 $\pm$ 7, and 70% were female. Whereas, for White participants, the mean age at the time of completion of the *Neighborhood Environment Scale* was 62 $\pm$ 7 years, and 63% were female (hence relatively similar by race). Both cohorts were of moderate to high SES. Each subgroup was comprised of a relatively healthy, predominantly non smoking cohort of individuals, who reported participating in moderate levels of physical activity. Additionally, the prevalence of cardiovascular risk factors and comorbidities found in both subgroups was relatively low for this age group. Black participants were found to have the following distributions of health conditions: diabetes (18.0%), hypertension (41.0%), low HDL (28.7%), and high or very high triglycerides (5.0%). In comparison, the White participants had an overall lower prevalence of analogous health conditions, including: diabetes (7.6%), hypertension (27.0%), and low HDL

(26.4%), yet a higher prevalence of high or very high triglycerides (11.0%). When specifically examining blood lipid levels, most participants had near optimal or above optimal LDL levels, as well as HDL levels above the gender-specific low range, and normal triglycerides.

Demographically, White participants were more likely than Black participants to be married (77% vs. 47%, respectively). Both subgroups differed in the types of neighborhoods in which they lived, with more Black participants residing in least favorable neighborhoods (37%), while more White participants lived in most favorable neighborhoods (33%). These subpopulations also differed in obesity status, with more Black participants being classified as obese (55.4%), while more White participants were non-obese (67.2%).

Table 26. Study Population Characteristics by Race

Characteristic	Black/African American (n = 385)	White/Caucasian (n = 517)
Age (y) at time of NES (mean ± SD)	61.4 ± 7.6	62.0 ± 7.4
WHR (mean ± SD)	0.9 ± 0.1	0.9 ± 0.1
BMI (mean ± SD)	31.5 ± 5.9	28.6 ± 5.5
Gender (%)		
Male	29.6	37.5
Female	70.4	62.5
Neighborhood Grade (%)		
Least Favorable	37.1	15.7
Mildly Favorable	28.8	22.2
Moderately Favorable	19.0	29.6
Most Favorable	15.1	32.5
Married (%)		
Yes	47.0	77.0
No	53.0	23.0
Work Status (%)		
Full-Time	49.9	45.5
Part-Time	10.7	17.3
Long-Term Sick Leave	0.5	0.2
Homemaker	1.6	6.6
Retired	27.9	26.2
Disabled	5.2	0.8
Unemployed/Looking for Work	1.8	1.7
Temporarily Laid Off	0.0	0.4
Other	2.4	1.4
Education (%)		
None or Some Grade School	0.0	0.2
Some High School	2.1	1.4
High School Diploma	16.7	13.8
Some College, No Degree	26.0	11.8
Vocational or Technical School	7.6	3.7
Associate (2 yr) Degree	11.7	8.0
Bachelor's Degree	18.2	26.6
Master's Degree	12.5	25.0
Doctoral Degree	3.7	8.1
Other Advanced Degree	1.6	1.6
Annual Income (%)		
Less Than $10,000	8.3	2.2
$10,000 - < $20,000	17.1	5.2
$20,000 - < $40,000	30.5	26.7
$40,000 - < $80,000	36.8	33.8
$80,000 or More	7.4	32.1

Table 26 (continued)

Insurance Type (%)		
Medicare	13.8	12.2
Medicaid	0.8	0.2
Other Public	1.8	1.2
Private	74.9	82.0
None/Self Pay	8.6	4.5
Smoking Status (%)		
Current	9.9	3.1
Former	45.7	40.6
Never	44.4	56.3
PA Level (%)		
Sedentary	9.4	5.1
Mild	28.5	30.5
Moderate	51.8	55.3
Strenuous	10.2	9.1
Obese (%)		
Yes	55.4	32.8
No	44.6	67.2
Diabetes (%)		
Yes	18.0	7.6
No	82.0	92.4
Metabolic Status (%)		
Normal	63.2	70.9
Metabolic Syndrome	19.2	22.4
History of Diabetes	17.6	6.6
Hypertension (%)		
Yes	41.0	27.0
No	59.0	73.1
LDL (%)		
Optimal	30.0	27.1
Near/Above Optimal	33.9	34.2
Borderline High	23.4	24.7
High	12.6	14.1
Low HDL (%)		
Yes	28.7	26.4
No	71.4	73.6
Triglycerides (%)		
Normal	85.3	73.6
Borderline High	9.7	15.4
High	5.0	10.6
Very High	0.0	0.4

SD = standard deviation; WHR = waist-hip ratio; BMI = body mass index;
PA = physical activity; LDL = low-density lipoprotein; HDL = high-density lipoprotein.

Table 27 contains a detailed description of the distribution of the measures of CVD risk across each level of neighborhood grade stratified by race. Among Whites, there was a significant increase in the proportion of moderate and strenuous physical activity ($p = 0.0030$) as neighborhood grade increases. BMI levels were significantly associated with neighborhood grade ($p = 0.0003$). There was also a borderline significant trend found among those with high HDL levels and neighborhood grade ($p = 0.0123$). However, there was a relatively consistent distribution of obese participants, as well those with low HDL levels, across each level of neighborhood grade. Furthermore, relationships between neighborhood grade and WHR, diabetes, metabolic status, hypertension, and lipid measures (i.e., LDLs and triglycerides) were not statistically significant. Conversely, there were no significant associations found between any measure of CVD risk and neighborhood grade in Black participants.

Table 27. Study Population Clinical Characteristics Stratified by Race

	Black (n = 385)						White (n = 517)					
Outcome	Neighborhood Grade (%)					p-trend	Neighborhood Grade (%)					p-trend
		Least Favorable (n = 143)	Mildly Favorable (n = 111)	Moderately Favorable (n = 73)	Most Favorable (n = 58)			Least Favorable (n = 81)	Mildly Favorable (n = 115)	Moderately Favorable (n = 153)	Most Favorable (n = 168)	
WHR						0.2389						0.0367
Yes	276	102 (37.0)	82 (29.7)	53 (19.2)	39 (14.1)		357	62 (17.4)	82 (23.0)	106 (29.7)	107 (30.0)	
No	88	31 (35.2)	22 (25.0)	16 (18.2)	19 (21.6)		141	16 (11.4)	29 (20.6)	43 (30.5)	53 (37.6)	
BMI						0.7087**						0.0015**
Underweight	1	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)		8	2 (25.0)	1 (12.5)	4 (50.0)	1 (12.5)	
Normal	41	16 (39.0)	10 (24.4)	6 (14.6)	9 (22.0)		120	15 (12.5)	20 (16.7)	37 (30.8)	48 (40.0)	
Overweight	122	43 (35.3)	34 (27.9)	29 (23.8)	16 (13.1)		208	20 (9.6)	54 (26.0)	68 (32.7)	66 (31.7)	
Obese	204	77 (37.8)	59 (28.9)	35 (17.2)	33 (16.2)		164	42 (25.6)	36 (22.0)	42 (25.6)	44 (26.8)	
PA Level						0.0340						0.0030
Sedentary	36	17 (47.2)	10 (27.8)	6 (16.7)	3 (8.3)		26	10 (38.5)	4 (15.4)	7 (26.9)	5 (19.2)	
Mild	109	44 (40.4)	40 (36.7)	14 (12.8)	11 (10.1)		157	27 (17.2)	36 (22.9)	49 (31.2)	45 (28.7)	
Moderate	198	60 (30.3)	55 (27.8)	47 (23.7)	36 (18.2)		285	41 (14.4)	63 (22.1)	83 (29.1)	98 (34.4)	
Strenuous	39	20 (51.3)	6 (15.4)	6 (15.4)	7 (18.0)		47	3 (6.4)	11 (23.4)	14 (29.8)	19 (40.4)	
Diabetes						0.3247						0.5323
Yes	65	29 (44.6)	17 (26.2)	8 (12.3)	11 (16.9)		38	8 (21.1)	9 (23.7)	8 (21.1)	13 (34.2)	
No	297	105 (35.4)	85 (28.6)	61 (20.5)	46 (15.5)		460	69 (15.0)	102 (22.2)	143 (31.1)	146 (31.7)	
Metabolic Status						0.2312						0.2593
Normal	230	80 (34.8)	68 (29.6)	45 (19.6)	37 (16.1)		354	47 (13.3)	83 (23.5)	109 (30.8)	115 (32.5)	
Metabolic Syndrome	70	25 (35.7)	19 (27.1)	16 (22.9)	10 (14.3)		112	25 (22.3)	21 (18.8)	34 (30.4)	32 (28.6)	
History of Diabetes	64	29 (45.3)	18 (28.1)	7 (10.9)	10 (15.6)		33	7 (21.2)	7 (21.2)	6 (18.2)	13 (39.4)	
Hypertension						0.1064						0.1382
Yes	151	61 (40.4)	43 (28.5)	29 (19.2)	18 (11.9)		135	27 (20.0)	31 (23.0)	37 (27.4)	40 (29.6)	
No	217	75 (34.6)	61 (28.1)	41 (18.9)	40 (18.4)		366	52 (14.2)	80 (21.9)	114 (31.2)	120 (32.8)	
LDL						0.0356						0.8772
Optimal	100	28 (28.0)	29 (29.0)	24 (24.0)	19 (19.0)		125	19 (15.2)	31 (24.8)	34 (27.2)	41 (32.8)	
Near/Above Optimal	113	42 (37.2)	35 (31.0)	19 (16.8)	17 (15.0)		158	25 (15.8)	37 (23.4)	48 (30.4)	48 (30.4)	
Borderline High	78	31 (39.7)	17 (21.8)	19 (24.4)	11 (14.1)		114	17 (14.9)	21 (18.4)	42 (36.8)	34 (29.8)	
High	42	19 (45.2)	13 (31.0)	5 (11.9)	5 (11.9)		65	11 (16.9)	15 (23.1)	17 (26.2)	22 (33.9)	
Low HDL						0.7281						0.0123
Yes	104	36 (34.6)	31 (29.8)	21 (20.2)	16 (15.4)		132	26 (19.7)	33 (25.0)	43 (32.6)	30 (22.7)	
No	259	99 (38.2)	71 (27.4)	48 (18.5)	41 (15.8)		368	53 (14.4)	78 (21.2)	107 (29.1)	130 (35.3)	
Triglycerides						0.9329						0.4824**
Normal	307	118 (38.4)	84 (27.4)	57 (18.6)	48 (15.6)		368	56 (15.2)	80 (21.7)	110 (29.9)	122 (33.2)	
Borderline High	35	8 (22.9)	13 (37.1)	8 (22.9)	6 (17.1)		77	13 (16.9)	23 (29.9)	18 (23.4)	23 (29.9)	
High	18	8 (44.4)	5 (27.8)	4 (22.2)	1 (5.6)		53	10 (18.9)	7 (13.2)	21 (39.6)	15 (28.3)	
Very High	0	-	-	-	-		2	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	

WHR = waist-hip ratio; BMI = body mass index; PA = physical activity; LDL = low-density lipoprotein; HDL = high-density lipoprotein.
* Due to missing data, numbers may not equal the total N for both groups.
** Monte Carlo estimate for Fisher's Exact Test

5.4.2 Specific Aim 3.1: Evaluate the Relationship between the Built Environment and Measures of Cardiovascular Disease Risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity)

5.4.3 Univariate Regression Analysis Results Stratified by Race

The results of the stratified data analyses conducted in the White subgroup confirmed significant associations between neighborhood grade and BMI, obesity, and physical inactivity. Specifically, compared to those residing in least favorable neighborhoods, an inverse relationship was found between those residing in moderately and most favorable neighborhoods and BMI ($p = 0.0002$ and $p = 0.0001$, respectively) (Table 28). This association was not observed in Black participants.

Similarly, when examining the association between neighborhood grade and obesity in Whites, an inverse relationship was found for all levels of neighborhood grade (mildly favorable: OR = 0.42, $p = 0.0045$; moderately favorable: OR = 0.34, $p = 0.0002$; most favorable: OR = 0.34, $p = 0.0002$) (Table 29). Again, no relationship was observed between neighborhood grade and obesity in Black participants.

Finally, compared to those residing in least favorable neighborhoods, the odds of being physically inactive among Whites were approximately 56% lower in those residing in most favorable neighborhoods (OR = 0.44; $p = 0.0017$) (Table 30). There was also a borderline association between residing in most favorable neighborhoods and lower odds of being physically inactive among Blacks (OR = 0.55; $p = 0.0482$).

Overall, these unadjusted analyses suggested the following: (i) residing in more favorable neighborhoods is associated with lower BMI, and lower odds of obesity and physical inactivity among Whites; (ii) among Blacks, these associations do not appear to be present with the possible exception of more favorable neighborhoods being associated with higher physical activity.

Table 28. Factors Associated with Body Mass Index (BMI) in Univariate Analyses

Variable	Reference Group	Black			White		
		Parameter Estimate	p-value	r_{xy}	Parameter Estimate	p-value	r_{xy}
Age (y)		-0.11	0.0094	-0.14	-0.02	0.5058	-0.03
Neighborhood Grade							
Mildly Favorable	Least Favorable	-0.06	0.9428	-0.004	-2.06	0.0105	-0.11
Moderately Favorable	Least Favorable	-0.88	0.3136	-0.05	-2.85	0.0002	-0.17
Most Favorable	Least Favorable	-0.66	0.4764	-0.04	-2.90	0.0001	-0.17
Gender							
Male	Female	-1.93	0.004	-0.15	1.18	0.0210	0.10
Physical Activity Level							
Sedentary	Moderate	5.53	<0.0001	0.27	2.77	0.0132	0.11
Mild	Moderate	2.14	0.0021	0.16	1.94	0.0005	0.16
Strenuous	Moderate	-1.83	0.0632	-0.10	-0.54	0.5360	-0.03

BMI (continuous).
r_{xy} = partial correlation coefficient.

Table 29. Factors Associated with Obesity in Univariate Analyses

Variable	Reference Group	Black Parameter Estimate	Black p-value	Black OR	Black 99% C.I.	White Parameter Estimate	White p-value	White OR	White 99% C.I.
Neighborhood Grade									
Mildly Favorable	Least Favorable	0.005	0.9860	1.01	(0.51 - 1.98)	-0.86	0.0045	0.42	(0.19 - 0.92)
Moderately Favorable	Least Favorable	-0.27	0.3669	0.77	(0.36 - 1.64)	-1.08	0.0002	0.34	(0.16 - 0.72)
Most Favorable	Least Favorable	0.01	0.9714	1.01	(0.45 - 2.29)	-1.09	0.0002	0.34	(0.16 - 0.71)
Physical Activity Level									
Sedentary	Moderate	1.20	0.0052	3.32	(1.10 -10.03)	1.03	0.0129	2.81	(0.96 - 8.18)
Mild	Moderate	0.68	0.0075	1.98	(1.03 - 3.83)	0.30	0.1593	1.35	(0.78 - 2.36)
Strenuous	Moderate	1.20	0.0052	3.32	(1.10 - 1.78)	0.05	0.8811	1.05	(0.43 - 2.57)

Obese (dichotomous).
OR = odds ratio. OR for being obese is presented here.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for obese * neighborhood grade: (1 degree of freedom) = 0.13; p = 0.7191.
Black: p-value for trend for neighborhood grade = 0.7185.
White: Mantel-Haenszel Chi-Square test of trend for obese * neighborhood grade: (1 degree of freedom) = 12.84; p = 0.0003.
White: p-value for trend for neighborhood grade = 0.0004.

Table 30. Factors Associated with Physical Inactivity in Univariate Analyses

Variable	Reference Group	Black Parameter Estimate	Black p-value	Black OR	Black 99% C.I.	White Parameter Estimate	White p-value	White OR	White 99% C.I.
Age (y)		-0.01	0.4947	0.99	(0.96 - 1.03)	-0.04	0.0021	0.97	(0.94 - 0.99)
Neighborhood Grade									
Mildly Favorable	Least Favorable	0.19	0.4384	1.20	(0.65 - 2.23)	-0.61	0.0303	0.55	(0.27 - 1.12)
Moderately Favorable	Least Favorable	-0.38	0.1650	0.68	(0.33 - 1.39)	-0.53	0.0439	0.59	(0.30 - 1.16)
Most Favorable	Least Favorable	-0.60	0.0482	0.55	(0.25 - 1.20)	-0.82	0.0017	0.44	(0.22 - 0.86)

Physical activity level (ordinal categorical).
OR = odds ratio. OR for being sedentary/inactive.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for physical activity level * neighborhood grade: (1 degree of freedom) = 4.50; p = 0.0340.
Black: p-value for trend for neighborhood grade = 0.0217.
White: Mantel-Haenszel Chi-Square test of trend for physical activity level * neighborhood grade: (1 degree of freedom) = 8.84; p = 0.0030.
White: p-value for trend for neighborhood grade = 0.0058.

As with the previous analyses, several other variables were associated with measures of cardiovascular disease risk not discussed above, independent of neighborhood grade. These variables were included individually as potential confounders (Appendix M).

5.4.4 Multivariate Regression Analysis Results Stratified by Race

Based on the results of the univariate analyses stratified by race, the investigator formally tested for interactions between race and neighborhood grade (race * neighborhood grade) for the following outcomes: BMI, obesity, and physical inactivity. The formal tests for interaction did not achieve statistical significance at the 0.01 level for any of the evaluated outcomes (BMI: $p = 0.1172$; obese: $p = 0.0304$; and physical inactivity: $p = 0.8799$). Nonetheless, these results were consistent with those of the race stratified analyses that indicated associations between neighborhood grade and cardiovascular risk in Whites, but not in Blacks.

After adjusting for all relevant covariates, in both linear and logistic models, neighborhood grade was significantly associated with BMI, obesity, and physical inactivity in the White subgroup. In fact, an inverse relationship was found between those residing in moderately and most favorable neighborhoods and BMI ($p = 0.0003$ and $p = 0.0005$, respectively) (Table 31). An inverse relationship was found between all levels of the neighborhood grade variable and obesity (mildly favorable: OR = 0.42, $p = 0.0046$; moderately favorable: OR = 0.32, $p = 0.0001$; most favorable: OR = 0.32, $p = 0.0001$) (Table 32). Furthermore, compared to those residing in least favorable neighborhoods, the odds of being inactive were approximately 54% lower in those residing in most favorable neighborhoods (OR = 0.46; $p = 0.0031$) (Table 33). The results of the data analyses stratified by race did not reveal any significant multivariate relationships between neighborhood grade and measures of cardiovascular disease risk among Black participants. Therefore, the results presented above, and in the tables below, reflect only those found among White participants. Furthermore, although the stratified analyses suggested that race modified several relationships between neighborhood grade and cardiovascular risk, our previous interaction results did not achieve statistical significance, therefore all models presented include main effects only.

Table 31. Multivariate Model of Factors Associated with Body Mass Index (BMI)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	-1.89	0.0180	-0.11
Moderately Favorable	Least Favorable	-2.76	0.0003	-0.16
Most Favorable	Least Favorable	-2.60	0.0005	-0.16
Physical Activity Level				
Sedentary	Moderate	2.09	0.0601	0.08
Mild	Moderate	1.91	0.0005	0.16
Strenuous	Moderate	-0.71	0.4073	-0.04

BMI (continuous).
*Model adjusted for: age, gender, physical activity level.
r_{xy} = partial correlation coefficient.

Table 32. Multivariate Model of Factors Associated with Obesity

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		-0.01	0.6885	1.00	(0.96 - 1.03)
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.86	0.0046	0.42	(0.19 - 0.92)
Moderately Favorable	Least Favorable	-1.13	0.0001	0.32	(0.15 - 0.68)
Most Favorable	Least Favorable	-1.13	0.0001	0.32	(0.15 - 0.68)
Gender					
Male	Female	0.47	0.0197	1.60	(0.95 - 2.67)

Obese (dichotomous).
OR = odds ratio. OR for being obese is presented here.
CI = confidence interval.
*Model adjusted for: age and gender.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 7.27; p = 0.5081.
p-value for trend for neighborhood grade = 0.0002.

Table 33. Multivariate Model of Factors Associated with Physical Inactivity

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		-0.03	0.0034	0.97	(0.94 - 1.00)
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.61	0.0310	0.55	(0.27 - 1.13)
Moderately Favorable	Least Favorable	-0.48	0.0702	0.62	(0.31 - 1.23)
Most Favorable	Least Favorable	-0.78	0.0031	0.46	(0.23 - 0.90)
Gender					
Male	Female	-0.39	0.0298	0.68	(0.43 - 1.08)

Physical activity level (ordinal categorical).
OR = odds ratio. OR for being sedentary/inactive.
CI = confidence interval.
*Model adjusted for: age and gender.
p-value for trend for neighborhood grade = 0.0117.

Multivariate analyses conducted in the White subgroup also identified several other variables that together, were associated with measures of cardiovascular disease risk not discussed above, independent of neighborhood grade (Appendix N).

5.4.5 Specific Aim 3.2: Evaluate the Extent to Which the Relationship between the Built Environment and Measures of Cardiovascular Disease Risk are Mediated through Physical Activity

5.4.6 Mediation Analysis Results

When examining the potential mediation of physical activity among Whites, BMI was the only measure of cardiovascular risk that met the criteria to serve as the dependent variable in mediational analyses. As seen in Tables 34-36, the results indicate that physical activity is one mechanism in which the positive indicators of the built environment favorably influence BMI, thereby suggesting that physical activity partially mediates the relationship between the built environment and BMI. The results of the Sobel Test further substantiate this finding (Sobel Z-statistic = -2.32; p = 0.0200), although the estimate was of borderline statistical significance. Because no measures of cardiovascular risk met the criteria for mediational analyses among Black participants, the results presented in Table 34-36 reflect only those found among our White participants.

Table 34. Relationship between Neighborhood Grade and Physical Inactivity in Univariate Analysis (When Testing for Mediation in Whites)

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.61	0.0303	0.55	(0.27 - 1.12)
Moderately Favorable	Least Favorable	-0.53	0.0439	0.59	(0.30 - 1.16)
Most Favorable	Least Favorable	-0.82	0.0017	0.44	(0.22 - 0.86)

Physical activity level (ordinal categorical).
OR = odds ratio. OR for being sedentary/inactive.
CI = confidence interval.

Table 35. Relationship between Neighborhood Grade and Body Mass Index (BMI) in Univariate Analysis (When Testing for Mediation in Whites)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	**-2.06**	0.0105	-0.11
Moderately Favorable	Least Favorable	**-2.85**	0.0002	-0.17
Most Favorable	Least Favorable	**-2.90**	0.0001	-0.17

BMI (continuous).
r_{xy} = partial correlation coefficient.

