RELATIONSHIP BETWEEN SOCIOECONOMIC STATUS, PHYSICAL ACTIVITY, AND HEALTH OUTCOMES: NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY

by
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A dissertation submitted to the Department of Health and Human Performance,
College of Liberal Arts and Social Sciences
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in Kinesiology

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August 2020

ACKNOWLEDGEMENTS

I owe a great deal of thanks to many individuals for their invaluable contributions to this project. I thank Dr. Daphne Hernandez for her wonderful mentorship throughout my doctoral studies, for always pushing me to accomplish more than I thought possible, and never accepting work that she knew was not to the best of my capabilities. I would not be the scientist I am today without her leadership, support, and endless patience.

I would also like to acknowledge Dr. Rosenda Murillo for taking me under her physical activity researcher wing and giving me the opportunity to assist on her projects and publications. Her mentorship enabled me to establish myself as a physical activity researcher during my graduate studies and pushed me to learn how to conduct advanced statistical analyses. I also thank Dr. Craig Johnston for his mentorship and assistance throughout my doctoral training. He provided me with data for my candidacy project and the opportunities he provided surrounding weight management interventions and excess summer weight gain of children/adolescents have greatly informed my career trajectory. Finally, I owe a special thanks to Dr. Dan O’Connor and Dr. Emily LaVoy for serving on my dissertation committee and their thoughtful feedback and assistance in shaping this project.

I also thank my family and friends; without their support I never could have accomplished this process. I especially thank my husband Zach for his endless patience and unwavering support of my career, my mother for instilling me with a strong work ethic and always believing that I would achieve my dreams, my fellow doctoral students Katie Arlinghaus and Stephanie Silveira who inspired me daily with their passion for science, and my grandparents Max and Charlotte Layton who are two of my greatest supporters.

ABSTRACT

According to the Social Determinants of Health, social factors such as education, income, and employment (i.e. factors that comprise socio-economic status, SES) impact adult health and associated health behaviors such as physical activity (PA). The purpose of this three-paper dissertation was to better understand the inter-relationship of SES, PA, sedentary behaviors (SB), and health (including metabolic syndrome and overweight/obesity) among a nationally representative sample of U.S. adults. Specifically, the three aims addressed the following 1) examined the relationship between three SES indicators: education, income, and employment status with non-leisure time physical activity (non-LTPA), 2) evaluated the relationship of occupational physical activity (OPA) and metabolic syndrome and its components, 3) assessed the role of LTPA and SB in the income-overweight/obesity relationship.

To do this, all three aims utilized four waves of publicly available data from The National Health and Nutrition Examination Survey (NHANES) (2007– 2014), which included a total of 15,376 non-pregnant, non-older adults (aged 20-59 years). The sample was reduced to only include individuals who met the criteria and without missing data on the variables of interest for each aim (Aim 1: n=11,985, Aim 2: n= 3,253, Aim 3: n =10,348). Descriptive statistics, as well as weighted linear and logistic regression analyses were conducted using STATA version 15.0 statistical software (Aim 1 and 2). Structural equation modeling was conducted in Mplus version 8.3 (Aim 3). Survey procedures were used in all analyses to account for the NHANES sampling design.

Aim 1: When examining the relationship between three SES indicators: education, income, and employment status with non-LTPA, findings indicated that only education and

employment were related to non-LTPA. Having less than a high school education [OR = 1.44 (0.18), $p < .01$] and having a high school education [OR = 1.43 (0.12), $p < .001$] were associated with increased odds of meeting PA guidelines from non-LTPA, compared to a college degree. Part-time employment was associated with increased odds of meeting PA guidelines from non-LTPA [OR= 1.28 (0.12); $p < .01$], compared to full-time employment.

Aim 2: When evaluating the relationship of OPA with metabolic syndrome and its components, findings suggest that OPA was not associated with metabolic syndrome, nor its components ($p >.05$). Further, the relationships did not differ between women and men (interaction term $p >.05$).

Aim 3: When assessing the role of LTPA and SB in the income-overweight/obesity relationship, income indirectly influences overweight/obesity through its association with LTPA and SB. Greater income was negatively associated with overweight/obesity (Total effect: B=-0.046; 95%CI=-0.07,-0.02). Income indirectly influenced overweight/obesity through LPTA (Indirect effect: B=-0.005; 95%CI=-0.01,-0.003) and through SB (Indirect effect: B=0.008; 95%CI=0.005,0.01), but in opposing directions. The direct effect from income to overweight/obesity remained statistically significant (Direct Effect: B=-0.049; 95%C =-0.07;-0.02). LTPA partially accounted for the negative relationship between income and overweight/obesity; SB reduced the strength of the negative relationship between income and overweight/obesity.

Aim 1 provides a comprehensive understanding of how SES is related to non-LTPA. Consequently, it raises awareness of the need to consider non-LTPA among low SES populations. Practitioners attempting to increase PA should consider these complexities and assess non-LTPA in addition to LTPA. *Aim 2* indicated that there were no substantial associations between OPA and cardiovascular health indicators among a U.S. nationally representative cross-sectional sample. This contrasts findings from non-US-based samples which identified OPA as a risk factor for cardiovascular disease, especially among males (i.e. PA Health Paradox), Future prospective, longitudinal studies are needed to understand the long-term effects of OPA on the risk of experiencing metabolic syndrome among the U.S. population. *Aim 3* suggests that targeted behavior approaches for weight management by income may be beneficial. Increasing LTPA among adults with lower income and decreasing SB among adults with higher income may provide some overweight/obesity protection. Taken together, these findings illustrate the complexities of the inter-relationships of SES, PA, SB, and health.

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CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND AND RATIONALE

According to the Social Determinants of Health, social factors are related to health through material, psychosocial and health behaviors. Early life experiences, genetics, and cultural factors influence the relationships of social factors with health (Marmot & Wilkinson, 2005). An aspect of the Social Determinants of Health particularly relevant to this dissertation is the concept of "the social gradient in health"; individuals with a higher social status have better health than those of lower social status (Marmot & Wilkinson, 2005). Socioeconomic status (SES) is one way of assessing the social standing of an individual within a social hierarchy (American Psychological Association & Task Force on Socioeconomic Status, 2007). Three measures are often used as indicators of SES in health behavior research: income, education, and employment status (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007). One pathway by which social factors (such as SES) impact health is through health behaviors, which result in physiological changes. Through the lens of the Social Determinants of Health, this study aims to better understand the complex inter-relationship of social status, health behaviors, and health outcomes. Specifically, this study investigated the inter-relationship of SES (one way of assessing social status), physical activity (PA) and sedentary behavior (SB) (important health behaviors which differ between those of low and high SES), and health (metabolic syndrome and overweight/obesity).

One health behavior, which may contribute to the social gradient of health is PA. PA has been operationally defined as bodily movement produced by skeletal muscles that increases energy expenditure (Caspersen, Powell, & Christenson, 1985). Individuals engage in PA through a variety of domains. The four domains of focus in this study include: leisure time PA, transportation PA, occupational PA, and household PA which all contribute to an overall physically active lifestyle (Chu & Moy, 2013). **Leisure Time Physical Activity** (LTPA) is voluntary PA that is conducted during one's unstructured time. This includes any PA for sport or recreation (Howley, 2001). **Transportation Physical Activity** (TPA) includes all types of active commuting, such as walking or cycling. **Occupational Physical Activity** (OPA) is PA accomplished at work. **Household Physical Activity** (HPA) includes PA engagement for the purpose of maintaining the home (Chu & Moy, 2013). A related but distinct concept is **Sedentary Behavior** (SB), which refers to periods of sitting or lying down (American College of Sports Medicine, 2017).

Adults in the United States are recommended to engage in a minimum of 150 minutes per week of moderate physical activity (PA), or 75 minutes of vigorous PA, or an equivalent combination of both (U.S. Department of Health and Human Services, 2018) as it is known to positively impact health. Adequate levels of PA are associated with increased life expectancy and decreased risk of chronic disease including cardiovascular disease, type 2 diabetes, obesity, metabolic syndrome, and certain cancers (U.S. Department of Health and Human Services, 2018). Booth, Roberts, and Laye (2012) concluded that most chronic diseases could be attributed to physical inactivity and that PA is able to prevent and delay chronic disease.

Despite clear benefits of PA engagement, many fail to meet the guidelines (Caban-Martinez et al., 2007). Overall, approximately 50% of U.S. adults failed to meet the PA guidelines in 2017 (Centers for Disease Control and Prevention). PA disparities exist, with those of low SES engaging in less LTPA than their more affluent peers (Elhakeem et al., 2015; Ford et al., 1991). However, many of the studies identifying PA disparities have focused on LTPA (Beenackers et al., 2012; Choi et al., 2017). There is a paucity of literature evaluating other domains, collectively referred to as non-LTPA. Those of low-SES may engage in less LTPA because they do not have the resources to do so (Gidlow et al., 2006). However, it is possible that those of low-SES may engage in greater amounts of TPA, OPA, or HHPA. Researchers often rely on a single SES indicator in PA research; however, including only one indicator as a proxy for SES is insufficient (Braveman et al., 2005). A three-pronged approach, which includes income, education, and employment status simultaneously is necessary to understand how SES is related to PA. Further, many studies have evaluated domains of PA independently of one another (Florindo et al., 2009; Kandula & Lauderdale, 2005; Wang et al., 2010). A recent study suggests that a more comprehensive approach may be to combine all non-LTPA (Kakinami et al., 2018). Therefore, the first aim of this study is to examine the relationship between three SES indicators: education, income, and employment status with a comprehensive measure of non-LTPA.

While Aim 1 utilizes the lens of the Social Determinants of Health by evaluating the relationship of social standing with health behaviors, another important component of the Social Determinants of Health Model is the relationship between health behaviors and health outcomes (Marmot & Wilkinson, 2005). Although the health benefits of LTPA are well documented, the literature has shown the relationship between OPA and health to be inconsistent (Li et al., 2013). Studies based on non-US primarily male samples have identified occupational PA (OPA) as a risk factor for cardiovascular disease (CVD). The contrasting impact of OPA and LTPA on health has been coined “The PA Health Paradox” (Holtermann et al., 2012). It has been suggested that PA guidelines may need to be updated to differentiate between domains of PA because the health benefits are not the same across domains (de Souto Barreto, 2015).

Despite research studies identifying a relationship between OPA and CVD (Li et al., 2013), little is known about the relationship of OPA and metabolic syndrome, a precursor to CVD. Metabolic syndrome is a cluster of biological risk factors, strongly associated with increased risk for chronic diseases such as CVD (Mottillo et al., 2010). Metabolic syndrome includes the following risk factors: central obesity, elevated blood pressure, dyslipidemia (low high-density lipoprotein cholesterol and elevated triglycerides), and elevated fasting blood glucose (Alberti et al., 2009). Aim 2 of this study is to evaluate the PA Health Paradox by examining the relationship of OPA and CVD risk indicators, specifically metabolic syndrome and its components (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose) among U.S. adults using a nationally representative dataset.

The first two aims of the study evaluated relationships between two variables within the Social Determinants of Health Framework (Marmot & Wilkinson, 2005). Aim 1 evaluated the relationship of social status (SES) with a health behavior (non-LTPA). Aim 2 evaluated the relationship of a health behavior (OPA) with health outcomes (metabolic syndrome and its components). The final aim of this study links these three components together. Aim 3 assesses the role of health behaviors (LTPA and SB) in the relationship of social status (income) and health (overweight/obesity).

The prevalence of overweight/obesity is higher among low-income households (National Center for Health Statistics, 2015). The health consequences associated with overweight/obesity include arthritis, diabetes, hypertension, and high cholesterol (Mokdad et al., 2003). LTPA is associated with decreased risk of overweight/obesity (King et al., 2001; Wanner et al., 2016); however, disparities exist with those of low-income engaging in less LTPA (Elhakeem et al., 2015; Ford et al., 1991). Another modifiable lifestyle behavior associated with overweight/obese weight status is time spent in SB. In contrast to LTPA, time spent in SB is positively associated with overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). Greater income is related to greater total time spent in SB (Kozo et al., 2012). Research has focused on how income, LTPA, and SB relate to weight status independently, but there is a lack of research evaluating LTPA and SB simultaneously within the income-overweight/obesity relationship.

Given that income-related overweight/obesity disparities exist, and LTPA and SB are related to both income and weight status, it is possible that these behaviors play an important role in the income-overweight/obesity relationship. The purpose of the third aim was to understand the modifiable lifestyle behavior mechanisms by which income influences overweight/obesity. Specifically, this study evaluated the role of LTPA and SB simultaneously controlling for the influence of each other in the income-overweight/obesity relationship.

1.2 PROBLEM STATEMENT AND RESEARCH AIMS

According to the Social Determinants of Health, social factors such as socioeconomic status (SES) impact the health of individuals (Marmot & Wilkinson, 2005). Those of lower SES have increased prevalence of overweight/obesity (National Center for Health Statistics, 2015); they engage in less LTPA (Elhakeem et al., 2015; Ford et al., 1991), but less SB (Kozo et al., 2012), and greater non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005), compared to those of higher SES. Adequate levels of LTPA are associated with decreased risk of overweight/obesity and chronic disease (King et al., 2001; Wanner et al., 2016), and SB is associated with increased risk of overweight/obesity (Biswas et al., 2015; Ching et al., 1996; Hu, Li, Colditz, Willett, & Manson, 2003; O'Donoghue et al., 2016; Thorp, Owen, Neuhaus, & Dunstan, 2011). The relationship between OPA and chronic disease (such as CVD) is less clear (Li et al., 2013). Differences in PA behaviors may be related to SES differences in overweight/obesity and chronic disease, such as CVD.

However, gaps in the literature remain. First, although research consistently reports that a disproportionate number of low SES adults fail to meet the PA guidelines (Centers for Disease Control and Prevention), much of the literature has focused on LTPA. There is a dearth of studies documenting SES-related variation of non-LTPA (Beenackers et al., 2012; Choi, Lee, Lee, Kang, & Choi, 2017). Second, while the relationship of LTPA and cardiovascular health is well documented (Li et al., 2013), more recent studies based on European male samples have identified occupational PA (OPA) as a risk factor for cardiovascular disease (CVD) (Holtermann et al., 2012; Holtermann et al., 2009, 2010), coined the PA Health Paradox (Holtermann et al., 2012). However, the PA Health Paradox has not been evaluated on a nationally representative sample of United States employees, and there is a lack of studies evaluating this relationship including women. Third, it is well known that income is related to LTPA (Elhakeem et al., 2015; Ford et al., 1991), SB (Kozo et al., 2012), and overweight/obesity (Paeratakul et al., 2002). However, studies have not been conducted to evaluate the role of LTPA and SB simultaneously in the income-overweight/obesity relationship. Addressing these three gaps will provide valuable insight into the inter-relationship of SES, PA, and health.

In order to address the gaps in the literature listed above, further research is needed to understand the inter-relationship of SES, PA, and health. Few studies have utilized U.S. nationally representative data to evaluate the relationship of SES with a comprehensive measure of non-LTPA, the relationship of OPA with CVD risk, or the role of LTPA and SB in the income-overweight/obesity relationship. Evaluating these topics within the context of a U.S. nationally representative dataset provides a level of generalizability that is unobtainable via most data collection methods. The findings from this study are highly generalizable and applicable to the American public.

Broadly, the purpose of this study was to better understand the inter-relationship of SES, PA, and health (metabolic syndrome and overweight/obesity) among a nationally representative sample of U.S. adults. Specifically, this study aimed to address the following: 1) examine the relationship between three SES indicators: education, income, and employment status with non-LTPA, 2) evaluate the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose), 3) assess the role of LTPA and SB in the income-overweight/obesity relationship.

1.3 SPECIFIC RESEARCH AIMS

This study included three general questions, each with related questions and hypotheses. *Figure 1* depicts the conceptual model for the overarching study. It includes study variables (broadly) and the theoretical relationships that this dissertation will examine.

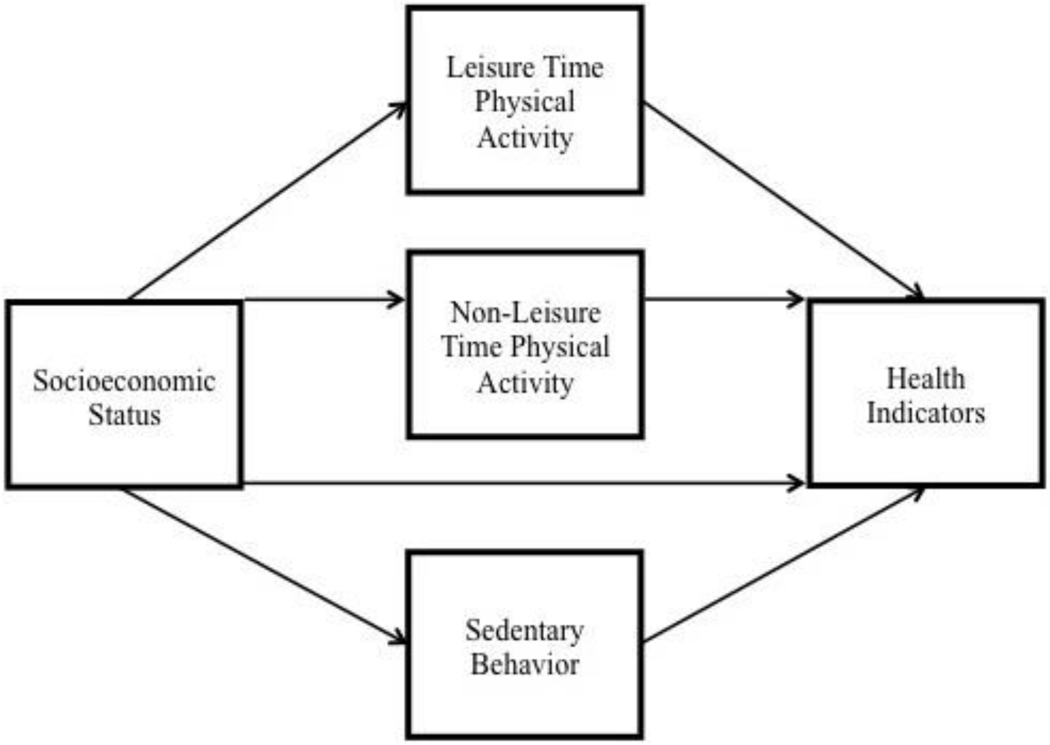


Figure 1. Overall Conceptual Model of Specific Aims

Research Aim 1: The purpose of this study was to evaluate the relationship of three indicators of SES (education, income, and employment) simultaneously on meeting the PA guidelines through a comprehensive measure of non-LTPA engagement

Research Question 1.1: Are education, income and employment status related to meeting the PA guidelines from non-LTPA engagement?

Hypothesis 1.11: It was expected that educational attainment would be negatively associated with non-LTPA, such that those with lower educational attainment would be at increased odds meeting the PA guidelines from non-LTPA (Kandula & Lauderdale, 2005; Leschied, Chiodo, Whitehead, & Hurley, 2005).

Hypothesis 1.12: It was expected that income would be negatively related to non-LTPA, such that those with lower income would be at increased odds of meeting the PA guidelines from non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005).

Hypothesis 1.13: It was expected that those who were unemployed would be at decreased odds and those employed part-time would be at increased odds of meeting the PA guidelines from non-LTPA, compared to those with full-time employment (Steeves et al., 2015; Valletta, Bengali, & Van der List, 2020).

Hypothesis 1.14: When evaluated simultaneously, it was expected that education, income, and employment status would remain related to meeting the PA guidelines from non-LTPA in the expected directions. However, relationships would be attenuated.

The purpose of **Aim 1** was to evaluate the relationship of three indicators of SES (education, income, and employment) simultaneously on meeting the PA guidelines through a comprehensive measure of non-LTPA engagement (Kakinami et al., 2018). Although individuals considered low SES are consistently classified as less active than their more affluent counterparts, many of these studies have focused on LTPA (Beenackers et al., 2012; Choi et al., 2017). This narrow focus overlooks other domains of PA (TPA, OPA, HHPA), which individuals may utilize to meet PA guidelines (U.S. Department of Health and Human Services, 2018). It is possible that individuals considered low SES may be more likely to meet the PA guidelines through engagement in non-LTPA due to lack of access to facilities to engage in LTPA and environments that are deemed safe for PA (Gidlow, Johnston, Crone, Ellis, & James, 2006). The research that has evaluated the relationship of SES with non-LTPA has largely focused on specific components of non-LTPA (e.g. OPA) (Florindo et al., 2009; Kandula & Lauderdale, 2005; Wang et al., 2010), rather than a comprehensive measure of non-LTPA (Kakinami et al., 2018). Further, previous research evaluating the relationship of SES and non-LTPA has primarily focused on education as the marker of SES (Beenackers et al., 2012; Choi et al., 2017). Much less is known about how income and employment status are simultaneously related to non-LTPA (Bauman et al., 2012; Choi et al., 2017), particularly in the United States. This is problematic as a three-pronged approach, which includes education, income, and employment status simultaneously (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007), is necessary to understand how SES is related to non-LTPA. Understanding how SES relates to adults' level of engagement in non-LTPA may be important to reducing chronic disease.

Research Aim 2: This study aims to evaluate the PA Health Paradox by examining the relationship of OPA and CVD risk indicators, specifically metabolic syndrome and its components (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose) among U.S. adults. A secondary aim was to evaluate if the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) differed between men and women.

Research Question 2.1: Is OPA related to metabolic syndrome and its components among U.S. adults?

Hypothesis 2.1: Similar to previous studies that have occurred in the past 15 years focused on various health outcomes (Holtermann et al., 2009; Krause, 2010; Krause et al., 2015; Krause et al., 2007; Li et al., 2013), it was expected that OPA would be associated with increased odds of metabolic syndrome and its components (elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose).

Hypothesis 2.12: It was expected that OPA would be associated with decreased odds of elevated waist circumference, similar to previous studies on OPA and obesity (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010; Steeves et al., 2012).

Research Question 2.2: Does the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) differ between men and women?

Hypothesis 2.2: It was expected that the relationships between OPA and CVD risk indicators would be moderated by sex, such that the relationships would be stronger among men than women.

The purpose of **Aim 2** was to evaluate the relationship of OPA with CVD risk (metabolic syndrome and its components) in a nationally representative sample of U.S. adult employees. Although the health benefits of LTPA are well documented, the health benefits associated with other domains of PA, such as OPA, are not consistently observed (Li et al., 2013). Landmark research studies establishing the health benefits of PA, such as decreased risk of cardiovascular disease (CVD) and obesity, utilized OPA as the marker of PA (Morris et al., 1953). However, the literature has shown the relationship between OPA and health to be inconsistent. Some studies conducted in the past decade have identified OPA as a risk factor for cardiovascular events (Holtermann et al., 2010) and heart attack incidence (Krause et al., 2015). Researchers have also found that greater OPA had an unhealthy impact on all-cause mortality (Clays et al., 2013; Coenen et al., 2018) and systolic blood pressure (Clays et al., 2012). The contrasting impact of OPA and LTPA on health has been coined "The PA Health Paradox" (Holtermann et al., 2012). It is important to highlight that many of the studies reporting OPA to be a risk factor for CVD focused on very specific populations such as Danish employees (Holtermann et al., 2012; Holtermann et al., 2009, 2010). Studies conducted in other locations have differed in their findings (Fransson, Alfredsson, de Faire, Knutsson, & Westerholm, 2003; Johnsen, Alfredsson, Knutsson, Westerholm, & Fransson, 2016; Probert, Tremblay, & Connor Gorber, 2008; Stamatakis et al., 2013). There is a paucity of large U.S. nationally representative studies examining the relationship of OPA and cardiovascular health (Li et al., 2013). Further, many of the research studies identifying OPA as a CVD risk factor were conducted on entirely male samples (Clays et al., 2013; Holtermann et al., 2010; Krause et al., 2015). The literature evaluating men and women separately is inconsistent (Coenen et al., 2018; Fransson et al., 2003; Li & Siegrist, 2012; Stamatakis et al., 2013). These discrepancies in the literature are confusing and there is a need to evaluate the relationship of OPA with CVD risk among a large nationally representative dataset of U.S. adult employees. This study will clarify mixed findings and help researchers and practitioners better understand the impact of OPA on cardiovascular health among the U.S. population, as well as understand how the PA Health Paradox applies to women.