Table 36. Multivariate Model Assessing Relationship between Physical Activity, Neighborhood Grade, and BMI (When Testing for Mediation in Whites)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Physical Activity Level		-1.24	0.0003	-0.16
Neighborhood Grade				
Mildly Favorable	Least Favorable	**-1.83**	0.0221	-0.10
Moderately Favorable	Least Favorable	**-2.57**	0.0006	-0.15
Most Favorable	Least Favorable	**-2.47**	0.0010	-0.15

BMI (continuous).
r_{xy} = partial correlation coefficient.

Table 37. Summary Statistics of Mediation Analysis for White Participants

Type of Statistics	Value
1. Sobel Z-statistic	-2.32
2. p-value of Sobel	0.0200

2. The p-value of Sobel: shows whether there is a significant independent effect associated with the postulated mediator.

5.5 SPECIFIC AIM 4: EVALUATE THE DEGREE OF CONCORDANCE AND DISCORDANCE OF THREE DIFFERENT METHODS OF MEASURING INDICATORS OF THE BUILT ENVIRONMENT

This assessment evaluated how well questions in the *Neighborhood Environment Scale* correlated with assessments of the environment made by external observers, as well as objective GIS measures using *ArcGIS 9* (Environmental Systems Research Institute Inc., Redlands, California, 2009). As mentioned previously, to satisfy Aims 4.1 and 4.2, only 21 items from the *Neighborhood Environment Scale* were used for these analyses (Cronbach's Coefficient α = 0.94).

5.5.1 Specific Aim 4.1: Assess Concordance and Discordance between Actual Heart SCORE Participants and the Independent Evaluators for Selected Questionnaire Items

As seen in Table 38, after calculating the overall kappa statistic (κ), these analyses revealed fair agreement between the ratings from the Heart SCORE participants and the independent evaluators (κ = 0.22). However, after examining each individual question, there was substantial agreement for presence of sidewalks (κ = 0.70), moderate agreement for presence of vacant lots (κ = 0.42), while fair agreement was observed for sidewalk maintenance (κ = 0.22), the presence of sidewalk debris (κ = 0.24), places to go (κ = 0.34), attractive natural sights (κ = 0.22), attractive buildings/homes (κ = 0.30), and neighborhood generally free from litter (κ = 0.30)

(Table 38). In aggregate, these results indicated only slight to fair agreement for the majority of questionnaire items.

Table 38. Agreement between Heart SCORE Participants and Independent Evaluators

NES Questionnaire Items	Kappa	99% C.I.
Overall Kappa	0.22	(0.10 - 0.34)
There are sidewalks on most of the streets in the neighborhood.	0.70	(0.14 - 1.26)
The sidewalks in the neighborhood are well maintained (paved, even, and not a lot of cracks).	0.22	(-0.30 - 0.73)
The sidewalks are usually free of debris (such as litter, leaves, snow, etc).	0.24	(-0.31 - 0.79)
There are walking trails in or near the neighborhood that are easy to get to.	0.19	(-0.34 - 0.73)
The neighborhood has school grounds or a track that is available as a place to walk.	0.19	(-0.34 - 0.72)
There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in the neighborhood.	0.18	(-0.37 - 0.73)
Most possible walking routes in the neighborhood involve crossing busy streets or intersections.	0.09	(-0.45 - 0.63)
There are well-marked crosswalks and pedestrian signals to help walkers cross busy streets in the neighborhood.	0.16	(-0.35 - 0.67)
The neighborhood streets are well lit at night.	0.19	(-0.30 - 0.67)
There are many places to go within easy walking distance of the homes in the neighborhood.	0.34	(-0.17 - 0.86)
There are barriers to walking in the neighborhood (for example, hillsides or freeways) that limit the number of routes for getting from place to place.	0.05	(-0.50 - 0.60)
There are trees along the streets in the neighborhood.	0.19	(-0.35 - 0.73)
There are many attractive natural sights (such as trees, flowers, landscaping, views) in the neighborhood.	0.22	(-0.33 - 0.78)
There are attractive buildings/homes in the neighborhood.	0.30	(-0.28 - 0.87)
There are many interesting things to look at while walking (e.g., yards, birds, creeks, and store windows) in the neighborhood.	0.15	(-0.38 - 0.68)
The neighborhood is generally free from litter.	0.30	(-0.24 - 0.85)
There are vacant lots and boarded up buildings in the neighborhood.	0.42	(-0.13 - 0.96)
When walking in the neighborhood, there are a lot of exhaust fumes (such as, from cars, buses).	0.07	(-0.48 - 0.63)
The climate/weather of the neighborhood makes walking uncomfortable most of the year.	0.12	(-0.47 - 0.70)
Mosquitoes, bees or insects make walking a problem in the neighborhood.	0.06	(-0.53 - 0.66)
There is a well-shaded walk route available in the neighborhood.	0.18	(-0.32 - 0.69)

***** Kappa levels of agreement (Kirtland et al., 2003; Landis & Koch, 1977):

- < 0.00 = poor;
- 0.00 - 0.20 = slight;
- 0.21 - 0.40 = fair;
- 0.41 - 0.60 = moderate;
- 0.61 - 0.80 = substantial;
- 0.81 - 1.00 = almost perfect.

CI = confidence interval.

5.5.2 Aim 4.2: Assess Concordance and Discordance between the Independent Evaluators for Selected Questionnaire Items by Neighborhood Type (of the Heart SCORE Participants)

In the following analyses, we sought to examine whether the race of the respondent was associated with the degree of concordance between the independent evaluators for selected questionnaire items. Since all of the independent evaluators were Black, we utilized neighborhood type (i.e., predominately White, predominately Black, and racially mixed) as a proxy measure for assessment by race. For that reason, agreement analyses were conducted separately by neighborhood type. Ratings from individuals who resided in each of the different types of neighborhoods were compared to the separate external evaluators' ratings, to identify whether the degree of concordance differed by neighborhood type. The distribution of *neighborhood type* is illustrated in Figure 9.

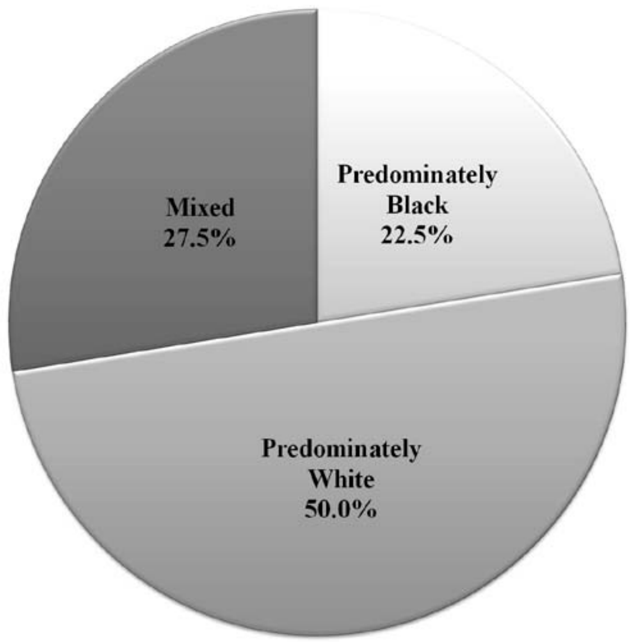


Figure 9. Distribution of Neighborhood Type

As seen in Table 39, the results of the stratified data analyses were similar to those found in our total sample. In fact, after calculating the overall kappa statistic for each neighborhood type, these results indicated slight and fair agreement between the independent evaluators and participants who resided in predominately Black neighborhoods, predominately White neighborhoods, and racially mixed neighborhoods ($_{K}$ = 0.11, $_{K}$ = 0.17, and $_{K}$ = 0.22, respectively) (Table 31). However, after examining each question separately for predominately Black neighborhoods, there was fair agreement for attractive buildings/homes and presence of vacant lots ($_{K}$ = 0.22 and $_{K}$ = 0.22, respectively) (Table 39).

After examining each question separately for predominately White neighborhoods, agreement was almost perfect for presence of sidewalks ($_{K}$ = 0.86). Additionally, there was fair agreement for school grounds and places to go ($_{K}$ = 0.25 and $_{K}$ = 0.40, respectively) (Table 33).

After examining each question separately for racially mixed neighborhoods, agreement was high for the presence of sidewalks ($_{K}$ = 0.65). In addition, there was fair agreement for sidewalk maintenance (κ = 0.28), presence of sidewalk debris (κ = 0.35), presence of school grounds (κ = 0.21), traffic (κ = 0.30), places to go (κ = 0.37), presence of trees (κ = 0.26), attractive natural sights (κ = 0.22), attractive buildings/homes (κ = 0.24), presence of vacant lots (κ = 0.25), and presence of a well-shaded walk route (κ = 0.23) (Table 39).

Overall, no kappa estimates exceeded 0.22 in Black neighborhoods compared to 3 items in White neighborhoods and 9 items in mixed neighborhoods. Thus, although agreement between Heart SCORE questionnaire respondents and independent evaluators was generally slight, there was some evidence of higher agreement for neighborhoods classified as racially mixed, suggesting that the race of the respondent (i.e., outside evaluator) may not matter in this type of investigation.

Table 39. Agreement between Independent Evaluators and Neighborhood Type

NES Questionnaire Items	White Kappa	White 99% C.I.	Black Kappa	Black 99% C.I.	Mixed Kappa	Mixed 99% C.I.
Overall Kappa	0.17	(0.02 - 0.31)	0.11	(-0.06 - 0.28)	0.22	(0.06 - 0.38)
There are sidewalks on most of the streets in the neighborhood.	0.86	(0.14 - 1.58)	0.09	(-0.78 - 0.95)	0.65	(-0.09 - 1.40)
The sidewalks in the neighborhood are well maintained (paved, even, and not a lot of cracks).	0.19	(-0.59 - 0.96)	0.10	(-0.63 - 0.84)	0.28	(-0.21 - 0.77)
The sidewalks are usually free of debris (such as litter, leaves, snow, etc).	0.04	(-0.83 - 0.91)	0.09	(-0.64 - 0.82)	0.35	(-0.41 - 1.11)
There are walking trails in or near the neighborhood that are easy to get to.	0.15	(-0.52 - 0.82)	0.01	(-0.95 - 0.96)	0.19	(-0.53 - 0.90)
The neighborhood has school grounds or a track that is available as a place to walk.	0.25	(-0.39- 0.88)	0.05	(-0.74- 0.85)	0.21	(-0.50- 0.93)
There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in the neighborhood.	0.18	(-0.47 - 0.84)	0.02	(-0.79 - 0.82)	0.30	(-0.47 - 1.07)
Most possible walking routes in the neighborhood involve crossing busy streets or intersections.	0.09	(-0.54 - 0.72)	0.02	(-0.81 - 0.85)	0.13	(-0.62 - 0.88)
There are well-marked crosswalks and pedestrian signals to help walkers cross busy streets in the neighborhood.	0.13	(-0.47 - 0.73)	0.13	(-0.65 - 0.91)	0.15	(-0.56 - 0.87)
The neighborhood streets are well lit at night.	0.19	(-0.40 - 0.78)	0.11	(-0.72 - 0.94)	0.13	(-0.48 - 0.73)
There are many places to go within easy walking distance of the homes in the neighborhood.	0.40	(-0.24 - 1.04)	0.17	(-0.58 - 0.91)	0.37	(-0.35 - 1.09)
There are barriers to walking in the neighborhood (for example, hillsides or freeways) that limit the number of routes for getting from place to place.	0.07	(-0.58 - 0.72)	0.07	(-0.73 - 0.88)	0.12	(-0.67 -0.90)
There are trees along the streets in the neighborhood.	0.18	(-0.48 - 0.84)	0.16	(-0.58 - 0.90)	0.26	(-0.51 - 1.03)
There are many attractive natural sights (such as trees, flowers, landscaping, views) in the neighborhood.	0.03	(-0.73 - 0.79)	0.05	(-0.70 - 0.80)	0.22	(-0.59 - 1.03)
There are attractive buildings/homes in the neighborhood.	0.01	(-0.77 - 0.79)	0.22	(-0.58 - 1.02)	0.24	(-0.58 - 1.06)
There are many interesting things to look at while walking (e.g., yards, birds, creeks, and store windows) in the neighborhood.	0.10	(-0.59 - 0.78)	0.10	(-0.67 - 0.86)	0.09	(-0.66 - 0.84)
The neighborhood is generally free from litter.	0.17	(-0.57 - 0.92)	0.19	(-0.55 - 0.93)	0.05	(-0.76 - 0.87)
There are vacant lots and boarded up buildings in the neighborhood.	0.02	(-0.67 - 0.71)	0.22	(-0.53 - 0.96)	0.25	(-0.56 - 1.06)
When walking in the neighborhood, there are a lot of exhaust fumes (such as, from cars, buses).	0.08	(-0.60 - 0.75)	0.15	(-0.67 - 0.96)	0.09	(-0.66 - 0.84)
The climate/weather of the neighborhood makes walking uncomfortable most of the year.	0.17	(-0.55 - 0.88)	0.13	(-0.72 - 0.97)	0.18	(-0.61 - 0.97)
Mosquitoes, bees or insects make walking a problem in the neighborhood.	0.04	(-0.63 - 0.70)	0.13	(-0.83 - 1.08)	0.10	(-0.81 - 1.01)
There is a well-shaded walk route available in the neighborhood.	0.10	(-0.50 - 0.71)	0.07	(-0.70 - 0.83)	0.23	(-0.48 - 0.94)

***** Kappa levels of agreement (Kirtland et al., 2003; Landis & Koch, 1977):

< 0.00 = poor;
0.00 - 0.20 = slight;
0.21 - 0.40 = fair;
0.41 - 0.60 = moderate;
0.61 - 0.80 = substantial;
0.81 - 1.00 = almost perfect.

CI = confidence interval.

5.5.3 Specific Aim 4.3: Comparison of Neighborhood Ratings and Average Distance to Objective Attributes

Most of the Kappa statistics identified in all of these analyses suggested slight agreement ($_K$ = 0.00 - 0.20); indicating that in all likelihood, at least one set of ratings investigated here was unreliable (i.e., either the Heart Score participants or the independent evaluators). This overall lack of agreement warranted the use of GIS methods to further evaluate concordance or discordance between the three different methods of measuring indicators of the built environment. We selected five variables (i.e., sidewalks, walking trails/parks, schools, trees, and vacant lots) that could be captured objectively, using geospatial data to directly examine the concordance with objective GIS measures of the environment. These items were derived from five questions on the *Neighborhood Environment Scale* that specifically inquired about the presence (or absence) of these neighborhood attributes. Since our evaluators provided three sets of ratings per question, we calculated the average rating for each question per observation (number of observations = 40).

Using spatial analysis tools, we calculated the exact distance between each participant's residence and the closest corresponding objective feature of interest (e.g., sidewalks, walking trails/parks, and vacant lots). Although the neighborhood ratings and the GIS measurements are not on the same scale, a comparison between the two groups of neighborhood ratings (agree vs. disagree) and the actual average distance to the objective measure was investigated by use of the t-test procedure. These analyses were conducted in order to assess differences in the mean distance between the groups based on the achieved rating. Separate analyses were conducted using the ratings (agree vs. disagree) of the participants, as well as those of the independent evaluators.

Table 40. Comparison of Neighborhood Ratings and Average Distance to Objective Attributes

	Participants			Evaluators		
Neighborhood Attributes	**n**	**Mean Distance (ft)**	**p-value**	**n**	**Mean Distance (ft)**	**p-value**
Sidewalks			<0.0001			<0.0001
Disagree	15	7881.1		14	8512.0	
Agree	25	1080.1		26	1002.0	
Walking Trails/Parks			0.7723			0.9686
Disagree	26	1394.4		30	1434.9	
Agree	14	1499.0		10	1419.3	
Schools			0.1178			0.3659
Disagree	15	3968.3		23	5203.8	
Agree	25	7204.8		17	7056.2	
Trees			<0.0001			0.5877
Disagree	3	176.8		10	3344.1	
Agree	37	4448.8		30	4389.8	
Vacant Lots*			0.8890			0.7918
Agree	9	1425826.0		8	1425051.0	
Disagree	31	1426792.0		32	1426955.0	

***Reversed coded questionnaire item.

As seen in Table 40, there was a significant difference in the mean distance between the neighborhood ratings for both participants and the independent observers for the presence of sidewalks ($p < 0.0001$ and $p < 0.0001$, respectively). Additionally, there was also a significant difference in the mean distance for the presence of trees between the neighborhood ratings of participants ($p < 0.0001$). Yet, these findings were not duplicated among independent evaluators. In conclusion, there is no evidence to suggest that the average distances were different between neighborhood ratings, when examining most of the selected attributes. These results were consistent for both, participants and independent evaluators.

6.0 DISCUSSION

6.1 SUMMARY OF FINDINGS

The purpose of this research was to examine the manner in which the built environment, both physical and social, is associated with physical activity and various measures of CVD risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, diabetes, and physical inactivity), and if these relationships differed by race. This research was guided by four aims: 1) to evaluate the relationship between the built environment and cardiovascular disease risk; 2) to evaluate if the relationship between the built environment and cardiovascular disease risk is mediated through physical activity; 3) to evaluate if the relationship between the built environment and cardiovascular disease risk varies by race; and 4) to evaluate the degree of agreement between three measures of the built environment.

The findings from this research indicate that, univariately, a significant inverse association exists between neighborhood grade (the primary measure of the built environment) and BMI, obesity, diabetes, hypertension, and physical inactivity. In multivariate regression analyses, significant inverse associations were found between neighborhood grade and obesity and physical inactivity.

The second aim was addressed by mediation analysis. Since both BMI and obesity are two highly correlated variables, BMI was selected to serve as the dependent variable for this analysis because, unlike obesity, it is a continuous variable which permitted greater assessment of variation in relation to neighborhood grade. Therefore, the analysis plan was amended to examine neighborhood grade as the independent variable, BMI as the dependent variable, and the contribution of physical activity as a mediator. The study findings indicate that physical activity is one mechanism (mediator) in which positive indicators of the built environment favorably influences BMI.

In order to satisfy aim 3, we conducted univariate and multivariate regression analyses, as well as mediational analysis, to examine the extent to which the above relationships differed by race (Black versus White participants). The results of the stratified data analyses revealed differences by race when assessing the relationship between the built environment and measures of CVD risk, where greater impacts were seen largely among White participants but not in Black participants. Among White participants, univariate and multivariate regression analyses confirmed significant inverse associations between neighborhood grade and BMI, obesity, and physical inactivity. The findings did not confirm any significant associations between neighborhood grade and measures of CVD risk among Black participants. Finally, although the formal tests for interaction did not achieve statistical significance at the 0.01 level, they were consistent with the results of the race stratified analyses that indicated associations between neighborhood grade and cardiovascular risk in Whites, but not in Blacks. Thereby, suggesting that race may modify the relationship between the built environment and measures of CVD risk.

Since there were no significant relationships found between the built environment and measures of CVD risk in Black participants, only the potential mediation by physical activity among White participants was examined. The results of this subgroup analysis indicated that among White participants, physical activity may partially mediate the relationship between the built environment and BMI.

Through agreement analysis, the degree of concordance and discordance of three different methods of measuring indicators of the built environment was explored. This included evaluating how well questions in the *Neighborhood Environment Scale* correlated with assessments of the environment made by external observers. Overall, these analyses of inter-rater reliability revealed fair agreement between the ratings from the Heart SCORE participants and the independent evaluators. However, when each question was examined individually, the level of agreement ranged from slight to substantial. Moreover, although the instruments were found independently effective in assessing the environment with fidelity, the individual items failed to correlate across assessments. Therefore, it is clear that both assessments are reliable however; they employ different avenues to reach the same overall ratings.

Additionally, agreement analysis was utilized to explore if the race of the respondent influenced the degree of concordance among participants for selected questionnaire items. Because all of the independent evaluators were Black, neighborhood type (i.e., predominately White, predominately Black, and racially mixed) was employed as a proxy measure for the inter-rater reliability by race. Overall, the results of the stratified data analyses were similar to those found in our total sample, indicating slight to fair agreement between the independent evaluators and participants who resided in predominately Black, White, and mixed neighborhoods. However, when each question was examined individually the level of agreement ranged from slight to almost perfect.

Many of the kappa statistics derived in all of these analyses indicated slight agreement; suggesting that, in all likelihood, at least one set of ratings investigated here was unreliable (i.e., either the Heart Score participants or the independent evaluators). This substantiated the use of GIS methods to further confirm concordance and discordance of the three different methods of measuring indicators of the built environment. Therefore, utilizing only items of the *Neighborhood Environment Scale* that specifically inquired about the presence or absence of a neighborhood attribute, and one of the spatial analyst statistical procedures in GIS, the investigator calculated the exact distance between each participant's residence and the closest corresponding objective feature of interest. These results revealed that for most neighborhood characteristics, the average distance was the same or similar regardless of neighborhood rating for both participants and independent evaluators.

6.2 RESEARCH IMPLICATIONS

This research serves not only to support the current body of literature focusing on the built environment and physical activity and inactivity but, also examines if CVD risk factors may also be influenced by the built environment, as few prior reports have examined the relationship between the built environment and cardiovascular disease risk. The results of the current study report an association between physical inactivity and the built environment, a finding that is consistent with the findings of previous research. This suggests that a more positive perception of the built environment is related to less inactivity, or more activity (Ball et al., 2001; M. L. Booth et al., 2000; Centers for Disease Control and Prevention, 1999b; Hooker et al., 2005; Humpel, Owen, Iverson et al., 2004; A. C. King et al., 2000; Kirtland et al., 2003; Wilbur et al., 2003). The literature also contains three reports by Li (2009), Mujahid (2008), and Rutt and Coleman (2005), who investigated the link between the built environment and measures of CVD risks (i.e., body weight and BMI) (Li et al., 2009; Mujahid et al., 2008; Rutt & Coleman, 2005). The research findings in this report also indicate that a more positive perception of the neighborhood is associated with lower BMI in the White participants. A similar result was also found by Mujahid (2008) (Mujahid et al., 2008).

Although the associations found between the built environment and other measures of CVD risk (i.e., obesity, diabetes, and hypertension) could not be confirmed by prior research, as there are no additional comparable findings available to support or refute the current findings, the results of the first aim highlight the premise that a more favorable neighborhood increases the likelihood of less physical inactivity. One rationale underpinning this apparent connection, is that better perceptions of the built environment (e.g., feeling safer, pleasant neighborhood aesthetics, etc.) as well as, more resources and or opportunities (e.g., access to services) to actually participate in physical activity, can potentially decrease one's BMI, and subsequently decrease the odds of having other factors related to obesity, such as diabetes and hypertension, all of which are risk factors for CVD. In further support of this premise, significant associations between the built environment and physical inactivity were consistently observed throughout this study. These findings were expected, as the instrument used to measure the built environment in the current study, the *Neighborhood Environment Scale*, was derived from the *Neighborhood Environment Walkability Survey* (*NEWS*), a questionnaire that is specifically designed to evaluate the perceptions of the neighborhood design features thought to be associated with physical activity (Active Living Research, 2006). Furthermore, the second aim served to better define the interaction of the built environment and BMI by the inclusion of a third factor. It is well cited in the literature that greater inactivity positively correlates with higher BMI (Pietilainen et al., 2008; World Health Organization, 2010), and findings in the current study observed that physical activity partially mediates the relationship between the built environment and BMI.

Given the disparities that exist in cardiovascular health, it was hypothesized that the above-defined relationships between the built environment and measures of CVD risk would differ significantly by race. In this analysis, there were no significant associations between the neighborhood grade and any measure of CVD risk among Black participants, however significant findings were observed among our White subpopulation, thereby confirming our original hypothesis. This finding may be influenced by the widespread observation that more Blacks live in poorly graded built environments, which may help to contribute to the evident health disparities in the U.S. (Fullilove & Fullilove, 2000; Leaderer et al., 2002; Srinivasan et al., 2003). This fact is also apparent in the results of the current study, where the majority of the Black participants resided in environments graded as ‘least favorable,’ whereas, the majority of the White participants resided in environments graded as ‘most favorable.’ Similar results regarding subgroup analyses by race were found by Hooker et al. (2005), in which the authors found no significant associations between the built environment and physical activity among Black participants (Hooker et al., 2005). In addition, the investigator also observed that among White participants, physical activity partially mediated the relationship between the built environment and BMI.

The fourth aim addressed measurement issues related to the built environment. While several measures of the built environment exist, no gold standard has yet been agreed upon. Many measures use subjective ratings of neighborhood quality as the primary method of evaluating the built environment. The goal of the analysis in this report was to examine the levels of agreement that may exist when neighborhood quality is evaluated by an independent investigator. To undertake this analysis, a group of outside evaluators was assembled and deployed to rate the built environments of a random sample of Heart SCORE participants using the same instrument as the residents/participants.

The results implied that overall, agreement was best for items such as, the presence of sidewalks and vacant lots, which indicates that the instrument effectively captures the grade of the built environment for those items that were less subjective. Additionally, it is imperative that consideration be given when examining the high level of agreement found for objective measures such as the presence of sidewalks, as these questions are probably easier to answer, as these neighborhood attributes are typically found closest to one's residence. Conversely, for survey items that were more subjective (e.g., the question, “there were many interesting things to look at”), lower agreement was observed, which may reflect individual perspectives or opinions as to what is interesting or attractive. In addition, the low agreement found between the outside evaluators and the Heart SCORE participants may have been due to the well-defined instructions on survey procedures and questionnaire completion each evaluator was given prior to conducting the neighborhood observations, while the participants, being part of an ongoing cohort study, completed a battery of questionnaires throughout the course of the study, may not have spent as much time and effort completing the *Neighborhood Environment Scale* when compared to the outside evaluators.

When evaluating the degree of concordance by race, overall there was evidence of higher agreement between the study participants and the outside evaluators for neighborhoods classified as racially mixed. With the exception of the presence of sidewalks question, agreement between study participants and the outside evaluators was relatively low or slight for neighborhoods classified as predominately White. This raises an interesting point, as all of the independent evaluators were Black; however, for neighborhoods classified as predominately Black, agreement between the study participants and outside evaluators was relatively low. One would expect more agreement in this subgroup analysis, yet this may suggest that the race of the respondent (i.e., outside evaluator) does not matter in this type of investigation, or that the results were skewed because of the lack of diversity found within the research team. This may also be an indicator of the SES, background, and experiences of the independent evaluators, who were all of moderate to high SES, and each grew up in middle class neighborhoods. Therefore, the investigators may not have been influenced by the characteristics of more affluent neighborhoods, where most of the White participants resided, or by the characteristics of the less affluent or economically challenged neighborhoods, where most of the Blacks participants resided. Therefore, the outside evaluators' perceptions of the neighborhoods appeared to be more aligned with those participants who resided in racially mixed neighborhoods. This notion regarding possible explanations for finding low levels of agreement in this type of research is also supported by Kirtland et al. (2003) (Chiricos, McEntire, & Gertz, 2001; Golledge & Stimson, 1997; Kirtland et al., 2003; Mesch & Manor, 1998; Pedersen, 1977; St. John, 1987; St. John & Bates, 1990; St. John & Cosby, 1995).

The findings from this analysis emphasize the need for the standardization of measurement tools and data collection techniques used in this type of research. Furthermore, although the *Neighborhood Environment Scale* used for these analyses, was derived from the *Neighborhood Environment Walkability Survey (NEWS)*, an instrument that has demonstrated high and acceptable test-retest reliability (Saelens, Sallis, Black et al., 2003), the findings suggest that this instrument may not have been the most ideal tool for external assessments of the neighborhood, as indicated by the generally poor agreement found between Heart SCORE questionnaire respondents and independent evaluators.

6.3 STRENGTHS OF THE STUDY

This study has several notable strengths, including a large sample size of participants (N = 902), which provided adequate power to detect "medium" effect sizes for all specific aims, and approached the required sample size to detect "small" effect sizes. The study also included a large sample of Black participants (n=385) for which to conduct comparative analyses by race. This large sample of Black participants included individuals who were equally of moderate to high SES. This population is unique, and although not without health challenges, is typically overlooked and not measured or addressed in research within the public health forum.

Additionally, the investigator utilized an extensive Heart SCORE data set that included a large array of demographic, anthropometric, behavioral, clinical, and biological measures collected on each participant. Furthermore, to the author's knowledge, this is one of the first studies to: 1) examine the relationship between the built environment and other measures of CVD risk in addition to physical inactivity (e.g., lipid abnormalities, hypertension, obesity, the metabolic syndrome, and diabetes); 2) specifically investigate the above relationships by race; and 3) evaluate and compare three different methods used to measure the built environment.

6.4 LIMITATIONS OF THE STUDY

Although this research study involved a novel and comprehensive assessment of relationships among the built environment, measures of CVD risk, and race, the study was subjected to several limitations. First, the study was based on a cross-sectional analysis. This type of study design did not permit the investigator to measure temporal sequence between exposure and disease, and therefore, causality could not be established. Second, the research questions in the study were dependent upon measures of physical activity and perceptions of the neighborhood environment, all of which were subjective in nature and involved self-reporting by the participants. Therefore, these self-report measures may have introduced reporting or recall bias into the study.

Third, the current study may be subject to self-selection bias. Initially, there were 955 out of 2,000 study participants who completed the *Neighborhood Environment Scale*; as a result, individuals who completed the questionnaires may have been different from individuals who did not complete the questionnaires. As our data set only included those participants who completed the *Neighborhood Environment Scale*, the investigator was not able to characterize what degree of self-selection bias may exist within the study. Nonetheless, this concept also raises another important question — does the built environment influence the activity level of its inhabitants, or do those of a certain activity level choose specific environments?

As individual behaviors were reported via the physical activity and neighborhood environment questionnaires, the study was also subjected to social desirability bias, "which describes the tendency of study participants to respond to survey questions in a manner that will be viewed favorably by others" (Presser & Stinson, 1998). In addition, although the physical activity measure utilized for this study has demonstrated relative validity and reliability (Ainsworth, Jacobs et al., 1993), this instrument may not have been able to accurately assess the participants overall level of activity, given only one question from the instrument was used in the analyses. Finally, the current study utilized a study population that was primarily of moderate to high SES, and whose prevalence of comorbidities related to CVD was low, therefore limiting the generalizability of the findings to all populations. This may have been an issue related to recruitment methods.

There were several issues found with regards to the methods used to measure the built environment in the current study. This is especially relevant for the examination of inter-rater reliability between independent evaluators' and participants' ratings for the *Neighborhood Environment Scale*, where many of the resultant kappa statistics indicated slight agreement, even though identical instruments were used. Several factors may have contributed to this lack of agreement between these measures: 1) there was an approximate 30-year age difference between the participants and the evaluators; 2) all of the independent evaluators were Black; 3) only two of the evaluators were native to the Pittsburgh area; and 4) although the independent evaluators followed strict instructions with regards to conducting the neighborhood assessment, it is unclear if the same efforts were followed by the participants, therefore potentially underestimating the neighborhood grade.

After completing a critical assessment of the *Neighborhood Environment Scale*, several issues related to specific questionnaire items should also be addressed. Questionnaire items that inquired about the climate/weather of the neighborhood and the presence of mosquitoes, bees, or insects, raise seasonality issues. Many insects, such as the mosquito, are found in tropical/warmer areas, unlike Pittsburgh, or they hibernate during the winter months. As all of the independent evaluators completed their surveys in the fall of 2009 (October – December), there was minimal observation of any insects during this time period. Additionally, Heart SCORE participants completed their surveys at various time points throughout the time period in which this data was collected, potentially limiting comparability. This is illustrated by the slight agreement denoted for these questions. Finally, the questionnaire item that inquired about neighborhood streets being well lit at night, may have also limited the comparability between the two groups, as this question can only be accurately assessed by individuals actually residing in the neighborhood being evaluated. As neighborhood observations were completed during the daylight hours, this item was sometimes completed by the independent evaluators, using the presence of street lamps as a proxy measure during the assessments. Although the *Neighborhood Environment Scale* used for these analyses was derived from an instrument that has demonstrated high and acceptable test-retest reliability (Saelens, Sallis, Black et al., 2003), the findings suggest that this modified instrument may not have been the most ideal tool for external assessments of the neighborhood.

In previous studies, the use of objective measures to evaluate individual and environmental characteristics has been proven to be an effective technique. However, for the current study, regarding the use of GIS, available data may have been incomplete, obsolete, or unavailable, as this data was derived from resources that function at the federal, state, and local level, such as the U.S. Census Bureau, or city planning department, who may not have updated their respective information on an annual basis. All Census data utilized for this study was derived from the 2000 Census, which is now 10 years old.

6.5 FUTURE RESEARCH

The current study extends the findings of prior research among White participants and opens a new area of study for Black participants, by utilizing what was already known about the relationship between the built environment and physical activity, and expanding this research to incorporate not only physical activity (inactivity), but other measures of CVD risk (i.e., lipid abnormalities, hypertension, obesity, the metabolic syndrome, and diabetes). Areas of future research that could potentially shape the foundation for the development of improved and more comparable analyses may involve examining the role of body image and race, and how this could potentially impact the relationship between the built environment, physical activity, and BMI. Previous reports have suggested that in spite of body size, Black women tend to have a more positive body image compared to White women (Altabe, 1998; Rucker & Cash, 1992), which may explain the lack of associations between the built environment, physical activity, and BMI among this subpopulation.

As previously mentioned, the current research raises another important question — does the built environment influence the activity level of its inhabitants, or do those of a certain activity level choose specific environments? Investigations that seek to determine what factors are related to selecting a specific neighborhood would provide useful information to better understand the relationship between the built environment and physical activity. Additionally, in a small-scale analysis to further examine the perceptions of the neighborhood for those residing in racially mixed neighborhoods, the investigator found that most of the Black participants lived in least favorable neighborhood (as also seen in the main analyses), while the proportion of

White participants was equally distributed across each level of neighborhood grade. This was an exploratory analysis that does not support or refute if racial differences still exist when neighborhoods are classified as racially mixed. However, it does establish a foundation for future research in this area. Future investigations may also include studies to assess:

- The relationship between the built environment, BMI, and physical activity, in order to develop prevention programs for all people;
- The establishment of a standardized set of environmental attributes based on those that are consistently examined in the literature, given appropriate reliability and validity are met;
- The use of more consistent methods of assessing physical activity, which also incorporate the use of objective measures (e.g., pedometers and accelerometers);
- An instrument that adequately captures varying degrees of physical activity and inactivity such as those related to daily household chores or repairs, or occupational activities (Ainsworth, Haskell et al., 1993);
- The establishment of standardized data collection procedures for use with built environment research;
- The current study in another study population during the analogous season so that the built environment can be adequately evaluated and limit the amount of variability due to excessive temperature and seasonal changes; and
- This research study in another area that has limited variability in terrain. This variability can not only impact the built environment assessment but also the consideration of physical activity or inactivity.

6.6 PUBLIC HEALTH SIGNIFICANCE

Information from this study is of public health significance, as it will provide information for future research studies and public health programs aimed at health promotion and disease prevention. The current study examines existing racial disparities, and therefore, creates a foundation for our understanding of the role of race in this area. This is of great importance, as indicated by the results of the current study in which associations were observed between measures and CVD risk factors and the built environment among White participants, but none in our Black subpopulation. While some of our results provide motivation for the design of intervention programs that utilize the built environment to influence higher levels of physical activity, they also necessitate future research to continue to explore the relationship between the built environment and CVD risk factors among Blacks. The data presented in this report imply that other, seemingly more powerful factors overshadow any appreciable impact that the built environment may have on CVD risks in Blacks. Therefore, it is imperative that these factors be systematically identified and targeted for intervention.

Previous reports suggest that the built environment may adversely affect health risks; and the current study sought to examine how the built environment may affect health, and the magnitude of this effect. Utilizing what is currently found in the literature concerning the relationship between the built environment and physical activity or inacitivity, this study has built upon the literature by including an examination of other measures of CVD risk, therefore laying a foundation with which continued research can build to determine how improving the built environment can subsequently improve health. An important issue that is raised in built environment research is that the understanding of the relative predictive value of different methods of measuring the physical and social environments, including the use of publicly-available data (e.g., census and geocoded data), participant self-report, and independent investigator observation, is unknown. Thus, the findings initiated by this research will provide more depth to our understanding of the methods underlying the assessment of the built environment. Therefore, incorporating the aforementioned novel assessment of the built environment, with the evaluation of these relationships by race, will offer insight on adequate and appropriate CVD interventions for all populations.

APPENDIX A: HEART SCORE SCREENING FORM

Form No. 1

Form Name SCREENING V.3

Participant ID # ☐☐☐☐

Date Form Completed

☐☐ / ☐☐ / 2 0 ☐☐

mm dd yyyy

Heart Score

(print left to right)

Title (Dr,Mr,Mrs,etc) ☐☐☐☐☐

First Name ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Initial ☐

Last Name ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Suffix (Jr,Sr, MD,etc.) ☐☐☐☐☐

What do you perfer to be called?

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

ELIGIBILITY CRITERIA

1. Age in Years:

☐☐ → (45 to 74 to be study eligible)*Up to their 75th BD,Not Including

2. Comorbidity expected to limit life expectancy to less than 5 years Yes O No O

3. Inability to undergo baseline or annual follow-up visits: Yes O 1 No O 0

If you answer yes to question 2 or 3, the participant is ineligible.

4. Pregnancy: Yes O 1 No O 0

↓

Ineligible for EBCT

5. Final eligibility status: Eligible O 1 Ineligible O 2

DEMOGRAPHIC INFORMATION

6. Gender: Male O 1 Female O 2

7. Ethnicity: Hispanic or Latino O 1 Non-Hispanic or Latino O 2

↓

Defined as: (Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin)

8. Race:(Select only one irrespective of ethnicity)

American Indian or Native Alaskan O 1

Asian O 2

Black or African- American O 3

Native Hawaiian or Pacific Islander O 4

White O 5

Other O 6

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Checked when scanned ______ Page 1 of 2

Form No. 1
Form Name: SCREENING

Participant ID # | | | | |

FRAMINGHAM RISK SCORE VARIABLES:

9. **Known history of CHD** Yes O 1 No O 0

If yes, cannot be randomized

9 a) MI Yes O No O 9 c) CABG Yes O No O

9 b) PCI Yes O No O 9 d) Abnormal Cath Yes O No O

10. **Total cholesterol (mg/dl)** | | | | 11. **HDL cholesterol (mg/dl)** | | | |

12. **Glucose (mg/dl)** | | | |

13. **Systolic blood pressure (sitting, mmHg)** | | | |

14. **Diastolic blood pressure (sitting, mmHg)** | | | |

15. **Classification Scale:**

	SBP (mmHg)		DBP (mmHg)
Normal	<120	and	<80
Prehypertension	120-139	or	80-89
Stage 1 - Hypertension	140-159	or	90-99
Stage 2- Hypertension	$\geq$ 160	or	$\geq$ 100

O Normal O Prehypertensive O Hypertensive Stage 1 O Hypertensive Stage 2

16. **History of treated diabetes** Yes O No O

17. **Current Smoker** Yes O No O

18. **Framingham Risk Strata (score)** O Low 0 O Intermediate 1 O High 2 O N/A

19. **Disposition Status of Eligible Person**

O Randomized Study, Consent Signed 1 O Observational Study, Consent Signed 4
O Randomized Study, Consent Taken 2 O Observational Study, Consent Taken 5
O Randomized Study, Refused 3 O Observational Study, Refused 6

20. **Referral Source:**

O Mailing 1 O Advertisement 5
O Community Screening Event 2 O Referral From Community 6
O Community Recruitment Event 3 O Referred From Participant 8
O MD Office 4 O Other 7

21. **Study Category:**

O Randomized to Multi-Disciplinary Intervention R1 O Observational OB
O Randomized to Usual Care R2 O Pre-Existing CHD PRE-EXIST CHD

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APPENDIX B: HEART SCORE DEMOGRAPHICS AND MEDICAL HISTORY FORM

Form No. 4

Form Name DEMO AND MEDICAL HISTORY

Participant ID # | | | | |

Baseline Date | | |/| | |/|2|0| | |
mm dd yyyy

Heart Score

DEMOGRAPHIC HISTORY

1. Date of Birth | | |/| | |/|1|9| | |
mm dd yyyy

Martial/ Living Status:

2. Are you presently legally married? O Yes O No
3. Do you currently live with your spouse or partner? O Yes O No
4. Have you become divorced within the past 12 months? O Yes O No
5. Have you become widowed within the past 12 months? O Yes O No

6. Work Status: (during the past 3 months)

O Working Full-time
O Working Part-time
O On Long-term Sick Leave
O Homemaker
O Retired
O Disabled
O Unemployed / Looking for Work
O Temporarily Laid Off
O Other

7. Highest Level of School Completed: (Fill in only one circle)

O None or Some Grade School
O Grade School
O Some High School
O High School Diploma
O Some College, No Degree
O Vocational or Tech School
O Associate (2 year) Degree
O Bachelors Degree
O Masters Degree
O Doctoral Degree
O Other Advanced Degree

8. Annual Income:(fill in only one circle)

O Less than $10,000
O $10,000 to <$20,000
O $20,000 to <$40,000
O $40,000 to <$80,000
O $80,000 or More

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Form No. 4

Form Name: DEMO AND MEDICAL HISTORY

Participant ID # | | | | |

DEMOGRAPHIC HISTORY *(Continued)*

9. How hard is it for you to Pay for the Very Basics like Food, Housing, Medical Care, & Heating?

O Very Hard
O Somewhat Hard
O Not very hard at all
O Don't know

10. Primary Method of Insurance:(Fill in only one circle)

O Medicare
O Medicaid
O Other Public (e.g. VA)
O Private (e.g. HMO, Blue Cross)
O None / Self Pay

MEDICAL HISTORY

*If Male, Skip to Question 13

11. If Female, Menopausal Status (Fill in only one circle)

O Pre-Menopause
O Peri-Menopause
O Post-Menopause
O Surgical Menopause
O Hysterectomy, No Ovaries Removed

12. If Female, Hormone use in the past 3 months (Fill in only one circle)

O None
O Estrogen Only
O Estrogen / Progesterone
O Other HRT

13. QOL: In General, Would you say that your Health is:

O Excellent
O Very Good
O Good
O Fair
O Poor

Family History of CAD/Sudden Death:

14. Before Age 55 in Male First Degree Relative O Yes O No O Unknown

15. Before Age 65 in Female First Degree Relative: O Yes O No O Unknown

Has a physician or other health care provider ever told you that you have any of the following conditions:

16. History of Hypertension: O Yes O No

16a. If Yes, Previous Drug Therapy: O Yes O No

46375

Form No. 4

Participant ID #

Form Name: DEMO AND MEDICAL HISTORY

MEDICAL HISTORY *(Continued)*

17. History of Diabetes ○ Yes ○ No

17a. If yes, Record Type of Treatment
○ Dietary Only ○ Insulin
○ Oral Agents Only ○ None

18. History of Hyperlipidemia ○ Yes ○ No

18a. If yes, Previous Drug Therapy ○ Yes ○ No

19. Prior Angiographic Evidence of CAD (greater than or equal to 50% stenosis) ○ Yes ○ No

20. History of Chest Pain ○ Yes ○ No

21. History of MI ○ Yes ○ No

22. History of PCI ○ Yes ○ No

23. History of CABG ○ Yes ○ No

24. History of CHF ○ Yes ○ No

25. History of Stroke ○ Yes ○ No

26. History of Abdominal Aneurysm ○ Yes ○ No

27. History of Non-Coronary Vascular Surgery ○ Yes ○ No

28. History of PVD ○ Yes ○ No

29. History of Kidney Disease ○ Yes ○ No

29a. Dialysis Treatment of Kidney Disease ○ Yes ○ No

30. History of Diagnosed Sleep Disorder ○ Yes ○ No

31. History of Treatment for Depression or Anxiety ○ Yes ○ No

32. History of Arthritis or Other Autoimmune Disease ○ Yes ○ No

33. History Malignancy other than Non-Melanoma Skin ○ Yes ○ No

33a. If Yes, Time Since last Diagnosis
○ > 5 Years Ago ○ Less Than or Equal to 5 Years Ago

Interviewer Initials

46375

APPENDIX C: HEART SCORE PHYSICAL EXAM FORM

Form No. 5 v2

Heart Score

Participant ID # [ ][ ][ ][ ]

Form Name PHYSICAL EXAM

Date Form Completed [ ][ ] / [ ][ ] / [2][0][ ][ ]
mm dd yyyy

Visit Schedule:

- O Baseline
- O 6 Month
- O 12 Months (1 yr)
- O 24 Months (2 yr)
- O 36 Month (3 yr)
- O 48 Month (4 yr)
- O 60 Month (5 yr)
- O Other

1. Date of Physical Exam [ ][ ] / [ ][ ] / [2][0][ ][ ]

2. Height (centimeters, no decimals) [ ][ ][ ]

3. Weight (kilograms, no decimals) [ ][ ][ ]

3 a. Weight Type

- O HeartScore
- O Verbal
- O Certified PCP
- O Home Scale
- O Certified Other ____________
- O Other ____________

Date of Weight (other than date of PE) [ ][ ] / [ ][ ] / [ ][ ][ ][ ]

4. Waist Circumference (centimeters, no decimals) [ ][ ][ ]

5. Hip Circumference (centimeters, no decimals) [ ][ ][ ]

6. Has the participant gained or lost more than 5 kg(~10 pds in the past 3 months)?

- O No
- O Yes, Gain Unintentional
- O Yes, Gain Intentional
- O Yes, Loss Unintentional
- O Yes, Loss Intentional

SKIN FOLD TEST:

7. Site caliper measurements (in centimeters, no decimals)

FEMALES		**MALES**	
7a. Tricep	[ ][ ]	Pectoral	[ ][ ]
7b. Iliac Crest	[ ][ ]	Abdomen	[ ][ ]
7c. Thigh	[ ][ ]	Thigh	[ ][ ]

8. Resting Pulse (beats per minute - no decimals) [ ][ ][ ]

9. Sitting Systolic Blood Pressure (mmHg- no decimals) [ ][ ][ ]

10. Sitting Diastolic Blood Pressure [ ][ ][ ]

Note: Use the highest systolic BP

11. Blood Pressure Classification:

	SBP (mmHg)		DBP (mmHg)
Normal:	<120	and	<80
Pre-Hypertension	120-139	or	80-89
Stage 1 Hypertension	140-159	or	90-99
Stage 2- Hypertension	$\geq$ 160	or	$\geq$ 100

- O Normal
- O Prehypertensive
- O Hypertensive Stage 1
- O Hypertensive Stage 2

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APPENDIX D: HEART SCORE BRACHIAL ARTERY ULTRASOUND FORM

Form No. 6 v4

Form Name BRACHIAL ARTERY ULTRA.