Last, **Aim 3** was to understand the modifiable lifestyle behavior mechanisms by which income influences overweight/obesity. Specifically, this study evaluated the role of

LTPA and SB simultaneously controlling for the influence of one another in the income-overweight/obesity relationship.

Research Question 3.1: What is the role of LTPA in the income-overweight/obesity relationship?

Hypothesis 3.1: Building on prior literature, it was expected that higher income would be positively related to LTPA (Elhakeem et al., 2015; Ford et al., 1991), and LTPA would be negatively related to overweight/obesity (Chen & Mao, 2006; King et al., 2001; Wanner et al., 2016). It was further hypothesized that there would be a negative indirect effect from income to overweight/obesity through LTPA, which would partially account for the overall negative association between income and overweight/obesity.

Research Question 3.2: What is the role of SB in the income-overweight/obesity relationship?

Hypothesis 3.2: It was expected that higher income would be positively related to SB (Kozo et al., 2012), and SB would be positively related to overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). It was further hypothesized that there would be a positive indirect effect from income to overweight/obesity through SB, working in the opposite direction of LTPA and the overall negative association between income and overweight/obesity.

The purpose of Aim 3 was to understand the modifiable lifestyle behavior mechanisms (LTPA and SB) by which income influences overweight/obesity. Given that income-related overweight/obesity disparities exist (National Center for Health Statistics, 2015), and LTPA and SB are related to both income and overweight/obesity (Chen & Mao, 2006; Ching et al., 1996; Hu et al., 2003; King et al., 2001; O'Donoghue et al., 2016; Thorp et al., 2011; Wanner et al., 2016), it is possible that these behaviors play an important role in the income-overweight/obesity relationship. Overweight/obesity prevalence is lower among those with higher incomes (National Center for Health Statistics, 2015). Previous studies have found that those with higher income engage in greater LTPA (Elhakeem et al., 2015; Ford et al., 1991), but also spend more time in SB (Kozo et al., 2012), which are known to be related to overweight/obesity. Greater LTPA is associated with decreased risk of overweight/obesity (King et al., 2001; Wanner et al., 2016), while more time spent in SB is associated with an increased risk of overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). However, there is a lack of research evaluating LTPA and SB simultaneously in relation to the income-overweight/obesity relationship. Because LTPA and SB are known to be inversely associated with one another (O'Donoghue et al., 2016), it is important to understand their roles in the income-overweight/obesity relationship simultaneously. This study provides a framework for understanding the role of LTPA and SB in the income-overweight obesity relationship. Findings will inform future longitudinal studies or randomized controlled trials attempting to better understand the income-overweight/obesity relationship.

1.4 OUTLINE

An overview of the details provided within this dissertation proposal follows.

Chapter 1, the Introduction, presents the topic for this dissertation. It serves as a guide for the chapters that follow.

Chapter 2, the Literature Review, explains the current research available on the topic and identifies limitations in the current knowledge. It further establishes the lack of knowledge on the following topics: 1) SES related to non-LTPA, 2) OPA related to CVD risk, and 3) the role of LTPA and SB in the income-overweight/obesity relationship. After reading this chapter the reader should understand the purpose for the investigation topic.

Chapter 3, the Methodology, will fully describe the planned methodology for executing the research necessary to fulfill Research Aim 1, 2, and 3.

Chapter 4, Manuscript 1, describes research and results regarding Aim 1: examine the relationship between three SES indicators: education, income, and employment status with non-LTPA.

Chapter 5, Manuscript 2, describes research and results regarding Aim 2: evaluate the relationship of occupational OPA and metabolic syndrome and its components.

Chapter 6, Manuscript 3, describes research and results regarding Aim 3: assess the role of LTPA and SB in the income-overweight/obesity relationship.

Chapter 7, the Conclusion, summarizes findings from this dissertation and describes future directions, limitations, and implications for research, policy, and practice.

1.5 DEFINITIONS OF IMPORTANT TERMS AND ABBREVIATIONS

FPL: Federal Poverty Level

HHPA: Household Physical Activity

LTPA: Leisure Time Physical Activity

MPA: Moderate Physical Activity

MVPA: Moderate to Vigorous Physical Activity

NHANES: National Health and Nutrition Examination Survey

OPA: Occupational Physical Activity

PA: Physical Activity

TPA: Transportation Physical Activity

SB: Sedentary Behavior

SES: Socioeconomic Status

VPA: Vigorous Physical Activity

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will provide the reader with an understanding of the rationale for this study and will demonstrate the importance of this work to the literature. Current literature will be included as related to the following topics: 1) Social Determinants of Health 2) domains of PA, 3) PA, an important health behavior, 4) socioeconomic status and non-LT PA 5) The PA Health Paradox, 6) the role of LTPA and SB in the social gradient of health, critical topics for understanding, preventing, and reducing health disparities. This chapter will identify current gaps in our knowledge regarding the inter-relationships of SES, PA/SB, and health (specifically metabolic syndrome and overweight/obesity).

2.2 SOCIAL DETERMINANTS OF HEALTH

According to the Social Determinants of Health, social factors are related to health through material, psychosocial and health behaviors. Early life experiences, genetics, and cultural factors influence the relationships of social factors with health (Marmot & Wilkinson, 2005). *Figure 2* models the complex inter-relationships within the Social Determinants of Health framework.

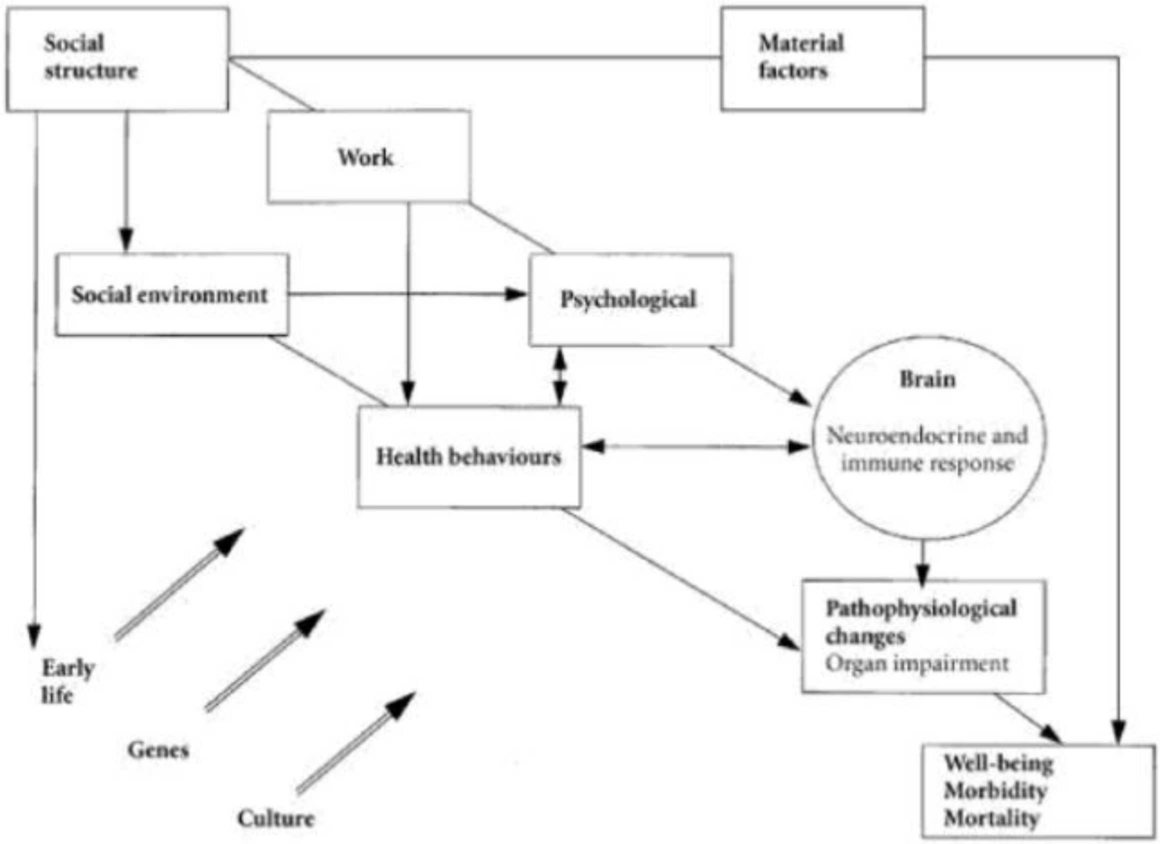


Figure 2 Social Determinants of Health Model from Marmot and Wilkinson (2005)

An aspect of the Social Determinants of Health particularly relevant to this dissertation is the concept of “the social gradient in health”; individuals with a higher social status have better health than those of lower social status. The gradient nature of this concept means that the impact of social status on health is hierarchical and not limited to the most vulnerable. The middle class has better health than those below them, but is less healthy than those above them. Health is a broad term, which can refer to many different outcomes. For example, HIV/AIDS, cardiovascular disease, and infant mortality are vastly different health outcomes but they all follow the social gradient pattern. Rates of many acute and chronic diseases are higher among those of lower social status (Marmot & Wilkinson, 2005).

Socioeconomic status is one way of assessing the social standing of an individual within a social hierarchy (American Psychological Association & Task Force on Socioeconomic Status, 2007). Three measures are often used as indicators of SES in health behavior research: income, education, and employment status, where those with higher income and greater educational attainment are considered to have higher social standing than those who make a lower income or have achieved a lower level of educational attainment (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007). Individuals who are employed full-time are considered to have higher social standing than those employed part-time, who are considered to have higher social standing than those unemployed (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007). It is important to understand the causes of the social gradient in health. As demonstrated in Figure 2, one pathway by which social factors impact health is through health behaviors, which result in physiological changes. Health behaviors can facilitate health (e.g. PA) or be detrimental to health (e.g. smoking).

Through the lens of the Social Determinants of Health, this study aims to better understand the complex inter-relationship of social status, health behaviors, and health outcomes. Specifically, this study investigated the inter-relationship of socioeconomic status (one way of assessing social status), PA and SB (important health behaviors which differ between those of low and high social status), and cardiovascular disease risk (including metabolic syndrome and overweight/obesity). Broadly, the purpose of this dissertation was to better understand the inter-relationship of SES, PA, and health (metabolic syndrome and overweight/obesity) among a nationally representative sample of U.S. adults. Specifically, this study aimed to address the following 1) examine the relationship between three SES indicators: education, income, and employment status with non-LTPA, 2) evaluate the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose), 3) assess the role of LTPA and SB in the income-overweight/obesity relationship.

2.3 DOMAINS OF PHYSICAL ACTIVITY

One health behavior, which contributes to the social gradient of health is PA. However, it is necessary to define key concepts related to PA prior to discussing the role of PA within the social gradient of health. PA has been operationally defined as bodily movement produced by skeletal muscles that increases energy expenditure (Caspersen et al., 1985). Individuals engage in PA through four of domains: leisure time PA, transportation PA, occupational PA, and household PA which all contribute to an overall physically active lifestyle (Chu & Moy, 2013). The following paragraphs describe each domain of PA.

Leisure Time Physical Activity (LTPA) is PA that is conducted during one's unstructured time. This includes any PA for sport or recreation (Howley, 2001). Exercise is a specific type of LTPA. During exercise, individuals engage in planned, structured, and repetitive bodily movements to improve/ maintain physical fitness (Caspersen et al., 1985). Exercise done for the purpose of improving health or weight loss is categorized as LTPA. Most of the research on PA and health has focused on LTPA as it is the domain of PA that individuals can modify with the greatest ease. However researchers recognize the need to evaluate all domains of PA in order to have an accurate representation on individual's PA engagement (Evenson, Rosamond, Cai, Pereira, & Ainsworth, 2003).

Transportation Physical Activity (TPA) includes all types of active commuting, such as walking or cycling. Walking from one location to another is included in TPA; walking from one location to public transportation and then from public transportation to another location is also considered TPA for the time spent walking, but not the time spent using public transportation.

Occupational Physical Activity (OPA) is PA accomplished at work. Typically, researchers think of OPA as occurring during traditional 8-hour work days. There is a wide range of amount and intensity of OPA conducted across professions. Examples of OPA include walking such as that conducted by nurses and waitresses, and heavy lifting such as that conducted by construction workers.

Household Physical Activity (HHPA) includes PA engagement for the purpose of maintaining the home. These activities range in intensity from light cleaning to vigorous home repairs which involve heavy lifting.

Total Physical Activity includes all PA accumulated across all domains. Studies using objective measures of PA (e.g. accelerometers; pedometers) typically assess total PA as they are unable to differentiate where participants are when engaging in PA.

Researchers have attempted to classify all PA into the four domains: LTPA, TPA, OPA, HHPA. However, this classification system is imperfect as individuals may perceive PA differently than researchers. For example, someone may choose to walk to the store, rather than drive their car because they know that being more active is good for them. Technically, researchers would classify this PA engagement as TPA. In this example the person engaged in active commuting; they walked from one location to another. However this person would say that they walked to the store because they wanted to take a walk for their health. They personally interpreted this PA engagement as LTPA. Gardening is technically classified as HHPA. However, individuals may garden in their unstructured time as a way to engage in PA for their health. These individuals may consider gardening LTPA.

Finally, group exercise instructors participate in PA that would typically be classified as exercise (LTPA). However, they are paid to do so. Is this activity OPA or LTPA? It is largely open to interpretation. In the methods section, the exact phrasing of the questions used to assess PA across domains is included. However it is possible that individuals interpreted the questions and their PA engagement differently resulting in overlap between domains of PA.

A related but distinct concept is **Sedentary Behavior** (SB)**,** which refers to periods of sitting or lying down (American College of Sports Medicine, 2017). Although related, SB differs from a lack of PA engagement/ physical inactivity. It is possible for individuals to be highly active (e.g. meet/ exceed PA recommendations), and yet spend many hours per day sedentary, such as in a desk job. The inverse is also possible. Individuals may spend many hours per day in light intensity activity, but not necessarily moderate to vigorous intensity PA necessary to meet the PA guidelines, yet spend very little time engaging in SB. Overall the research indicates that time spent in SB is inversely related to PA (O'Donoghue et al., 2016).

2.4 PHYSICAL ACTIVITY IS AN IMPORTANT HEALTH BEHAVIOR

Adults are recommended to engage in a minimum of 150 minutes per week of moderate PA, or 75 minutes of vigorous PA, or an equivalent combination of both (U.S. Department of Health and Human Services, 2018) as it is known to positively impact health. All domains of PA contribute to an overall physically active lifestyle (Chu & Moy, 2013), and “count” towards meeting the guidelines (U.S. Department of Health and Human Services, 2018). Adequate levels of PA are associated with increased life expectancy and decreased risk of chronic disease including cardiovascular disease, type 2 diabetes, obesity, metabolic syndrome, and certain cancers (U.S. Department of Health and Human Services, 1996). Booth et al. (2012) concluded that most chronic diseases could be attributed to physical inactivity and that PA is able to prevent and delay chronic disease.

Engaging in PA, even at levels below recommendations provides protection against all-cause mortality, with greater benefits garnered by those who engage in sufficient levels of PA (Leitzmann et al., 2007). Wen et al. (2011) found that as little as 15 minutes of PA per day reduced all-cause mortality by 14% and increased life expectancy by 3 years, compared to those who did not engage in PA. PA is known to reduce insulin resistance and improve glucose intolerance among obese adults (Kelley & Goodpaster, 1999). Among those with diabetes, PA of all intensities (including light) were found to be negatively associated with elevated glucose. In the opposite direction, time spent in SB was directionally associated with elevated glucose. These findings indicate that replacing sedentary activities with even light intensity PA can offer benefits to those with diabetes (Healy et al., 2007). PA is protective against obesity, even when controlling for energy intake (Wanner et al., 2016). Frugé et al. (2015) concluded that increased PA offered greater protection against metabolic syndrome than decreased caloric intake.

In contrast to PA, time spent in SB is detrimental to health. SB is related to overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011), as well as all-cause mortality, cardiovascular disease mortality, cardiovascular disease incidence, cancer mortality, cancer incidence, and type 2 diabetes incidence, independent of PA engagement (Biswas et al., 2015). Although specific guidelines for SB do not exist, individuals are encouraged to minimize time spent in SB (American College of Sports Medicine, 2017).

2.5 SOCIOECONOMIC STATUS AND PHYSICAL ACTIVITY

Despite clear benefits of PA engagement, many individuals are insufficiently active (Caban-Martinez et al., 2007). Overall, approximately 50% of U.S. adults failed to meet the PA guidelines in 2017(Centers for Disease Control and Prevention).PA disparities exist, with those of low SES engaging in less LTPA than their more affluent peers (Elhakeem et al., 2015; Ford et al., 1991). For example, only 41% of adults with an income below $15,000 met the PA guidelines from LTPA compared to 59% of adults with an income of $75,000 or greater; 37% of those with less than a high school education met the PA guidelines from LTPA compared to 59% of those with a college degree (Centers for Disease Control and Prevention). However, many of the studies identifying PA disparities have focused on LTPA (Beenackers et al., 2012; Choi et al., 2017). There is a paucity of literature evaluating other domains, collectively referred to as non-LTPA. This is problematic as each domain of PA (LTPA, TPA, OPA, HHPA) contributes to meeting the PA guidelines (U.S. Department of Health and Human Services, 2018). Those of low-SES may engage in less LTPA because they do not have the resources to do so (Gidlow et al., 2006). However, it is possible that those of low-SES may engage in greater amounts of TPA, OPA, or HHPA.

A better understanding of how SES is related to non-LTPA is necessary as it may provide insight into a more comprehensive view of total PA. There are gaps in the literature. First, researchers often rely on a single SES indicator; however, including only one indicator as a proxy for SES is insufficient (Braveman et al., 2005). A three-pronged approach, which includes income, education, and employment status simultaneously is necessary to understand how SES is related to PA. Second, it is difficult to elucidate the relationships of SES indicators with non-LTPA as the literature has inconsistently assessed components of non-LTPA. Many studies have evaluated domains of PA independently of one another

(Florindo et al., 2009; Kandula & Lauderdale, 2005; Wang et al., 2010), while others combined select components of non-LTPA such as HHPA/OPA, excluding TPA (He & Baker, 2005; Scholes & Bann, 2018). This is problematic because it is not best practice to evaluate each domain of PA independently when evaluating whether individuals meet the PA guidelines, as they all contribute to being sufficiently active (U.S. Department of Health and Human Services, 2018). A recent study suggests that a more comprehensive approach may be to combine all non-LTPA (Kakinami et al., 2018). Creating more confusion, different outcome measures of PA have been utilized. Some studies evaluate whether markers of SES relate to a binary measure of whether individuals *engage in any* non-LTPA from specific domains (Bauman et al., 2011; Salmon et al., 2000), or whether individuals *meet the PA guidelines* from specific domains (Florindo et al., 2009; Kandula & Lauderdale, 2005; Scholes & Bann, 2018). Others utilize *continuous measures* of domain specific non-LTPA (Ford et al., 1991; He & Baker, 2005). Given these inconsistencies, I have attempted to summarize how education, income, and employment status relate to non-LTPA.

Education. The most common indicator of SES utilized in PA research was education (Beenackers et al., 2012). Most studies evaluated specific components of non-LTPA (e.g. HHPA, TPA, OPA), rather than the combination of all domains of non-LTPA. In the United States, all components of non-LTPA were higher among those with lower education. HHPA/OPA engagement was greatest among those with high school or some college education, and was lowest amongst college graduates or higher (Scholes & Bann, 2018). Having a high school degree or less was associated with increased HHPA/OPA compared to those with additional education (He & Baker, 2005). Among Californians, men with greater education were less likely to meet PA guidelines from TPA (Kandula &

Lauderdale, 2005). Similar results were observed in European studies; education was negatively associated with OPA (Beenackers et al., 2012). Those classified as engaging in the most OPA had fewer years of educational attainment, compared to those in lower OPA categories (Wang et al., 2010). Similarly, in Australia those with lower education were at decreased odds of engaging in any vigorous HHPA/OPA (Salmon et al., 2000). Further, those classified as having a "medium" or "high" education in China were at decreased odds of having high OPA or high TPA (Bauman et al., 2011). In contrast, education was unrelated to TPA in European studies (Beenackers et al., 2012), and unrelated to both OPA and TPA in Brazilian adults (Florindo et al., 2009). Based on components of non-LTPA, it appears that those with greater education engage in less non-LTPA overall. However, there is a need to evaluate the relationship between education and a comprehensive measure of non-LTPA (Kakinami et al., 2018). In addition, some of the research studies evaluated the relationship of education and non-LTPA without considering income (He & Baker, 2005; Salmon et al., 2000; Scholes & Bann, 2018); none of the cited studies included a measure of employment status. Since, a single proxy measure of SES is insufficient (Braveman et al., 2005), studies are needed that evaluate education, income, and employment status simultaneously with a comprehensive measure of non-LTPA.

Income. There is a paucity of literature evaluating the relationship between income and non-LTPA (Bauman et al., 2012; Choi et al., 2017), particularly in the United States. However, several studies have evaluated the relationship between income and components of non-LTPA (e.g. OPA, TPA). Cohen et al. (2013) found differences in OPA by income such that those in the lowest (<$15,000) and highest (≥$50,000) household income categories engaged in less OPA than those in the middle income categories ($15,000 – $24,999,

$25,000 - $49,999). Among a sample of California residents, those with higher income had decreased odds of meeting the PA guidelines from TPA, or having a physically active occupation (Kandula & Lauderdale, 2005). In European studies, income was unrelated to OPA and TPA (Beenackers et al., 2012). However, in China higher income was associated with decreased odds of engaging in OPA (Bauman et al., 2011). In a multi-ethnic Asian population, income was negatively associated with OPA (Khaing Nang et al., 2010). Overall, based on research evaluating the relationship between income and components of non-LTPA it appears that those with higher income engage in less non-LTPA than those with lower income. However, with most of the research on income and components of non-LTPA occurring in other countries, there is a need to evaluate these relationships among a U.S. sample. Additionally, there is a need to evaluate the relationship of income with a comprehensive measure of non-LTPA (Kakinami et al., 2018).

Employment. Much less is known about how employment status relates to non-LTPA. Although employment status (e.g. full time, part time, unemployed) is often considered an indicator of SES (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007), much of the literature has evaluated how job classification (e.g. blue collar vs. white collar), rather than employment status relates to PA. The use of job classification as an indicator of SES is particularly common among European studies (Braveman et al., 2005). Unsurprisingly, the literature consistently identifies having a job classified as “blue collar” to be associated with greater OPA (a component of non-LTPA) compared to jobs classified as “white collar” or “professional” (Beenackers et al., 2012; Bennie, Timperio, Dunstan, Crawford, & Salmon, 2010; Schofield, Badlands, & Oliver, 2005; Smith et al., 2016; Steele & Mummery, 2003). However less is known about how employment status (e.g. full time, part time, unemployed), a commonly utilized marker of SES (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007), relates to non-LTPA. It is clear by definition that those who are employed will engage in greater OPA than those who are unemployed (and therefore do not have a job where they could engage in OPA). Further, it is feasible that differences in OPA could exist between part-time and full-time employment. Part-time employment is much more common in certain service industries (e.g. retail, restaurants) (Valletta et al., 2020), which are known to have greater levels of OPA (Steeves et al., 2015). However, the relationship between employment status and other components on non-LTPA is less clear. It is possible that, those who are unemployed and therefore have more unstructured time throughout the day may engage in greater HHPA or TPA. Thus, it is necessary to examine the association of employment status, in addition to income and education, in relation to a comprehensive measure of non-LTPA among a U.S. sample of adults.

One component of the Social Determinants of Health it that social standing impacts health behaviors (Marmot & Wilkinson, 2005). Currently, there is a dearth of information regarding how SES indicators (specifically income and employment status) relate to non-LTPA. Therefore, the first aim of this study is to examine the relationship between three SES indicators: education, income, and employment status with a comprehensive measure of non-LTPA. *Figure 3* depicts the conceptual model for Aim 1 of this dissertation.