Participant ID # [ ][ ][ ][ ]

Date Form Completed [ ][ ] / [ ][ ] / [2][0][ ][ ]
mm dd yyyy

Heart Score

Date of Test [ ][ ] / [ ][ ] / [2][0][ ][ ]
mm dd yyyy

Time of Test (military) [ ][ ] : [ ][ ]
hh mm

Visit Schedule:
- O Baseline
- O 6 Month
- O 12 Month (1 yr)
- O 24 Month (2 yr)
- O 36 Month (3 yr)
- O 48 Month (4 yr)
- O 60 Month (5 yr)
- O Other

Medications taken within the past 48 hours(that may impact BA results)

1. Anti-Hypertensive O Yes O No → skip to question 2

1a. Beta-blocker	O Yes O No	1e. Sublingual nitrate	O Yes O No
1b. ACE inhibitor	O Yes O No	1f. Other Anti-hypertensive	O Yes O No
1c. Calcium channel blocker	O Yes O No	1g. Diuretic	O Yes O No
1d. Long-acting nitrate	O Yes O No	1h. Taken HTN Med other than for HTN	O Yes O No

2. Are the BA test readings acceptable? O Yes O No

1 centimeter = 10 millimeter
example .53 cm =5.3 mm

Test results: Heart Rate (bpm) [ ][ ][ ] Brachial Artery Diameter (mm) [ ][ ][ ][ ]

Other medications taken within the past 48 hours (non test-related):

3. Lipid-Lowering O Yes O No → skip to question 4

3a. Lipid-Lowering Statin	O Yes O No
3b. Other lipid-lowering drug	O Yes O No
4. Aspirin	O Yes O No
5. Anti-Angina/Ischemia Agent	O Yes O No
6. Oral Hypoglycemic Agent	O Yes O No
7. Insulin	O Yes O No
8. Corticosteroid	O Yes O No
9. NSAID	O Yes O No
10. Anti-depressive agent	O Yes O No
11. Anti-anxiety drug	O Yes O No
12. Psychotropic drug	O Yes O No
13. Estrogen	O Yes O No
14. Estrogen and Progesterone	O Yes O No
15. Sleep Medications	O Yes O No
16. C-Pap or Bi-Pap	O Yes O No

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date last modified-05/05/2005

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APPENDIX E: HEART SCORE LAB FORM

Heart Score

Form No 9

Form Name LAB v.3

Participant ID # [| | |]

Date Form Completed

[|] / [|] / [2|0| |]
mm dd yyyy

Date of Blood Draw:

[|] / [|] / [2|0| |]
mm dd yyyy

NOTE: The blood draw should occur on the same day as the Brachial Artery (BA) test since the BA form collects data on which medications have been taken in the past 48 hours.

Visit Schedule:

- O Baseline
- O 6 Month
- O 12 Month (1 yr)
- O 24 Month (2 yr)
- O 36 Month (3 yr)
- O 48 Month (4 yr)
- O 60 Month (5 yr)
- O Other

VAP LAB VALUES:

NOTE: It is assumed that VAP lab data will be supplied in electronic form, such as in a Excel spreadsheet, and will include the following measures:

Total cholesterol (mg/dL)
LDL cholesterol (mg/dL)
HDL cholesterol (mg/dL)
Plasma triglycerides (mg/dL)
VLDL triglycerides (mg/dL)
LDL size (mean,nm)
HDL size (mean,nm)
VLDL size (mean,nm)
LDL particle concentration(nmol/L)
Chylomicrons (mg/dL triglyceride)
VLDL subpopulation concentrations (mg/dL triglyceride)-(V6-V1)
VLDL subclass concentrations(mg/dL triglyceride)-(large-V56;intermediate-V34;small-V-12)
IDL concentration (mg/dL)
LDL subclass concentrations (mg/dL cholesterol)-(Large-L3;intermediate-L2;small-L1)
HDL subpopulation concentrations(mg/dL cholesterol) - (H5-H1)
HDL subclass concentrations (mg/dL cholesterol)- (large-H45;intermediate-H3;small-H12)

OTHER CONTRACTED SAMPLE:

NOTE: It is assumed that these lab data will be supplied in electronic form, such as in an Excel spreadsheet, and will include the following measures:

Lp(a)(mg/dl), apoB(mg/dl), hsCRP (mg/dl)

OTHER INTERNALLY DETERMINED LAB MEASURES: (Creatinine and urinary albumin)- Baseline, 1 yr, 2 yr, 3yr, etc.

Glucose Fasting (mg/dl) [| |]

Creatinine (mg/dl) [| | |]

Urinary albumin (g/dL) [| | | |]

Total Cholesterol (mg/dL) [| |]

HDL cholesterol (mg/dL) [| |]

date last modified-05/01/2005

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51911

APPENDIX F: HEART SCORE PHYSICAL ACTIVITY FORM

Form No. 10

Participant ID # | | | | |

Form Name PHYSICAL ACTIVITY

Date Form Completed

__ __ / __ __ / 2 0 __ __
mm dd yyyy

Heart Score

Visit Schedule:

- O Baseline 0
- O 6 Month .50
- O 12 Month (1 yr)
- O 18 Month (1.5 yr)
- O 24 Month (2 yr)
- O 30 Month (2.5 yr)
- O 36 Month (3 yr)
- O 42 Month (3.5 yr)
- O 48 Month (4 yr)
- O 54 Month (4.5 yr)
- O 60 Month (5 yr)
- O Other

LIPIDS RESEARCH CLINICS QUESTIONNAIRE

1. Thinking about the things you do at work, how would you rate yourself as to the amount of physical activity you get compared with others of your age and sex ?

   - O Much More Active 1
   - O Somewhat More Active 2
   - O About the Same 3
   - O Somewhat Less Active 4
   - O Much Less Active 5
   - O Not Applicable 6

2. Now, thinking about the things you do outside of work, how would you rate yourself as to the amount of physical activity you get compared with others of your age and sex?

   - O Much More Active 1
   - O Somewhat More Active 2
   - O About the Same 3
   - O Somewhat Less Active 4
   - O Much Less Active 5

3. Do you regularly engage in strenuous activity or hard physical labor? O Yes O No

4. Do you exercise or labor at least 3 times a week? O Yes O No

Checked when scanned ______

42154

Form No. 10

Participant ID # | | | | |

Form Name: PHYSICAL ACTIVITY

Heart Score

OTHER QUESTIONS:

5. At least once a week, do you engage in any regular activity long enough to work up a sweat? O Yes O No

5a. If yes, how many times a week? | | |

6. What is your current overall level of physical activity?

O Sedentary 1
O Moderate 3
O Mild 2
O Strenuous 4

7. Do you regularly perform the following types of exercise?

Cardiovascular / Endurance (e.g. walking, jogging, swimming) O Yes O No

Weight / Strength Training O Yes O No

Flexibility Training O Yes O No

Other type(s) of Exercise O Yes O No

APPENDIX G: HEART OTHER LIFESTYLE FORM

Form No. 11

Heart Score

Participant ID # [ ][ ][ ][ ]

Form Name OTHER LIFESTYLE

Date Form Completed [ ][ ] / [ ][ ] / [2][0][ ][ ]

mm dd yyyy

Visit Schedule:

- O Baseline 0
- O 6 Month .50
- O 12 Month (1 yr)
- O 18 Month (1.5 yr)
- O 24 Month (2 yr)
- O 30 Month (2.5 yr)
- O 36 Month (3 yr)
- O 42 Month (3.5 yr)
- O 48 Month (4 yr)
- O 54 Month (4.5 yr)
- O 60 Month (5 yr)
- O Other 6

1. Smoking Status:

O Current Smoker 1 O Former Smoker 2 O Never Smoker 3

1a. If current smoker, are you willing to quit? O Yes O No

1b. If current smoker, have you tried previous cessation treatments within the past 3 months?
O Yes O No

If yes, have you tried any of the following smoking cessation treatments:

Practical Counseling	O Yes	O No	Smoking Cessation Program	O Yes	O No
Bupropion (Wellbutrin)	O Yes	O No	Other	O Yes	O No
Nicotine Replacement Therapy	O Yes	O No			

2. During the past 3 months, have you consumed an average of $\geq$ 1 alcoholic beverage pre week? O Yes O No

Answers must be in whole numbers (no symbols)

2a. On Average, number of 12 oz bottle/cans of beer consumed per week [ ][ ]

2b. On Average, number of 4 oz glasses of wine consumed per week [ ][ ]

2c. On Average, number of 1.5 oz shots of hard liquor or mixed drinks per week [ ][ ]

Checked when Scanned ____
last date modified- 06/22/2004

Page 1 of 1

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APPENDIX H: HEART SCORE NEIGHBORHOOD ENVIRONMENT SCALE

Form No. 34

Form Name NEIGHBORHOOD ENVIRONMENT SCALE

Participant ID # [ ][ ][ ][ ]

Date Form Completed

[ ][ ] / [ ][ ] / [2][0][ ][ ]

mm dd yyyy

Visit Schedule: (office use only)

○ 12 Month (1 yr) ○ 36 Month (3 yr) ○ 60 Month (5 yr)

○ 24 Month (2 yr) ○ 48 Month (4 yr) ○ 72 Month (6 yr)

**Directions: We would like to find out information on how you think about your neighborhood. Please answer the following questions and provide only one for each item. There are no right or wrong answers and your information is answerconfidential.
kept**

1. What is the name of your neighborhood? ______________________________

Fill in the most appropriate circle for each question:

Streets in my neighborhood:

1. **The streets in my neighborhood DO NOT have many, or any, cul-de-sacs(dead-end streets).**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

2. **The distance between intersections in my neighborhood is usually short (100 yards or less; the length of a football field or less).**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. **There are alternative routes for getting from place to place in my neighborhood(I don't have to go the same way every time.)**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Places for walking and cycling:

1. **There are sidewalks on most of the streets in my neighborhood.**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

note: if strongly disagree, skip to question #6

2. **The sidewalks in my neighborhood are well maintained (paved, even, and not a lot of cracks).**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. **The sidewalks are usually free of debris (such as litter, leaves, snow, etc).**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

4. **There is a grass/dirt strip or cement barrier that separates the streets from the sidewalks in my neighborhood.**
   ○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Neighborhood Environment Scale

Date form completed _____/_____/_____

Places for walking and cycling (Continued):

5. Sidewalks are separated from the road/traffic in my neighborhood by parked cars.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

6.There are walking trails in or near my neighborhood that are easy to get to.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

7. My neighborhood has school's grounds or a track that is available as a place to walk.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Safety from traffic:

1. There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

2. The speed of the traffic on most nearby streets is usually slow(25 mph or less).
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. Most drivers exceed the posted speed limits while driving in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

4. Most possible walk routes in my neighborhood involve crossing busy streets or intersections.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

5. There are well-marked crosswalks and pedestrian signals to help walkers cross busy streets in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Safety from crime:

1. My neighborhood streets are well lit at night.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

2. Walkers and bikers on the streets in my neighborhood can be easily seen by people in their homes.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. There is a lot of crime in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

4. The crime in my neighborhood makes it unsafe to go on walks during the day.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

5. The crime in my neighborhood makes it unsafe to go on walks at night.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

6. There are people who make me feel unsafe to walk in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

7. There are dogs or other animals which make me feel unsafe to walk in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Neighborhood Environment Scale

Date form completed _____/_____/_____

Access to services:

1. Stores are within easy walking distance of my home.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

2. There are many places to go within easy walking distance of my home.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. I do most of my shopping at stores within easy walking distance of my home.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

4. The Streets in my neighborhood are hilly, making my neighborhood difficult to walk in.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

5. There are barriers to walking in my neighborhood(for example, hillsides or freeways) that limit the number of routes for getting from place to place.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

6. It is easy to walk to a transit stop (bus, train) from my home.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

7. When I want to go shopping or run errands I have access to a car.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

8. Parking is difficult in local shopping areas.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Neighborhood surroundings:

1. There are trees along the streets in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

2. There are many attractive natural sights(such as trees, flowers, landscaping, views)in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. There are attractive buildings/homes in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

4. There are many interesting things to look at while walking (e.g., yards, birds, creeks, store windows) in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

5. My neighborhood is generally free from litter.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

6. There are vacant lots and boarded up buildings in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

7. When walking in my neighborhood, there are a lot of exhaust fumes (such as, from cars, buses).
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Neighborhood Environment Scale

Date form completed _____/_____/_____

Neighborhood surroundings (Continued):

8. Outside, my neighborhood is noisy (due to traffic sounds, construction, etc).
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

9. The climate/weather where I live makes walking uncomfortable most of the year.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

10. Mosquitoes, bees or insects make walking a problem in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

11. There is a well-shaded walk route available in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

12. There are benches or other places to rest along sidewalks in my neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Sense of Community:(my neighborhood block)

1. People around here are willing to help their neighbors.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

2. This is a close-knit neighborhood.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

3. People in this neighborhood can be trusted.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

4. People in this neighborhood generally don't get along with each other.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

5. People in this neighborhood do not share the same values.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

6. I can recognize most of the people who live on my block.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

7. Very few of my neighbors know me.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

8. I have almost no influence over what this block is like.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

9. My neighbors and I want the same thing from the block.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

10. If there is a problem on this block people who live here can get it solved.
○ Strongly Disagree ○ Somewhat Disagree ○ Somewhat Agree ○ Strongly Agree

Neighborhood Environment Scale

Date form completed _____/_____/_____

Only enter your street address of your neighborhood

What is your zip code of your neighborhood?

APPENDIX I: NEIGHBORHOOD ENVIRONMENT SCALE FOR INDEPENDENT INVESTIGATOR

ID # _______________

Date form completed (mm/dd/yy) ____/____/_____

NEIGHBORHOOD ENVIRONMENT SCALE FOR INDEPENDENT INVESTIGATOR

Directions: We would like to find out information on what you think about the neighborhood you are observing. Please answer the following questions and provide only one answer for each item. There are no right or wrong answers and your information will be kept confidential.

1. What is the name of the neighborhood you are observing? ______________________________

After observing the neighborhood corresponding to each residence, circle the most appropriate response for each question:

Streets in the neighborhood:

1. The streets in the neighborhood DO NOT have many, or any, cul-de-sacs (dead-end streets).
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

2. The distance between intersections in the neighborhood is usually short (100 yards or less; the length of a football field or less).
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

Places for walking and cycling:

1. There are sidewalks on most of the streets in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

<u>Note: if "Strongly Disagree" to question 1, skip to question #6</u>

2. The sidewalks in the neighborhood are well maintained (paved, even, and not a lot of cracks).
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

3. The sidewalks are usually free of debris (such as litter, leaves, snow, etc).
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

ID # ________________

Date form completed (mm/dd/yy) ____/____/_____

Places for walking and cycling (Continued):

4. There is a grass/dirt strip or cement barrier that separates the streets from the sidewalks in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

5. Sidewalks are separated from the road/traffic in the neighborhood by parked cars.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

6. There are walking trails in or near the neighborhood that are easy to get to.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

7. The neighborhood has school grounds or a track that is available as a place to walk.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

Safety from traffic:

1. There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

2. Most possible walking routes in the neighborhood involve crossing busy streets or intersections.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

3. There are well-marked crosswalks and pedestrian signals to help walkers cross busy streets in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

Safety from crime:

1. The neighborhood streets are well lit at night.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

ID # ________________

Date form completed (mm/dd/yy) ____/____/_____

Access to services:

1. Stores are within easy walking distance of the homes in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

2. There are many places to go within easy walking distance of the homes in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

3. The Streets in the neighborhood are hilly, making the neighborhood difficult to walk in.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

4. There are barriers to walking in the neighborhood (for example, hillsides or freeways) that limit the number of routes for getting from place to place.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

5. It is easy to walk to a transit stop (bus, train) from the homes in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

6. Parking is difficult in local shopping areas.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

Neighborhood surroundings:

1. There are trees along the streets in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

2. There are many attractive natural sights (such as trees, flowers, landscaping, views) in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

3. There are attractive buildings/homes in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

4. There are many interesting things to look at while walking (e.g., yards, birds, creeks, and store windows) in the neighborhood.
   Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

ID # ________________

Date form completed (mm/dd/yy) ____/____/_____

Neighborhood surroundings (Continued):

5. The neighborhood is generally free from litter.
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

6. There are vacant lots and boarded up buildings in the neighborhood.
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

7. When walking in the neighborhood, there are a lot of exhaust fumes (such as, from cars, buses).
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

8. Outside, the neighborhood is noisy (due to traffic sounds, construction, etc).
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

9. The climate/weather of the neighborhood makes walking uncomfortable most of the year.
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

10. Mosquitoes, bees or insects make walking a problem in the neighborhood.
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

11. There is a well-shaded walk route available in the neighborhood.
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

12. There are benches or other places to rest along sidewalks in the neighborhood.
Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

Overall neighborhood:

1. Overall, how would you rate the neighborhood as a place to walk? Would you say.....?

Very pleasant

Somewhat pleasant

Not very pleasant

Not at all pleasant

ID # ________________

Date form completed (mm/dd/yy) ____/____/_____

Comments: ____

APPENDIX J: ITEMS FROM NEIGHBORHOOD ENVIRONMENT SCALE FOR INDEPENDENT INVESTIGATOR USED TO CREATE SURROGATE GIS INDICATORS

ITEMS FROM *NEIGHBORHOOD ENVIRONMENT SCALE FOR INDEPENDENT INVESTIGATOR* USED TO CREATE SURROGATE GIS INDICATORS

1. There are sidewalks on most of the streets in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

2. There are walking trails/parks in or near the neighborhood that are easy to get to.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

3. The neighborhood has school grounds or a track that is available as a place to walk.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

4. There are trees along the streets in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

5. There are vacant lots and boarded up buildings in the neighborhood.
   Strongly Disagree   Somewhat Disagree   Somewhat Agree   Strongly Agree

APPENDIX K: UNIVARIATE REGRESSION ANALYSIS RESULTS

Table A1. Factors Associated with Waist-Hip Ratio (WHR) in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Age (y)		0.002	< .0001	0.17
Male	Female	0.09	< .0001	0.52
Marital Status				
Not Married	Married	-0.02	0.0006	-0.12
Insurance Type				
Medicare	Private	0.03	0.0026	0.10
Medicaid	Private	-0.03	0.5318	-0.02
Other Public	Private	0.07	0.0042	0.10
None/Self Pay	Private	-0.00007	0.9957	-0.0002
Smoking Status				
Current Smoker	Never Smoker	-0.003	0.7905	-0.01
Former Smoker	Never Smoker	0.02	0.0010	0.11

WHR (continuous).
r_{xy} = partial correlation coefficient.

Table A2. Factors Associated with the Metabolic Syndrome/History of Diabetes in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Age (y)		0.03	0.0030	1.03	(1.00 - 1.06)
Annual Income					
< \$10,000	\$40,000 - < \$80,000	-0.12	0.7568	0.89	(0.33 - 2.40)
\$10,000 - < \$20,000	\$40,000 - < \$80,000	0.17	0.5199	1.19	(0.60 - 2.34)
\$20,000 - < \$40,000	\$40,000 - < \$80,000	0.06	0.7496	1.06	(0.65 - 1.73)
\$80,000 or More	\$40,000 - < \$80,000	-0.66	0.0040	0.52	(0.29 - 0.93)
Insurance Type					
Medicare	Private	0.57	0.0061	1.78	(1.04 - 3.05)
Other Public	Private	0.68	0.2292	1.97	(0.46 - 8.38)
None/Self Pay	Private	0.19	0.5209	1.22	(0.56 - 2.65)
Physical Activity Level					
Sedentary	Moderate	0.85	0.0024	2.33	(1.14 - 4.78)
Mild	Moderate	0.55	0.0010	1.73	(1.13 - 2.65)
Strenuous	Moderate	0.06	0.8120	1.07	(0.54 - 2.10)

Metabolic syndrome/history of diabetes (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome or a history of diabetes is presented here.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for metabolic syndrome/history of diabetes * neighborhood grade: (1 degree of freedom) = 5.08; p = 0.0242.
p-value for trend for neighborhood grade = 0.0244.
Too few subjects with Medicaid to be assessed.

Table A3. Factors Associated with the Metabolic Syndrome in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Annual Income					
< $10,000	$40,000 - < $80,000	-0.37	0.4370	0.69	(0.20 - 2.37)
$10,000 - < $20,000	$40,000 - < $80,000	0.07	0.8268	1.07	(0.49 - 2.35)
$20,000 - < $40,000	$40,000 - < $80,000	-0.04	0.8422	0.96	(0.55 - 1.68)
$80,000 or More	$40,000 - < $80,000	-0.77	0.0046	0.46	(0.23 - 0.93)
Physical Activity Level					
Sedentary	Moderate	0.91	0.0033	2.49	(1.12 - 5.52)
Mild	Moderate	0.47	0.0147	1.61	(0.97 - 2.65)
Strenuous	Moderate	-0.07	0.8153	0.93	(0.41 - 2.12)

Metabolic syndrome (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome only is presented here.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for metabolic syndrome * neighborhood grade: (1 degree of freedom) = 1.26; p = 0.2614.
p-value for trend for neighborhood grade = 0.2615.

Table A4. Factors Associated with Low HDL Levels in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Physical Activity Level					
Sedentary	Moderate	0.55	0.0582	1.74	(0.82 - 3.69)
Mild	Moderate	0.51	0.0029	1.67	(1.07 - 2.61)
Strenuous	Moderate	-0.13	0.6573	0.88	(0.42 - 1.85)

Low HDL (dichotomous).
OR = odds ratio. OR for having low HDL levels.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for low HDL levels * neighborhood grade: (1 degree of freedom) = 3.17; p = .0752.
p-value for trend for neighborhood grade = 0.0754.