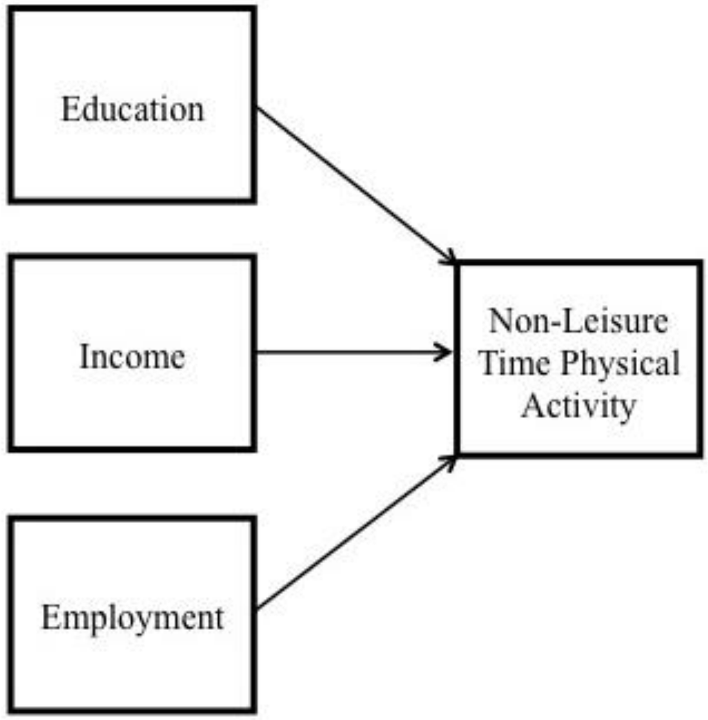


Figure 3 Conceptual Model of Specific Aim 1

It was expected that income would be negatively related to non-LTPA, such that those with lower income would be at increased odds of meeting the PA guidelines from non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005). It was also expected that educational attainment would be negatively associated with non-LTPA, such that those with lower educational attainment would be at increased odds meeting the PA guidelines from non-LTPA (Kandula & Lauderdale, 2005; Leschied et al., 2005). Finally, it was expected that those who were unemployed would be at decreased odds and those employed part-time would be at increased odds of meeting the PA guidelines from non-LTPA, compared to those with full-time employment (Steeves et al., 2015; Valletta et al., 2020).

2.6 PHYSICAL ACTIVITY HEALTH PARADOX

While Aim 1 utilizes the lens of the Social Determinants of Health by evaluating the relationship of social standing with health behaviors, another important component of the Social Determinants of Health Model is the relationship between health behaviors and health outcomes (Marmot & Wilkinson, 2005). Although the health benefits of LTPA are well documented, the health benefits associated with other domains of PA, such as OPA, are not consistently observed (Li et al., 2013). Many of the landmark research studies establishing the health benefits of PA, such as decreased risk of cardiovascular disease (CVD) and obesity, utilized OPA as the marker of PA. For example, it was found that London bus conductors, who spent their days walking to collect tickets had much lower incidences of coronary heart disease and "sudden death" than similarly aged bus drivers who spent their days sitting (Morris et al., 1953). Further, research indicates that greater OPA levels promote a healthy weight status (Bonauto et al., 2014; Choi et al., 2010; Church et al., 2011; Steeves et al., 2012).

However, the literature has shown the relationship between OPA and health to be inconsistent. In 2012, a meta-Analyses concluded that OPA had a beneficial impact on cardiovascular health. OPA reduced the risk of coronary heart disease and stroke among men and women (Li & Siegrist, 2012). This study was later updated and the authors found that greater OPA was associated with a slight increase in CVD; they later concluded that the role of OPA in cardiovascular health is not well understood (Li et al., 2013). Other studies conducted in the past decade have identified OPA as a risk factor for cardiovascular events (Holtermann et al., 2010) and heart attack incidence (Krause et al., 2015). Researchers have also found that greater OPA had an unhealthy impact on all-cause mortality (Clays et al., 2013; Coenen et al., 2018) and systolic blood pressure (Clays et al., 2012). The contrasting impact of OPA and LTPA on health has been coined “The PA Health Paradox” (Holtermann et al., 2012). It is important to highlight that many of the studies reporting OPA to be a risk factor for CVD focused on very specific populations such as Danish employees (Holtermann et al., 2012; Holtermann et al., 2009, 2010). Studies conducted in other locations have differed in their findings (Fransson et al., 2003; Johnsen et al., 2016; Probert et al., 2008; Stamatakis et al., 2013). There is a paucity of large U.S. nationally representative studies examining the relationship of OPA and cardiovascular health (Li et al., 2013). Further, many of the research studies identifying OPA as a CVD risk factor were conducted on entirely male samples (Clays et al., 2013; Holtermann et al., 2010; Krause et al., 2015). The literature evaluating men and women separately is inconsistent (Coenen et al., 2018; Fransson et al., 2003; Li & Siegrist, 2012; Stamatakis et al., 2013).

It has been suggested that PA guidelines need to be updated to differentiate between domains of PA because the health benefits of OPA are not the same as those of LTPA (de Souto Barreto, 2015). However, it is important to understand why OPA does not influence health similarly to LTPA. Holtermann, Krause, van der Beek, and Straker (2018) hypothesized that six potential mechanisms explain why OPA does not influence health similar to LTPA: lack of intensity, elevated 24-hour heart rate/ blood pressure, lack of recovery time, lack of worker control, and increased inflammation. Others have argued that the recent influx of articles identifying OPA as a health risk factor is due to methodological issues, such as measurement issues of OPA, and inadequately controlling for smoking status and socioeconomic factors (Shephard, 2019). It is necessary to better understand how OPA impacts health among U.S. citizens and women in order to foster healthier worksites and create policies to protect U.S. employees’ health.

Metabolic syndrome, a cluster of biological risk factors, is particularly relevant as it is highly associated with increased risk for chronic diseases such as CVD (Mottillo et al., 2010). Metabolic syndrome includes the following risk factors: central obesity, elevated blood pressure, dyslipidemia (low high-density lipoprotein cholesterol and elevated triglycerides), and elevated fasting blood glucose (Alberti et al., 2009). Despite research studies identifying a relationship between OPA and CVD, little is known about the relationship of OPA and metabolic syndrome, a precursor to CVD.

Aim 2 of this study is to evaluate the PA Health Paradox by examining the relationship of OPA and CVD risk indicators, specifically metabolic syndrome and its components (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose) among U.S. adults using a nationally representative dataset. *Figure 4* depicts the conceptual model for Aim 2 of this dissertation.

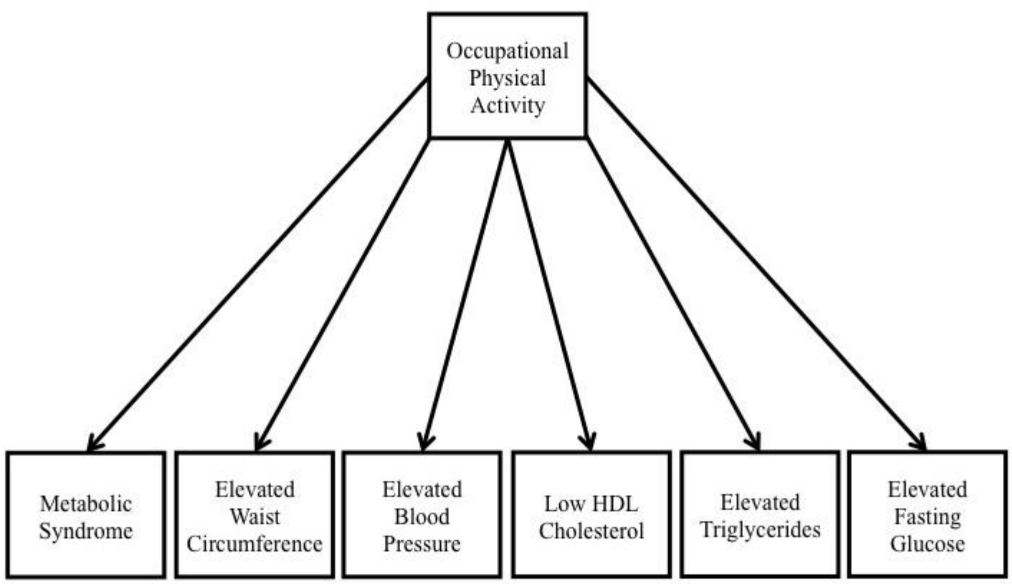


Figure 4. Conceptual Model of Aim 2

Similar to previous studies that have occurred in the past 15 years focused on various health outcomes (Holtermann et al., 2009; Krause, 2010; Krause et al., 2015; Krause et al., 2007; Li et al., 2013), it was expected that OPA would be associated with increased odds of metabolic syndrome and its components (elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose), with the exception of waist circumference. In contrast, it was expected that OPA would be associated with decreased odds of elevated waist circumference, similar to previous studies on OPA and obesity (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010; Steeves et al., 2012). The secondary aim was to evaluate if the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) differed between men and women. Men engage in greater OPA than women (Allender, Foster, & Boxer, 2008; He & Baker, 2005; Scholes & Bann, 2018), and men and women may differ in the type of OPA performed. Further, findings on the relationship between OPA and health have been more consistent among men (Clays et al., 2013; Holtermann et al., 2010; Krause et al., 2015) than women (Coenen et al., 2018; Fransson et al., 2003; Li & Siegrist, 2012; Stamatakis et al., 2013). Therefore, it was expected that the relationships between OPA and CVD risk indicators would be moderated by sex, such that the relationships would be stronger among men than women.

This aim evaluates how a health behavior (OPA) relates to a health outcome (metabolic syndrome). This aim also fits within the context of the Social Determinants of Health (Marmot & Wilkinson, 2005) because “blue collar” vs.“white collar” jobs are considered a marker of social standing, with “blue collar” jobs considered being of lower social standing. “blue collar” jobs involve more OPA, therefore OPA may be a contributor to the social gradient in health where those of lower social standing have poorer health, specifically greater prevalence of CVD risk (metabolic syndrome and its components).

2.7 THE ROLE OF LEISURE TIME PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR IN THE SOCIAL GRADIENT OF HEALTH

The first two aims of the study evaluated relationships between two variables within the Social Determinants of Health Framework (Marmot & Wilkinson, 2005). Aim 1 evaluated the relationship of social status (SES) with a health behavior (non-LTPA). Aim 2 evaluated the relationship of health behavior (OPA) with a health outcome (CVD risk as metabolic syndrome). The final aim of this study was to determine if specific health behaviors explained the social gradient in health by assessing the role of health behaviors in the relationship of social status and health outcomes. Specifically the third aim assessed the role of LTPA and SB in the income-overweight/obesity relationship.

Seventy percent of U.S. adults are considered overweight or obese (Fryar, Carroll, & Ogden, 2016), with obesity being more prevalent among those with low-income (Paeratakul et al., 2002). For example, the prevalence of overweight and obesity is higher among low-income households (74%) [i.e. income 100%-199% of the Federal Poverty Line (FPL)] compared to those whose household income is 400% FPL or greater (66%) (National Center for Health Statistics, 2015). The health consequences associated with overweight/obesity include arthritis, diabetes, hypertension, and high cholesterol (Mokdad et al., 2003). Subsequently, obesity and its comorbidities are associated with the staggering cost of health care in the United States (Finkelstein, Trogdon, Cohen, & Dietz, 2009). Obesity prevention programs are designed to target lifestyle behaviors that are modifiable, regardless of an individual's income bracket. The health consequences associated with overweight and obesity make it important to understand how modifiable lifestyle behaviors, such as LTPA and SB, are related to the income-overweight/obesity relationship.

PA is an important behavior for obesity prevention (King et al., 2001; Wanner et al., 2016). However, disparities exist with those of low-income engaging in less LTPA (Elhakeem et al., 2015; Ford et al., 1991). Only 41% of adults with an income below $15,000 met the PA guidelines from LTPA compared to 59% of adults with an income of $75,000 or greater (Centers for Disease Control and Prevention). PA is known to positively impact health, with adequate levels of PA associated with decreased risk of obesity and chronic disease (U.S. Department of Health and Human Services, 1996). LTPA in particular is protective against obesity (King et al., 2001), even when controlling for energy intake (Wanner et al., 2016). In general, there appears to be a linear relationship with body mass index (BMI) and LTPA, such that those with higher BMIs engage in less LTPA (Chen & Mao, 2006).

Another modifiable lifestyle behavior associated with overweight/obese weight status is time spent sedentary. In contrast to LTPA, time spent in SB is positively associated with overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). Specific guidelines for SB time do not exist, but individuals are encouraged to minimize sedentary time (American College of Sports Medicine, 2017). The relationship between income and SB time is less clear than the relationship of income and PA. Overall it appears that greater income is related to greater total time spent in SB. For example, Kozo et al. (2012) found that residents of higher income neighborhoods spent more objectively measured time in SB than those living in lower income neighborhoods. However the relationship between income and SB differs when evaluating *specific types* of SB (e.g.

television watching vs. occupational sitting) (O'Donoghue et al., 2016). SB is known to have health consequences (all-cause mortality, cardiovascular disease, cancer, type 2 diabetes incidence) independent of PA (Biswas et al., 2015).

Research has focused on how income, LTPA, and SB relate to weight status independently, but there is a lack of research evaluating LTPA and SB simultaneously within the income-overweight/obesity relationship. Because LTPA and SB are known to be inversely related to one another (O'Donoghue et al., 2016), it is important to understand their roles in the income-overweight/obesity relationship simultaneously.

Given that income-related overweight/obesity disparities exist, and LTPA and SB are related to both income and weight status, it is possible that these behaviors play an important role in the income-overweight/obesity relationship. The purpose of the third aim was to understand the modifiable lifestyle behavior mechanisms by which income influences overweight/obesity. Specifically, this study evaluated the role of LTPA and SB simultaneously controlling for the influence of each other in the income-overweight/obesity relationship. *Figure 5* contains the hypothesized model for Aim 3 of this dissertation.

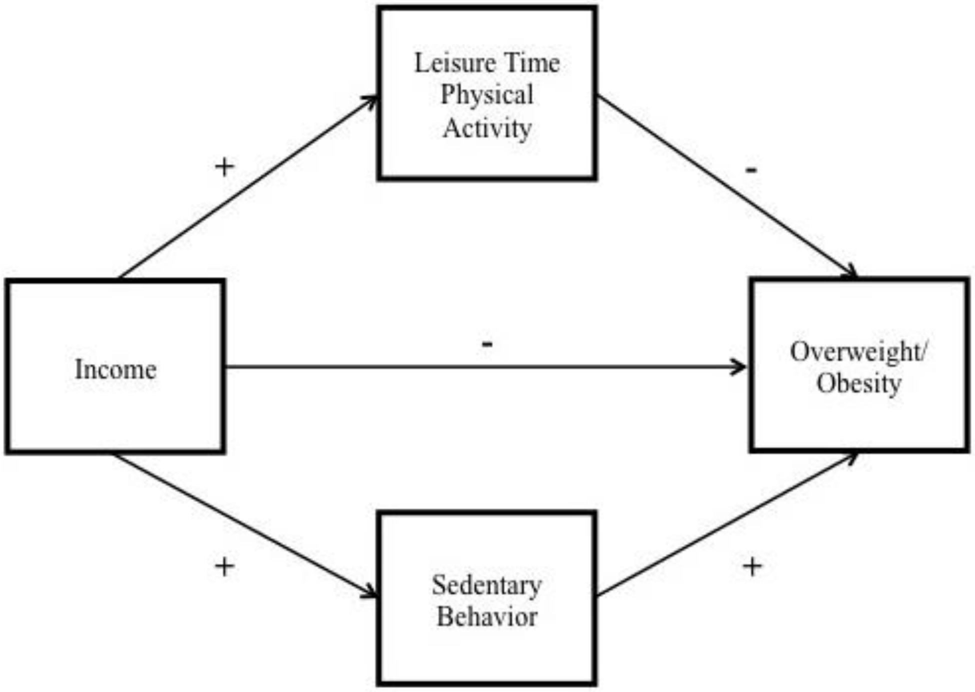


Figure 5. Hypothesized Model of Aim 3

This study evaluated the indirect effect of income on overweight/obesity through LTPA, controlling for SB. Building on prior literature, it was expected that higher income would be positively related to LTPA (Elhakeem et al., 2015; Ford et al., 1991), and LTPA would be negatively related to overweight/obesity (Chen & Mao, 2006; King et al., 2001; Wanner et al., 2016). It was further hypothesized that there would be a negative indirect effect from income to overweight/obesity through LTPA, which would partially account for the overall negative association between income and overweight/obesity. The second aim was to evaluate the indirect effect of SB on the income-overweight/obesity relationship, controlling for LTPA. Also building on prior literature it was expected that higher income would be positively related to SB (Kozo et al., 2012) and SB would be positively related to overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). It was further hypothesized that there would be a positive indirect effect from income to overweight/obesity through SB, working in the opposite direction of LTPA and the overall negative association between income and overweight/obesity. Although it was expected that there would be significant indirect effects through LTPA and SB, it was also expected that there would still be a significant direct effect from income to overweight/obesity (Paeratakul et al., 2002) because of the complex multifaceted nature of this relationship.

2.8 SUMMARY

The intention of this literature review was to provide the reader with a detailed summary of the current knowledge on the inter-relationships of SES, PA, and health, a critical topic for understanding, preventing, and reducing health disparities. All sections and literature were included in order for the reader to comprehend the background, significance, and underlying mechanisms for the proposed methodology of this research. The next chapter (Chapter 3, Methodology) will explain the procedures and methods of the proposed research, which was designed to fulfill the following three aims: 1) examine the relationship between three SES indicators: education, income, and employment status with non-LTPA, 2) evaluate the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose), 3) assess the role of LTPA and SB in the income-overweight/obesity relationship.

The following outcomes were anticipated: Aim 1: It was expected that educational attainment would be negatively associated with non-LTPA, such that those with lower educational attainment would be at increased odds meeting the PA guidelines from non-LTPA (Kandula & Lauderdale, 2005; Leschied et al., 2005). It was expected that income would be negatively related to non-LTPA, such that those with lower income would be at increased odds of meeting the PA guidelines from non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005). It was expected that those who were unemployed would be at decreased odds and those employed part-time would be at increased odds of meeting the PA guidelines from non-LTPA, compared to those with full-time employment (Steeves et al., 2015; Valletta et al., 2020). When evaluated simultaneously, it was expected that education, income, and employment status would remain related to meeting the PA guidelines from non-LTPA in the expected directions. However, relationships would be attenuated. Aim 2: Similar to previous studies that have occurred in the past 15 years focused on various health outcomes (Holtermann et al., 2009; Krause, 2010; Krause et al., 2015; Krause et al., 2007; Li et al., 2013), it was expected that OPA would be associated with increased odds of metabolic syndrome and its components (elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose). It was expected that OPA would be associated with decreased odds of elevated waist circumference, similar to previous studies on OPA and obesity (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010; Steeves et al., 2012). It was expected that the relationships between OPA and CVD risk indicators would be moderated by sex, such that the relationships would be stronger among men than women. Aim 3: It was hypothesized that there would be a negative indirect effect from income to overweight/obesity through LTPA, which would partially account for the overall negative association between income and overweight/obesity. It was further hypothesized that there would be a positive indirect effect from income to overweight/obesity through SB, working in the opposite direction of LTPA and the overall negative association between income and overweight/obesity.

CHAPTER 3

3. METHODOLOGY

3.1 DATASET

This study utilized publicly available data from The National Health and Nutrition Examination Survey (NHANES). The NHANES is a cross-sectional study, which combines surveys, examinations, and lab measures to assess health and nutrition in the United States population. NHANES uses a complex, multistage stratified probability cluster sample design to obtain a nationally representative sample of the non-institutionalized U.S. civilian population (Johnson, Dohrmann, Burt, & Mohadjer, 2014a). The present study examined participants from four NHANES waves (2007– 2014). These cycles contain consistent measures of PA variables and yielded a total of 40,617 adults and children. The initial sample was reduced to a non-pregnant, non-older adult sample (ages 20 and over) (n= 15,376). Further, the analytical sample only included individuals who met the criteria and without missing data on the variables of interest for each aim (Aim 1: n=11,985, Aim 2: n= 3,253, Aim 3: n =10,348). The University of Houston's IRB has approved this study.

3.2 MEASURES

3.2.1 PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR VARIABLES

All PA and SB measures were self-reported through surveys.

Leisure Time Physical Activity. Participants were given the following instructions prior to questions regarding LTPA, "The next questions exclude the work and transportation activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities." Then participants were asked, "Do you do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 minutes continuously?” Participants who responded “no” were considered to engage on 0 minutes of vigorous intensity LTPA (VLTPA); participants who responded “yes” were asked additional questions about their VLTPA, such as “In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational activities?” Response options varied from 1-7 days. Next participants were asked, “How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?” Responses were recorded in minutes with values ranging from 10 to 960 minutes. Total weekly VLTPA was calculated by multiplying days per week of VLTPA engagement by minutes of VLTPA engagement.

Participants were asked, “Do you do any moderate-intensity sports, fitness, or recreational activities that cause a small increase in breathing or heart rate such as brisk walking, bicycling, swimming, or golf for at least 10 minutes continuously?” Participants who responded “no” were considered to engage on 0 minutes of moderate intensity LTPA (MLTPA); participants who responded “yes” were asked additional questions about their MLTPA, such as “In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational activities?” Response options varied from 1-7 days. Next participants were asked, “How much time do you spend doing moderate-intensity sports, fitness or recreational activities on a typical day?” Responses were recorded in minutes with values ranging from 10 to 720 minutes. Total weekly MLTPA was calculated by multiplying days per week of MLTPA engagement by minutes of MLTPA engagement.

In order to calculate an equivalent combination of moderate and vigorous-intensity LTPA (MVLTPA), minutes of vigorous-intensity activity were assigned twice the weight of moderate-intensity activity minutes as suggested by the 2018 PA Guidelines for Americans

(U.S. Department of Health and Human Services, 2018). This value was divided by sixty to provide an assessment of average weekly hours of LTPA engagement.

Transportation Physical Activity. Participants were given the following instructions prior to questions regarding transportation TPA, "The next questions exclude the PA of work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to school." Then they were asked, "Do you walk or use a bicycle for at least 10 minutes continuously to get to and from places?". Participants who responded "yes" were asked additional questions about their TPA; participants who responded "no" were considered to engage on 0 minutes of TPA. Those who responded "yes" to the previous question were asked, "In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?" Response options varied from 1-7 days. Next participants were asked, "How much time do you spend walking or bicycling for travel on a typical day?" Responses were recorded in minutes with values ranging from 10 to 600 minutes. Total weekly TPA was calculated by multiplying days per week of TPA engagement by minutes of TPA engagement. This value was divided by sixty to provide an assessment of average weekly hours of TPA engagement.

Occupational/ Household Physical Activity. Participants were given the following instructions prior to questions regarding occupational OPA, "Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, studying or training, household chores, and yard work. In answering the following questions, 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, and 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate".

Then participants were asked, "Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like carrying or lifting heavy loads, digging or construction work for at least 10 minutes continuously?" Participants who responded "no" were considered to engage on 0 minutes of vigorous intensity OPA (VOPA); participants who responded "yes" were asked additional questions about their VOPA, such as "In a typical week, on how many days do you do vigorous-intensity activities as part of your work?" Response options varied from 1-7 days. Next participants were asked, "How much time do you spend doing vigorous-intensity activities at work on a typical day?" Responses were recorded in minutes with values ranging from 10 to 960 minutes. Total weekly VOPA was calculated by multiplying days per week of VOPA engagement by minutes of VOPA engagement.

Participants were asked, "Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking or carrying light loads for at least 10 minutes continuously?" Participants who responded "no" were considered to engage on 0 minutes of moderate intensity OPA (MOPA); participants who responded "yes" were asked additional questions about their MOPA, such as "In a typical week, on how many days do you do moderate-intensity activities as part of your work?" Response options varied from 1-7 days. Next participants were asked, "How much time do you spend doing moderate-intensity activities at work on a typical day?" Responses were recorded in minutes with values ranging from 10 to 1440 minutes. Total weekly MOPA was calculated by multiplying days per week of MOPA engagement by minutes of MOPA engagement.

In order to calculate an equivalent combination of moderate and vigorous-intensity OPA (MVOPA), minutes of vigorous-intensity activity were assigned twice the weight of moderate-intensity activity minutes as suggested by the 2018 PA Guidelines for Americans (U.S. Department of Health and Human Services, 2018). This value was divided by sixty to provide an assessment of average weekly hours of OPA engagement.

Non-Leisure Time Physical Activity was calculated by combining OPA with TPA to create a variable, which included all domains of PA.