Table A5. Factors Associated with High LDL Levels in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Gender					
Male	Female	-0.49	0.0003	0.61	(0.43 - 0.87)
Insurance Type					
Medicare	Private	0.23	0.2199	1.26	(0.77 - 2.06)
Medicaid	Private	-0.25	0.8154	0.78	(0.05 - 11.79)
Other Public	Private	-0.13	0.8082	0.88	(0.21 - 3.62)
None/Self Pay	Private	0.76	0.0051	2.13	(1.06 - 4.28)

High LDL (ordinal categorical).
OR = odds ratio. OR for having high LDL levels.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for LDL * neighborhood grade: (1 degree of freedom) = 0.87; p = 0.3506.
p-value for trend for neighborhood grade = 0.3591.

Table A6. Factors Associated with High Triglyceride Levels in Univariate Analyses

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Race					
Black	White	-0.74	<.0001	0.48	(0.30- 0.76)
Physical Activity Level					
Sedentary	Moderate	0.45	0.1618	1.56	(0.69 - 3.55)
Mild	Moderate	0.56	0.0023	1.76	(1.09 - 2.82)
Strenuous	Moderate	0.08	0.7827	1.09	(0.50 - 2.34)

High triglyceride (ordinal categorical).
OR = odds ratio. OR for having high triglyceride levels.
CI = confidence interval.
Mantel-Haenszel Chi-Square test of trend for triglycerides * neighborhood grade: (1 degree of freedom) = 0.36; p = 0.5512.
p-value for trend for neighborhood grade = 0.5028.

APPENDIX L: MULTIVARIATE REGRESSION ANALYSIS RESULTS

Table A7. Multivariate Model of Factors Associated with Waist-Hip Ratio (WHR)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	-0.005	0.4836	-0.02
Moderately Favorable	Least Favorable	-0.016	0.0229	-0.08
Most Favorable	Least Favorable	-0.013	0.0718	-0.06
Insurance Type				
Medicare	Private	0.005	0.5293	0.02
Medicaid	Private	-0.003	0.9399	-0.00
Other Public	Private	0.052	0.0094	0.09
None/Self Pay	Private	-0.005	0.6750	-0.01
Smoking Status				
Current Smoker	Never Smoker	-0.002	0.8348	-0.01
Former Smoker	Never Smoker	0.012	0.0176	0.08

WHR (continuous).
*Model adjusted for: age, gender, insurance type, and smoking status.
r_{xy} = partial correlation coefficient.

Table A8. Multivariate Model of Factors Associated with Body Mass Index (BMI)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	-0.69	0.2016	-0.04
Moderately Favorable	Least Favorable	-1.29	0.0200	-0.08
Most Favorable	Least Favorable	-1.09	0.0551	-0.07
Race				
Black	White	2.40	<.0001	0.20
Education Level				
High School or Less	Bachelor's Degree	0.49	0.4346	0.03
Some College	Bachelor's Degree	0.92	0.0786	0.06
More than Bachelor's Degree	Bachelor's Degree	0.12	0.8176	0.01
Physical Activity Level				
Sedentary	Moderate	4.15	<.0001	0.18
Mild	Moderate	1.89	<.0001	0.15
Strenuous	Moderate	-1.26	0.0569	-0.07

BMI (continuous).
*Model adjusted for: age, gender, race, education level, and physical activity level.
r_{xy} = partial correlation coefficient.

Table A9. Multivariate Model of Factors Associated with Diabetes

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.37	0.1894	0.69	(0.33 - 1.43)
Moderately Favorable	Least Favorable	-0.77	0.019	0.46	(0.20 - 1.08)
Most Favorable	Least Favorable	-0.29	0.3376	0.75	(0.35 - 1.63)
Race					
Black	White	0.93	<.0001	2.54	(1.40 - 4.60)

Diabetes (dichotomous).
OR = odds ratio. OR for being diabetic is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, and race.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 4.13; p = 0.8454.
p-value for trend for neighborhood grade = 0.1757.

Table A10. Multivariate Model of Factors Associated with the Metabolic Syndrome/History of Diabetes

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.49	0.0269	0.61	(0.35 - 1.08)
Moderately Favorable	Least Favorable	-0.41	0.074	0.66	(0.37 - 1.20)
Most Favorable	Least Favorable	-0.38	0.1005	0.68	(0.38 - 1.24)
Annual Income					
< $10,000	$40,000 - < $80,000	-0.17	0.6649	0.84	(0.30 - 2.36)
$10,000 - < $20,000	$40,000 - < $80,000	-0.05	0.8628	0.95	(0.46 - 1.96)
$20,000 - < $40,000	$40,000 - < $80,000	-0.05	0.7821	0.95	(0.57 - 1.57)
$80,000 or More	$40,000 - < $80,000	-0.61	0.0099	0.54	(0.30 - 1.00)
Physical Activity Level					
Sedentary	Moderate	0.67	0.0337	1.95	(0.87 - 4.36)
Mild	Moderate	0.57	0.0017	1.76	(1.11 - 2.81)
Strenuous	Moderate	0.08	0.7824	1.08	(0.52 - 2.24)

Metabolic syndrome/history of diabetes (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome or a history of diabetes is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, income, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 9.41; p = 0.3092.
p-value for trend for neighborhood grade = 0.1500.

Table A11. Multivariate Model of Factors Associated with the Metabolic Syndrome

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.44	0.0948	0.64	(0.33 - 1.27)
Moderately Favorable	Least Favorable	-0.14	0.6016	0.87	(0.45 - 1.71)
Most Favorable	Least Favorable	-0.29	0.2853	0.75	(0.37 - 1.50)
Annual Income					
< $10,000	$40,000 - < $80,000	-0.33	0.499	0.72	(0.20 - 2.53)
$10,000 - < $20,000	$40,000 - < $80,000	-0.07	0.8319	0.93	(0.41 - 2.14)
$20,000 - < $40,000	$40,000 - < $80,000	-0.13	0.5573	0.88	(0.49 - 1.56)
$80,000 or More	$40,000 - < $80,000	-0.73	0.009	0.48	(0.24 - 0.99)
Physical Activity Level					
Sedentary	Moderate	0.72	0.0388	2.05	(0.84 - 5.01)
Mild	Moderate	0.47	0.0258	1.60	(0.93 - 2.74)
Strenuous	Moderate	-0.03	0.9256	0.97	(0.40 - 2.35)

Metabolic syndrome (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome only is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, income, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 4.87; p = 0.7709.
p-value for trend for neighborhood grade = 0.5181.

Table A12. Multivariate Model of Factors Associated with Hypertension

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.27	0.1914	0.76	(0.45 - 1.30)
Moderately Favorable	Least Favorable	-0.38	0.0779	0.69	(0.40 - 1.19)
Most Favorable	Least Favorable	-0.56	0.0105	0.57	(0.32 - 1.00)
Race					
Black	White	0.61	<.0001	1.84	(1.23 - 2.76)

Hypertension (dichotomous).
OR = odds ratio. OR for being hypertensive is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, and race.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 7.57; p = 0.4771.
p-value for trend for neighborhood grade = 0.0100.

Table A13. Multivariate Model of Factors Associated with Low HDL Levels

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	0.03	0.8834	1.03	(0.59 - 1.80)
Moderately Favorable	Least Favorable	0.03	0.8759	1.03	(0.59 - 1.80)
Most Favorable	Least Favorable	-0.40	0.0831	0.67	(0.37 - 1.21)
Physical Activity Level					
Sedentary	Moderate	0.54	0.0687	1.72	(0.80 - 3.70)
Mild	Moderate	0.50	0.0041	1.65	(1.05 - 2.59)
Strenuous	Moderate	-0.19	0.5109	0.83	(0.39 - 1.75)

Low HDL (dichotomous).
OR = odds ratio. OR for having low HDL levels.
CI = confidence interval.
*Model adjusted for: age, gender, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 16.89; p = 0.0313.
p-value for trend for neighborhood grade = 0.1101.

Table A14. Multivariate Model of Factors Associated with High LDL Levels

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.19	0.3136	0.83	(0.52 - 1.34)
Moderately Favorable	Least Favorable	-0.03	0.8663	0.97	(0.61 - 1.55)
Most Favorable	Least Favorable	-0.07	0.6983	0.93	(0.58 - 1.50)
Insurance Type					
Medicare	Private	0.48	0.0297	1.61	(0.92 - 2.83)
Medicaid	Private	-0.41	0.6997	0.67	(0.04 - 10.09)
Other Public	Private	-0.02	0.968	0.98	(0.24 - 4.07)
None/Self Pay	Private	0.77	0.0049	2.17	(1.07 - 4.41)

High LDL (ordinal categorical).
OR = odds ratio. OR for having high LDL levels.
CI = confidence interval.
*Model adjusted for: age, gender, and insurance type.
p-value for trend for neighborhood grade = 0.9285.

Table A15. Multivariate Model of Factors Associated with High Triglyceride Levels

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	0.12	0.6335	1.13	(0.60 - 2.13)
Moderately Favorable	Least Favorable	0.19	0.4496	1.20	(0.64 - 2.27)
Most Favorable	Least Favorable	-0.04	0.8751	0.96	(0.50 - 1.86)
Race					
Black	White	-0.75	<.0001	0.47	(0.29 - 0.77)
Physical Activity Level					
Sedentary	Moderate	0.60	0.0663	1.82	(0.79 - 4.23)
Mild	Moderate	0.58	0.0020	1.79	(1.10 - 2.90)
Strenuous	Moderate	0.16	0.5997	1.17	(0.54 - 2.57)

High triglyceride (ordinal categorical).
OR = odds ratio. OR for having high triglyceride levels.
CI = confidence interval.
*Model adjusted for: age, gender, race, and physical activity level.
p-value for trend for neighborhood grade = 0.9073.

APPENDIX M: UNIVARIATE REGRESSION ANALYSIS RESULTS STRATIFIED BY RACE

Table A16. Factors Associated with Waist-Hip Ratio (WHR) in Univariate Analyses

Variable	Reference Group	Black Parameter Estimate	Black p-value	Black r_{xy}	White Parameter Estimate	White p-value	White r_{xy}
Age (y)		0.002	0.0016	0.16	0.002	0.0001	0.17
Gender							
Male	Female	0.09	<.0001	0.47	0.10	<.0001	0.55
Marital Status							
Not Married	Married	-0.02	0.0526	-0.10	-0.03	0.0038	-0.13
Smoking Status							
Current Smoker	Never Smoker	-0.02	0.2597	-0.06	0.02	0.3179	0.04
Former Smoker	Never Smoker	0.01	0.2739	0.06	0.03	0.0008	0.15

WHR (continuous).
r_{xy} = partial correlation coefficient.

Table A17. Factors Associated with Diabetes in Univariate Analyses

Variable	Black Parameter Estimate	Black p-value	Black OR	Black 99% C.I.	White Parameter Estimate	White p-value	White OR	White 99% C.I.
Age (y)	0.04	0.0207	1.04	(1.00 - 1.09)	0.07	0.0032	1.07	(1.01 - 1.14)

Diabetes (dichotomous).
OR = odds ratio. OR for being diabetic is presented here.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for diabetes * neighborhood grade: (1 degree of freedom) = 0.97; p = 0.3247.
Black: p-value for trend for neighborhood grade = 0.3249.
White: Mantel-Haenszel Chi-Square test of trend for diabetes * neighborhood grade: (1 degree of freedom) = 0.39; p = 0.5323.
White: p-value for trend for neighborhood grade = 0.5323.

Table A18. Factors Associated with the Metabolic Syndrome/History of Diabetes in Univariate Analyses

Variable	Reference Group	Black Parameter Estimate	Black p-value	Black OR	Black 99% C.I.	White Parameter Estimate	White p-value	White OR	White 99% C.I.
Physical Activity Level									
Sedentary	Moderate	0.41	0.2844	1.51	(0.56 -4.03)	1.29	0.0020	3.64	(1.24 - 10.67)
Mild	Moderate	0.61	0.0173	1.83	(0.95 -3.53)	0.51	0.0205	1.67	(0.94 - 2.96)
Strenuous	Moderate	0.11	0.7667	1.12	(0.42 -2.94)	-0.02	0.9577	0.98	(0.38 - 2.56)

Metabolic syndrome/history of diabetes (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome or a history of diabetes is presented here.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for metabolic syndrome/history of diabetes * neighborhood grade: (1 degree of freedom) = 0.76; p = 0.3831.
Black: p-value for trend for neighborhood grade = 0.3828.
White: Mantel-Haenszel Chi-Square test of trend for metabolic syndrome/history of diabetes * neighborhood grade: (1 degree of freedom) = 2.02; p = 0.1553.
White: p-value for trend for neighborhood grade = 0.1556.

Table A19. Factors Associated with the Metabolic Syndrome in Univariate Analyses

		Black				White			
Variable	**Reference Group**	**Parameter Estimate**	**p-value**	**OR**	**99% C.I.**	**Parameter Estimate**	**p-value**	**OR**	**99% C.I.**
Physical Activity Level									
Sedentary	Moderate	0.19	0.7070	1.21	(0.33 - 4.45)	1.53	0.0003	4.60	(1.55 - 13.66)
Mild	Moderate	0.54	0.0888	1.72	(0.76 - 3.89)	0.43	0.0765	1.55	(0.82 - 2.91)
Strenuous	Moderate	0.25	0.5730	1.29	(0.40 - 4.13)	-0.39	0.4027	0.68	(0.20 - 2.26)

Metabolic syndrome (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome only is presented here.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for metabolic syndrome * neighborhood grade: (1 degree of freedom) = 0.007; p = 0.9325.
Black: p-value for trend for neighborhood grade = 0.9325.
White: Mantel-Haenszel Chi-Square test of trend for metabolic syndrome * neighborhood grade: (1 degree of freedom) = 2.29; p = 0.1301.
White: p-value for trend for neighborhood grade = 0.1305.

Table A20. Factors Associated with Hypertension in Univariate Analyses

		Black				White			
Variable	**Reference Group**	**Parameter Estimate**	**p-value**	**OR**	**99% C.I.**	**Parameter Estimate**	**p-value**	**OR**	**99% C.I.**
Age (y)		0.04	0.0109	1.04	(1.00 - 1.08)	0.07	<.0001	1.07	(1.03 - 1.11)
Education Level									
High School or Less	Bachelor's Degree	0.23	0.5242	1.26	(0.50 - 3.15)	0.82	0.0068	2.28	(1.04 - 5.00)
Some College	Bachelor's Degree	0.27	0.3706	1.30	(0.61 - 2.80)	0.06	0.8437	1.06	(0.50 - 2.22)
More than Bachelor’s Degree	Bachelor's Degree	0.12	0.7242	1.13	(0.46 - 2.81)	-0.20	0.4657	0.82	(0.41 - 1.65)

Hypertension (dichotomous).
OR = odds ratio. OR for being hypertensive is presented here.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for hypertension * neighborhood grade: (1 degree of freedom) = 2.61; p = 0.1064.
Black: p-value for trend for neighborhood grade = 0.1067.
White: Mantel-Haenszel Chi-Square test of trend for hypertension * neighborhood grade: (1 degree of freedom) = 2.20; p = 0.1382.
White: p-value for trend for neighborhood grade = 0.1385.

Table A21. Factors Associated with Low HDL Levels in Univariate Analyses

		Black				White			
Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.	Parameter Estimate	p-value	OR	99% C.I.
Physical Activity Level									
Sedentary	Moderate	0.12	0.7701	1.13	(0.39 - 3.25)	0.55	0.0582	1.74	(0.82 - 3.69)
Mild	Moderate	0.13	0.6405	1.14	(0.56 - 2.31)	0.51	0.0029	1.67	(1.07 - 2.61)
Strenuous	Moderate	0.30	0.4228	1.35	(0.51 - 3.57)	-0.13	0.6573	0.88	(0.42 - 1.85)

Low HDL (dichotomous).
OR = odds ratio. OR for having low HDL levels.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for low HDL levels * neighborhood grade: (1 degree of freedom) = 0.12; p = 0.7281.
Black: p-value for trend for neighborhood grade = 0.7277.
White: Mantel-Haenszel Chi-Square test of trend for low HDL levels * neighborhood grade: (1 degree of freedom) = 6.27; p = 0.0123.
White: p-value for trend for neighborhood grade = 0.0127.

Table A22. Factors Associated with High LDL Levels in Univariate Analyses

		Black				White			
Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.	Parameter Estimate	p-value	OR	99% C.I.
Gender									
Male	Female	-0.20	0.3619	0.82	(0.47 - 1.43)	-0.71	<.0001	0.49	(0.31- 0.77)

High LDL (ordinal categorical).
OR = odds ratio. OR for having high LDL levels.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for LDL * neighborhood grade: (1 degree of freedom) = 4.41; p = 0.0356.
Black: p-value for trend for neighborhood grade = 0.0364.
White: Mantel-Haenszel Chi-Square test of trend for LDL * neighborhood grade: (1 degree of freedom) = 0.02; p = 0.8772.
White: p-value for trend for neighborhood grade = 0.8621.

Table A23. Factors Associated with High Triglyceride Levels in Univariate Analyses

Variable	Reference Group	Black				White			
		Parameter Estimate	p-value	OR	99% C.I.	Parameter Estimate	p-value	OR	99% C.I.
Smoking Status									
Current Smoker	Never Smoker	0.65	0.1796	1.92	(0.55 - 6.75)	1.40	0.0036	4.07	(1.18 - 14.07)
Former Smoker	Never Smoker	0.53	0.1048	1.70	(0.73 - 3.95)	-0.09	0.6836	0.92	(0.53 - 1.58)
Physical Activity Level									
Sedentary	Moderate	-0.40	0.5312	0.67	(0.13 - 3.44)	1.18	0.0032	3.27	(1.16- 9.21)
Mild	Moderate	0.57	0.0821	1.76	(0.76 - 4.07)	0.57	0.0116	1.77	(0.99- 3.16)
Strenuous	Moderate	-0.33	0.5612	0.72	(0.16 - 3.16)	0.57	0.0116	1.38	(0.55- 3.48)

High triglyceride (ordinal categorical).
OR = odds ratio. OR for having high triglyceride levels.
CI = confidence interval.
Black: Mantel-Haenszel Chi-Square test of trend for triglycerides * neighborhood grade: (1 degree of freedom) = 0.007; p = 0.9329.
Black: p-value for trend for neighborhood grade = 0.7232.
White: Mantel-Haenszel Chi-Square test of trend for triglycerides * neighborhood grade: (1 degree of freedom) = 0.52; p = 0.4693.
White: p-value for trend for neighborhood grade = 0.3764.

APPENDIX N: MULTIVARIATE REGRESSION ANALYSIS RESULTS STRATIFIED BY RACE (WHITE PARTICIPANTS ONLY)

Table A24. Multivariate Model of Factors Associated with Waist-Hip Ratio (WHR)

Variable	Reference Group	Parameter Estimate	p-value	r_{xy}
Neighborhood Grade				
Mildly Favorable	Least Favorable	-0.01	0.4055	-0.04
Moderately Favorable	Least Favorable	-0.02	0.0658	-0.08
Most Favorable	Least Favorable	-0.02	0.1141	-0.07
Smoking Status				
Current Smoker	Never Smoker	0.01	0.5335	0.03
Former Smoker	Never Smoker	0.02	0.0206	0.10

WHR (continuous).
*Model adjusted for: age, gender, and smoking status.
r_{xy} = partial correlation coefficient.

Table A25. Multivariate Model of Factors Associated with Diabetes

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.34	0.5118	0.71	(0.19 - 2.70)
Moderately Favorable	Least Favorable	-0.80	0.1286	0.45	(0.12 - 1.75)
Most Favorable	Least Favorable	-0.38	0.4347	0.69	(0.20 - 2.37)

Diabetes (dichotomous).
OR = odds ratio. OR for being diabetic is presented here.
CI = confidence interval.
*Model adjusted for: age and gender.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 12.83; p = 0.1177.
p-value for trend for neighborhood grade = 0.4144.

Table A26. Multivariate Model of Factors Associated with the Metabolic Syndrome/History of Diabetes

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.68	0.0401	0.51	(0.22 - 1.19)
Moderately Favorable	Least Favorable	-0.54	0.0766	0.58	(0.27 - 1.28)
Most Favorable	Least Favorable	-0.44	0.1387	0.64	(0.30 - 1.39)
Physical Activity Level					
Sedentary	Moderate	1.31	0.0023	3.72	(1.23 - 11.30)
Mild	Moderate	0.62	0.0067	1.87	(1.03 - 3.37)
Strenuous	Moderate	0.09	0.8218	1.09	(0.41 - 2.92)

Metabolic syndrome/history of diabetes (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome or a history of diabetes is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 1.95; p = 0.9824.
p-value for trend for neighborhood grade = 0.3416.

Table A27. Multivariate Model of Factors Associated with the Metabolic Syndrome

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.66	0.0684	0.52	(0.20 - 1.32)
Moderately Favorable	Least Favorable	-0.39	0.2347	0.68	(0.29 - 1.58)
Most Favorable	Least Favorable	-0.47	0.1564	0.63	(0.27 - 1.47)
Physical Activity Level					
Sedentary	Moderate	1.51	0.0005	4.55	(1.48 - 13.94)
Mild	Moderate	0.51	0.0428	1.67	(0.87 - 3.21)
Strenuous	Moderate	-0.27	0.5704	0.76	(0.22 - 2.60)

Metabolic syndrome (dichotomous).
OR = odds ratio. OR for having the metabolic syndrome only is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 11.51; p = 0.1742.
p-value for trend for neighborhood grade = 0.3744.

Table A28. Multivariate Model of Factors Associated with Hypertension

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.34	0.3101	0.72	(0.31 - 1.68)
Moderately Favorable	Least Favorable	-0.46	0.1445	0.63	(0.28 - 1.43)
Most Favorable	Least Favorable	-0.47	0.1330	0.62	(0.28 - 1.40)
Education Level					
High School or Less	Bachelor's Degree	0.53	0.1016	1.69	(0.74 - 3.88)
Some College	Bachelor's Degree	-0.02	0.9469	0.98	(0.45 - 2.12)
More than Bachelor’s Degree	Bachelor's Degree	-0.31	0.2656	0.73	(0.36 - 1.50)

Hypertension (dichotomous).
OR = odds ratio. OR for being hypertensive is presented here.
CI = confidence interval.
*Model adjusted for: age, gender, and education level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 5.25; p = 0.7310.
p-value for trend for neighborhood grade = 0.1516.

Table A29. Multivariate Model of Factors Associated with Low HDL Levels

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.05	0.8734	0.95	(0.41 - 2.22)
Moderately Favorable	Least Favorable	-0.13	0.6712	0.88	(0.40 - 1.95)
Most Favorable	Least Favorable	-0.62	0.0565	0.54	(0.23 - 1.24)
Physical Activity Level					
Sedentary	Moderate	0.89	0.0408	2.42	(0.80 - 7.40)
Mild	Moderate	0.76	0.0008	2.15	(1.19 - 3.88)
Strenuous	Moderate	-0.86	0.0893	0.43	(0.12 - 1.56)

Low HDL (dichotomous).
OR = odds ratio. OR for having low HDL levels.
CI = confidence interval.
*Model adjusted for: age, gender, and physical activity level.
Hosmer and Lemeshow Goodness-of-Fit Test: Chi-Square = 9.17; p = 0.3284.
p-value for trend for neighborhood grade = 0.0409.