Sedentary Behavior was measured in average hours per day. It was assessed with the following question, "The following question is about sitting or reclining at work, at home, or at school. Include time spent sitting at a desk, sitting with friends, traveling in a car, bus, or train, reading, playing cards, watching television, or using a computer. Do not include time spent sleeping. How much time do you usually spend sitting or reclining on a typical day? Hours per day spent sedentary was utilized in analyses.

3.2.2 HEALTH INDICATOR VARIABLES

Weight status, waist circumference, and blood pressure were measured through an examination in the NHANES Mobile Examination Centers (MEC) (CDC/National Center for Health Statistics, 2011).

Weight Status was directly assessed with Body Mass Index (BMI) criteria. BMI was calculated as weight in kilograms divided by height in meters squared, and then rounded to one decimal place. BMI was used to classify participants as underweight (< 18.5), normal weight (18.5 – 24.9), overweight (25-29.9) and obese (≥ 30) based on standards published by the CDC (Centers for Disease Control and Prevention, 2015). Those classified as overweight or obese were considered to have elevated weight status and the comparison group was normal weight. Adults who were underweight were excluded from the outcome variable.

Waist Circumference was measured by a trained health technician. Women who had a measured waist circumference greater than 88 cm and men who had a measured waist circumference greater than 102 cm were classified as having an elevated waist circumference.

Blood Pressure was measured by NHANES blood pressure examiners after participants sat quietly for five minutes. Three consecutive readings were conducted; a fourth measure was conducted if one of the initial three readings were interrupted or incomplete. An average blood pressure was calculated and used for classification. Participants were considered to have elevated blood pressure if their averaged values were out of the healthy range (systolic ≥130 mm Hg, or diastolic ≥85 mm Hg, or both).

The following health indicators are laboratory measures that were also collected in the NHANES MEC:

Fasting Blood Glucose was measured using the Hexokinase-mediated reaction Roche/Hitachi Modular P Chemistry Analyzer in the morning. Participants were considered to have elevated fasting blood glucose if their measured level was ≥100 mg/dL (Alberti et al., 2009). This measure was only collected on a portion of the sample; fasting blood glucose was not assessed on those who completed laboratory measures in the afternoon.

Triglycerides were measured in serum using Roche Modular P chemistry analyzer in the morning while fasted. Participants were classified as having elevated triglycerides if their measured value was ≥150 mg/dL (Alberti et al., 2009). This measure was only collected on a portion of the sample; triglycerides were not assessed on those who completed laboratory measures in the afternoon.

High Density Lipoprotein Cholesterol (HDL) was measured in refrigerated serum using the Beckman Synchron LX20 method. Participants were considered to have low HDL cholesterol if their measured value was <40 mg/dL for men and <50 mg/dL for women (Alberti et al., 2009).

Metabolic Syndrome is a cluster of risk factors associated with increased risk of multiple chronic diseases, including cardiovascular disease (Alberti et al., 2009). Similar to previous studies evaluating metabolic syndrome with NHANES data (Moore, Chaudhary, & Akinyemiju, 2017), participants who had three or more of the following risk factors were considered to have metabolic syndrome: elevated waist circumference, elevated triglycerides, low HDL cholesterol, elevated blood pressure, and elevated fasting blood glucose. Fasting glucose and triglycerides were only assessed on those whose laboratory measures were taken in the morning; therefore, metabolic syndrome was only calculated for those with morning laboratory measures.

3.2.3 SOCIO-DEMOGRAPHIC VARIABLES

All socio-demographic variables were self-reported through a survey.

Age was recorded in years. NHANES top coded age at 80 years so all participants age 80 and above have an age value of 80 years.

Sex was recorded as female or male (comparison group).

Race/Ethnicity was indicated as: Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, or other. Those who identified as Mexican-American and other

Hispanic were combined to form one Hispanic group. White was the comparison group in all analyses.

Foreign Birth Status was assessed when participants identified their country of birth from the following categories: United States/ Washington, DC, Mexico, other Spanish speaking country, other non-Spanish speaking country. Those not born in the United States/ Washington, DC were categorized as "Foreign Born"; those born in the United States/ Washington, DC were categorized as "native" (reference group).

Marital Status was assessed with a single item**.** Participants indicated whether they were: married, widowed, divorced, separated, never married, or living with a partner. Similar to previous studies, those who were married or living with a partner were classified as "married/cohabitating"; those who were widowed, divorced, separated, or never married were classified as "single".

Education. Participants indicated their highest level of education obtainment: less than 9th grade, 9th -11th grade, high school graduate or GED, some college or associate's degree, college graduate or above. Less than 9th grade and 9th-11th grade responses were collapsed to form a single group called "less than high school education". High school graduate or GED, and some college or associate's degree were also collapsed to form a single group called "high school diploma". College graduate or above was the reference group in all models.

Employment Status was assessed with the following question, "Which of the following were you doing last week?". Response options included: "working at a job or business", "with a job or business, but not at work", "looking for work", or "not working at a job or business”. Those who selected “working at a job or business” were classified as employed (reference); all other options were collapsed as unemployed.

Health Insurance status was assessed with the following question, “Are you covered by health insurance or some other kind of health care plan? Include health insurance obtained through employment or purchased directly as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills.” Participants who responded “no” were considered uninsured. Participants who responded yes indicated whether they were covered by the following options: private insurance, Medicare, Medicaid, military health care, Indian Health Service, state sponsored health plan, or other government insurance. These responses were collapsed to indicate whether the participant had public or private health insurance. Models included the following health insurance categories: uninsured, public health insurance, private health insurance (reference).

Federal Poverty Level (FPL) was self-reported using annual household income and number of individuals residing in the household. Using this information, NHANES calculated the income to poverty ratio.

Diet was assessed by two 24-hour dietary recall interviews. The first interview was conducted in-person in the Mobile Examination Center (MEC); the second interview was conducted by telephone 3 to 10 days later (Ahluwalia, Dwyer, Terry, Moshfegh, & Johnson, 2016). Information collected during these recalls was used to calculate a Healthy Eating Index (HEI) score, a measure of diet quality that reflects how well an individual adheres to the dietary guidelines. The following dietary components are used to calculate an individual’s HEI score: total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, protein, seafood and plant protein, fatty acids, refined grains, sodium, added sugars, and saturated fats. Potential scores ranged from 0 to 100, with higher scores indicating greater adherence to the dietary guidelines (Schap, Kuczynski, & Hiza, 2017).

Smoking Status. Participants were classified as smokers by their responses to two survey items. In order to be classified as a smoker, participants had to respond affirmatively to the following question, “Have you smoked at least 100 cigarettes in your entire life”. Those who responded negatively were classified as non-smokers. Those who responded affirmatively were asked “Do you now smoke cigarettes”. Those who responded, “every day” or “some days” were classified as smokers; those who responded “not at all” were classified as non-smokers.

Alcohol Consumption. An average number of drinks per day was calculated for each participant. Those who responded negatively to the following two questions were considered to have an average of 0 drinks per day: “The next questions are about drinking alcoholic beverages. Included are liquor (such as whiskey or gin), beer, wine, wine coolers, and any other type of alcoholic beverage. In any one year, have you had at least 12 drinks of any type of alcoholic beverage? By a drink, I mean a 12 oz. beer, a 5 oz. glass of wine, or one and half ounces of liquor.”, “In your entire life, have you had at least 12 drinks of any type of alcoholic beverage?”. Those who did not respond negatively to the previous two items were asked additional questions regarding their alcohol consumption. Participants reported their drinking frequency, “In the past 12 months, how often did drink any type of alcoholic beverage?” they responded with a range of values as per week, month, or year. Participants were asked, “In the past 12 months, on those days that you drank alcoholic beverages, on the average, how many drinks did you have?”. The number of drinks a participant reported was multiplied by their drinking frequency. This number was divided by the appropriate unit (year: 365, month: 30, week: 7) to calculate an average number of drinks per day.

Table 1. Variables of Interest for Each Aim: National Health and Nutrition Examination Survey 2007-2014

	Aim 1	**Aim 2**	**Aim 3**
Independent Variable	*The following were self-reported:*	Occupational Physical Activity (*hours/ week; self-reported*)	*Self-reported measures in minutes:*
	Education *(less than high school, high school diploma, college degree or greater)*		Income *(Federal Poverty Level)*
	Income *(Federal Poverty Level)*		**Mediating Variables**
	Employment Status *(categorized as: unemployed, employed part-time, employed full-time)*	Sex (self-reported)	Leisure Time Physical Activity *(hours/ week)*
			Sedentary Behavior *(hours/ day)*
Dependent Variable	Non-Leisure Time Physical Activity *(weekly hours; self-reported)*	*The following were collected either through direct assessment or laboratory measures:*	Overweight/obese Weight Status (*directly assessed body mass index ≥ 25*)
		Metabolic Syndrome	
		Elevated Waist Circumference	
		Elevated Blood Pressure	
		Low High Density Lipoprotein Cholesterol	
		Elevated Triglycerides	
		Elevated Fasting Glucose	
Control Variables (*All control variables are self-reported.*)	Age	Age	Age
	Sex	Race/ Ethnicity	Sex
	Race/ Ethnicity	Foreign Birth	Race/ Ethnicity
	Foreign Birth	Marital Status	Foreign Birth
	Marital Status	Education	Marital Status
	Weight Status	Income	Education
		Health Insurance	Employment
		Leisure Time Physical Activity	Health Insurance
		Sedentary Behavior	Diet (Healthy Eating Index Score)
		Diet (Healthy Eating Index Score)	Smoking Status
		Weight Status[a]	Alcohol Consumption
		Smoking Status	Sleep
		Alcohol Consumption	

[a]Not included as a covariate when waist circumference was the dependent variable.

3.3 METHODOLOGY FOR RESEARCH AIM 1

Aim 1: Examine the relationship between three SES indicators: education, income, and employment status with non-LTPA.

Research Question 1.1: Are education, income and employment status related to meeting the PA guidelines from non-LTPA engagement?

3.3.1 SAMPLE SELECTION FOR RESEARCH AIM 1

The initial sample was reduced to a non-pregnant, non-older adult sample (aged 20-59 years) (n= 15,376). Age 20 was selected because weight status assessments for adults begin at age 20. Age 59 was selected as the cut-off because the Administration on Aging refers to individuals over the age of 60 as older adults, who may have behavioral and physiological differences from their younger counterparts (Adminstration for Community Living, 2015). Additionally, those with PA values deemed unrealistic (values > 3 standard deviations above the mean; approximately 40 hours per week of OPA and 16 hours per week of TPA) were eliminated from analyses (n = 966). Finally, individuals with missing data on non-LTPA (n=808), education (n= 8), income (n=1,145), employment (n = 6), and control variables (n=458) were eliminated from analyses. The final analytical sample included 11,985 U.S. adults.

A lower proportion of those in the analytical sample were sufficiently active from non-LTPA compared to those excluded due to missing data ($p < .001$). Overall, the analytical sample was more advantaged than those who were excluded due to missing data. The analytical sample was more educated; a lower proportion of the analytical sample had less than a high school degree ($p < .001$), a greater proportion of the analytical sample had a high school degree ($p < .001$), or a college degree ($p < .001$), compared to those excluded due to missing data. The analytical sample had higher income ($p < .001$), but a greater proportion of the analytical sample was unemployed ($p < .05$) and a lower proportion of the analytical sample was employed full-time ($p <.01$), compared to those excluded due to missing data. The analytical sample was older ($p < .001$); a greater percentage of the analytical sample was female, and white ($p < .001$), whereas a lower percentage was Hispanic ($p < .001$), or black ($p < .05$); a lower proportion of the analytical sample was born outside the United States ($p < .001$), in comparison to those excluded due to missing data. A greater proportion had private health insurance ($p < .001$), and a lower proportion were ($p < .001$), uninsured compared to those excluded due to missing data.

The following underlying assumptions of regression are discussed: normality, linearity, homogeneity of variance, and multicollinearity. According to the *central limit theorem*, in large samples parameter estimates are drawn from normally distributed data; therefore, the shape of the data does not impact significance tests. Because the analytical sample included almost 12,000 adults, and the sample was designed to be representative of the population of interest, the data meets the assumption of normality. There is some concern regarding linearity because the interaction term between the predictor and its log transformation was significantly related to the dependent variable for some of the independent variables. However, because the variables of interest have been widely used and are well accepted it was decided to proceed with the analyses. Levene's tests indicated that the assumption of homogeneity of variance was violated ($p < .05$); however, this may be due to the extremely large sample size. The variance ratios were quite small (<1.07). All tolerance values were greater than .1 and all VIF values were below 10, indicating there was not a biasing effect of collinearity; the assumption of multicollinearity was met.

3.3.2 DATA ANALYSES FOR RESEARCH AIM 1

Means and standard errors or frequencies of participant characteristics were computed. Four logistic regression models were conducted to evaluate the association of SES indicators independently: education (model 1), income (model 2), employment status (model 3), and simultaneously (model 4) on meeting the PA guidelines from non-LTPA. Unstandardized model results are presented as OR (SE). Additionally, four linear regression models were conducted to evaluate the association of SES indicators independently: education (model 1), income (model 2), employment status (model 3), and simultaneously (model 4) with non-LTPA measured continuously. All models controlled for age, sex, race/ethnicity, foreign birth, marital status, health insurance, and weight status. Descriptive statistics and logistic regression models were conducted using STATA version 15.0 statistical software (StataCorp LP, College Station, Texas). Survey procedures (ie, “svy” command) were used to account for the NHANES sampling design.

3.3.3 EXPECTED FINDINGS FOR RESEARCH AIM 1

It was expected that income would be negatively related to non-LTPA, such that those with lower income would be at increased odds of meeting the PA guidelines from non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005). It was also expected that educational attainment would be negatively associated with non-LTPA, such that those with lower educational attainment would be at increased odds meeting the PA guidelines from non-LTPA (Kandula & Lauderdale, 2005; Leschied et al., 2005). Finally, it was expected that those who were unemployed would be at decreased odds and those employed part-time would be at increased odds of meeting the PA guidelines from non-LTPA, compared to those with full-time employment (Steeves et al., 2015; Valletta et al., 2020).

3.4 METHODOLOGY FOR RESEARCH AIM 2

Aim 2: Evaluate the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose).

Research Question 2.1: Is OPA related to metabolic syndrome and its components among U.S. adults?

Research Question 2.2: Does the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) differ between men and women?

3.4.1 SAMPLE SELECTION FOR RESEARCH AIM 2

The initial sample was reduced to a non-pregnant, non-older adult sample (aged 20-59 years) (n= 15,376). Age 20 was selected because weight status assessments for adults begin at age 20. Age 59 was selected as the cut-off because the Administration on Aging refers to individuals over the age of 60 as older adults, who may have behavioral and physiological differences from their younger counterparts (Adminstration for Community Living, 2015). The primary variable of interest of this study is OPA and by definition, only those employed engage in OPA. Therefore, 2,194 unemployed individuals were excluded from the analytical sample (n = 13,182). Finally, only those with complete data on all target variables were included in the final analytical sample. Fasting glucose and triglycerides were only assessed on those whose laboratory measures were taken in the morning; for this reason, 8,524 individuals who were assessed in the afternoon were eliminated from the analytical sample (n=4,658).

Individuals with missing data on the following variables were excluded: waist circumference (n=117), blood pressure (n=164), glucose (n=7), triglycerides (n=5), HDL cholesterol (n=28), OPA (n=266), and control variables (n= 912). The final analytical sample consisted of 3,159 adults.

Overall, the analytical sample was healthier than those excluded due to missing data; a lower proportion of those in the analytical sample had metabolic syndrome ($p < .001$) and each of its components: elevated waist circumferences ($p < .001$), elevated blood pressure ($p < .001$), low HDL cholesterol ($p < .001$) elevated triglycerides ($p < .001$), and elevated glucose ($p < .001$).The analytical sample engaged in greater OPA than those excluded due to missing data ($p < .001$). The analytical sample was younger ($p < .001$); a greater percentage of the analytical sample was white ($p < .001$), whereas a lower percentage was Hispanic ($p < .01$), or a race other than black, white or Hispanic ($p < .05$); a greater proportion of the analytical sample was born outside the United States ($p < .001$), in comparison to those excluded due to missing data. A greater percentage of the analytical sample was married/cohabitating ($p < .01$). Overall, the analytical sample was more advantaged than those who were excluded due to missing data. The analytical sample was more educated; a lower proportion of the analytical sample had less than a high school degree ($p < .001$), or a high school degree ($p < .001$); a greater proportion of the analytical sample attended some college/ had an Associate’s degree ($p < .001$), or a college degree ($p < .001$). The analytical sample had higher income ($p < .001$), and a greater proportion had health insurance ($p < .001$), compared to those excluded due to missing data. The analytical sample had higher HEI scores ($p < .01$), and a lower proportion was classified as a smoker ($p < .001$), compared to those excluded due to missing data. Finally, the analytical sample engaged in greater LTPA

($p < .001$), but also spent more time in SB ($p < .001$) on average, compared to those excluded due to missing data.

The following underlying assumptions of regression are discussed: normality, linearity, homogeneity of variance, and multicollinearity. According to the *central limit theorem*, in large samples parameter estimates are drawn from normally distributed data; therefore, the shape of the data does not impact significance tests. Because the analytical sample included over 3,000 adults, and the sample was designed to be representative of the population of interest, the data meets the assumption of normality. There is some concern regarding linearity because the interaction term between the predictor (OPA) and its log transformation was significantly related to the dependent variable for some of the independent variables. However, because the variables of interest are established in the literature it was decided to proceed with the analyses. Levene's tests indicated that the assumption of homogeneity of variance was violated ($p < .05$); however, this may be due to the large sample size. The variance ratios were all acceptable (<1.60). All tolerance values were greater than .1 and all VIF values were below 10, indicating there was not a biasing effect of collinearity; the assumption of multicollinearity was met. There was also some concern regarding incomplete information from the predictors due to the large number of control variables. It is likely that some combinations of variables do not include any participants. However, standard errors were small, indicating that this is not problematic. It was decided to keep all covariates in the model because eliminating covariates known to be related to both the independent variable (OPA) and the dependent variables (metabolic syndrome and its components) in would result in confounding

3.4.2 DATA ANALYSES FOR RESEARCH AIM 2

Means, frequencies and standard errors of participant characteristics were computed for the total sample and separately for women and men. Logistic regression models were conducted to evaluate the association of OPA and metabolic syndrome/the components of metabolic syndrome (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose) among U.S. adults. All models controlled for age, sex, race/ethnicity, nativity, marital status, education, income, hours worked, health insurance, weight status (when not the outcome of interest), Healthy Eating Index, alcohol consumption, smoking status, LTPA, and SB. The models were repeated with the inclusion of an interaction term (sex* OPA) to determine if the relationship on OPA with metabolic syndrome and its components differed between men and women. Analyses were conducted using STATA version 15.0 statistical software (StataCorp LP, College Station, Texas). Survey procedures were used to account for the NHANES sampling design.

3.4.3 EXPECTED FINDINGS FOR RESEARCH AIM 2

Similar to previous studies that have occurred in the past 15 years focused on various health outcomes (Holtermann et al., 2009; Krause, 2010; Krause et al., 2015; Krause et al., 2007; Li et al., 2013), it was expected that OPA would be associated with increased odds of metabolic syndrome and its components (elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose), with the exception of waist circumference. In contrast, it was expected that OPA would be associated with decreased odds of elevated waist circumference, similar to previous studies on OPA and obesity (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010; Steeves et al., 2012). The secondary aim was to evaluate if the relationship of OPA and CVD risk indicators (e.g.

metabolic syndrome and its components) differed between men and women. Men engage in greater OPA than women (Allender et al., 2008; He & Baker, 2005; Scholes & Bann, 2018), and men and women may differ in the type of OPA performed. Further, findings on the relationship between OPA and health have been more consistent among men (Clays et al., 2013; Holtermann et al., 2010; Krause et al., 2015) than women (Coenen et al., 2018; Fransson et al., 2003; Li & Siegrist, 2012; Stamatakis et al., 2013). Therefore, it was expected that the relationships between OPA and CVD risk indicators would be moderated by sex, such that the relationships would be stronger among men than women.

3.5 METHODOLOGY FOR RESEARCH AIM 3

Aim 3: Assess the role of LTPA and SB in the income-overweight/obesity relationship.

Research Question 3.1: What is the role of LTPA in the income-overweight/obesity relationship?

Research Question 3.2: What is the role of SB in the income-overweight/obesity relationship?

3.5.1 SAMPLE SELECTION FOR RESEARCH AIM 3

The initial sample was reduced to a non-pregnant, non-older adult sample (aged 20-59 years) (n= 15,376). Age 20 was selected because weight status assessments for adults begin at age 20. Age 59 was selected as the cut-off because the Administration on Aging refers to individuals over the age of 60 as older adults, who may have behavioral and physiological differences from their younger counterparts (Adminstration for Community Living, 2015). Those with PA values deemed unrealistic (values > 3 standard deviations above the mean; approximately 25 hours per week) were eliminated from analyses (n = 226).

Additionally, due to small sample size those with a BMI value categorized as underweight (BMI < 18.5, underweight category) were excluded from the analytical sample (n= 261). Finally, only those with complete data on all target variables were included in the analytical sample. Individuals with missing data on the following variables were excluded: body mass index (n= 609), income (n = 1,193), LTPA (n = 14), SB (n =27), and control variables (n= 2,698). The final analytical sample consisted of 10,348 adults.

Differences were present between the analytical sample and those excluded due to missing data. A lower proportion of those in the analytical sample were classified as overweight/obese, compared to those excluded due to missing data ($p < .05$). The analytical sample spent a greater amount of time in LTPA ($p < .001$), but also a greater amount of time in SB ($p < .001$), compared to those excluded due to missing data. Overall, the analytical sample was more advantaged than those who were excluded due to missing data. The analytical sample was more educated; a lower proportion of the analytical sample had less than a high school degree ($p < .001$), a greater proportion of the analytical sample had a high school degree ($p < .001$), or a college degree ($p < .001$), compared to those excluded due to missing data. The analytical sample had higher income ($p < .001$), and a lower proportion of the analytical sample was unemployed ($p < .05$), compared to those excluded due to missing data.

The analytical sample was younger ($p < .001$), and white ($p < .001$), whereas a lower percentage was Hispanic ($p < .001$), black ($p < .05$), or another race ($p <.001$); a lower proportion of the analytical sample was born outside the United States ($p < .001$), in comparison to those excluded due to missing data. A greater proportion had private health insurance ($p < .001$), and a lower proportion had public health insurance ($p < .001$), or were uninsured ($p < .001$), compared to those excluded due to missing data. A lower proportion of the analytical sample was classified as a smoker ($p < .001$).

Data were not screened to ensure that assumptions were met because it was not necessary with the utilized methodology. The distribution of LTPA and SB is known to not follow a normal distribution curve; data is highly skewed, as expected. Further, the distribution of the indirect effects in structural equation modeling is known to be non-normal even when the variables of interest do follow a normal distribution. For these reasons, this study utilized 95% bootstrapping with 5,000 resamples, a method that is robust to the violation of assumptions and outliers.

3.5.2 DATA ANALYSES FOR RESEARCH AIM 3

Means, frequencies and standard errors of participant characteristics were computed for the full sample and by BMI category (overweight/obese vs. normal). Independent samples t-tests and chi-square analyses were used to determine differences by BMI category. Descriptive statistics, independent samples t-tests and chi-square analyses were conducted using Stata SE version 15.0 statistical software (College Station, TX). To test whether LTPA and SB time contributed uniquely to the relationship of income and overweight/obesity in combination with each other, a multiple mediator structural equation model was conducted. Standardized estimates are presented with 95% bootstrapped confidence intervals (5,000 resamples). Structural equation models were conducted in Mplus version 8.3 (Muthen & Muthen, Los Angeles, CA). Survey procedures were used to account for the complex NHANES sampling design.

3.5.3 EXPECTED FINDINGS FOR RESEARCH AIM 3

Building on prior literature, it was expected that higher income would be positively related to LTPA (Elhakeem et al., 2015; Ford et al., 1991) and LTPA would be negatively related to overweight/obesity (Chen & Mao, 2006; King et al., 2001; Wanner et al., 2016). It was further hypothesized that there would be a negative indirect effect from income to overweight/obesity through LTPA, which would partially account for the overall negative association between income and overweight/obesity. The second aim was to evaluate the indirect effect of SB on the income-overweight/obesity relationship, controlling for LTPA. Also building on prior literature it was expected that higher income would be positively related to SB (Kozo et al., 2012) and SB would be positively related to overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). It was further hypothesized that there would be a positive indirect effect from income to overweight/obesity through SB, working in the opposite direction of LTPA and the overall negative association between income and overweight/obesity. Although it was expected that there would be significant indirect effects through LTPA and SB, it was also expected that there would still be a significant direct effect from income to overweight/obesity (Paeratakul et al., 2002) because of the complex multifaceted nature of this relationship.

3.6 POTENTIAL CONTRIBUTIONS

According to the Social Determinants of Health (Marmot & Wilkinson, 2005), social factors such as socioeconomic status (SES) impact the health of individuals. Those of higher SES have decreased prevalence of overweight/obesity and CVD; they engage in more LTPA, and more SB, but less non-LTPA, compared to those of lower SES. Adequate levels of PA are associated with decreased risk and SB is associated with increased risk of chronic disease and overweight/obesity. Differences in PA behaviors may be related to SES differences in

CVD risk and overweight/obesity. Overall, the purpose of this study was to better understand the inter-relationship of SES, PA, and health (including CVD risk factors and overweight/obesity) among a nationally representative sample of U.S. adults. Specifically, this study aimed to fill important gaps in the literature by addressing the following 1) examine the relationship between three SES indicators: education, income, and employment status with non-LTPA, 2) evaluate the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose), 3) assess the role of LTPA and SB in the income-overweight/obesity relationship. Taken together, these findings will illustrate the complexities of the inter-relationships of SES, PA, and health. This study provides a framework for understanding these relationships among a U.S. nationally representative sample. This study demonstrates how 1) SES relates to non-LTPA, 2) OPA relates to CVD risk, and 3) the role of LTPA and SB in the income-overweight/obesity relationship. These findings inform future longitudinal studies or randomized controlled trials attempting to better understand the inter-relationships of SES, PA, SB, and health.

CHAPTER 4

4. MANUSCRIPT 1: ASSOCIATION BETWEEN EDUCATION, INCOME, AND EMPLOYMENT STATUS WITH A COMPREHENSIVE MEASURE OF NON-LEISURE TIME PHYSICAL ACTIVITY AMONG U.S. ADULTS

4.1 ABSTRACT

Background: This study simultaneously examined three socio-economic status (SES) indicators - education, income, employment status - to understand the relationship between SES and non-LTPA among a U.S. adult sample.

Methods: Cross-sectional data from NHANES 2007-2014 with participants aged 20 to 59 years (n=11,985) was utilized. All measures were self-reported. Meeting the PA guidelines from non-LTPA was based on time engaged in non-LTPA according to the 2018 Physical Activity Guidelines for Americans.

Results: Weighted logistic regression models indicated that only education and employment were related to non-LTPA. Having less than a high school education [OR = 1.44 (0.18), $p < .01$] and having a high school education [OR = 1.43 (0.12), $p < .001$] were associated with increased odds of meeting PA guidelines from non-LTPA compared to a college degree. Part-time employment was associated with increased odds of meeting PA guidelines from non-LTPA [OR= 1.28 (0.12); $p < .01$] compared to full-time employment.

Conclusions: This study provides a comprehensive understanding of how SES is related to non-LTPA. Consequently, it raises awareness of the need to consider non-LTPA among low SES populations. Practitioners attempting to increase PA should consider these complexities and assess non-LTPA in addition to LTPA.

4.2 INTRODUCTION

Adults are recommended to engage in a minimum of 150 minutes per week of moderate physical activity (PA), 75 minutes of vigorous PA, or an equivalent combination of both (U.S. Department of Health and Human Services, 2018). Individuals engage in PA through a variety of domains: leisure time (LTPA), transportation (TPA), occupational (OPA), and household (HHPA) (Pratt, Macera, Sallis, O'Donnell, & Frank, 2004); each of these domains contribute to meeting the PA guidelines (U.S. Department of Health and Human Services, 2018). However, much of the PA literature has focused on LTPA (Beenackers et al., 2012; Choi et al., 2017). Prior research has indicated that individuals fail to meet the PA guidelines from LTPA alone: in 2017 approximately 50% of U.S. adults fell short of meeting the PA guidelines from LTPA (Centers for Disease Control and Prevention). There is a paucity of literature evaluating the other domains, collectively referred to as non-LTPA. Understanding adults' level of engagement in different domains of PA is important to reducing chronic disease. Adequate levels of PA are associated with increased life expectancy and decreased risk of chronic disease including cardiovascular disease, type 2 diabetes, obesity, metabolic syndrome, and certain cancers (Booth et al., 2012; U.S. Department of Health and Human Services, 2018).

SES is defined as the social standing of an individual within a social hierarchy (American Psychological Association & Task Force on Socioeconomic Status, 2007). Three measures are often used as indicators of SES in health behavior research: education, income, and employment status (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007). Prior research has indicated that PA disparities exist with those of low socio-economic status (SES) engaging in less PA (Elhakeem et al., 2015; Ford et al., 1991; Seiluri et al., 2011). For instance, 37% of those with less than a high school education met the PA guidelines from LTPA compared to 59% of those with a college degree; 41% of adults with an income below $15,000 met the PA guidelines from LTPA compared to 59% of adults with an income of $75,000 or greater (Centers for Disease Control and Prevention). However, how all three indicators of SES (education, income, and employment) simultaneously influence non-LTPA is lacking in the literature. A three-pronged approach, which includes education, income, and employment status simultaneously, is necessary to understand how SES is related to non-LTPA. Yet, it is difficult to elucidate the relationships of SES indicators with non-LTPA as the literature has inconsistently assessed components of non-LTPA. For example, many studies have evaluated domains of PA independently of each other (Florindo et al., 2009; Kandula & Lauderdale, 2005; Wang et al., 2010), while others combined select components of non-LTPA such as HHPA/OPA, excluding TPA (Leschied et al., 2005; Scholes & Bann, 2018). This is problematic when evaluating whether individuals meet the PA guidelines. It is not best practice to evaluate each domain of PA independently, as they all contribute to being sufficiently active (U.S. Department of Health and Human Services, 2018). It has been recommended that a more comprehensive approach may be to combine all non-LTPA (Kakinami et al., 2018).

4.2.1 EDUCATION, INCOME, AND EMPLOYMENT STATUS AND NON-LEISURE TIME PHYSICAL ACTIVITY

The most common indicator of SES utilized in PA research was education (Beenackers et al., 2012). Generally, those with greater education engage in less non-LTPA (evaluated by individual components) (Beenackers et al., 2012; Kandula & Lauderdale, 2005; Leschied et al., 2005; Salmon et al., 2000; Scholes & Bann, 2018; Wang et al., 2010).

However, some of the research studies that evaluated the relationship of education and non-LTPA did so without considering income (Leschied et al., 2005; Salmon et al., 2000; Scholes & Bann, 2018); none of the cited studies included a measure of employment status.

In regard to research evaluating the relationship between income and components of non-LTPA, it appears that those with higher income engage in less non-LTPA than those with lower income (Bauman et al., 2011; Cohen et al., 2013; Kandula & Lauderdale, 2005; Khaing Nang et al., 2010). However, most of this research has occurred among non-United States based samples (Bauman et al., 2011; Kandula & Lauderdale, 2005; Khaing Nang et al., 2010). Further, there is a paucity of literature evaluating the relationship between income and non-LTPA that have included employment (Bauman et al., 2012; Choi et al., 2017).

The least common SES indicator in the PA literature is employment status (e.g. full time, part time, unemployed). Although employment status is a commonly utilized indicator of SES (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007), a considerable amount of the literature has evaluated how job classification (e.g. blue collar vs. white collar), rather than employment status, relates to OPA, a component of non-LTPA. It is clear by definition that those who are employed will engage in greater OPA than those who are unemployed; it is possible that those employed part-time may engage in greater OPA than those employed full-time. Part-time employment is more common in certain service industries (e.g. retail, restaurants) (Valletta et al., 2020), which are known to have higher levels of OPA (Steeves et al., 2015). It is also possible that, those who are unemployed and therefore have more unstructured time throughout the day may engage in greater HHPA or TPA. Since, a single proxy measure of SES is insufficient (Braveman et al., 2005), studies are needed that evaluate education, income, and employment status simultaneously with a comprehensive measure of non-LTPA among a U.S. sample of adults (Kakinami et al., 2018).

4.2.2 CURRENT STUDY

Previous research evaluating the relationship of SES and non-LTPA has primarily focused on education as the marker of SES (Beenackers et al., 2012; Choi et al., 2017). Much less is known about how income and employment status are simultaneously related to non-LTPA (Bauman et al., 2012; Choi et al., 2017), particularly in the United States. Further, a dearth of studies exist that use a comprehensive measure of non-LTPA, rather than individual domains, despite all domains contributing to whether adults meet the PA guidelines (U.S. Department of Health and Human Services, 2018). Therefore, the purpose of this study was to evaluate the relationship of three indicators of SES (education, income, and employment) simultaneously on meeting the PA guidelines through a comprehensive measures of non-LTPA engagement among a nationally representative sample of U.S. adults. It was expected that income would be negatively related to non-LTPA, such that those with lower income would be at increased odds of meeting the PA guidelines from non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005). It was also expected that educational attainment would be negatively associated with non-LTPA, such that those with lower educational attainment would be at increased odds meeting the PA guidelines from non-LTPA (Kandula & Lauderdale, 2005; Leschied et al., 2005). Finally, it was expected that those who were unemployed would be at decreased odds and those employed part-time would be at increased odds of meeting the PA guidelines from non-LTPA, compared to those with full-time employment (Steeves et al., 2015; Valletta et al., 2020).

4.3 METHODS

4.3.1 DATASET

This study utilized publicly available data from The National Health and Nutrition Examination Survey (NHANES). The NHANES is a cross-sectional study, which combines surveys, examinations, and lab measures to assess health and nutrition in the United States population. NHANES uses a complex, multistage stratified probability cluster sample design to obtain a nationally representative sample of the non-institutionalized U.S. civilian population (Johnson et al., 2014a). The present study examines participants from four NHANES waves (2007– 2014) as these cycles contain consistent measures of physical activity. This yielded a total of 40,617 adults and children. The initial sample was reduced to a non-pregnant adult sample (ages 20 to 59) (n=15,376). Age 59 was selected as the cut-off because the Administration on Aging refers to individuals over the age of 60 as older adults, who may have behavioral and physiological differences from their younger counterparts (Adminstration for Community Living Adminstration for Community Living, 2015). Additionally, those with PA values deemed unrealistic (values > 3 standard deviations above the mean; approximately 40 hours per week of OPA and 16 hours per week of TPA) were eliminated from analyses (n = 966). Finally, individuals with missing data on non-LTPA (n=808), education (n= 8), income (n=1,145), employment (n = 6), and control variables (n=458) were eliminated from analyses. The final analytical sample included 11,985 U.S. adults. The University of Houston IRB approved this study.

4.3.2 MEASURES

4.3.2.1 DEPENDENT VARIABLE

Non-Leisure Time Physical Activity. Participants self-reported the amount of time (weekly hours) they engage in vigorous and moderate intensity activities for “paid or unpaid work…" and "spend walking or bicycling for travel…" during a typical week. Responses to these two questions were combined to calculate total non-LTPA. An equivalent combination of moderate and vigorous-intensity non-LTPA was calculated by assigning vigorous intensity activities twice the weight of moderate-intensity activity as suggested by the 2018 Physical Activity Guidelines for Americans (U.S. Department of Health and Human Services, 2018). Individuals who reported engaging in 150 minutes per week of moderate intensity non-LTPA, 75 minutes of vigorous intensity non-LTPA, or an equivalent combination of both were classified as sufficiently active (U.S. Department of Health and Human Services, 2018).

4.3.2.2 INDEPENDENT VARIABLES

Education. Individuals indicated their highest level of education from the following options: less than high school, high school or equivalent, college graduate or greater (reference).

Income. Income is a continuous measure based on the Federal Poverty Level (FPL). The Department of Health and Human Services issues the FPL based on annual average estimates of the cost to cover basic needs. Income level for each participant was calculated by NHANES dividing self-reported annual household income by the FPL corresponding to the number of individuals residing in the household. An income level of less than 1 is considered to be poor.

Employment. Individuals reported the number of hours they worked last week at all jobs. Those who indicated they were not working at a job or business were classified as unemployed. Those who indicated they worked between 1 and 34 hours were classified as employed part time. Those who indicated they worked 35 hours or greater were classified as employed full time. These cut-points were determined by the NHANES (Johnson et al., 2014a).

4.3.2.3 CONTROL VARIABLES

The following socio-demographic variables, known to be related to both SES and physical activity were self-reported through a survey: age (years), sex [female vs. male (reference)] race/ethnicity [black, white (reference), Hispanic, other] nativity status [foreign vs native (reference)], marital status [single vs. married/cohabitating (reference)], health insurance coverage [uninsured, public health insurance, private health insurance (reference)], overweight/obese weight status [body mass index (BMI) $\geq$ 25] (Centers for Disease Control and Prevention, 2015).

4.4 ANALYSES

Means and standard errors or frequencies of participant characteristics were computed. Four logistic regression models were conducted to evaluate the association of SES indicators independently: education (model 1), income (model 2), employment status (model 3), and simultaneously (model 4) on meeting the PA guidelines from non-LTPA. Unstandardized model results are presented as OR (SE). Additionally, four linear regression models were conducted to evaluate the association of SES indicators independently: education (model 1), income (model 2), employment status (model 3), and simultaneously (model 4) with non-LTPA measured continuously. All models controlled for age, sex, race/ethnicity, foreign birth, marital status, health insurance, and weight status. Descriptive statistics and logistic regression models were conducted using STATA version 15.0 statistical software (StataCorp LP, College Station, Texas). Survey procedures (ie, “svy” command) were used to account for the NHANES sampling design.

4.5 RESULTS

4.5.1 DESCRIPTIVE STATISTICS

Descriptive statistics of the sample are presented in Table 1. On average, participants reported almost 5 hours per week of non-LTPA; 26% met the PA guidelines (150 minutes per week) from non-LTPA. The sample was socioeconomically diverse, 15% had less than a high school diploma, 53% had a high school degree or equivalent, and 32% of the sample had a college degree or greater, with a mean income (FPL) of 3.00 (0.05). Most individuals were employed either full time (56%) or part time (15%). The mean age of the sample was approximately 40 years old. The majority of participants were white (65%), followed by Hispanic (15%), black (12%), and any other race/ethnicity (8%). Most participants were native to the United States (82%), married/cohabitating with a partner (63%), had private health insurance (65%) and were classified as overweight/obese (68%).

Table 1. Characteristics of Aim 1 participants: National Health and Nutrition Examination Survey 2007-2014, M (SE) or %

	N = 11,985
Dependent variables	
Non LTPA^ (hours per week)	4.89 (0.16)
≥ 150 minutes/ week	26%
Independent variables	
Education	
< High school degree	15%
High school degree	53%
≥ College graduate	32%
Income (FPL^)	3.00 (0.05)
Employment	
Unemployed	29%
Part time	15%
Full time	56%
Demographic characteristics	
Age	39.87 (0.23)
Race	
White	65%
Black	12%
Hispanic	15%
Other	8%
Nativity	
Foreign born	18%
Native born	82%
Marital status	
Single	37%
Married/cohabiting	63%
Health insurance	
Public	13%
Private	65%
Uninsured	22%
Weight status	
Normal weight	32%
Overweight/obese	68%

^ LTPA leisure time physical activity, FPL federal poverty level

4.5.2 LOGISTIC REGRESSION MODELS PREDICTING MEETING THE PHYSICAL ACTIVITY GUIDELINES FROM NON-LEISURE TIME PHYSICAL ACTIVITY

The association of markers of socioeconomic status and meeting the PA guidelines (150 minutes per week) from non-LTPA among U.S. adults are presented in Table 2. Models 1-3 evaluate each SES indicator independently of each other. Lower educational obtainment was associated with 48% - 51% increased odds of being sufficiently active from non-LTPA [less than high school: OR = 1.51 (0.18), $p < .001$] [high school OR= 1.48 (0.12), $p < .001$], compared to those with a college degree (Model 1). Higher income (based on FPL) was associated with decreased odds of being sufficiently active from non-LTPA; every one unit increase in FPL, was associated with 7% decreased odds of being sufficiently active from non-LTPA [OR = 0.93 (0.02); $p < .01$] (Model 2). Those who were unemployed compared to those who were employed full-time were at similar odds of being sufficiently active from non-LTPA [OR= 1.05 (0.08); p > .05]. Part-time employment was associated with 32% increased odds of being sufficiently active from non-LTPA [OR= 1.32 (0.12); p < .001], compared to those employed full-time (Model 3).

Model 4 evaluated the association of all three markers of socioeconomic status and meeting the PA guidelines simultaneously. In the fully adjusted model, the relationship between education and non-LTPA was slightly attenuated; lower educational attainment was associated with 43% - 44% increased odds of being sufficiently active from non-LTPA [less than high school: OR = 1.44 (0.18), $p < .01$] [high school OR= 1.43 (0.12), $p < .001$], compared to those with a college degree. Income was no longer associated with being sufficiently active from non-LTPA [OR = 0.96 (0.02); $p > .05$]). The relationship between unemployment and of being sufficiently active from non-LTPA remained insignificant. The relationship between part-time employment and non-LTPA was slightly attenuated; part-time employment was associated with 28% increased odds of being sufficiently active from non-LTPA [OR= 1.28 (0.12); p < .01], compared to those employed full-time.

Table 2. Adjusted odds ratio and standard error for estimating meeting the physical activity guidelines^ from non-leisure time physical activity associated with socioeconomic status among U.S. adults: National Health and Nutrition Examination Survey 2007-2014, N = 11,985

	Model 1 OR (SE)	Model 2 OR (SE)	Model 3 OR (SE)	Model 4 OR (SE)
Characteristics				
Independent variables				
Education				
Less than high school	1.51 (0.18)***	---	---	1.44 (0.18)**
High school education	1.48 (0.12)***	---	---	1.43 (0.12)***
College graduate	---	---	---	---
Income (FPL)^	---	0.93 (0.02)**	---	0.96 (0.02)
Employment				
Unemployed	---	---	1.05 (0.08)	1.00 (0.07)
Part time	---	---	1.32 (0.12)**	1.28 (0.12)**
Full time	---	---	---	---

**p* < .05, ***p* < .01, ****p* < .001
^Individuals who reported engaging in 150 minutes per week of moderate intensity non-LTPA, 75 minutes of vigorous intensity non-LTPA, or an equivalent combination of both were classified as sufficiently active. FPL Federal Poverty Limit
Models included the following covariates: age, race, nativity, marital status, health insurance, and weight status.

4.5.3 SENSITIVITY ANALYSES: LINEAR REGRESSION MODELS PREDICTING CONTINUOUSLY MEASURED NON-LEISURE TIME PHYSICAL ACTIVITY

Additional models were conducted to evaluate the association of markers of socioeconomic status and non-LTPA measured continuously (Table 3). Models 1-3 evaluate each SES indicator independently of each other. Lower educational obtainment was associated with greater non-LTPA [less than high school: B = 2.71 (0.49), *p* < .001] [high school B = 2.92 (0.27), *p* < .001], compared to those with a college degree (Model 1).

Income was negatively associated with non-LTPA [B = -0.36 (0.09); $p < .001$] (Model 2). Unemployment status was associated with decreased non-LTPA [B= -1.64 (0.26); p < .001], but part-time employment was associated with greater non-LTPA [OR= 1.12 (0.42); p < .01], compared to those employed full-time (Model 3). Model 4 evaluated the association of all three markers of socioeconomic status with non-LTPA simultaneously. In the fully adjusted model (Model 4), the relationship between education and non-LTPA was slightly attenuated; lower educational obtainment was associated with greater non-LTPA [less than high school: B = 2.68 (0.52), $p < .001$] [high school B = 2.81 (0.29), $p < .001$], compared to those with a college degree. Income was no longer associated with non-LTPA [B = -0.18 (0.11); $p > .05$]. Unemployment status was associated with decreased non-LTPA [B= -1.64 (0.26); p < .001], the relationship between part-time employment and non-LTPA was slightly attenuated; part-time employment was associated with greater non-LTPA [B= 0.93 (0.42); p < .05], compared to those employed full-time.

Table 3. Adjusted unstandardized beta coefficients and standard error for estimating continuous non-leisure time physical activity associated with socioeconomic status among U.S. adults: National Health and Nutrition Examination Survey 2007-2014, N = 11,985

	Model 1 *B* (SE)	Model 2 *B* (SE)	Model 3 *B* (SE)	Model 4 *B* (SE)
Characteristics				
Independent variables				
Education				
Less than high school	2.71 (0.49)***	---	---	2.68 (0.52)***
High school education	2.92 (0.27)***	---	---	2.81 (0.29)***
College graduate	---	---	---	---
Income (FPL)^	---	-0.36 (0.09)***	---	-0.18 (0.11)
Employment				
Unemployed	---	---	-1.64 (0.26)***	-1.89 (0.27)***
Part time	---	---	1.12 (0.42)**	0.93 (0.42)*
Full time	---	---	---	---

*$p < .05$, **$p < .01$, ***$p < .001$
^FPL Federal Poverty Limit
Models included the following covariates: age, race, nativity, marital status, health insurance, and weight status

4.6 DISCUSSION

The purpose of this study was to evaluate the role of three indicators of SES (education, income, and employment) simultaneously on non-LTPA among a nationally representative sample of U.S. adults. Specifically, the study focused on creating a comprehensive measure of meeting PA guidelines using all domains of non-LTPA (OPA, TPA, HHPA) (Kakinami et al., 2018). Three of the five hypotheses regarding the relationship of SES with meeting the PA guidelines from non-LTPA were supported.

In support of our hypothesis, lower education was associated with increased odds of being sufficiently active from non-LTPA. The relationship between education and non-LTPA remained consistent whether evaluating education independent of the other SES indicators or simultaneously, using the three-pronged approach for both the dichotomous and continuous outcome. This finding parallels previous research studies which found that education was inversely related to OPA, a component of non-LTPA (Beenackers et al., 2012; Florindo et al., 2009; Leschied et al., 2005; Lissner, Bengtsson, Bjorkelund, & Wedel, 1996; Scholes & Bann, 2018). The finding that education, but not income is related to non-LTPA among U.S. adults strengthens the argument for not treating different measures of SES as interchangeable (Galobardes, Lynch, & Smith, 2007; Geyer, Hemstrom, Peter, & Vagero, 2006).

When evaluated independently of other SES indicators, income was associated with decreased odds of being sufficiently active from non-LTPA, as expected similar to previous studies on income (Cohen et al., 2013; Kandula & Lauderdale, 2005). However in contrast to our hypothesis, income was not associated with being sufficiently active from non-LTPA when evaluated alongside the other SES indicators. These findings were consistent in the sensitivity analyses, which evaluated the relationships with non-LTPA measured continuously. This indicates that education and employment are more strongly associated with non-LTPA than income. This may explain why more literature has focused on education when evaluating non-LTPA; publication biases may make the education-related findings more desirable. This finding also indicates that the three indicators of SES are not interchangeable; income was only related to non-LTPA because of its shared variance with education. Had we only assessed the relationship of income with non-LTPA we would not have understood this nuance.

The findings that income was unrelated to non-LTPA in the fully adjusted model align with previous studies on European adults, which also indicated that income was unrelated to OPA, one component of non-LTPA (Beenackers et al., 2012). However, it contrasts studies on California residents (Kandula & Lauderdale, 2005), adults in China (Bauman et al., 2011), and a multi-ethnic Asian population (Khaing Nang et al., 2010). The contrasting findings may be due to differences in study population (U.S. adults, rather than a subpopulation of U.S. adults or adults from foreign countries), the outcome of interest (a comprehensive measure of non-LTPA, rather than specific domains), or the three-pronged approach to SES utilized in this study.