Table A30. Multivariate Model of Factors Associated with High LDL Levels

Variable *(Dummy Variable)*	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.10	0.7193	0.91	(0.44 - 1.85)
Moderately Favorable	Least Favorable	0.15	0.5669	1.16	(0.59 - 2.29)
Most Favorable	Least Favorable	0.02	0.9379	1.02	(0.52 - 2.00)

High LDL (ordinal categorical).
OR = odds ratio. OR for having high LDL levels.
CI = confidence interval.
*Model adjusted for: age and gender.
p-value for trend for neighborhood grade = 0.6903.

Table A31. Multivariate Model of Factors Associated with High Triglyceride Levels

Variable	Reference Group	Parameter Estimate	p-value	OR	99% C.I.
Neighborhood Grade					
Mildly Favorable	Least Favorable	-0.11	0.7413	0.90	(0.39 - 2.08)
Moderately Favorable	Least Favorable	-0.04	0.9071	0.97	(0.44 - 2.13)
Most Favorable	Least Favorable	-0.26	0.4107	0.77	(0.35 - 1.72)
Smoking Status					
Current Smoker	Never Smoker	1.42	0.0033	4.15	(1.19 - 14.45)
Former Smoker	Never Smoker	-0.06	0.7653	0.94	(0.54 - 1.63)

High triglyceride (ordinal categorical).
OR = odds ratio. OR for having high triglyceride levels.
CI = confidence interval.
*Model adjusted for: age, gender, and smoking status.
p-value for trend for neighborhood grade = 0.4478.

BIBLIOGRAPHY

Active Living Research. (2006). Neighborhood environment walkability survey (NEWS) & neighborhood environment walkability survey – abbreviated (NEWS-A). Retrieved November 6, 2008, from http://www.activelivingresearch.org/node/10649

Ainsworth, B. E., Haskell, W. L., Leon, A. S., Jacobs, D. R., Jr., Montoye, H. J., Sallis, J. F., et al. (1993). Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc, 25*(1), 71-80.

Ainsworth, B. E., Jacobs, D. R., Jr., & Leon, A. S. (1993). Validity and reliability of self-reported physical activity status: the Lipid Research Clinics questionnaire. *Med Sci Sports Exerc, 25*(1), 92-98.

Alberti, K. G., Zimmet, P., & Shaw, J. (2005). The metabolic syndrome--a new worldwide definition. *Lancet, 366*(9491), 1059-1062.

Altabe, M. (1998). Ethnicity and body image: Quantitative and qualitative analysis. *International Journal of Eating Disorders, 23*(2), 153-159.

American College of Sports Medicine. (2000). ACSM's Guidelines for exercise testing and prescription. In B. A. Franklin, M. H. Whaley & E. T. Howley (Eds.), (6th ed., pp. 62-66). Philadelphia: Lippincott Williams & Wilkins.

American College of Sports Medicine. (2007). Physical activity and public health guidelines. Retrieved January 8, 2008, from http://www.acsm.org/AM/Template.cfm?Section=Home_Page&TEMPLATE=/CM/HTMLDisplay.cfm&CONTENTID=7764

American Diabetes Association. (2004). Screening for type 2 diabetes. *Diabetes Care, 27 Suppl 1*, S11-14.

American Diabetes Association. (2009). Diagnosis and classification of diabetes mellitus. *Diabetes Care, 32 Suppl 1*, S62-67.

American Heart Association. (2008a). Cholesterol-lowering drugs. Retrieved August 28, 2008, from http://www.americanheart.org/presenter.jhtml?identifier=163

American Heart Association. (2008b). Metabolic syndrome. Retrieved January 14, 2008, from http://www.americanheart.org/presenter.jhtml?identifier=4756

American Heart Association. (2008c). Obesity and Overweight. Retrieved March 1, 2008, from http://www.americanheart.org/presenter.jhtml?identifier=4639

American Heart Association. (2008d). Physical inactivity, overweight and obesity. Retrieved October 1, 2008, from http://www.americanheart.org/presenter.jhtml?identifier=742

American Heart Association. (2008e). What is high blood pressure? Retrieved January 14, 2008, from http://www.americanheart.org/presenter.jhtml?identifier=2112

American Heart Association. (2009). Heart disease and stroke statistics -- 2009 update at-a-glance. Retrieved February 1, 2009, from http://www.americanheart.org/downloadable/heart/1240250946756LS-1982%20Heart%20and%20Stroke%20Update.042009.pdf

American Heart Association & American Stroke Association. (2007). Heart disease and stroke statistics -- 2007 update at-a-glance. Retrieved January 24, 2008, from http://www.americanheart.org/downloadable/heart/1166712318459HS_StatsInsideText.pdf

American Heart Association & American Stroke Association. (2008). Heart disease and stroke statistics -- 2008 update at-a-glance. Retrieved June 9, 2008, from http://www.americanheart.org/downloadable/heart/1200078608862HS_Stats%202008.final.pdf

Anderson, K. M., Wilson, P. W., Odell, P. M., & Kannel, W. B. (1991). An updated coronary risk profile. A statement for health professionals. *Circulation, 83*(1), 356-362.

Anonymous. (1996). Physical activity and cardiovascular health. NIH Consensus Development Panel on Physical Activity and Cardiovascular Health. *JAMA, 276*, 241-246.

Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. (2004). *Lancet, 363*(9403), 157-163.

Australian Department of Health and Aged Care. (1999). *National physical activity guidelines for Australians*. Canberra: Department of Health and Aged Care.

Australian Institute of Health and Welfare. (2003). *The active Australia survey: A guide and manual for implementation, analysis and reporting*. Canberra: Australian Institute of Health and Welfare.

Bach, P. B., Pham, H. H., Schrag, D., Tate, R. C., & Hargraves, J. L. (2004). Primary care physicians who treat blacks and whites. *N Engl J Med, 351*(6), 575-584.

Bakris, G. L. (2007). Current perspectives on hypertension and metabolic syndrome. *J Manag Care Pharm, 13*(5 Suppl), S3-5.

Balkau, B., & Charles, M. A. (1999). Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabet Med, 16*(5), 442-443.

Ball, K., Bauman, A., Leslie, E., & Owen, N. (2001). Perceived environmental aesthetics and convenience and company are associated with walking for exercise among Australian adults. *Prev Med, 33*(5), 434-440.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality & Social Psychology, 51*(6), 1173-1182.

Bashir, S. A. (2002). Home is where the harm is: inadequate housing as a public health crisis. *Am J Public Health, 92*(5), 733-738.

Baskin, M. L., Ard, J., Franklin, F., & Allison, D. B. (2005). Prevalence of obesity in the United States. *Obes Rev, 6*(1), 5-7.

Bassett, D. R., Jr., Ainsworth, B. E., Leggett, S. R., Mathien, C. A., Main, J. A., Hunter, D. C., et al. (1996). Accuracy of five electronic pedometers for measuring distance walked. *Med Sci Sports Exerc, 28*(8), 1071-1077.

BatchGeo. (2010). Make google maps using many addresses/coordinates. Retrieved January 4, 2010, from http://www.batchgeocode.com/

Baum, A., & Paulus, P. B. (1987). Crowding. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology* (pp. 533-570). New York: Wiley.

Bauman, A., Sallis, J. F., & Owen, N. (2002). Environmental and policy measurement in physical activity research. In G. Welk (Ed.), *Physical activity assessment for health-related research*. Champaign, IL: Human Kinetics.

Beauchemin, K. M., & Hays, P. (1996). Sunny hospital rooms expedite recovery from severe and refractory depressions. *J Affect Disord, 40*(1-2), 49-51.

Becker, L. B., Han, B. H., Meyer, P. M., Wright, F. A., Rhodes, K. V., Smith, D. W., et al. (1993). Racial differences in the incidence of cardiac arrest and subsequent survival. The CPR Chicago Project. *N Engl J Med, 329*(9), 600-606.

Bender, A. P., Sprafka, J. M., Jagger, H. G., Muckala, K. H., Martin, C. P., & Edwards, T. R. (1986). Incidence, prevalence, and mortality of diabetes mellitus in Wadena, Marshall, and Grand Rapids, Minnesota: the Three-City Study. *Diabetes Care, 9*(4), 343-350.

Black, S. A. (2002). Diabetes, diversity, and disparity: what do we do with the evidence? *Am J Public Health, 92*(4), 543-548.

Blair, S. N., Kohl, H. W., 3rd, Paffenbarger, R. S., Jr., Clark, D. G., Cooper, K. H., & Gibbons, L. W. (1989). Physical fitness and all-cause mortality. A prospective study of healthy men and women. *Jama, 262*(17), 2395-2401.

Block, G., Woods, M., Potosky, A., & Clifford, C. (1990). Validation of a self-administered diet history questionnaire using multiple diet records. *J Clin Epidemiol, 43*(12), 1327-1335.

Bonow, R. O., & Gheorghiade, M. (2004). The diabetes epidemic: a national and global crisis. *Am J Med, 116 Suppl 5A*, 2S-10S.

Booth, K. M., Pinkston, M. M., & Poston, W. S. (2005). Obesity and the built environment. *J Am Diet Assoc, 105*(5 Suppl 1), S110-117.

Booth, M. L., Hunter, C., Gore, C. J., Bauman, A., & Owen, N. (2000). The relationship between body mass index and waist circumference: implications for estimates of the population prevalence of overweight. *Int J Obes Relat Metab Disord, 24*(8), 1058-1061.

Booth, M. L., Owen, N., Bauman, A., Clavisi, O., & Leslie, E. (2000). Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Prev Med, 31*(1), 15-22.

Bouchard, C. (1995). Genetics and the metabolic syndrome. *Int J Obes Relat Metab Disord, 19 Suppl 1*, S52-59.

Brancati, F. L., Kao, W. H., Folsom, A. R., Watson, R. L., & Szklo, M. (2000). Incident type 2 diabetes mellitus in African American and white adults: the Atherosclerosis Risk in Communities Study. *Jama, 283*(17), 2253-2259.

Braunwald's heart disease: A textbook of cardiovascular medicine, 8th ed. (2007). Retrieved May 5, 2008, from http://online5.hsls.pitt.edu:2532/das/book/body/98278507-7/0/1549/1.html

Bray, G. A. (1989). Classification and evaluation of the obesities. *Med Clin North Am, 73*(1), 161-184.

Bull, F., Milligan, R., Rosenberg, M., & MacGowan, H. (2000). *Physical activity levels of western Australian adults 1999*. Perth: Western Australia: Health Department of Western Australia and Sport and Recreation Way2Go, Western Australian Government.

Bullinger, M., Hygge, S., Evans, G. W., Meis, M., & von Mackensen, S. (1999). The psychological cost of aircraft noise for children. *Zentralbl Hyg Umweltmed, 202*(2-4), 127-138.

Burt, V. L., Whelton, P. K., Roccella, E. J., Brown, C., Cutler, J. A., Higgins, M., et al. (1995). Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. *Hypertension., 25*(3), 305-313.

Burton, N. W., Turrell, G., Oldenburg, B., & Sallis, J. F. (2005). The relative contributions of psychological, social, and environmental variables to explain participation in walking, moderate-, and vigorous intensity leisure-time physical activity. *J Phys Act Health, 2*(2), 181-196.

Butler, W. J., Ostrander, L. D., Jr., Carman, W. J., & Lamphiear, D. E. (1985). Mortality from coronary heart disease in the Tecumseh study. Long-term effect of diabetes mellitus, glucose tolerance and other risk factors. *Am J Epidemiol, 121*(4), 541-547.

Cameron, A. J., Shaw, J. E., & Zimmet, P. Z. (2004). The metabolic syndrome: prevalence in worldwide populations. *Endocrinol Metab Clin North Am, 33*(2), 351-375, table of contents.

Carter, J. S., Pugh, J. A., & Monterrosa, A. (1996). Non-insulin-dependent diabetes mellitus in minorities in the United States. *Ann Intern Med, 125*(3), 221-232.

Cavalini, P. M., Koeter-Kemmerling, L. G., & Pulles, M. P. J. (1991). Coping with odour annoyance and odour concentrations: Three field studies. *Journal of Environmental Psychology, 11*(2), 123-142.

Centers for Disease Control and Prevention. (1996). *The Third National Health and Nutrition Examination Survey (NHANES III 1988-94) Reference Manuals and Reports.*

Centers for Disease Control and Prevention. (1999a). *1998 BRFSS summary prevalence report*. Atlanta, GA: Behavioral Surveillance Branch, Division of Adult and Community health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. (1999b). Neighborhood safety and the prevalence of physical inactivity -- selected states, 1996. *MMWR Morbidity and Mortality Weekly Report., 48*(7), 143-146.

Centers for Disease Control and Prevention. (2002). BRFSS prevalence data, 2002. Retrieved November 25, 2002, from http://apps.nccd.cdc.gov/brfss

Centers for Disease Control and Prevention. (2006). National Health and Nutrition Examination Survey. Retrieved February 27, 2006, from http://www.cdc.gov/nchs/about/major/nhanes/datalink.htm

Centers for Disease Control and Prevention. (2008a). Behavioral risk factor surveillance system. Retrieved May 1, 2008, from http://www.cdc.gov/brfss

Centers for Disease Control and Prevention. (2008b). Compressed mortality file: Underlying cause-of-death. Retrieved June 14, 2008, from http://wonder.cdc.gov/mortSQL.html

Centers for Disease Control and Prevention. (2008c). Crude and age-adjusted percentage of civilian, noninstitutionalized population with diagnosed diabetes, United States, 1980–2006. Retrieved January 28, 2009, from http://www.cdc.gov/diabetes/statistics/prev/national/figage.htm

Centers for Disease Control and Prevention. (2008d). Heart disease facts and statistics. Retrieved April 1, 2008, from http://www.cdc.gov/HeartDisease/facts.htm

Centers for Disease Control and Prevention. (2008e). *National diabetes fact sheet: general information and national estimates on diabetes in the United States, 2007*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. (2008f). Physical activity for everyone. Retrieved January 8, 2008, from http://www.cdc.gov/nccdphp/dnpa/physical/everyone/glossary/index.htm

Centers for Disease Control and Prevention. (2009). Leading causes of death. Retrieved January 28, 2009, from http://www.cdc.gov/nchs/FASTATS/lcod.htm

Chen, B., Zaebst, D., & Seel, L. (2005). *A macro to calculate kappa statistics for categorizations by multiple raters*. Paper presented at the Thirtieth Annual SAS® Users Group International Conference. Retrieved January 4, 2010, from http://www2.sas.com/proceedings/sugi30/155-30.pdf

Chiricos, T., McEntire, R., & Gertz, M. (2001). Perceived racial and ethnic composition of neighborhood and perceived risk of crime. *Social Problems, 48*(3), 322-340.

Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, L. A., Izzo, J. L., Jr., et al. (2003). Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension, 42*(6), 1206-1252.

Cleeman, J. I. (1997). Adults aged 20 and older should have their cholesterol measured. *Am J Med, 102*(2A), 31-36.

Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. (1998). *Obes Res, 6 Suppl 2*, 51S-209S.

Cody, R. P., & Smith, J. K. (2006). *Applied statistics and the SAS® programming language* (5th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, J. D. (1997). A population-based approach to cholesterol control. *Am J Med, 102*(2A), 23-25.

Colagiuri, R. (2007). The lion, the wardrobe and the witch hunt: an alternative take on obesity. *Med J Aust, 186*(9), 476-477.

Colditz, G. A., Willett, W. C., Rotnitzky, A., & Manson, J. E. (1995). Weight Gain as a Risk Factor for Clinical Diabetes Mellitus in Women. *Ann Intern Med, 122*(7), 481-486.

Cooper, R., Cutler, J., Desvigne-Nickens, P., Fortmann, S. P., Friedman, L., Havlik, R., et al. (2000). Trends and disparities in coronary heart disease, stroke, and other cardiovascular diseases in the United States: findings of the national conference on cardiovascular disease prevention. *Circulation, 102*(25), 3137-3147.

Cossrow, N., & Falkner, B. (2004). Race/ethnic issues in obesity and obesity-related comorbidities. *J Clin Endocrinol Metab, 89*(6), 2590-2594.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334.

Dalton, M., Cameron, A. J., Zimmet, P. Z., Shaw, J. E., Jolley, D., Dunstan, D. W., et al. (2003). Waist circumference, waist-hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. *Journal of Internal Medicine, 254*(6), 555-563.

Damcott, C. M., Sack, P., & Shuldiner, A. R. (2003). The genetics of obesity. *Endocrinol Metab Clin North Am, 32*(4), 761-786.

DeFronzo, R. A., & Ferrannini, E. (1991). Insulin resistance. A multifaceted syndrome responsible for NIDDM, obesity, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease. *Diabetes Care, 14*(3), 173-194.

DeMers, M. N. (1997). *Fundamentals of geographic information systems* New York: John Wiley & Sons.

Dietz, W. H. (1996). The role of lifestyle in health: the epidemiology and consequences of inactivity. *Proc Nutr Soc, 55*(3), 829-840.

Dishman, R. K., & Steinhardt, M. (1988). Reliability and concurrent validity for a 7-d re-call of physical activity in college students. *Med Sci Sports Exerc, 20*(1), 14-25.

Dubbert, P. M., Carithers, T., Sumner, A. E., Barbour, K. A., Clark, B. L., Hall, J. E., et al. (2002). Obesity, physical inactivity, and risk for cardiovascular disease. *Am J Med Sci, 324*(3), 116-126.

Duke, S. A., Colagiuri, S., & Colagiuri, R. (2009). Individual patient education for people with type 2 diabetes mellitus. *Cochrane Database Syst Rev*(1), CD005268.

Duncan, M., & Mummery, K. (2005). Psychosocial and environmental factors associated with physical activity among city dwellers in regional Queensland. *Prev Med, 40*(4), 363-372.

Eckel, R. H. (1997). Obesity and heart disease: a statement for healthcare professionals from the Nutrition Committee, American Heart Association. *Circulation, 96*(9), 3248-3250.

Eckel, R. H., Grundy, S. M., & Zimmet, P. Z. (2005). The metabolic syndrome. *Lancet, 365*(9468), 1415-1428.

Egede, L. E., & Zheng, D. (2002). Modifiable cardiovascular risk factors in adults with diabetes: prevalence and missed opportunities for physician counseling. *Arch Intern Med, 162*(4), 427-433.

Engelgau, M. M., Geiss, L. S., Saaddine, J. B., Boyle, J. P., Benjamin, S. M., Gregg, E. W., et al. (2004). The evolving diabetes burden in the United States. *Ann Intern Med, 140*(11), 945-950.

Evans, G. W. (2001). Environmental stress and health. In A. Baum, T. Revenson & J. E. Singer (Eds.), *Handbook of health psychology* (pp. 571-610). Mahwah, NJ: Lawrence Erlbaum Associates.

Evans, G. W. (2003). The built environment and mental health. *J Urban Health, 80*(4), 536-555.

Evans, G. W., Lepore, S. J., & Allen, K. M. (2000). Cross-cultural differences in tolerance for crowding: fact or fiction? *J Pers Soc Psychol, 79*(2), 204-210.

Evans, G. W., Lercher, P., Meis, M., Ising, H., & Kofler, W. W. (2001). Community noise exposure and stress in children. *J Acoust Soc Am, 109*(3), 1023-1027.

Evans, G. W., Wells, N. M., & Moch, A. (2003). Housing and mental health: A review of the evidence and a methodological and conceptual critique. *Journal of Social Issues, 59*(3), 475-500.

Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). (2001). *Jama, 285*(19), 2486-2497.

Eyler, A. A., Baker, E., Cromer, L., King, A. C., Brownson, R. C., & Donatelle, R. J. (1998). Physical activity and minority women: a qualitative study. *Health Educ Behav, 25*(5), 640-652.

Farrell, S. W., Kampert, J. B., Kohl, H. W., 3rd, Barlow, C. E., Macera, C. A., Paffenbarger, R. S., Jr., et al. (1998). Influences of cardiorespiratory fitness levels and other predictors on cardiovascular disease mortality in men. *Med Sci Sports Exerc, 30*(6), 899-905.

Fields, L. E., Burt, V. L., Cutler, J. A., Hughes, J., Roccella, E. J., & Sorlie, P. (2004). The burden of adult hypertension in the United States 1999 to 2000: a rising tide. *Hypertension, 44*(4), 398-404.

Finkelstein, E. A., Ruhm, C. J., & Kosa, K. M. (2005). Economic causes and consequences of obesity. *Annu Rev Public Health, 26*, 239-257.

Flack, J. M., Neaton, J., Grimm, R., Jr., Shih, J., Cutler, J., Ensrud, K., et al. (1995). Blood pressure and mortality among men with prior myocardial infarction. Multiple Risk Factor Intervention Trial Research Group. *Circulation, 92*(9), 2437-2445.

Flegal, K. M., Carroll, M. D., Ogden, C. L., & Johnson, C. L. (2002). Prevalence and trends in obesity among US adults, 1999-2000. *Jama, 288*(14), 1723-1727.

Fleiss, J. L. (1971). Measuring nominal scale agreement among many raters. *Psychological Bulletin, 76*(5), 378-382.

Fleiss, J. L. (1981). *Statistical methods for rates and proportions* (2nd ed.). New York: John Wiley & Sons, Inc.

Ford, E. S., & Giles, W. H. (2003). A comparison of the prevalence of the metabolic syndrome using two proposed definitions. *Diabetes Care, 26*(3), 575-581.

Ford, E. S., Giles, W. H., & Dietz, W. H. (2002). Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. *Jama, 287*(3), 356-359.

Framingham Heart Study. (2008). History of the Framingham Heart Study. Retrieved March 5, 2008, from http://www.framinghamheartstudy.org/about/index.html

Franco, O. H., Peeters, A., Bonneux, L., & de Laet, C. (2005). Blood pressure in adulthood and life expectancy with cardiovascular disease in men and women: life course analysis. *Hypertension, 46*(2), 280-286.

Frank, L. D., Schmid, T. L., Sallis, J. F., Chapman, J., & Saelens, B. E. (2005). Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. *Am J Prev Med, 28*(2 Suppl 2), 117-125.

Franklin, S. S., Gustin, W. 4th, Wong, N.D., Larson, M.G., Weber, M.A., Kannel, W.B., & Levy, D. (1997). Hemodynamic patterns of age-related changes in blood pressure. The Framingham Heart Study. *Circulation, 96*(1), 308-315.