In contrast to our hypothesis, unemployment was not associated with meeting the PA guidelines from non-LTPA among U.S. adults once evaluated with all three markers of SES. However, in line with our hypothesis, part-time employment was associated with increased odds of being sufficiently active from non-LTPA. The relationships between part-time employment status and non-LTPA remained consistent whether evaluating employment status independent of the other SES indicators or simultaneously, using the three-pronged approach. The relationships between part-time employment status and non-LTPA remained consistent in the sensitivity models, which utilized a continuous measure of non-LTPA. However, results for unemployment status differed in the sensitivity models. The main models indicated that unemployed individuals were at similar odds of meeting the PA guidelines from non-LTPA compared to those employed full time. In contrast, the sensitivity models indicated that unemployment was negatively associated with non-LTPA, compared to those employed full time. This calls into question the practical meaningfulness of the relationship between unemployment status and non-LTPA. Admittedly, OPA is most likely the reason why employment is related to non-LTPA. Those employed part-time likely have more active occupations (Steeves et al., 2015; Valletta et al., 2020), whereas many of those employed full-time likely have highly sedentary occupations. Those who are unemployed are not engaging in any OPA (by definition) and are not compensating with additional HHPA or TPA. This novel approach to evaluating how SES (employment status rather than job classification, along with income and education) relates to non-LTPA (total non-LTPA rather than OPA specifically) is an important contribution to the literature as it evaluates a frequently utilized marker of SES, which is novel to the PA literature.

This study also raises awareness of the need to consider non-LTPA rather than LTPA exclusively when assessing PA. This may be particularly relevant among those of low SES, as indicators of low SES (education, part-time employment) were associated with increased odds of meeting the PA guidelines from non-LTPA. Although many studies have identified individuals of low SES as being at risk for PA disparities (Beenackers et al., 2012; Elhakeem et al., 2015; Ford et al., 1991; Gidlow et al., 2006; Seiluri et al., 2011), they have mainly focused on LTPA. LTPA only accounts for a portion of the amount of time individuals spend engaging in physical activity.

There are known limitations with self-reported PA data, specifically over-reporting of PA (Celis-Morales et al., 2012). Future studies are encouraged to utilize objective measures when evaluating non-LTPA. Additionally, the cross-sectional nature of this study prevents us from inferring causation. It is possible for non-LTPA to change over time, regardless of changes in SES. Longitudinal studies, which evaluate changes in PA engagement following changes in SES indicators are needed to better understand these relationships. Additionally, there are factors not assessed by NHANES such as urbanicity and climate, which may be related to non-LTPA and are important factors when understanding the relationship of SES with non-LTPA. Despite these known limitations, there are also benefits to utilizing NHANES; the findings are highly generalizable to the U.S. population. To our knowledge, this is the first study to utilize a three-pronged approach, which includes education, income, and employment status simultaneously as well as a comprehensive measure of non-LTPA among a U.S. sample.

4.7 CONCLUSION

The findings have implications for researchers and practitioners. This study adds to existing health behavior literature suggesting a three-pronged approach to measure SES is necessary to understand how SES is related to health behaviors (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007). Further, when evaluating whether individuals meet the PA guidelines, this study emphasizes the need to utilize a comprehensive measure of non-LTPA (Kakinami et al., 2018), because it is more informative than evaluating specific domains as they all contribute to being sufficiently active (U.S. Department of Health and Human Services, 2018). Those of low SES are disproportionately affected by a lack of leisure time physical activity (Centers for Disease Control and Prevention). However, the findings from this study indicate they engage in greater non-LTPA. Researchers assessing physical activity, particularly among low SES communities must take a more comprehensive approach to measuring physical activity. LTPA alone is not an accurate reflection of total physical activity; non-LTPA varies considerably and can be a substantial contributor to total PA. It is important for practitioners attempting to increase PA to consider these complexities.

CHAPTER 5

5. MANUSCRIPT 2: EVALUATING THE PHYSICAL ACTIVITY HEALTH PARADOX IN THE UNITED STATES: OCCUPATIONAL PHYSICAL ACTIVITY IS NOT RELATED TO METABOLIC SYNDROME

5.1 ABSTRACT

Background: It is well established that physical activity (PA) confers health benefits; however, more recent studies based on non-US primarily male samples have identified occupational PA (OPA) as a risk factor for cardiovascular disease (CVD). This inconsistent relationship has been coined the PA Health Paradox. However, research on OPA and CVD among a United States sample and including women is needed.

Purpose: This study evaluated the PA Health Paradox by examining the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose) among U.S. adults. A secondary aim was to evaluate if these relationships differed between men and women.

Methods: Using the National Health and Nutrition Examination Survey (2007-2014), non-older employed adults (aged 20-59 years) were included (n=3,253). Unadjusted and covariate adjusted logistic regression analyses were conducted to evaluate the relationships of OPA (self-reported weekly hours) with metabolic syndrome and its components (directly assessed). An interaction term (OPA*sex) was utilized to determine if relationships differed between men and women. Covariates included: age, race/ethnicity, education, income, weight status, diet, alcohol consumption, smoking status, LTPA, sedentary behavior, and other variables.

Results: OPA was not associated with metabolic syndrome, nor its components ($p>.05$). The relationships did not differ between women and men ($p >.05$).

Conclusions: We found no substantial associations between OPA and cardiovascular health in this U.S. nationally representative cross-sectional study. Future prospective, longitudinal studies are needed to understand the long-term effects of OPA on CVD in the U.S. population.

5.2 INTRODUCTION

Although the health benefits of leisure-time physical activity (LTPA) are well documented, the health benefits associated with other domains of physical activity (PA), such as occupational physical activity (OPA), are not consistently observed (Li et al., 2013). Many of the landmark research studies establishing the health benefits of PA, such as decreased risk of cardiovascular disease (CVD) and obesity, utilized OPA as the marker of PA. For example, it was found that London bus conductors, who spent their days walking to collect tickets had much lower incidences of coronary heart disease and "sudden death" than similarly aged bus drivers who spent their days sitting (Morris et al., 1953). Further, research indicates that greater OPA levels promote a healthy weight status (Bonauto et al., 2014; Choi et al., 2010; Church et al., 2011; Steeves et al., 2012).

However, the literature has shown the relationship between OPA and health to be inconsistent. In 2012, a meta-analysis concluded that OPA had a beneficial impact on cardiovascular health. OPA reduced the risk of coronary heart disease and stroke among men and women (Li & Siegrist, 2012). This study was later updated and the authors found that greater OPA was associated with a slight increase in CVD; they later concluded that the role of OPA in cardiovascular health is not well understood (Li et al., 2013). Other studies conducted in the past decade have identified OPA as a risk factor for cardiovascular events (Holtermann et al., 2010) and heart attack incidence (Krause et al., 2015). Researchers have also found that greater OPA had an unhealthy impact on all-cause mortality (Clays et al., 2013; Coenen et al., 2018) and systolic blood pressure (Clays et al., 2012). The contrasting impact of OPA and LTPA on health has been coined "The PA Health Paradox" (Holtermann et al., 2012). It is important to highlight that many of the studies reporting OPA to be a risk factor for CVD focused on very specific populations such as Danish employees (Holtermann et al., 2012; Holtermann et al., 2009, 2010). Studies conducted in other locations have differed in their findings (Fransson et al., 2003; Johnsen et al., 2016; Probert et al., 2008; Stamatakis et al., 2013). There is a paucity of large U.S. nationally representative studies examining the relationship of OPA and cardiovascular health (Li et al., 2013). Further, many of the research studies identifying OPA as a CVD risk factor were conducted on entirely male samples (Clays et al., 2013; Holtermann et al., 2010; Krause et al., 2015). The literature evaluating men and women separately is inconsistent (Coenen et al., 2018; Fransson et al., 2003; Li & Siegrist, 2012; Stamatakis et al., 2013).

It has been suggested that PA guidelines need to be updated to differentiate between domains of PA because the health benefits of OPA are not the same as those of LTPA (de Souto Barreto, 2015). However, it is important to understand why OPA does not influence health similarly to LTPA. Holtermann et al. (2018) hypothesized that six potential mechanisms explain why OPA does not influence health similar to LTPA: lack of intensity, elevated 24 hour heart rate/ blood pressure, lack of recovery time, lack of worker control, and increased inflammation. Others have argued that the recent influx of articles identifying OPA as a health risk factor is due to methodological issues, such as measurement issues of OPA, and inadequately controlling for smoking status and socioeconomic factors (Shephard, 2019). It is necessary to better understand how OPA impacts health among U.S. citizens and women in order to foster healthier worksites and create policies to protect U.S. employees' health.

Metabolic Syndrome, a cluster of biological risk factors, is particularly relevant as it is highly associated with increased risk for chronic diseases such as CVD (Mottillo et al., 2010). Metabolic syndrome includes the following risk factors: central obesity, elevated blood pressure, dyslipidemia (low high-density lipoprotein cholesterol and elevated triglycerides), and elevated fasting blood glucose (Alberti et al., 2009). Despite research studies identifying a relationship between OPA and CVD, little is known about the relationship of OPA and metabolic syndrome, a precursor to CVD.

This study aims to evaluate the PA Health Paradox by examining the relationship of OPA and CVD risk indicators, specifically metabolic syndrome and its components (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose) among U.S. adults using a nationally representative dataset. Similar to previous studies that have occurred in the past 15 years focused on various health outcomes (Holtermann et al., 2009; Krause, 2010; Krause et al., 2015; Krause et al., 2007; Li et al., 2013), it was expected that OPA would be associated with increased odds of metabolic syndrome and its components (elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose), with the exception of waist circumference. In contrast, it was expected that OPA would be associated with decreased odds of elevated waist circumference, similar to previous studies on OPA and obesity (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010; Steeves et al., 2012). The secondary aim was to evaluate if the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) differed between men and women. Men engage in greater OPA than women (Allender et al., 2008; He & Baker, 2005; Scholes & Bann, 2018), and men and women may differ in the type of OPA performed. Further, findings on the relationship between OPA and health have been more consistent among men (Clays et al., 2013; Holtermann et al., 2010; Krause et al., 2015) than women (Coenen et al., 2018; Fransson et al., 2003; Li & Siegrist, 2012; Stamatakis et al., 2013). Therefore, it was expected that the relationships between OPA and CVD risk indicators would be moderated by sex, such that the relationships would be stronger among men than women.

5.3 METHODS

5.3.1 DATASET

This study utilized publicly available data from The National Health and Nutrition Examination Survey (NHANES). The NHANES is a cross-sectional study, which combines surveys, examinations, and lab measures to assess health and nutrition in the United States population. NHANES uses a complex, multistage stratified probability cluster sample design to obtain a nationally representative sample of the non-institutionalized U.S. civilian population (Johnson et al., 2014a). .

The present study includes participants from four NHANES waves (2007–2014). These cycles contain consistent measures of physical activity variables and yielded a total of 40,617 adults and children. The initial sample was reduced to a non-pregnant adult sample (ages 20 and over) (n= 23,235). Further, the analytical sample was reduced to only include adults age 20-59 (n= 15,376). Age 59 was selected as the cut-off because the Administration on Aging refers to individuals over the age of 60 as older adults; a risk factor for the outcomes of interest (Adminstration for Community Living, 2015). Because a primary variable of interest of this study is OPA and by definition, only those employed engage in OPA, 2,194 unemployed individuals were excluded from the analytical sample (n = 13,182). Finally, only those with complete data on all target variables were included in the final analytical sample. Fasting glucose and triglycerides were only assessed on those whose laboratory measures were taken in the morning; for this reason, 8,524 individuals who were assessed in the afternoon were eliminated from the analytical sample (n=4,658).

Individuals with missing data on the following variables were excluded: waist circumference (n=117), blood pressure (n=164), glucose (n=7), triglycerides (n=5), HDL cholesterol (n=28), OPA (n=266), and control variables (n= 912). The final analytical sample consisted of 3,159 adults. The University of Houston's IRB has approved this study.

5.3.2 MEASURES

5.3.2.1 DEPENDENT VARIABLES

Metabolic Syndrome. Similar to previous studies evaluating metabolic syndrome using NHANES data (Moore et al., 2017), participants who had three or more of the following risk factors were considered to have metabolic syndrome: elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated fasting blood glucose.

Elevated Waist Circumference. Women who had a measured waist circumference greater than 88 cm and men who had a measured waist circumference greater than 102 cm were classified as having an elevated waist circumference (Alberti et al., 2009).

Elevated Blood Pressure. Participants were considered to have elevated blood pressure if the averaged values of three blood pressure readings were out of the healthy range (systolic ≥130 mm Hg, or diastolic ≥85 mm Hg, or both) (Alberti et al., 2009).

Low High Density Lipoprotein Cholesterol. Men with measured values <40 mg/dL and women with measured values <50 mg/dL were considered to have low high density lipoprotein (HDL) cholesterol (Alberti et al., 2009).

Elevated Triglycerides. Participants were classified as having elevated triglycerides if their measured value was ≥150 mg/dL (Alberti et al., 2009).

Elevated Fasting Blood Glucose. Participants were considered to have elevated fasting blood glucose if their measured level was ≥100 mg/dL (Alberti et al., 2009).

5.3.2.2 INDEPENDENT VARIABLE

Occupational Physical Activity. Participants self-reported the amount of time (weekly hours) they engage in vigorous and moderate intensity activities for "paid or unpaid work…" during a typical week. Vigorous intensity was described to participants as "requiring hard physical effort and causing large increases in breathing or heart rate" and the following examples were provided, "carrying or lifting heavy loads, digging or construction work". Moderate intensity was described as "requiring moderate physical effort and causing small increases in breathing or heart rate" and the following examples were provided, "brisk walking or carrying light loads". An equivalent combination of moderate and vigorous-intensity OPA was calculated by assigning vigorous intensity activities twice the weight of moderate-intensity activity as suggested by the 2018 Physical Activity Guidelines for Americans (U.S. Department of Health and Human Services, 2018).

5.3.2.3 CONTROL VARIABLES

The following socio-demographic variables, related to both OPA and metabolic syndrome were self-reported: age (years), sex [female vs. male (reference)], race/ethnicity [black, Hispanic, white (reference), other race], nativity status [foreign vs native (reference)], marital status [single vs. married/cohabitating (reference)], education [less than high school, high school or equivalent, college graduate or greater (reference)], income [continuous as federal poverty level (FPL)], hours worked weekly (continuous), health insurance coverage [uninsured vs. insured (reference)], and directly assessed weight status based on body mass index (BMI; BMI ≥ 25 was categorized as overweight/obese) (Centers for Disease Control and Prevention, 2015). Several health behaviors were also included as covariates: Healthy Eating Index (HEI; continuous), alcohol consumption (drinks per day continuous), smoking status [smoker vs. non-smoker (reference)], weekly LTPA (hours, continuous), and daily SB (hours, continuous). Weight status was included as a control variable except for the models predicting elevated waist circumference, and metabolic syndrome which included elevated waist circumference (Centers for Disease Control and Prevention, 2015).

5.4 ANALYSES

Means, frequencies and standard errors of participant characteristics were computed for the total sample and separately for women and men. Logistic regression models were conducted to evaluate the association of OPA and metabolic syndrome/the components of metabolic syndrome (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, and elevated blood glucose) among U.S. adults. All models controlled for age, sex, race/ethnicity, nativity, marital status, education, income, hours worked, health insurance, weight status (when not the outcome of interest), Healthy Eating Index, alcohol consumption, smoking status, LTPA, and SB. The models were repeated with the inclusion of an interaction term (sex* OPA) to determine if the relationship on OPA with metabolic syndrome and its components differed between men and women.

Analyses were conducted using STATA version 15.0 statistical software (StataCorp LP, College Station, Texas). Survey procedures were used to account for the NHANES sampling design.

5.5 RESULTS

5.5.1 SAMPLE

Characteristics of the full sample and for women and men separately are presented in Table 1. Twenty-four percent of participants (21% women; 27% men) met the criteria for metabolic syndrome. Among women the average waist circumference was 95.09 (0.51) cm, among men the average waist circumference was 99.49 (0.50) cm; overall 48% of the sample had an elevated waist circumference. The sample had a mean systolic blood pressure of 117.58 (0.37) mm Hg and diastolic blood pressure of 70.72 (0.28) mm Hg; 18% had elevated blood pressure. Among women the average HDL value was 58.88 (0.59) mg/dL, and among men the average HDL value was 47.67 (0.40) mg/dL; overall 27% had low HDL cholesterol. The sample had a mean triglyceride level of 124.62 (2.10) mg/dL; 24% had elevated triglycerides. The average fasting blood glucose of the sample was 5.69 (0.03) mg/dL; 42% had elevated fasting blood glucose. On average women engaged in 4.23 (0.48) hours per week and men engaged in 12.63 (0.85) hours per week of OPA.

The average age of the sample was 39.92 (0.32) years. Sixty-nine percent of the sample was white, followed by Hispanic (14%), black (10%), and another race/ethnicity (7%). Seventeen percent of the sample was foreign born, 65% were married or cohabitating, and 51% had a high school diploma but not a college degree. The average income (FPL) of the sample was 3.27 (0.05) and participants reported working almost 41.62 (0.37) hours per week. Twenty percent of the sample did not have health insurance and 68% had an overweight/obese weight status. Participants reported an average HEI score of 52.97 (0.36) and drank an average of 0.57 (0.02) alcoholic beverages per day. Nineteen percent of the sample was categorized as a smoker. Participants reported engaging in 4.18 (0.20) hours per week of moderate to vigorous LTPA and 6.39 (0.11) hours per day of SB.

Table 1. Characteristics of Aim 2 participants by sex: National Health and Nutrition Examination Survey 2007-2014, M (95% confidence interval) or %

	Full Sample (n = 3,159)	Women (n = 1,469)	Men (n = 1,690)
Dependent variable			
Metabolic syndrome			
Meets criteria^	24%	21%	27%
Does not meet criteria	76%	79%	73%
Waist circumference (cm)	97.46 (0.38)	95.09 (0.51)	99.49 (0.50)
Elevated^	48%	59%	39%
Not elevated	52%	41%	61%
Blood pressure^			
Systolic (mm Hg)	117.58 (0.37)	114.68 (0.45)	120.06 (0.44)
Diastolic (mm Hg)	70.72 (0.28)	68.93 (0.33)	72.25 (0.35)
Elevated	18%	14%	21%
Not elevated	82%	86%	79%
HDL cholesterol^ (mg/dL)	52.83 (0.41)	58.88 (0.59)	47.67 (0.40)
Low	27%	27%	27%
Normal	73%	73%	73%
Triglycerides^ (mg/dL)	124.62 (2.10)	106.53 (2.40)	140.09 (3.04)
Elevated	24%	17%	30%
Not elevated	76%	83%	70%
Glucose^ (mg/dL)	5.69 (0.03)	5.51 (0.04)	5.84 (0.05)
Elevated	42%	31%	51%
Not elevated	58%	69%	49%
Independent variable			
Occupational PA^ (hours)	8.75 (7.59 – 9.91)	4.23 (0.48)	12.63 (0.85)
Demographic characteristics			
Age	39.92 (0.32)	40.41 (0.41)	39.51 (0.41)
Sex			
Female	46%	---	---
Male	54%	---	---
Race/ethnicity			
White	69%	68%	69%
Black	10%	12%	8%
Hispanic	14%	13%	16%
Other	7%	7%	7%
Nativity status			
Foreign born	17%	14%	19%
Native born	83%	86%	81%
Marital status			
Single	35%	39%	32%
Married/cohabiting	65%	61%	68%
Education			
Less than high school degree	12%	10%	15%
High school degree	19%	18%	20%

Some college	32%	35%	30%
College graduate or greater	36%	37%	35%
Income (FPL)^	3.27 (0.05)	3.25 (0.07)	3.30 (0.06)
Hours worked	41.62 (0.37)	38.41 (0.53)	44.37 (0.43)
Health insurance			
Insured	80%	83%	78%
Uninsured	20%	17%	22%
Weight status^			
Normal weight	32%	36%	28%
Overweight/obese	68%	64%	72%
Health behaviors			
Healthy Eating Index	52.97 (0.36)	54.46 (0.44)	51.69 (0.46)
Average alcoholic drinks per day	0.57 (0.02)	0.34 (0.02)	0.78 (0.03)
Smoking status			
Smoker	19%	17%	21%
Non-smoker	81%	83%	79%
Weekly leisure time PA^	4.18 (0.20)	3.17 (0.16)	5.05 (0.29)
Daily sedentary behavior	6.39 (0.11)	6.49 (0.14)	6.31 (0.12)

^Those with 3-5 risk factors were considered to have metabolic syndrome. Women with waist circumference > 88 cm; men with waist circumference >102 cm were classified as elevated. Those with systolic blood pressure ≥130 mm Hg, or diastolic blood pressure ≥85 mm Hg were considered to have elevated blood pressure. Men with measured values <40 mg/dL and women with measured values <50 mg/dL were considered to have low high density lipoprotein (HDL) cholesterol. Participants were classified as having elevated triglycerides if their measured value was ≥150 mg/dL; elevated fasting blood glucose if their measured level was ≥100 mg/dL. PA physical activity; FPL federal poverty level; Weight status is based on Body Mass Index. Those with a body mass index 18.5 to 24.9 were classified as normal weight; those with a body mass index > 24.9 were classified as overweight/obese.

5.5.2 LOGISTIC REGRESSION MODELS EVALUATING THE RELATIONSHIP OF OCCUPATIONAL PHYSICAL ACTIVITY WITH METABOLIC SYNDROME AND ITS COMPONENTS

The odds ratios and standard errors for estimating metabolic syndrome and its components associated with occupational physical activity among U.S. adults are presented in Table 2. In the unadjusted models, OPA was only related to elevated waist circumference (OR 0.996; SE 0.00; $p < .05$); OPA was not related to metabolic syndrome (OR 1.00; SE 0.00), elevated blood pressure (OR 1.00; SE 0.00), low HDL cholesterol (OR 1.00; SE 0.00), elevated triglycerides (OR 1.00; SE 0.00), nor elevated glucose (OR 1.00; SE 0.00) ($p > .05$) (Panel A). Further, in the covariate adjusted logistic regression models OPA was not related to metabolic syndrome (OR 1.00; SE 0.00), elevated waist circumference (OR 1.00; SE 0.00), elevated blood pressure (OR 1.00; SE 0.00), low HDL cholesterol (OR 1.00; SE 0.00), elevated triglycerides (OR 1.00; SE 0.00), nor elevated glucose (OR 1.00; SE 0.00) ($p > .05$) (Panel B). Finally, the relationship between OPA and metabolic syndrome/ the components of metabolic syndrome did not differ by gender. The interaction term (OPA*gender) was not significant in any of the models ($p > .05$) (Panel C).

Table 2. Adjusted odds ratios and standard errors for estimating metabolic syndrome and its components associated with occupational physical activity among U.S. adults: National Health and Nutrition Examination Survey 2007-2014, n = 3,159

	Metabolic Syndrome OR (SE)	Elevated Waist Circumference OR (SE)	Elevated Blood Pressure OR (SE)	Low HDL Cholesterol OR (SE)	Elevated Triglycerides OR (SE)	Elevated Glucose OR (SE)
Panel A. Unadjusted Models						
Occupational PA+	1.00 (0.00)	1.00 (0.00)*	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Panel B. Covariate Adjusted^ Models						
Occupational PA	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Panel C. Covariate Adjusted Models^ with Interaction by Sex						
Occupational PA	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Sex (male reference)	0.62 (0.08)***	2.40 (0.25)***	0.52 (0.07)***	0.90 (0.08)	0.46 (0.06)***	0.39 (0.04)***
Interaction	1.00 (0.01)	1.00 (0.00)	1.00 (0.01)	0.99 (0.00)	1.01 (0.01)	1.00 (0.01)

***$p < .001$, *$p < .05$

Those with 3-5 risk factors were considered to have metabolic syndrome. Women with waist circumference > 88 cm; men with waist circumference >102 cm were classified as elevated. Those with systolic blood pressure ≥130 mm Hg, or diastolic blood pressure ≥85 mm Hg were considered to have elevated blood pressure. Men with measured values <40 mg/dL and women with measured values <50 mg/dL were considered to have low high density lipoprotein (HDL) cholesterol. Participants were classified as having elevated triglycerides if their measured value was ≥150 mg/dL; elevated fasting blood glucose if their measured level was ≥100 mg/dL.

+PA physical activity.

^Covariate adjusted models controlled for age, sex, race/ethnicity, nativity, marital status, education, income, hours worked, health insurance, weight status (not included in the models predicting metabolic syndrome nor elevated waist circumference), Healthy Eating Index, alcohol consumption, smoking status, LTPA, and SB. Weight status is based on Body Mass Index. Those with a body mass index 18.5 to 24.9 were classified as normal weight; those with a body mass index > 24.9 were classified as overweight/obese.