Franklin, S. S., Larson, M. G., Khan, S. A., Wong, N. D., Leip, E. P., Kannel, W. B., et al. (2001). Does the relation of blood pressure to coronary heart disease risk change with aging? The Framingham Heart Study. *Circulation, 103*(9), 1245-1249.

Freeman, H. L. (1984). Housing. In H. L. Freeman (Ed.), *Mental health and the environment* (pp. 197-225). London, England: Churchill Livingstone.

Fullilove, M. T. (1998). Promoting social cohesion to improve health. *J Am Med Womens Assoc, 53*(2), 72-76.

Fullilove, M. T., & Fullilove, R. E., 3rd. (2000). What's housing got to do with it? *Am J Public Health, 90*(2), 183-184.

Gaillard, T. R., Schuster, D. P., Bossetti, B. M., Green, P. A., & Osei, K. (1997). Do sociodemographics and economic status predict risks for type II diabetes in African Americans? *Diabetes Educ, 23*(3), 294-300.

Galea, S., Ahern, J., Rudenstine, S., Wallace, Z., & Vlahov, D. (2005). Urban built environment and depression: a multilevel analysis. *J Epidemiol Community Health, 59*(10), 822-827.

Garmin. (2008). What is GPS? Retrieved July 1, 2008, from http://www8.garmin.com/aboutGPS/

Gaziano, T., Reddy, K. S., Paccaud, F., Horton, S., & Chaturvedi, V. (2006). Cardiovascular disease. In D. T. Jamison, J. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills & P. Musgrove (Eds.), *Disease control priorities in developing countries* (2nd ed., pp. 645-662). Washington, DC & New York, NY: The World Bank & Oxford University Press.

Geiss, L. S., Herman, W. H., & Smith, P. J. (1995). Mortality in non-insulin dependent diabetes. In N. D. D. Group (Ed.), *Diabetes in America* (2nd ed., pp. 233-257). Bethesda, MD: National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health.

Genuth, S. (2003). Lowering the criterion for impaired fasting glucose is in order. *Diabetes Care, 26*(12), 3331-3332.

Genuth, S., Alberti, K. G., Bennett, P., Buse, J., Defronzo, R., Kahn, R., et al. (2003). Follow-up report on the diagnosis of diabetes mellitus. *Diabetes Care, 26*(11), 3160-3167.

Geographical variation in the major risk factors of coronary heart disease in men and women aged 35-64 years. The WHO MONICA Project. (1988). *World Health Stat Q, 41*(3-4), 115-140.

Gifford, R. ((n.d.)). Satisfaction, health, security, and social relationships in high-rise buildings. In A. Seidel & T. Heath (Eds.), *Social effects of the built environment*. London, England: E & FN Spon.

Giles-Corti, B., & Donovan, R. J. (2002a). The relative influence of individual, social and physical environment determinants of physical activity. *Soc Sci Med, 54*(12), 1793-1812.

Giles-Corti, B., & Donovan, R. J. (2002b). Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Prev Med, 35*(6), 601-611.

Giles-Corti, B., Macintyre, S., Clarkson, J. P., Pikora, T., & Donovan, R. J. (2003). Environmental and lifestyle factors associated with overweight and obesity in Perth, Australia. *Am J Health Promot, 18*(1), 93-102.

Gillum, R. F., Mussolino, M. E., & Madans, J. H. (1998). Coronary heart disease risk factors and attributable risks in African-American women and men: NHANES I epidemiologic follow-up study. *Am J Public Health, 88*(6), 913-917.

Goldstein, L. B., Adams, R., Becker, K., Furberg, C. D., Gorelick, P. B., Hademenos, G., et al. (2001). Primary prevention of ischemic stroke: A statement for healthcare professionals from the Stroke Council of the American Heart Association. *Circulation, 103*(1), 163-182.

Golledge, R. G., & Stimson, R. J. (1997). *Spatial behavior: A geographic perspective*. New York: Guilford Press.

Goran, M. I., & Treuth, M. S. (2001). Energy expenditure, physical activity, and obesity in children. *Pediatr Clin North Am, 48*(4), 931-953.

Gove, W. R., & Hughes, M. (1983). *Overcrowding in the household: An analysis of determinants and effects*. New York: Academic Press

Griffin, S. F., Wilson, D. K., Wilcox, S., Buck, J., & Ainsworth, B. E. (2008). Physical activity influences in a disadvantaged African American community and the communities' proposed solutions. *Health Promot Pract, 9*(2), 180-190.

Groop, L., Forsblom, C., Lehtovirta, M., Tuomi, T., Karanko, S., Nissen, M., et al. (1996). Metabolic consequences of a family history of NIDDM (the Botnia study): evidence for sex-specific parental effects. *Diabetes, 45*(11), 1585-1593.

Grundy, S. M., Brewer, H. B., Jr., Cleeman, J. I., Smith, S. C., Jr., & Lenfant, C. (2004). Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation, 109*(3), 433-438.

Guite, H. F., Clark, C., & Ackrill, G. (2006). The impact of the physical and urban environment on mental well-being. *Public Health, 120*(12), 1117-1126.

Haines, M. M., Stansfeld, S. A., Brentnall, S., Head, J., Berry, B., Jiggins, M., et al. (2001). The West London Schools Study: the effects of chronic aircraft noise exposure on child health. *Psychol Med, 31*(8), 1385-1396.

Haines, M. M., Stansfeld, S. A., Job, R. F., Berglund, B., & Head, J. (2001a). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychol Med, 31*(2), 265-277.

Haines, M. M., Stansfeld, S. A., Job, R. F., Berglund, B., & Head, J. (2001b). A follow-up study of effects of chronic aircraft noise exposure on child stress responses and cognition. *Int J Epidemiol, 30*(4), 839-845.

Hajjar, I., & Kotchen, T. A. (2003). Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988-2000. *Jama, 290*(2), 199-206.

Han, T. S., McNeill, G., Seidell, J. C., & Lean, M. E. (1997). Predicting intra-abdominal fatness from anthropometric measures: the influence of stature. *Int J Obes Relat Metab Disord, 21*(7), 587-593.

Han, T. S., van Leer, E. M., Seidell, J. C., & Lean, M. E. (1995). Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. *Bmj, 311*(7017), 1401-1405.

Hansen, W. G. (1959). How accessibility shapes land use. *J Am Inst Planners 15*, 73-76.

Harris, M. I., Eastman, R. C., Cowie, C. C., Flegal, K. M., & Eberhardt, M. S. (1999). Racial and ethnic differences in glycemic control of adults with type 2 diabetes. *Diabetes Care, 22*(3), 403-408.

Hazlett, B. E. (2000). Historical perspective: The discovery of insulin. In J. K. Davidson (Ed.), *Clinical diabetes mellitus : A problem-oriented approach* (pp. 3-11). New York: Thieme.

HealthGoods. (2007). Patterns and trends in physical activity -- physical activity and health: a report of the Surgeon General. Retrieved November 6, 2008, from https://www.healthgoods.com/Education/Fitness_Information/Physical_Activity_and_Your_Health/patterns_and_trends.htm

Hertz, R. P., Unger, A. N., Cornell, J. A., & Saunders, E. (2005). Racial disparities in hypertension prevalence, awareness, and management. *Arch Intern Med, 165*(18), 2098-2104.

Ho, S. C., Chen, Y. M., Woo, J. L., Leung, S. S., Lam, T. H., & Janus, E. D. (2001). Association between simple anthropometric indices and cardiovascular risk factors. *Int J Obes Relat Metab Disord, 25*(11), 1689-1697.

Hodgson, M. (2002). Indoor Environmental Exposures and Symptoms. *Environmental Health Perspectives, 110*, 663-667.

Hooker, S. P., Wilson, D. K., Griffin, S. F., & Ainsworth, B. E. (2005). Perceptions of environmental supports for physical activity in African American and white adults in a rural county in South Carolina. *Prev Chronic Dis, 2*(4), A11.

Humpel, N., Marshall, A. L., Leslie, E., Bauman, A., & Owen, N. (2004). Changes in neighborhood walking are related to changes in perceptions of environmental attributes. *Ann Behav Med, 27*(1), 60-67.

Humpel, N., Owen, N., Iverson, D., Leslie, E., & Bauman, A. (2004). Perceived environment attributes, residential location, and walking for particular purposes. *Am J Prev Med, 26*(2), 119-125.

Humpel, N., Owen, N., & Leslie, E. (2002). Environmental factors associated with adults' participation in physical activity: a review. *Am J Prev Med, 22*(3), 188-199.

Humpel, N., Owen, N., Leslie, E., Marshall, A. L., Bauman, A. E., & Sallis, J. F. (2004). Associations of location and perceived environmental attributes with walking in neighborhoods. *Am J Health Promot, 18*(3), 239-242.

International Diabetes Federation. (2005). Diabetes atlas. Retrieved March 18, 2009, from http://www.eatlas.idf.org/

Irwin, M. L., Mayer-Davis, E. J., Addy, C. L., Pate, R. R., Durstine, J. L., Stolarczyk, L. M., et al. (2000). Moderate-intensity physical activity and fasting insulin levels in women: the Cross-Cultural Activity Participation Study. *Diabetes Care, 23*(4), 449-454.

Isomaa, B., Almgren, P., Tuomi, T., Forsén, B., Lahti, K., Nissén, M., Taskinen, M.R., and Groop, L. . (2001). Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care, 24*, 683-689.

Jackson, R. J. (2003). The impact of the built environment on health: an emerging field. *Am J Public Health, 93*(9), 1382-1384.

Jackson, R. J., & Kochtitzky, C. (2003). Creating a healthy environment: the impact of the built environment on public health. [Electronic Version]. *Sprawl Watch Clearinghouse Monograph Series.* Retrieved July 7, 2003, from http://www.sprawlwatch.org/health.pdf;2003.

Jacobs, D. R. J., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Med Sci Sports Exerc, 25*(1), 81-91.

James, W. P. T. (1996). The epidemiology of obesity. In D. H. J. Chadwick & G. C. Cardew (Eds.), *The origins and consequences of obesity*. New York: Wiley.

Jones, D. W., Sempos, C. T., Thom, T. J., Harrington, A. M., Taylor, H. A., Jr., Fletcher, B. W., et al. (2000). Rising levels of cardiovascular mortality in Mississippi, 1979-1995. *Am J Med Sci, 319*(3), 131-137.

Kaiser Family Foundation. (2002). *Racial/ethnic differences in cardiac care: The weight of the evidence*. Menlo Park, CA: Kaiser Family Foundation.

Kaplan, N. M. (1989). The deadly quartet. Upper-body obesity, glucose intolerance, hypertriglyceridemia, and hypertension. *Arch Intern Med, 149*(7), 1514-1520.

Kawachi, I. (1999). Social capital and community effects on population and individual health. *Ann N Y Acad Sci, 896*, 120-130.

Kearney, P. M., Whelton, M., Reynolds, K., Whelton, P. K., & He, J. (2004). Worldwide prevalence of hypertension: a systematic review. *J Hypertens, 22*(1), 11-19.

Kelley, G. A., Kelley, K. S., & Franklin, B. (2006). Aerobic exercise and lipids and lipoproteins in patients with cardiovascular disease: a meta-analysis of randomized controlled trials. *J Cardiopulm Rehabil, 26*(3), 131-139; quiz 140-131, discussion 142-134.

Kelley, G. A., Kelley, K. S., & Tran, Z. V. (2004). Walking, lipids, and lipoproteins: a meta-analysis of randomized controlled trials. *Prev Med, 38*(5), 651-661.

King, A. C., Castro, C., Wilcox, S., Eyler, A. A., Sallis, J. F., & Brownson, R. C. (2000). Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychol, 19*(4), 354-364.

King, A. C., Jeffery, R. W., Fridinger, F., Dusenbury, L., Provence, S., Hedlund, S. A., et al. (1995). Environmental and policy approaches to cardiovascular disease prevention through physical activity: issues and opportunities. *Health Educ Q, 22*(4), 499-511.

King, W. C., Belle, S. H., Brach, J. S., Simkin-Silverman, L. R., Soska, T., & Kriska, A. M. (2005). Objective measures of neighborhood environment and physical activity in older women. *Am J Prev Med, 28*(5), 461-469.

King, W. C., Brach, J. S., Belle, S., Killingsworth, R., Fenton, M., & Kriska, A. M. (2003). The relationship between convenience of destinations and walking levels in older women. *Am J Health Promot, 18*(1), 74-82.

Kip, K. E. (2006). Research plan. Unpublished Grant Proposal. University of Pittsburgh.

Kip, K. E., Marroquin, O. C., Mulukutla, S., Aiyer, A., Brown, V. L., Peters, R. E., et al. (2005). Racial disparities in cardiovascular risk: Initial description of the Heart Strategies Concentrating On Risk Evaluation (Heart SCORE) Study. University of Pittsburgh.

Kirtland, K. A., Porter, D. E., Addy, C. L., Neet, M. J., Williams, J. E., Sharpe, P. A., et al. (2003). Environmental measures of physical activity supports: perception versus reality. *Am J Prev Med, 24*(4), 323-331.

Kjaergaard, S. C., Hansen, H. H., Fog, L., Bulow, I., & Christensen, P. D. (1999). In-hospital outcome for diabetic patients with acute myocardial infarction in the thrombolytic era. *Scand Cardiovasc J, 33*(3), 166-170.

Kleinman, J. C., Donahue, R. P., Harris, M. I., Finucane, F. F., Madans, J. H., & Brock, D. B. (1988). Mortality among diabetics in a national sample. *Am J Epidemiol, 128*(2), 389-401.

Kostis, J. B., Davis, B. R., Cutler, J., Grimm, R. H., Jr., Berge, K. G., Cohen, J. D., et al. (1997). Prevention of heart failure by antihypertensive drug treatment in older persons with isolated systolic hypertension. SHEP Cooperative Research Group. *Jama, 278*(3), 212-216.

Kraemer, H. C., Stice, E., Kazdin, A., Offord, D., & Kupfer, D. (2001). How do risk factors work together? Mediators, moderators, and independent, overlapping, and proxy risk factors. *Am J Psychiatry, 158*(6), 848-856.

Kramer, H., Han, C., Post, W., Goff, D., Diez-Roux, A., Cooper, R., et al. (2004). Racial/ethnic differences in hypertension and hypertension treatment and control in the multi-ethnic study of atherosclerosis (MESA). *Am J Hypertens, 17*(10), 963-970.

Kuo, F. E., & Sullivan, W. C. (2001). Environment and Crime in the Inner City: Does Vegetation Reduce Crime? *Environment and Behavior, 33*(3), 343-367.

Kylin, E. (1923). Studien ueber das Hypertonie-Hyperglyka "mie-Hyperurika" miesyndrom. *Zentralblatt fuer Innere Medizin, 44*, 105-127.

Labarthe, D. R. (1998). *Epidemiology and prevention of cardiovascular diseases: a global challenge*. Gaithersburg, MD: Aspen Publishers, Inc.

Lake, A., & Townshend, T. (2006). Obesogenic environments: exploring the built and food environments. *J R Soc Health, 126*(6), 262-267.

Lakka, H. M., Laaksonen, D. E., Lakka, T. A., Niskanen, L. K., Kumpusalo, E., Tuomilehto, J., et al. (2002). The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *Jama, 288*(21), 2709-2716.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159-174.

Leaderer, B. P., Belanger, K., Triche, E., Holford, T., Gold, D. R., Kim, Y., et al. (2002). Dust mite, cockroach, cat, and dog allergen concentrations in homes of asthmatic children in the northeastern United States: impact of socioeconomic factors and population density. *Environ Health Perspect, 110*(4), 419-425.

Lean, M. E., Han, T. S., & Morrison, C. E. (1995). Waist circumference as a measure for indicating need for weight management. *Bmj, 311*(6998), 158-161.

Lemieux, S., Prud'homme, D., Bouchard, C., Tremblay, A., & Despres, J. P. (1996). A single threshold value of waist girth identifies normal-weight and overweight subjects with excess visceral adipose tissue. *Am J Clin Nutr, 64*(5), 685-693.

Lepore, S. J., Evans, G. W., & Schneider, M. L. (1991). Dynamic role of social support in the link between chronic stress and psychological distress. *J Pers Soc Psychol, 61*(6), 899-909.

Lercher, P., Evans, G. W., Meis, M., & Kofler, W. W. (2002). Ambient neighbourhood noise and children's mental health. *Occup Environ Med, 59*(6), 380-386.

Levy, D., Larson, M. G., Vasan, R. S., Kannel, W. B., & Ho, K. K. (1996). The progression from hypertension to congestive heart failure. *JAMA, 275*(20), 1557-1562.

Lewington, S., Clarke, R., Qizilbash, N., Peto, R., & Collins, R. (2002). Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet, 360*(9349), 1903-1913.

Li, F., Harmer, P., Cardinal, B. J., Bosworth, M., Johnson-Shelton, D., Moore, J. M., et al. (2009). Built environment and 1-year change in weight and waist circumference in middle-aged and older adults: Portland Neighborhood Environment and Health Study. *Am J Epidemiol, 169*(4), 401-408.

Li, F., Harmer, P. A., Cardinal, B. J., Bosworth, M., Acock, A., Johnson-Shelton, D., et al. (2008). Built environment, adiposity, and physical activity in adults aged 50-75. *Am J Prev Med, 35*(1), 38-46.

Liese, A. D., Mayer-Davis, E. J., & Haffner, S. M. (1998). Development of the multiple metabolic syndrome: an epidemiologic perspective. *Epidemiol Rev, 20*(2), 157-172.

Litaker, D., & Koroukian, S. M. (2004). Racial differences in lipid-lowering agent use in medicaid patients with cardiovascular disease. *Med Care, 42*(10), 1009-1018.

London Department of Health. (2004). *At least five a week: Evidence on the impact of physical activity and its relationship to health. A report from the chief medical officer.* London: The Department of Health.

Luepker, R. V., Arnett, D. K., Jacobs, D. R., Jr., Duval, S. J., Folsom, A. R., Armstrong, C., et al. (2006). Trends in blood pressure, hypertension control, and stroke mortality: the Minnesota Heart Survey. *Am J Med, 119*(1), 42-49.

Mair, C., Diez Roux, A. V., & Galea, S. (2008). Are neighbourhood characteristics associated with depressive symptoms? A review of evidence. *J Epidemiol Community Health, 62*(11), 940-946, 948 p following 946.

Malecki, M. T. (2005). Genetics of type 2 diabetes mellitus. *Diabetes Res Clin Pract, 68 Suppl1*, S10-21.

Malecki, M. T., & Klupa, T. (2005). Type 2 diabetes mellitus: from genes to disease. *Pharmacol Rep, 57 Suppl*, 20-32.

Mayer-Davis, E. J., Vitolins, M. Z., Carmichael, S. L., Hemphill, S., Tsaroucha, G., Rushing, J., et al. (1999). Validity and reproducibility of a food frequency interview in a Multi-Cultural Epidemiology Study. *Ann Epidemiol, 9*(5), 314-324.

McColl, S. L., & Veitch, J. A. (2001). Full-spectrum fluorescent lighting: a review of its effects on physiology and health. *Psychol Med, 31*(6), 949-964.

McCullough, M. L., Feskanich, D., Stampfer, M. J., Giovannucci, E. L., Rimm, E. B., Hu, F. B., et al. (2002). Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. *Am J Clin Nutr, 76*(6), 1261-1271.

McCullough, M. L., & Willett, W. C. (2006). Evaluating adherence to recommended diets in adults: the Alternate Healthy Eating Index. *Public Health Nutr, 9*(1A), 152-157.

McGinn, A. P., Evenson, K. R., Herring, A. H., Huston, S. L., & Rodriguez, D. A. (2007). Exploring Associations between Physical Activity and Perceived and Objective Measures of the Built Environment. *J Urban Health, 84*(2), 162-184.

McGovern, P. G., Pankow, J. S., Shahar, E., Doliszny, K. M., Folsom, A. R., Blackburn, H., et al. (1996). Recent trends in acute coronary heart disease--mortality, morbidity, medical care, and risk factors. The Minnesota Heart Survey Investigators. *N Engl J Med, 334*(14), 884-890.

McKinlay, J., & Marceau, L. (2000). US public health and the 21st century: diabetes mellitus. *Lancet, 356*(9231), 757-761.

McTigue, K. M., Garrett, J. M., & Popkin, B. M. (2002). The natural history of the development of obesity in a cohort of young U.S. adults between 1981 and 1998. *Ann Intern Med, 136*(12), 857-864.

Meigs, J. B. (2000). Invited commentary: insulin resistance syndrome? Syndrome X? Multiple metabolic syndrome? A syndrome at all? Factor analysis reveals patterns in the fabric of correlated metabolic risk factors. *Am J Epidemiol, 152*(10), 908-911; discussion 912.

Meigs, J. B. (2002). Epidemiology of the metabolic syndrome, 2002. *Am J Manag Care, 8*(11 Suppl), S283-292; quiz S293-286.

Melanson, K. J., McInnis, K. J., Rippe, J. M., Blackburn, G., & Wilson, P. F. (2001). Obesity and cardiovascular disease risk: research update. *Cardiol Rev, 9*(4), 202-207.

Mensah, G. A. (2005). Eliminating disparities in cardiovascular health: six strategic imperatives and a framework for action. *Circulation, 111*(10), 1332-1336.

Mensah, G. A., Mokdad, A. H., Ford, E. S., Greenlund, K. J., & Croft, J. B. (2005). State of disparities in cardiovascular health in the United States. *Circulation, 111*(10), 1233-1241.

Mesch, G. S., & Manor, O. (1998). Social ties, environmental perception, and local attachment. *Environment and Behavior, 30*(4), 504-519.

Miser, W. F. (2007). The management of type 2 diabetes mellitus focus on quality. *Prim Care, 34*(1), 1-38.

Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinicor, F., Bales, V. S., et al. (2003). Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *Jama, 289*(1), 76-79.

Moss, S. E., Klein, R., & Klein, B. E. (1991). Cause-specific mortality in a population-based study of diabetes. *Am J Public Health, 81*(9), 1158-1162.

Mujahid, M. S., Diez Roux, A. V., Morenoff, J. D., & Raghunathan, T. (2007). Assessing the measurement properties of neighborhood scales: from psychometrics to ecometrics. *Am J Epidemiol, 165*(8), 858-867.

Mujahid, M. S., Diez Roux, A. V., Shen, M., Gowda, D., Sanchez, B., Shea, S., et al. (2008). Relation between neighborhood environments and obesity in the Multi-Ethnic Study of Atherosclerosis. *Am J Epidemiol, 167*(11), 1349-1357.

Murray, C. J., & Lopez, A. D. (1994). *Global comparative assessments in the health sector: Disease burden, expenditures, and intervention packages*. Geneva, Switzerland: World Health Organization.