5.6 DISCUSSION

This study evaluated the PA Health Paradox by examining the relationship of OPA and CVD risk indicators, specifically metabolic syndrome and its components (metabolic syndrome, waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose) among U.S. adults ages 20-59 years of age using a nationally representative dataset. Contrary to the hypotheses, findings indicated that OPA was not related to metabolic syndrome nor its components (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, elevated blood glucose) when models were adjusted for covariates. These findings remained consistent whether evaluating the outcomes categorically (within the healthy range vs. outside of the healthy range) or continuously. The findings from this cross-sectional study that OPA was not related to CVD risk factors (metabolic syndrome and its components) add to previous longitudinal studies which indicated that OPA was not related to heart attack incidence (Johnsen et al., 2016). However, it differs from other research, which found that OPA was related to all-cause mortality (Clays et al., 2013), systolic blood pressure (Clays et al., 2012), and heart attack incidence (Krause et al., 2015). These findings also differ from the seminal research identifying OPA as protective against CVD and sudden death (Morris et al., 1953).

There are several methodological differences, which could account for why this study differed from previous studies evaluating the PA Health Paradox. The most blatant difference is the study population. Our sample was representative of the United States population, and as such was both racially and socioeconomically diverse, while much of the literature identifying OPA as a health risk factor focused on European men (Clays et al., 2013; Hallman et al., 2017; Holtermann et al., 2012; Krause et al., 2015). A number of cultural, environmental, and policy differences between the United States and the European countries (e.g. Denmark, Belgium, Finland) of previous studies could also contribute to inconsistent findings. Further, our study was cross-sectional and included data from 2007-2014. Many of the studies identifying OPA as a health risk factor used longitudinal methodology (Clays et al., 2013; Hallman et al., 2017; Holtermann et al., 2012; Krause et al., 2015) and began collecting data on participants in the 1970s (Clays et al., 2013; Holtermann et al., 2010) and 1980s (Krause et al., 2015). Similarly, much of the research informing the PA Health Paradox utilized all-cause mortality or early mortality as the outcome (Clays et al., 2013; Coenen et al., 2018). All-cause mortality may be inherently linked to job-related injuries, which are more common among highly active occupations. Importantly, OPA was assessed differently between studies and although most of the literature utilized self-report to assess OPA, questions were not asked in the same manner. NHANES asks the amount of time individuals engage in vigorous and moderate intensity activities for "paid or unpaid work…" during a typical week; therefore, this study utilized weekly hours of moderate to vigorous PA as the measure of OPA. However, other studies assessed OPA by describing categories of typical job-related tasks (mostly sitting, walking up/down stairs, heavy lifting, etc.) and examples of what types of occupations would fall into each category. This is inherently different from the measure used in the current study, which calculated the amount of time individuals engage in OPA and had no measure of the type of activity. It is possible that the *type* of OPA a person engages in is more important for health than the amount of *time* a person spends engaging in OPA.

In contrast to previous studies (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010; Steeves et al., 2012), our results indicate that OPA was unrelated to obesity. Similar to other health outcomes, discrepancies in the relationship between OPA and obesity may be due to the methodological differences mentioned above. Again, our sample was designed to be representative of the U.S. population; previous studies evaluating OPA and obesity included samples of Australian adults (Chau et al., 2012), Washington state residents (Bonauto et al., 2014), or included older adults (Choi et al., 2010; Steeves et al., 2012). There were also measurement differences in both OPA (as discussed above) and obesity. Rather than using elevated waist circumference as the outcome of interest (as was done in this study), previous studies utilized BMI to categorize individuals as overweight/obese (Bonauto et al., 2014; Chau et al., 2012; Choi et al., 2010), with two studies relying on self-reported height and weight (Bonauto et al., 2014; Choi et al., 2010). Importantly, Steeves et al. (2012) also utilized NHANES data and directly assessed waist circumference. The findings from this study may have contradicted with Steeves et al. (2012) because of different study samples; they utilized older data (1999-2004), included older adults in their sample, and assessed OPA differently (categorized based on job).

A secondary aim was to evaluate if the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) differed between men and women. It was expected that the relationships between OPA and CVD risk indicators would be moderated by sex, such that the relationships would be stronger among men than women. Similar to previous studies (Allender et al., 2008; He & Baker, 2005; Scholes & Bann, 2018), men engaged in greater OPA than women [4.23 (0.48) vs. 12.63 (0.85), p <.001; data not shown]. However, our hypothesis was not supported; the relationship of OPA and CVD risk indicators (e.g. metabolic syndrome and its components) was not moderated by sex. This differed from previous studies, which found that the relationship of OPA with various health indicators differed between men and women including: all-cause mortality (Coenen et al., 2018; Stamatakis et al., 2013), hypertension (Fransson et al., 2003), low HDL cholesterol (Fransson et al., 2003), and cancer mortality (Stamatakis et al., 2013). The lack of sex differences in this study align with others who also found that the relationship of OPA and various health outcomes were similar among men and women (Holtermann et al., 2012; Li & Siegrist, 2012). Our results inform the literature on the relationship between OPA and metabolic syndrome and its components; OPA was not associated with metabolic syndrome nor its components, and these relationships did not differ between men and women.

Strengths and Limitations

Some studies have suggested that physical fitness plays a protective role in the PA Health Paradox (Holtermann et al., 2010). It was not possible to include fitness in this study, as it was not directly assessed in the secondary dataset. However, this study did include a number of covariates known to be related to physical fitness (e.g. age, sex, LTPA, weight status). Future studies evaluating OPA and CVD risk indicators such as metabolic disease and its components are encouraged to evaluate the role of physical fitness. Another limitation is the cross-sectional nature of NHANES. Much of the research which informed this study utilized longitudinal designs (Clays et al., 2013; Hallman et al., 2017; Holtermann et al., 2012; Krause et al., 2015). The relationship between OPA and CVD appears to differ when following individuals over an extended period of time and evaluating actual CVD, rather than evaluating the relationship between OPA and CVD risk factors at a single time point. Additionally, the measurement of OPA utilized in this study (weekly hours) does not take into consideration specifically what activities individuals are doing in their occupation. It is possible that certain types of OPA such as those which involve monotonous movements and awkward postures impact health differently than others, such as walking during the work day (Holtermann et al., 2018). The measurement utilized by this study does not differentiate between these two inherently different types of activities. Having more information about individuals' occupations and exactly how they are engaging in OPA may clarify findings related to the PA Health Paradox.

The health outcomes included in this study were all directly assessed (not self-reported), which is a strength of this study. Perhaps the greatest strength is the generalizability of the study sample. This study draws from NHANES, designed to be representative of the United States population. Because much of the PA Health Paradox literature focuses on European men, this study with a nationally representative U.S. sample fills a gap in the literature (Clays et al., 2013; Hallman et al., 2017; Holtermann et al., 2012; Krause et al., 2015). Additionally, there are fewer studies evaluating the PA Health Paradox among women than there are among men (Coenen et al., 2018). It is a strength that this study includes women and evaluates if the PA Health Paradox differs between men and women in the U.S. However, if sex differences had been detected methods utilized by this study would have prevented us from determining if it was differences in volume of OPA or differences in type of OPA that were responsible for sex differences. Again, having more information about individual's occupations is necessary to clarify findings related to the PA Health Paradox.

5.7 CONCLUSION

Overall, our findings indicate that OPA was not related to metabolic syndrome, nor its components among U.S. workers. It is important that U.S. workers understand that being highly active at work is not an adequate substitute for LTPA and its health benefits. LTPA may be particularly important to U.S. workers who engage in high levels of OPA as previous studies indicate that physical fitness is important among highly active workers (Holtermann et al., 2010). However, it is important to understand why OPA does not influence health similarly to LTPA. Holtermann et al. (2018) hypothesized that six potential mechanisms explain why OPA does not influence health similar to LTPA: lack of intensity, elevated 24 hour heart rate/ blood pressure, lack of recovery time, lack of worker control, and increased inflammation. Others have argued that the recent influx of articles identifying OPA as a health risk factor is due to methodological issues, such as measurement issues of OPA, and inadequately controlling for smoking status and socioeconomic factors (Shephard, 2019). More substantive research is needed to better understand the mechanisms by which OPA influences cardiovascular health. Longitudinal studies are needed in order to understand the association between OPA and cardiovascular health in the United States.

CHAPTER 6

6. MANUSCRIPT 3: THE ROLE OF LEISURE TIME PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR IN THE INCOME-OVERWEIGHT/OBESITY RELATIONSHIP

6.1 ABSTRACT

Overweight/obesity is more prevalent among those with low-income; income is related to both leisure time physical activity (LTPA) and sedentary behavior (SB), which are known to influence overweight/obesity. The health consequences associated with overweight and obesity make it important to understand how modifiable lifestyle behaviors, such as LTPA and SB, are related to the income-overweight/obesity relationship. This study aims to evaluate the role of LTPA and SB simultaneously controlling for the influence of one another in the income-overweight/obesity relationship. Cross-sectional data from the National Health and Nutrition Examination Survey (2007-2014) with a sample that included 10,348 non-older adults (aged 20-59 years) was utilized. A structural equation model with multiple mediators was conducted to evaluate the indirect effects from income (based on Federal Poverty Level, FPL) to overweight/obesity (BMI ≥25) through LTPA and SB simultaneously, controlling for a number of confounding variables, including diet, smoking, and alcohol consumption. Greater income was negatively associated with overweight/obesity (Total effect: B=-0.046; 95%CI=-0.07,-0.02). Income indirectly influences overweight/obesity through LTPA (Indirect effect: B=-0.005; 95%CI=-0.01,-0.003), and through SB (Indirect effect: B=0.008; 95%CI=0.005,0.01), but in opposing directions. The direct effect from income to overweight/obesity remained statistically significant (Direct Effect: B=-0.049; 95%C =-0.07;-0.02). LTPA partially accounts for the negative relationship between income and

overweight/obesity; SB reduces the strength of the negative relationship between income and overweight/obesity. Targeted behavior approaches for weight management by income may be beneficial. Increasing LTPA among adults with lower income and decreasing SB among adults with higher income may provide some overweight/obesity protection.

6.2 INTRODUCTION

Seventy percent of U.S. adults are considered overweight or obese (Fryar et al., 2016), with obesity being more prevalent among those with low-income (Paeratakul et al., 2002). For example, the prevalence of overweight and obesity is higher among low-income households (74%) [i.e. income 100%-199% of the Federal Poverty Line (FPL)] compared to those whose household income is 400% FPL or greater (66%) (National Center for Health Statistics, 2015). The health consequences associated with overweight and obesity (Mokdad et al., 2003) make it important to prevent and reduce overweight/obesity. Obesity prevention programs are designed to target lifestyle behaviors that are modifiable, regardless of an individual's income bracket. A better understanding of how modifiable lifestyle behaviors, such as leisure time physical activity (LTPA) and sedentary behavior (SB) are related to the income-overweight/obesity relationship will inform obesity prevention programs tailored to those with low-income.

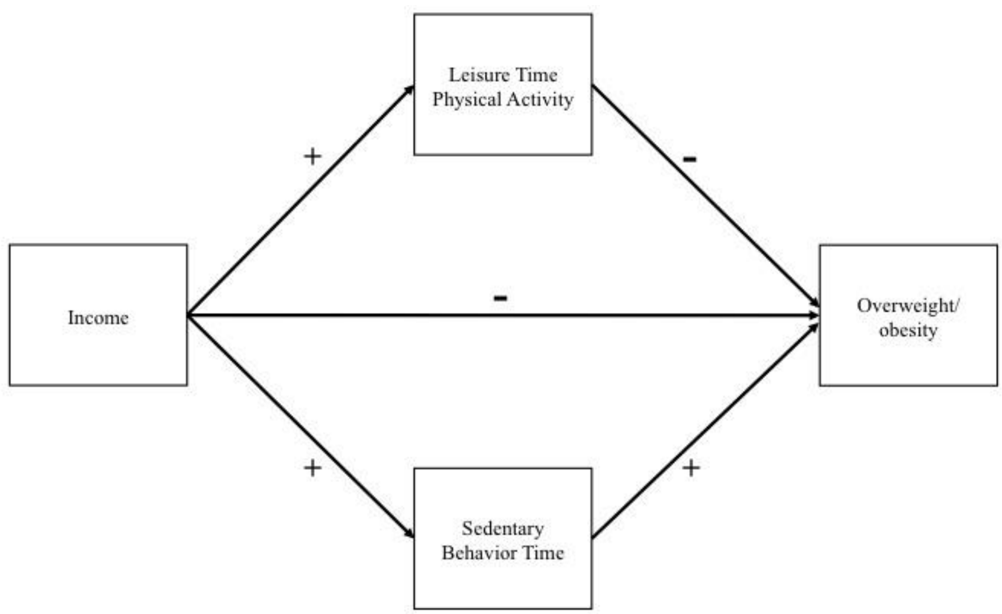
LTPA is an important behavior for obesity prevention (King et al., 2001). LTPA is known to positively impact health; adequate levels are associated with decreased risk of obesity and chronic disease (U.S. Department of Health and Human Services, 1996). LTPA is protective against obesity; those who engage in greater LTPA have decreased risk of overweight/obesity, even when controlling for energy intake (Wanner et al., 2016). In general, there appears to be a linear relationship with body mass index (BMI) and LTPA, such that those with higher BMIs engage in less LTPA (Chen & Mao, 2006). Despite these benefits, many U.S. adults are insufficiently active (Centers for Disease Control and Prevention).Further, disparities exist with those of low-income engaging in less LTPA (Elhakeem et al., 2015; Ford et al., 1991). Only 41% of adults with an income below $15,000 met the PA guidelines from LTPA compared to 59% of adults with an income of $75,000 or greater (Centers for Disease Control and Prevention).

Another modifiable lifestyle behavior associated with overweight/obese weight status is SB. In contrast to LTPA, SB is positively associated with overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). SB is known to have health consequences (all-cause mortality, cardiovascular disease, cancer, type 2 diabetes incidence) independent of physical activity (Biswas et al., 2015). Specific guidelines for SB do not exist, but individuals are encouraged to minimize SB (American College of Sports Medicine, 2017). The relationship between income and SB is less clear than the relationship of income and LTPA. Overall it appears that greater income is related to greater total time spent in SB. For example, Kozo et al. (2012) found that residents of higher income neighborhoods spent more objectively measured time in SB than those living in lower income neighborhoods. However the relationship between income and SB differs when evaluating *specific types* of SB (e.g. television watching vs. occupational sitting) (O'Donoghue et al., 2016). Some studies suggest that leisure time SB is more strongly related to poor health outcomes than occupational SB (Garcia et al., 2019).

Although related, LTPA and SB represent two distinct concepts. It is possible for individuals to be highly active (e.g. meet/ exceed PA recommendations), and yet spend many hours per day in SB, such as in a desk job. The inverse is also possible. Individuals may spend many hours per day in light intensity activity, but not necessarily moderate to vigorous intensity physical activity necessary to meet the PA guidelines, yet spend very little time engaging in SB. Overall the research indicates that time spent in SB is inversely related to physical activity and the behaviors differ based on household income (O'Donoghue et al., 2016). While research has focused on these behaviors concurrently in relation to weight status, there is a lack of research evaluating LTPA and SB simultaneously in relation to the income-overweight/obesity relationship. Because LTPA and SB are known to be inversely related to each other (O'Donoghue et al., 2016), it is important to understand their roles in the income-overweight/obesity relationship simultaneously.

Given that income-related overweight/obesity disparities exist, and LTPA and SB are related to both income and weight status, it is possible that these behaviors play an important role in the income-overweight/obesity relationship. The purpose of this study was to understand the modifiable lifestyle behavior mechanisms by which income influences overweight/obesity. Specifically, this study evaluated the role of LTPA and SB simultaneously controlling for the influence of one another in the income-overweight/obesity relationship. Figure 1 illustrates the hypothesized model.

Figure 1. Hypothesized model of the modifiable lifestyle behavior mechanisms (leisure time physical activity and sedentary behavior time) by which income influences overweight/obesity



The first aim was to evaluate the indirect effect of LTPA on the income-overweight/obesity relationship, controlling for SB. Building on prior literature, it was expected that higher income would be positively related to LTPA (Elhakeem et al., 2015; Ford et al., 1991) and LTPA would be negatively related to overweight/obesity (Chen & Mao, 2006; King et al., 2001; Wanner et al., 2016). It was further hypothesized that there would be a negative indirect effect from income to overweight/obesity through LTPA, which would partially account for the overall negative association between income and overweight/obesity. The second aim was to evaluate the indirect effect of SB on the income-overweight/obesity relationship, controlling for LTPA. Also building on prior literature it was expected that higher income would be positively related to SB (Kozo et al., 2012) and SB would be positively related to overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). It was further hypothesized that there would be a positive indirect effect from income to overweight/obesity through SB, working in the opposite direction of LTPA and the overall negative association between income and overweight/obesity. Although it was expected that there would be significant indirect effects through LTPA and SB, it was also expected that there would still be a significant direct effect from income to overweight/obesity (Paeratakul et al., 2002) because of the complex multifaceted nature of this relationship.

6.3 METHODS

6.3.1 DATASET

This study utilized publicly available data from The National Health and Nutrition Examination Survey (NHANES). The NHANES is a cross-sectional study, which combines surveys, examinations, and lab measures to assess health and nutrition in the United States population. NHANES uses a complex, multistage stratified probability cluster sample design to obtain a nationally representative sample of the non-institutionalized U.S. civilian population (Johnson, Dohrmann, Burt, & Mohadjer, 2014b). The present study includes participants from four NHANES waves (2007–2014). These four waves of data contain consistent measures of physical activity variables and yielded a total of 40,617 adults and children. The initial sample was reduced to a non-pregnant adult sample (ages 20 and over) (n= 23,235). Further, the analytical sample was reduced to only include adults age 20-59 (n= 15,376). Age 59 was selected as the cut-off because the Administration on Aging refers to individuals over the age of 60 as older adults, who may have behavioral and physiological differences from their younger counterparts (Adminstration for Community Living, 2015). Those with PA values deemed unrealistic (values > 3 standard deviations above the mean; approximately 25 hours per week) were eliminated from analyses (n = 226). Additionally, due to small sample size those with a BMI value categorized as underweight (BMI < 18.5, underweight category) were excluded from the analytical sample (n= 261). Finally, only those with complete data on all target variables were included in the analytical sample. Individuals with missing data on the following variables were excluded: body mass index (n= 609), income (n = 1,193), LTPA (n = 14), SB (n =27), and control variables (n= 2,698). The final analytical sample consisted of 10,348 adults.

6.3.2 MEASURES

6.3.2.1 DEPENDENT VARIABLE

Overweight/Obese Weight Status. Height and weight were directly assessed by NHANES. Body Mass Index (BMI) was calculated as kg/m^2. Individuals were classified as underweight (BMI < 18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese

(BMI > 30) based on CDC guidelines (Centers for Disease Control and Prevention, 2015). The overweight and obese categories were collapsed in order to compare those with an elevated weight status to those with a normal weight status [overweight/obese vs. normal (reference)].

6.3.2.2 INDEPENDENT VARIABLE

Income. Income is a continuous measure based on the Federal Poverty Level (FPL). The Department of Health and Human Services issues the FPL based on annual average estimates of the cost to cover basic needs. Income level for each participant was calculated by NHANES dividing self-reported annual household income by the FPL corresponding to the number of individuals residing in the household. An income level of less than 1 is considered to be poor.

6.3.2.3 MEDIATING VARIABLES

Leisure Time Physical Activity. Participants self-reported the amount of time they typically engage in moderate or vigorous intensity activity from "sports, fitness and recreational activities". The variable was coded as weekly hours (continuous) and an equivalent combination of moderate and vigorous-intensity LTPA was calculated by assigning vigorous intensity activities twice the weight of moderate-intensity activity as suggested by the 2018 Physical Activity Guidelines for Americans (U.S. Department of Health and Human Services, 2018).

Sedentary Behavior. Participants self-reported the amount of time they typically spend sitting or reclining excluding sleep per day. The variable was coded as daily hours (continuous).

6.3.2.4 CONTROL VARIABLES

The following socio-demographic variables, known to be related to income, LTPA, SB, and overweight/obesity were self-reported through a survey: age (years), sex [male vs. female (reference)] race/ethnicity [black, white (reference), Hispanic, other] nativity status [foreign vs. native (reference)], marital status [single vs. married/cohabitating (reference)], education [less than high school diploma, high school diploma, college degree or greater (reference)], employment [unemployed vs. employed (reference)], health insurance coverage [does not have health insurance coverage vs. has health insurance coverage (reference)]. Several health behaviors were also included as covariates: Healthy Eating Index (HEI; continuous), alcohol consumption (drinks per day continuous), smoking status [smoker vs. non-smoker (reference)], and sleep (average hours per night continuous).

6.4 STATITISTICAL ANALYSES

Means, frequencies and standard errors of participant characteristics were computed for the full sample and by BMI category (overweight/obese vs. normal). Independent samples t-tests and chi-square analyses were used to determine differences by BMI category. Descriptive statistics, independent samples t-tests and chi-square analyses were conducted using Stata SE version 15.0 statistical software (College Station, TX). To test whether LTPA and SB contributed uniquely to the relationship of income and overweight/obesity in combination with each other, a multiple mediator structural equation model was conducted. Standardized estimates are presented with 95% bootstrapped confidence intervals (5,000 resamples). The residual errors of LTPA and SB were correlated. Structural equation models were conducted in Mplus version 8.3 (Muthen & Muthen, Los Angeles, CA). Survey procedures were used to account for the complex NHANES sampling design.

6.5 RESULTS

6.5.1 DESCRIPTIVE STATISTICS

Characteristics of the full sample and by weight status are presented in Table 1. Sixty nine percent of participants were classified as overweight/obese. The average income (FPL) of the sample was 3.04 (0.05). Participants reported engaging in 3.48 (0.10) hours per week of moderate to vigorous LTPA and 6.25 (0.07) hours per day of SB.

The average age of the sample was 39.47 (0.23) years. Sixty-seven percent of the sample was white, followed by Hispanic (15%), black (11%), and another race/ethnicity (7%). Seventeen percent of the sample was foreign born, 63% were married or cohabitating, and 55% had a high school diploma but not a college degree. Twenty-three percent of the sample did not have health insurance. Participants reported an average HEI score of 52.54 (0.27) and consumed an average of 0.60 (0.02) alcoholic beverages per day. Twenty-three percent of the sample was categorized as a smoker.

Differences were detected by weight status. Participants classified as overweight/obese had lower income ($p < .05$), engaged in less LTPA ($p < .001$), and more time in SB ($p < .001$) than their counterparts classified as normal weight. Those classified as overweight/obese were older ($p < .001$); a greater percentage were male ($p < .001$), black ($p < .001$), and Hispanic ($p < .001$), but a lower percentage were white ($p < .01$), or another race ($p < .001$), compared to compared to those classified as normal weight. A greater percentage of those classified as overweight/obese were married/cohabitating ($p < .001$), had less than a high school education ($p < .01$), or a high school education ($p < .001$), but a lower percentage had a college degree or greater (p < ($p < .001$). HEI scores ($p < .001$),) and alcoholic beverage consumption ($p < .05$) were lower among those classified as overweight/obese than those classified as normal weight. Smoking was less common among those classified as overweight/obese than those classified as normal weight ($p < .001$).

Table 1. Characteristics of participants by weight status: National Health and Nutrition Examination Survey 2007-2014, M (SE) or %

	Full Sample (n = 10,348)	Normal Weight (n = 3,136)	Overweight/obese (n =7,212)
Dependent variable			
Weight Status^			
Overweight/obese	69%	---	---
Normal Weight	31%	---	---
Independent variable			
Income (FPL)^	3.04 (0.05)	3.11 (0.07)	3.01 (0.05)*
Mediating Variables			
Leisure Time Physical Activity (Weekly Hours)	3.48 (0.10)	4.30 (0.17)	3.11 (0.09)***
Sedentary Behavior (Daily Hours)	6.25 (0.07)	5.98 (0.10)	6.37 (0.08)***
Demographic characteristics			
Age	39.47 (0.23)	36.79 (0.41)	40.69 (0.22)***
Sex			
Female	50%	56%	48%***
Male	50%	44%	52%
Race/ethnicity			
White	67%	70%	65%**
Black	11%	8%	13%***
Hispanic	15%	11%	17%***
Other	7%	11%	5%***
Nativity status			
Foreign born	17%	19%	17%
Native born	83%	81%	83%
Marital status			
Single	37%	42%	35%***
Married/cohabiting	63%	58%	65%
Education			
Less than high school degree	14%	12%	15%**
High school degree	55%	50%	56%***
College graduate or greater	31%	37%	29%***
Employment			
Employed	74%	73%	75%
Unemployed	26%	27%	25%
Health insurance			
Insured	77%	77%	75%
Uninsured	23%	23%	25%
Health behaviors			
Healthy Eating Index	52.54 (0.27)	54.08 (0.43)	51.84 (0.25)***
Average alcoholic drinks per day	0.60 (0.02)	0.66 (0.04)	0.58 (0.02)*
Smoking status			
Smoker	23%	27%	21%***
Non-smoker	77%	73%	79%
Average hours sleep per night	6.83 (0.02)	6.97 (0.03)	6.76 (0.02)***

*$p < .05$, **$p < .01$, ***$p < .001$

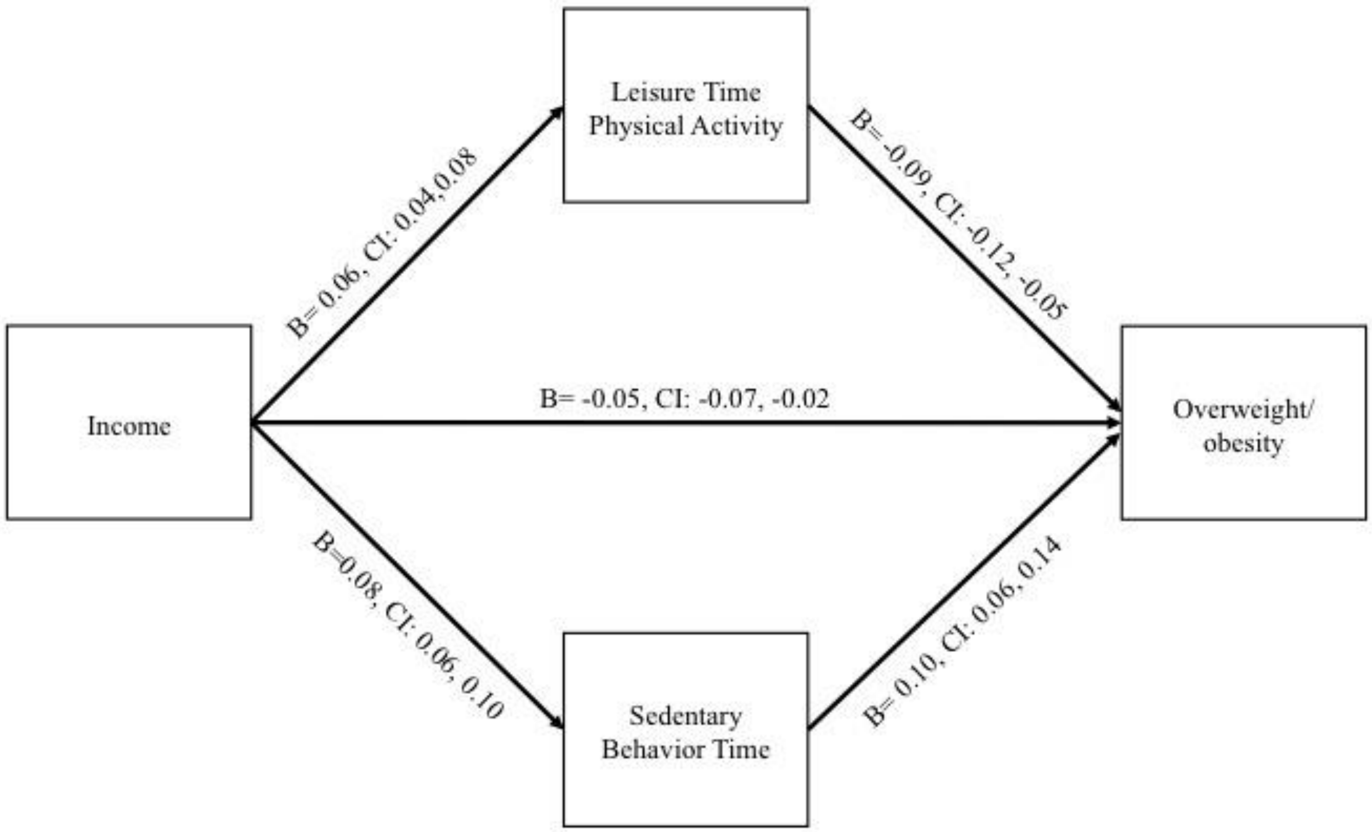
^Those with a body mass index 18.5 to 24.9 were classified as normal weight; those with a body mass index > 24.9 were classified as overweight/obese; FPL federal poverty level; *** indicates.

6.5.2 STRUCTURAL EQUATION MODELING

Standardized estimates are presented with 95% bootstrapped confidence intervals (5,000 resamples). Greater income was associated with decreased risk of overweight/obesity (Total effect: B = -0.046; CI = -0.07,-0.02). In the context of the overall model, income was positively associated with LTPA (B=0.06, CI: 0.04, 0.08), and greater LTPA was associated with decreased risk of overweight/obesity (B=-0.09, CI: -0.12, -0.05). The indirect effect from income to overweight/obesity through LTPA was statistically significant (B=-0.005; 95%CI=-0.01, -0.003). LTPA partially accounted for the negative relationship between income and overweight/obesity.

Further, in the context of the overall model income was positively associated with SB (B=0.08, CI: 0.06, 0.10), and greater SB was associated with increased risk of overweight/obesity (B=0.10, CI: 0.06, 0.14). The indirect effect from income to overweight/obesity through SB was also statistically significant (specific indirect: B=0.008; 95%CI=0.005, 0.01). SB reduced the negative relationship between income and overweight/obesity. The direct effect from income to overweight/obesity remained statistically significant (B=-0.050; 95%CI =-0.07;-0.02) such that greater income was associated with decreased risk of overweight/obesity. See Figure 2. The specified model contains the maximum number of possible pathways (“just identified” model); for this reason we were unable to assess model fit indices.

Figure 6.2. Multiple Mediator Structural Equation Model Assessing the Role of Leisure Time Physical Activity and Time in Sedentary Behaviors on the Income-Overweight/obesity Relationship



NOTE: Standardized estimates are presented with 95% bootstrapped confidence intervals (5,000 resamples). The specified model contains the maximum number of possible pathways ("just identified" model); for this reason we were unable to assess model fit indices. Each pathway includes the following covariates (not pictured): age, sex, race/ ethnicity, nativity status, marital status, education, employment status, health insurance, Healthy Eating Index, alcoholic beverage consumption, and smoking status. The residual errors of leisure time physical activity and sedentary behavior were correlated (not pictured). All depicted pathways were statistically significant (95% confidence interval did not contain zero).

6.6 DISCUSSION

The purpose of this study was to understand the modifiable lifestyle behavior mechanisms by which income influences overweight/obesity. Specifically, this study evaluated the role of LTPA and SB simultaneously, controlling for one another in the income-overweight/obesity relationship. The hypotheses were supported. As expected, higher income was positively related to LTPA (Elhakeem et al., 2015; Ford et al., 1991) and LTPA was negatively related to overweight/obesity (Chen & Mao, 2006; King et al., 2001; Wanner et al., 2016). The significant indirect effect from income to overweight/obesity through LTPA indicated that greater LTPA among those with higher income may partially explain how having a higher income is protective against overweight/obesity. Further, as expected income was positively related to SB (Kozo et al., 2012) and SB was positively related to overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). Greater SB among those with higher income buffered the negative association between income and overweight/obesity. The indirect effect of SB worked in the opposite direction of LTPA and the overall negative association between income and overweight/obesity. Also in line with the hypotheses, there was a significant negative direct effect from income to overweight/obesity, such that those with greater income were at decreased odds having an overweight/obese weight status (Paeratakul et al., 2002). This indicates that the relationship between income and overweight/obesity is not entirely accounted for by LTPA and SB. In fact the direct effect from income to overweight/obesity was much larger than the indirect effects through LTPA and SB. This is unsurprising because the income-overweight/obesity relationship is complex and influenced by several factors.

This study sheds light on two modifiable health behaviors related to the income-overweight/obesity relationship. It informs healthcare practitioners attempting to address overweight/obesity among both high and low-income populations. According to the results, there was a significant negative indirect effect from income to overweight/obesity through LTPA. This indicates that LTPA may partially account for the negative relationship of income and overweight/obesity. Thus, higher participation in LTPA may partially explain the lower prevalence of overweight/obesity among those with higher income; while lower participation in LTPA may partially explain the greater prevalence of overweight/obesity among those with lower income. How this mechanism may function is as follows. Those with higher income may utilize their resources to engage in LTPA (Gidlow et al., 2006). For example, individuals with high incomes may use their funds to purchase memberships at fitness facilities, to live in areas with greater walkability, or increased access to places, such as parks and trails that promote LTPA. Some individuals with higher income may use their funds to outsource household chores (cleaning, lawn care etc.) or live closer to their place of employment (e.g. shorter commute); thus, having more available time to engage in LTPA. Whereas those with lower income may not have the discretionary funds to invest in facilities nor the time for LTPA. Additionally, greater education among those with higher income may be a factor. In this sample, those with a college degree or greater had a much higher income (FPL $M = 4.02$, $SE = 0.05$) than those with less than a high school degree ($M = 1.76$, $SE = 0.06$; $p < .001$), or a high school degree ($M = 2.82$, $SE = 0.05$; $p < .001$). Previous studies have found that those with higher educational attainment engage in greater LTPA (Centers for Disease Control and Prevention). Those with greater educational attainment may be able to more easily understand and interpret health literature and therefore engage in more health promoting behaviors, such as LTPA.

In contrast, there was a significant positive indirect effect from income to overweight/obesity through SB. The indirect effect through SB is in the opposite direction of the overall effect of income on overweight/obesity. SB reduces the strength of the negative relationship of income and overweight/obesity. However, it does not reduce the negative association completely. In fact, a lower amount of time spent in SB among those with lower-income appears to be protective against having an overweight/obese weight status. The relationship between income and SB is likely a reflection of different types of occupations. “White collar” or “professional” occupations associated with higher socioeconomic status are considered less active and higher in SB compared to “blue collar” occupations, traditionally considered lower socioeconomic status (Beenackers et al., 2012; Bennie et al., 2010; Schofield et al., 2005; Smith et al., 2016; Steele & Mummery, 2003). Further, some individuals with lower income may engage in more household or transportation physical activity due to a lack of resources and therefore spend less time in SB.

Although previous studies have not evaluated the indirect effect of income on overweight/obesity through LTPA and SB, this study aligns with others who evaluated specific pathways of interest. The findings that income was associated with decreased risk of overweight/obesity (Paeratakul et al., 2002), positively associated with LTPA (Elhakeem et al., 2015; Ford et al., 1991) and that LTPA was associated with decreased risk of overweight/obesity (Chen & Mao, 2006; King et al., 2001; Wanner et al., 2016) are not novel. Nor are the findings that income was positively related to SB (Kozo et al., 2012) and SB was associated with increased risk of overweight/obesity (Ching et al., 1996; Hu et al., 2003; O'Donoghue et al., 2016; Thorp et al., 2011). However, the finding that income indirectly affects overweight/obesity through *both* LTPA and SB is novel and important. A better understanding of modifiable health behaviors related to the income-overweight/obesity relationship will help healthcare practitioners develop targeted approaches for weight management.

In general, healthcare practitioners attempting to address overweight/obesity among those with higher income may want to consider focusing on decreasing SB, rather than increasing LTPA, which appears to be protective against overweight/obesity. In contrast, healthcare practitioners attempting to reduce overweight/obesity among those with lower income may want to consider focusing on increasing LTPA, rather than decreasing SB. Randomized controlled trials to decrease overweight/obesity among income-specific populations using these targeted approaches (increasing LTPA vs. decreasing SB) are needed to better understand the efficacy of targeting specific health behavior by income status. The results from this study lay the groundwork for future research studies utilizing more sophisticated approaches (e.g. randomized controlled trials with objective measures of activity) to understand the roles of LTPA and SB in the income-overweight/obesity relationship.

6.6.1 LIMITATIONS

This study attempted to understand the mechanisms by which income influences overweight/obesity, specifically LTPA and SB. In doing so, this study included a number of covariates in order to isolate the indirect effects from income to overweight/obesity through LTPA and SB, including a number of modifiable lifestyle behaviors such as diet (HEI), alcohol consumption, and smoking status. However, the relationship between income and overweight/obesity is complex, and there are numerous factors, which may be involved in this relationship that were not available in the dataset. This includes measures of the neighborhood environment, such as walkability (Murillo, Reesor-Oyer, Hernandez, Liu, & Obasi, 2020) and proximity to fast food (Reitzel et al., 2016). Additionally, the cross-sectional design of the publicly available data prevents one from establishing the directionality of the study variables. However, this study does lay the groundwork for future studies to examine the association between income, LTPA, SB, and overweight/obesity using longitudinal data and randomized controlled trials. Further, there are known limitations with self-reported LTPA data, specifically over-reporting of LTPA (Celis-Morales et al., 2012). Future studies are encouraged to utilize objective measures when evaluating LTPA. Despite these known limitations, there are also strengths of utilizing NHANES. For example, the NHANES study sample is designed to be nationally representative, making the findings are highly generalizable. Further, weight status was directly assessed by trained research staff, rather than self-reported, which is known to have error.

6.7 CONCLUSION

This study provides a framework for understanding the role of LTPA and SB in the income-overweight obesity relationship. Findings from this study indicate that greater LTPA among those with higher income partially accounts for the lower prevalence of overweight/obesity among those with higher income. Restated, lower LTPA among those with lower income partially accounts for the higher prevalence of overweight/obesity among those with lower income. In contrast, SB reduces the strength of the income-overweight/obesity relationship. SB works in the opposite direction of the overall negative association of income with overweight/obesity, buffering the influence of income on overweight/obesity. A lower amount of time spent in SB among those with lower-income provides some protection against overweight/obesity among this vulnerable population. These findings inform future longitudinal studies or randomized controlled trials attempting to better understand the income-overweight/obesity relationship.

CHAPTER 7

7. SUMMARY, FUTURE DIRECTIONS AND LIMITATIONS

7.1 SUMMARY

According to the Social Determinants of Health, social factors such as SES impact the health of individuals (Marmot & Wilkinson, 2005). Those of higher SES have decreased prevalence of overweight/obesity (National Center for Health Statistics, 2015); they engage in more LTPA (Elhakeem et al., 2015; Ford et al., 1991), and more SB (Kozo et al., 2012), but less non-LTPA (Cohen et al., 2013; Kandula & Lauderdale, 2005), compared to those of lower SES. Adequate levels of PA are associated with decreased risk and SB is associated with increased risk of chronic disease and overweight/obesity (Chen & Mao, 2006; Ching et al., 1996; Hu et al., 2003; King et al., 2001; O'Donoghue et al., 2016; Thorp et al., 2011; Wanner et al., 2016). Differences in PA behaviors may be related to SES differences in metabolic syndrome and overweight/obesity. However, gaps in the literature remain.

A disproportionate number of low SES adults fail to meet the PA guidelines (Centers for Disease Control and Prevention). However, much of the literature has focused on LTPA (Beenackers et al., 2012; Choi et al., 2017). There is a dearth of studies documenting SES-related variation of non-LTPA. Further, although the relationship of LTPA and cardiovascular health is well documented, more recent studies based on European male samples have identified OPA as a risk factor for CVD (Li et al., 2013), coined the PA Health Paradox (Holtermann et al., 2012; Holtermann et al., 2009, 2010). However, the PA Health Paradox has not been evaluated on a nationally representative sample of United States employees, and there is a lack of studies evaluating this relationship including women. Finally, it is well known that income is related to LTPA (Centers for Disease Control and

Prevention), SB (Kozo et al., 2012), and overweight/obesity (National Center for Health Statistics, 2015). However, studies have not been conducted to evaluate the role of LTPA and SB simultaneously in the income-overweight/obesity relationship.

This dissertation project fulfilled three important aims: 1) examined the relationship between three SES indicators: education, income, and employment status with non-LTPA, 2) evaluated the relationship of OPA and CVD risk, specifically metabolic syndrome and its components (waist circumference, blood pressure, HDL cholesterol, triglycerides, and blood glucose), 3) assessed the role of LTPA and SB in the income-overweight/obesity relationship.

7.11 THE RELATIONSHIP BETWEEN THREE SES INDICATORS: EDUCATION, INCOME, AND EMPLOYMENT STATUS WITH NON-LTPA

Findings from this dissertation project demonstrate that when evaluated simultaneously education and employment status, but not income are related with non-LTPA, such that those with lower education and those employed part-time engage are at increased odds for meeting the PA guidelines from non-LTPA. This raises awareness of the need to consider non-LTPA rather than LTPA exclusively when assessing PA. This may be particularly relevant among those of low SES, as indicators of low SES (education, part-time employment) were associated with increased odds of meeting the PA guidelines from non-LTPA. Although many studies have identified individuals of low SES as being at risk for PA disparities (Beenackers et al., 2012; Elhakeem et al., 2015; Ford et al., 1991; Gidlow et al., 2006; Seiluri et al., 2011), they have mainly focused on LTPA. LTPA only accounts for a portion of the amount of time individuals spend engaging in PA. This study adds to existing health behavior literature suggesting a three-pronged approach to measure SES is necessary to understand how SES is related to health behaviors (Braveman et al., 2005; Schaap & Kunst, 2009; Shavers, 2007). Further, when evaluating whether individuals meet the PA guidelines, this study emphasizes the need to utilize a comprehensive measure of non-LTPA (Kakinami et al., 2018), because it is more informative than evaluating specific domains as they all contribute to being sufficiently active (U.S. Department of Health and Human Services, 2018). Those of low SES are disproportionately affected by a lack of LTPA (Centers for Disease Control and Prevention). However, the findings from this study indicate they engage in greater non-LTPA. Researchers assessing PA, particularly among low SES communities must take a more comprehensive approach to measuring PA. LTPA alone is not an accurate reflection of total PA; non-LTPA varies considerably and can be a substantial contributor to total PA. It is important for practitioners attempting to increase PA to consider these complexities.

7.12 THE RELATIONSHIP OF OPA AND CVD RISK

This dissertation project evaluated the PA Health paradox utilizing a novel sample (U.S. nationally representative sample). Unlike previous studies focused on various health outcomes (Holtermann et al., 2009; Krause, 2010; Krause et al., 2015; Krause et al., 2007; Li et al., 2013), findings indicated that OPA was not related to metabolic syndrome nor its components (elevated waist circumference, elevated blood pressure, low HDL cholesterol, elevated triglycerides, elevated blood glucose) when models were adjusted for covariates. Results were not moderated by sex. It is important that U.S. workers understand that being highly active at work is not an adequate substitute for LTPA and its health benefits. LTPA may be particularly important to U.S. workers who engage in high levels of OPA as previous studies indicate that physical fitness is important among highly active workers (Holtermann et al., 2010). More substantive research is needed to better understand the mechanisms by which OPA influences cardiovascular health. Longitudinal studies are needed in order to understand the temporal association between OPA and cardiovascular health in the United States.

7.13 THE ROLE OF LTPA AND SB IN THE INCOME-OVERWEIGHT/OBESITY RELATIONSHIP

This study provides a framework for understanding the role of LTPA and SB in the income-overweight obesity relationship. Findings from this study indicate that greater LTPA among those with higher income partially accounts for the lower prevalence of overweight/obesity among those with higher income. Restated, lower LTPA among those with lower income partially accounts for the higher prevalence of overweight/obesity among those with lower income. In contrast, SB reduces the strength of the income-overweight/obesity relationship. SB works in the opposite direction of the overall negative association of income with overweight/obesity, buffering the influence of income on overweight/obesity. A lower amount of time spent in SB among those with lower-income provides some protection against overweight/obesity among this vulnerable population. These findings inform future longitudinal studies or randomized controlled trials attempting to better understand the income-overweight/obesity relationship.

7.2 STRENGTHS AND LIMITATIONS

Broadly, the purpose of this study was to better understand the inter-relationship of SES, PA, and health (including CVD risk factors and overweight/obesity) among a nationally representative sample of U.S. adults. A fundamental strength of this study is the generalizability of the study sample. The NHANES study sample is designed to be nationally representative, making findings applicable to the U.S. population. Further, the health outcomes in this study (metabolic syndrome, its components, and overweight/obesity) were directly assessed by trained research staff, rather than self-reported, which is known to have error. The inter-relationship of SES, PA, and health is influenced by a number of factors. In order to account for this, a number of covariates were included in order to isolate the relationships of interest. These included a number of modifiable lifestyle behaviors such as diet (HEI), alcohol consumption, and smoking status. However, the relationships of interest are complex, and there are numerous factors, which may be involved that were not available in the dataset. This includes measures of the neighborhood environment, such as walkability (Murillo et al., 2020), and proximity to fast food (Reitzel et al., 2016), as well as urbanicity and climate. Additionally, the cross-sectional design of the publicly available data prevents this study from establishing the directionality of the study variables. However, this study does lay the groundwork for future studies to examine the associations between SES, PA/SB, and health using longitudinal data and randomized controlled trials. Although health outcomes were objectively measured, PA was self-reported by participants. This a limitation because there are known limitations with self-reported PA data, specifically over-reporting of PA (Celis-Morales et al., 2012). Future studies are encouraged to utilize objective measures when evaluating LTPA.

7.3 FUTURE DIRECTIONS

Findings from this dissertation project illustrate the complexities of the inter-relationships of SES, PA/SB, and health. This study raises awareness of the need to consider non-LTPA among low SES populations; it provides initial insight into the relationship of OPA and metabolic syndrome among the U.S. population, and indicates that targeted behavior approaches for weight management by income may be beneficial. However, future research projects are needed to extend knowledge surrounding the inter-relationships of SES, PA/SB, and health and address the limitations in this study. Although this study included numerous covariates in order to isolate the relationships of interest, due to the nature of the dataset, there are numerous factors, which were not included as covariates. Future studies evaluating the inter-relationships of SES, PA/SB, and health are encouraged to include measures of the neighborhood environment, such as walkability (Murillo et al., 2020), and proximity to fast food (Reitzel et al., 2016), as well as urbanicity and climate. Perhaps the greatest limitation of this dissertation project is the cross-sectional design of the publicly available data, which prevented this study from establishing the directionality of the study variables. Longitudinal studies and randomized controlled trials are needed to observe how changes in one variable of interest relate to changes in other variables of interest. Finally, there are known limitations with self-reported PA data, specifically over-reporting of PA (Celis-Morales et al., 2012). Future studies are encouraged to utilize objective measures when evaluating PA/SB.

In addition to addressing the limitations of this study, future studies are needed to address research questions that were beyond the scope of this three-paper dissertation project. For example, this study evaluated the relationship of OPA and CVD risk, specifically metabolic syndrome and its components. Future studies are encouraged to evaluate the relationship of OPA with other health outcomes, such as actual CVD. In addition, this study assessed the role of LTPA and SB in the income-overweight/obesity relationship, but there are many modifiable lifestyle behaviors related to the income-overweight/obesity relationship. Future studies assessing other modifiable lifestyle behaviors, such as diet and sleep are needed to better understand the income-overweight/obesity relationship. Further, overweight/obesity is only one income-related health disparity. Future studies are needed to evaluate the role of modifiable lifestyle behaviors in the relationship of income with other health outcomes, such as metabolic syndrome and diabetes. Finally, as demonstrated in Aim 1, income is only one marker of SES. It is important to evaluate the role of modifiable lifestyle behaviors in the relationship of other markers of SES (e.g. education, employment status) with health outcomes. The overall purpose of this three-paper dissertation was to better understand the inter-relationship of SES, PA/SB, and health. This overall goal was achieved by addressing three specific aims: 1) examining the relationship between three SES indicators: education, income, and employment status with non-LTPA, 2) evaluating the relationship of OPA with metabolic syndrome and its components, 3) assessing the role of LTPA and SB in the income-overweight/obesity relationship. However, future studies utilizing different methodology and evaluating different modifiable lifestyle behaviors and health outcomes are needed. A more thorough understanding of how SES impacts health through modifiable lifestyle behaviors (such as PA and SB) is needed in order to develop target approaches to eliminate health disparities.

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