National Aeronautics and Space Administration. (2008). Global positioning system (GPS). Retrieved July 1, 2008, from http://leonardo.jpl.nasa.gov/msl/Programs/gps.html

National Center for Health Statistics. (2007). Health, United States, 2007: With chartbook on trends in the health of Americans. Retrieved June 18, 2008, from http://www.cdc.gov/nchs/data/hus/hus07.pdf

National Center for Health Statistics. (2008). National Health Interview Survey (NHIS) description. Retrieved October 1, 2008, from http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm

National Cholesterol Education Program. Second Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel II). (1994). *Circulation, 89*(3), 1333-1445.

National Heart, L., and Blood Institute & National Institute of Diabetes and Digestive and Kidney Diseases,. (1998). *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report* (No. 98-4083). Bethesda, MD. (N. H. National Institutes of Health, Lung, and Blood Institute o. Document Number)

National Heart, L., and Blood Institute & National Institute of Diabetes and Digestive and Kidney Diseases,. (2010). Disease statistics: Prevalence of common cardiovascular and lung diseases by age, U.S., 2006. Retrieved June 4, 2010, from http://www.nhlbi.nih.gov/about/factbook/chapter4.htm#4_5

National Institute of Diabetes and Digestive and Kidney Diseases. (2008). National diabetes statistics, 2007. Retrieved January 21, 2009, from http://diabetes.niddk.nih.gov/dm/pubs/statistics/

National Institutes of Health. (2004). NIH Guide: Obesity and the built environment. RFA-ES-04-003. Bethesda, MD: Department of Health and Human Services (DHHS).

Nelson, D. E., Holtzman, D., Waller, M., Leutzinger, C. L., & Condon, K. (1998). Objectives and design of the Behavioral Risk Factor Surveillance System. In *Proceedings of the* *section on survey methods, American Statistical Association National Meeting*. Dallas, TX.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Obesity: preventing and managing the global epidemic. Report of a WHO consultation. (2000). *World Health Organ Tech Rep Ser, 894*, i-xii, 1-253.

Ochi, J. W., Melton, L. J., 3rd, Palumbo, P. J., & Chu, C. P. (1985). A population-based study of diabetes mortality. *Diabetes Care, 8*(3), 224-229.

Ogden, C. L., Carroll, M. D., Curtin, L. R., McDowell, M. A., Tabak, C. J., & Flegal, K. M. (2006). Prevalence of overweight and obesity in the United States, 1999-2004. *Jama, 295*(13), 1549-1555.

Ogden, C. L., Yanovski, S. Z., Carroll, M. D., & Flegal, K. M. (2007). The epidemiology of obesity. *Gastroenterology, 132*(6), 2087-2102.

Oguma, Y., & Shinoda-Tagawa, T. (2004). Physical activity decreases cardiovascular disease risk in women: review and meta-analysis. *Am J Prev Med, 26*(5), 407-418.

Ong, K. L., Cheung, B. M., Man, Y. B., Lau, C. P., & Lam, K. S. (2007). Prevalence, awareness, treatment, and control of hypertension among United States adults 1999-2004. *Hypertension, 49*(1), 69-75.

Ostchega, Y., Dillon, C. F., Hughes, J. P., Carroll, M., & Yoon, S. (2007). Trends in hypertension prevalence, awareness, treatment, and control in older U.S. adults: data from the National Health and Nutrition Examination Survey 1988 to 2004. *J Am Geriatr Soc, 55*(7), 1056-1065.

Overweight and obesity threaten US health gains; communities can help address the problem, Surgeon General says [press release]. (2001). Washington, DC: US Dept of Health and Human Services.

Owen, N., Humpel, N., Leslie, E., Bauman, A., & Sallis, J. F. (2004). Understanding environmental influences on walking; Review and research agenda. *Am J Prev Med, 27*(1), 67-76.

Paeratakul, S., Lovejoy, J. C., Ryan, D. H., & Bray, G. A. (2002). The relation of gender, race and socioeconomic status to obesity and obesity comorbidities in a sample of US adults. *Int J Obes Relat Metab Disord, 26*(9), 1205-1210.

Park, Y. W., Zhu, S., Palaniappan, L., Heshka, S., Carnethon, M. R., & Heymsfield, S. B. (2003). The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. *Arch Intern Med, 163*(4), 427-436.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Jama, 273*(5), 402-407.

Patel, A., Barzi, F., Jamrozik, K., Lam, T. H., Ueshima, H., Whitlock, G., et al. (2004). Serum triglycerides as a risk factor for cardiovascular diseases in the Asia-Pacific region. *Circulation, 110*(17), 2678-2686.

Paulus, P. B. (1988). *Prison crowding: A psychological perspective*. New York: Springer.

Pedersen, D. M. (1977). Effects of size of home town on environmental perception. *Percept Mot Skills, 45*(3 Pt 1), 955-966.

Perdue, W. C., Stone, L. A., & Gostin, L. O. (2003). The built environment and its relationship to the public's health: the legal framework. *Am J Public Health, 93*(9), 1390-1394.

Pettee, K. K., Ham, S. A., Macera, C. A., & Ainsworth, B. E. (2009). The reliability of a survey question on television viewing and associations with health risk factors in US adults. *Obesity (Silver Spring), 17*(3), 487-493.

Pietilainen, K. H., Kaprio, J., Borg, P., Plasqui, G., Yki-Jarvinen, H., Kujala, U. M., et al. (2008). Physical inactivity and obesity: a vicious circle. *Obesity (Silver Spring), 16*(2), 409-414.

Pikora, T., Giles-Corti, B., Bull, F., Jamrozik, K., & Donovan, R. (2003). Developing a framework for assessment of the environmental determinants of walking and cycling. *Soc Sci Med, 56*(8), 1693-1703.

Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94. Series 1: programs and collection procedures. (1994). *Vital Health Stat 1*(32), 1-407.

Poirier, P., & Eckel, R. H. (2000). The heart and obesity. In V. Fuster, Alexander, R.W., King, S., O'Rourke, R.A., Roberts, R., Wellens, H.J.J. (Ed.), *Hurst's The Heart* (pp. 2289-2303). New York: McGraw-Hill Companies.

Poirier, P., & Eckel, R. H. (2002). Obesity and cardiovascular disease. *Curr Atheroscler Rep, 4*(6), 448-453.

Poirier, P., Giles, T. D., Bray, G. A., Hong, Y., Stern, J. S., Pi-Sunyer, F. X., et al. (2006). Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association Scientific Statement on Obesity and Heart Disease from the Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. *Circulation, 113*(6), 898-918.

Poortinga, W. (2006). Perceptions of the environment, physical activity, and obesity. *Soc Sci Med, 63*(11), 2835-2846.

Porter, D. E., Kirtland, K. A., Neet, M. J., Williams, J. E., & Ainsworth, B. E. (2004). Considerations for using a geographic information system to assess environmental supports for physical activity. *Prev Chronic Dis, 1*(4), A20.

Pouliot, M. C., Despres, J. P., Lemieux, S., Moorjani, S., Bouchard, C., Tremblay, A., et al. (1994). Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *Am J Cardiol, 73*(7), 460-468.

Pratt, M., Macera, C. A., & Blanton, C. (1999). Levels of physical activity and inactivity in children and adults in the United States: current evidence and research issues. *Med Sci Sports Exerc, 31*(11 Suppl), S526-533.

Presser, S., & Stinson, L. (1998). Data collection mode and social desirability bias in self-reported religious attendance *American Sociological Review, 63*(1), 137-145

Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension. Final results of the Systolic Hypertension in the Elderly Program (SHEP). SHEP Cooperative Research Group. (1991). *JAMA, 265*(24), 3255-3264.

Reaven, G. M. (1988). Banting lecture 1988. Role of insulin resistance in human disease. *Diabetes, 37*(12), 1595-1607.

Reaven, G. M. (2004). Insulin resistance, cardiovascular disease, and the metabolic syndrome: how well do the emperor's clothes fit? *Diabetes Care, 27*(4), 1011-1012.

Reis, S. E., Edmundowicz, D., Kuller, K., Thomas, S., Kip, K. E., Peters, R. E., et al. (2003). Heart Strategies Concentrating on Risk Evaluation (Heart SCORE) Study (pp. 135). University of Pittsburgh.

Remington, P. L., Smith, M. Y., Williamson, D. F., Anda, R. F., Gentry, E. M., & Hogelin, G. C. (1988). Design, characteristics, and usefulness of state-based behavioral risk factor surveillance: 1981-87. *Public Health Rep, 103*(4), 366-375.

Rizzo, M., & Berneis, K. (2006). Low-density lipoprotein size and cardiovascular risk assessment. *Qjm, 99*(1), 1-14.

Rosenthal, N. E., Sack, D. A., Gillin, J. C., Lewy, A. J., Goodwin, F. K., Davenport, Y., et al. (1984). Seasonal affective disorder: A description of the syndrome and preliminary findings with light therapy. *Arch Gen Psychiatry, 41*(1), 72-80.

Ross, R., Leger, L., Morris, D., de Guise, J., & Guardo, R. (1992). Quantification of adipose tissue by MRI: relationship with anthropometric variables. *J Appl Physiol, 72*(2), 787-795.

Rotton, J. (1983). Affective and cognitive consequences of malodorous pollution. *Basic and Applied Social Psychology, 4*(2), 171 - 191.

Rotton, J., & Cohn, E. G. (2002). Climate, weather, and crime. In R. B. Bechtel & A. Churchman (Eds.), *Handbook of environmental psychology* (2nd ed., pp. 481-498). New York: J. Wiley & Sons.

Rucker, I., C.E.,, & Cash, T. F. (1992). Body images, body-size perceptions, and eating behaviors among African-American and white college women. *International Journal of Eating Disorders, 12*(3), 291-299.

Rutt, C. D., & Coleman, K. J. (2005). Examining the relationships among built environment, physical activity, and body mass index in El Paso, TX. *Prev Med, 40*(6), 831-841.

Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health, 93*(9), 1552-1558.

Saelens, B. E., Sallis, J. F., & Frank, L. D. (2003). Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med, 25*(2), 80-91.

Sallis, J. F., Johnson, M. F., Calfas, K. J., Caparosa, S., & Nichols, J. F. (1997). Assessing perceived physical environmental variables that may influence physical activity. *Res Q Exerc Sport, 68*(4), 345-351.

Sallis, J. F., & Owen, N. (1997). Ecological Models. In F. M. Lewis & B. K. Rimer (Eds.), *Health Behavior and Health Education: Theory, Research, and Practice* (2nd ed., pp. 403-424). San Francisco: Jossey-Bass.

Sampson, R. J., Raudenbush, S. W., & Earls, F. (1997). Neighborhoods and Violent Crime: A Multilevel Study of Collective Efficacy. *Science, 277*(5328), 918-924.

Sanderson, B., Littleton, M., & Pulley, L. (2002). Environmental, policy, and cultural factors related to physical activity among rural, African American women. *Women Health, 36*(2), 75-90.

Schoenborn C.A. & Barnes, P. M. (2002). *Leisure-time physical activity among adults: United States, 1997-1998*. Hyattsville, MD: National Center for Health Statistics.

Smith, D. (2006). Encyclopedia of public health -- blood lipids. Retrieved July 1, 2008, from http://www.enotes.com/public-health-encyclopedia/blood-lipids

Southern California Integrated GPS Network. (1998). What is GPS? Retrieved July 1, 2008, from http://scign.jpl.nasa.gov/learn/gps1.htm

Sowers, J. R. (2003). Obesity as a cardiovascular risk factor. *Am J Med, 115*(8A), 37S-41S.

Sowers, J. R., Epstein, M., & Frohlich, E. D. (2001). Diabetes, hypertension, and cardiovascular disease: an update. *Hypertension, 37*(4), 1053-1059.

Sowers, J. R., Ferdinand, K. C., Bakris, G. L., & Douglas, J. G. (2002). Hypertension-related disease in African Americans. Factors underlying disparities in illness and its outcome. *Postgrad Med, 112*(4), 24-26, 29-30, 33-24 passim.

Srinivasan, S., O'Fallon, L. R., & Dearry, A. (2003). Creating healthy communities, healthy homes, healthy people: initiating a research agenda on the built environment and public health. *Am J Public Health, 93*(9), 1446-1450.

St. John, C. (1987). Racial differences in neighborhood evaluation standards. *Urban Affairs Quarterly, 22*(3), 377-398.

St. John, C., & Bates, N. A. (1990). Racial composition and neighborhood evaluation. *Soc Sci Res, 19*(1), 47-61.

St. John, C., & Cosby, V. (1995). Life cycle differences in neighborhood satisfaction. *Soc Spectrum, 15*(2), 147-160.

Staessen, J. A., Thijs, L., Fagard, R., O'Brien, E. T., Clement, D., de Leeuw, P. W., et al. (1999). Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. *Jama, 282*(6), 539-546.

Stahl, T., Rutten, A., Nutbeam, D., Bauman, A., Kannas, L., Abel, T., et al. (2001). The importance of the social environment for physically active lifestyle--results from an international study. *Soc Sci Med, 52*(1), 1-10.

Stamler, J., Stamler, R., & Neaton, J. D. (1993). Blood pressure, systolic and diastolic, and cardiovascular risks. US population data. *Arch Intern Med, 153*(5), 598-615.

Stamler, J., Stamler, R., Neaton, J. D., Wentworth, D., Daviglus, M. L., Garside, D., et al. (1999). Low risk-factor profile and long-term cardiovascular and noncardiovascular mortality and life expectancy: findings for 5 large cohorts of young adult and middle-aged men and women. *Jama, 282*(21), 2012-2018.

State-specific cholesterol screening trends--United States, 1991-1999. (2000). *MMWR Morb Mortal Wkly Rep, 49*(33), 750-755.

Sturm, R. (2004). The economics of physical activity: societal trends and rationales for interventions. *Am J Prev Med, 27*(3 Suppl), 126-135.

Sturm, R. (2007). Increases in morbid obesity in the USA: 2000-2005. *Public Health, 121*(7), 492-496.

Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? *J Epidemiol Community Health, 62*(5), e9.

Suminski, R. R., Poston, W. S., Petosa, R. L., Stevens, E., & Katzenmoyer, L. M. (2005). Features of the neighborhood environment and walking by U.S. adults. *Am J Prev Med, 28*(2), 149-155.

Sundquist, J., Winkleby, M. A., & Pudaric, S. (2001). Cardiovascular disease risk factors among older black, Mexican-American, and white women and men: an analysis of NHANES III, 1988-1994. Third National Health and Nutrition Examination Survey. *J Am Geriatr Soc, 49*(2), 109-116.

Swinburn, B., & Egger, G. (2002). Preventive strategies against weight gain and obesity. *Obes Rev, 3*(4), 289-301.

Tan, C. E., Ma, S., Wai, D., Chew, S. K., & Tai, E. S. (2004). Can we apply the National Cholesterol Education Program Adult Treatment Panel definition of the metabolic syndrome to Asians? *Diabetes Care, 27*(5), 1182-1186.

Taylor, H. L., Jacobs, D. R., Jr., Schucker, B., Knudsen, J., Leon, A. S., & Debacker, G. (1978). A questionnaire for the assessment of leisure time physical activities. *J Chronic Dis, 31*(12), 741-755.

Taylor, R. B., & Harrell, A. V. (1996). *Physical Environment and Crime*. Washington, D.C.

The Metabolic Syndrome Institute. (2008). Retrieved January 29, 2008, from http://www.metabolic-syndrome-institute.org/informations/history/index.php

Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. (2002). *Circulation, 106*(25), 3143-3421.

Transportation Research Board. (2005). *Does the built environment influence physical activity? Examining the evidence*. Washington, D.C.

Trends in leisure-time physical inactivity by age, sex, and race/ethnicity--United States, 1994-2004. (2005). *MMWR Morb Mortal Wkly Rep, 54*(39), 991-994.

Trevisan, M., Liu, J., Bahsas, F. B., & Menotti, A. (1998). Syndrome X and mortality: a population-based study. Risk Factor and Life Expectancy Research Group. *Am J Epidemiol, 148*(10), 958-966.

Troped, P. J., Saunders, R. P., Pate, R. R., Reininger, B., Ureda, J. R., & Thompson, S. J. (2001). Associations between self-reported and objective physical environmental factors and use of a community rail-trail. *Prev Med, 32*(2), 191-200.

United States Census Bureau. (2010). Population finder. Retrieved February 10, 2010, from http://www.factfinder.census.gov/home/saff/main.html?_lang=en

United States Department of Agriculture. (2007). Food surveys products and services. Retrieved September 22, 2008, from http://www.ars.usda.gov/Services/docs.htm?docid=14531

United States Department of Health and Human Services. (1996a). *Physical activity and health: a Report of the Surgeon General.* Atlanta, GA: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.

United States Department of Health and Human Services. (1996b). *Physical activity and health: a report of the Surgeon General.* Atlanta, GA.

United States Department of Health and Human Services. (2000, January 2000). *Healthy People 2010 (Conference Edition, in Two Volumes)*, Washington, DC.

University of Illinois at Urbana-Champaign. (2006). Waist circumference. Retrieved June 17, 2008, from http://www.mckinley.uiuc.edu/Handouts/pdfs/waist_circumference.pdf

University of Virginia. (2007). Type 2 diabetes. Retrieved January 21, 2009, from http://www.healthsystem.virginia.edu/uvahealth/adult_diabetes/type2.cfm

Vague, J. (1947). Sexual differentiation, a factor affecting the forms of obesity. *Presse Méd, 30*, 339-340.

Vanltallie, T. B. (1998). Waist circumference: a useful index in clinical care and health promotion. *Nutr Rev, 56*(10), 300-302.

Vasan, R. S., Beiser, A., Seshadri, S., Larson, M. G., Kannel, W. B., D'Agostino, R. B., et al. (2002). Residual lifetime risk for developing hypertension in middle-aged women and men: The Framingham Heart Study. *Jama, 287*(8), 1003-1010.

Vasan, R. S., Larson, M. G., Leip, E. P., Evans, J. C., O'Donnell, C. J., Kannel, W. B., et al. (2001). Impact of high-normal blood pressure on the risk of cardiovascular disease. *N Engl J Med, 345*(18), 1291-1297.

Visscher, T. L., Kromhout, D., & Seidell, J. C. (2002). Long-term and recent time trends in the prevalence of obesity among Dutch men and women. *Int J Obes Relat Metab Disord, 26*(9), 1218-1224.

Wadden, T. A., Womble, L. G., Stunkard, A. J., & Anderson, D. A. (2002). Psychosocial consequences of obesity and weight loss. In T. A. Wadden & J. Stundards (Eds.), *Handbook of obesity treatment* (pp. 144-169). New York: Guildford Press.

Wannamethee, S. G., & Shaper, A. G. (2001). Physical activity in the prevention of cardiovascular disease: an epidemiological perspective. *Sports Med, 31*(2), 101-114.

Wei, M., Kampert, J. B., Barlow, C. E., Nichaman, M. Z., Gibbons, L. W., Paffenbarger, R. S., Jr., et al. (1999). Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men. *Jama, 282*(16), 1547-1553.

Wener, R. E., & Keys, C. (1988). The effects of changes in jail population densities on crowding, sick call, and spatial behavior. *J Appl Soc Psychol 18*(10), 852-866.

Whelton, P. K., He, J., Appel, L. J., Cutler, J. A., Havas, S., Kotchen, T. A., et al. (2002). Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. *Jama, 288*(15), 1882-1888.

Whitaker, R. C. (2002). Understanding the complex journey to obesity in early adulthood. *Ann Intern Med, 136*(12), 923-925.

Wilbur, J., Chandler, P. J., Dancy, B., & Lee, H. (2003). Correlates of physical activity in urban Midwestern African-American women. *Am J Prev Med, 25*(3 Suppl 1), 45-52.

Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care, 27*(5), 1047-1053.

Wilson, A., Seal, J., McManigal, L., Lovins, L., Cureton, M., & Browning, W. (1998). *Green Development: Integrating Ecology and Real Estate*. New York: John Wiley.

Wilson P.W.F., D'Agostino R.B., Levy D., Belanger A.M., Silbershatz H., & W.B., K. (1998). Prediction of coronary heart disease using risk factor categories. *Circulation 97*, 1837-1847.

Wilson, P. W., D'Agostino, R. B., Parise, H., Sullivan, L., & Meigs, J. B. (2005). Metabolic syndrome as a precursor of cardiovascular disease and type 2 diabetes mellitus. *Circulation, 112*(20), 3066-3072.

Wilson, P. W. F., D'Agostino, R. B., Sullivan, L., Parise, H., & Kannel, W. B. (2002). Overweight and obesity as determinants of cardiovascular risk. *Arch Intern Med, 162*(16), 1867-1872.

Wingard, D. L., & Barret-Conner, E. (1995). Heart disease and diabetes. In N. D. D. Group (Ed.), *Diabetes in America* (2nd ed., pp. 429-448). Bethesda, MD: National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health.

Winkleby, M. A., Kraemer, H. C., Ahn, D. K., & Varady, A. N. (1998). Ethnic and socioeconomic differences in cardiovascular disease risk factors: findings for women from the Third National Health and Nutrition Examination Survey, 1988-1994. *Jama, 280*(4), 356-362.

Wong, M. D., Shapiro, M. F., Boscardin, W. J., & Ettner, S. L. (2002). Contribution of major diseases to disparities in mortality. *N Engl J Med, 347*(20), 1585-1592.

World Health Organization. (2008a). BMI Classification. Retrieved March 5, 2008, from http://www.who.int/bmi/index.jsp?introPage=intro_3.html

World Health Organization. (2008b). Cardiovascular disease. Retrieved January 13, 2008, from http://www.who.int/cardiovascular_diseases/en/

World Health Organization. (2010). Obesity and overweight. Retrieved May 31, 2010, from http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/

Yarnell, J. W., Patterson, C. C., Bainton, D., & Sweetnam, P. M. (1998). Is metabolic syndrome a discrete entity in the general population? Evidence from the Caerphilly and Speedwell population studies. *Heart, 79*(3), 248-252.

Yeshurun, D., & Gotto, A. M., Jr. (1995). Hyperlipidemia: perspectives in diagnosis and treatment. *South Med J, 88*(4), 379-391.

Zhu, S., Heshka, S., Wang, Z., Shen, W., Allison, D. B., Ross, R., et al. (2004). Combination of BMI and Waist Circumference for Identifying Cardiovascular Risk Factors in Whites. *Obes Res, 12*(4), 633-645.

Zhu, S., Heymsfield, S. B., Toyoshima, H., Wang, Z., Pietrobelli, A., & Heshka, S. (2005). Race-ethnicity-specific waist circumference cutoffs for identifying cardiovascular disease risk factors. *Am J Clin Nutr, 81*(2), 409-415.

Zhu, S., Wang, Z., Heshka, S., Heo, M., Faith, M. S., & Heymsfield, S. B. (2002). Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. *Am J Clin Nutr, 76*(4), 743-749.

Zimmet, P., Alberti, K. G., & Shaw, J. (2001). Global and societal implications of the diabetes epidemic. *Nature, 414*(6865), 782-787.