ABSTRACT

Physical Activity, Sedentary Behavior, and Perceived Stress among Adults:
An Application of the Theory of Planned Behavior

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Background: Young and middle-aged adults engage in low levels of physical activity, high levels of sedentary behavior, and experience high levels of stress. Examining physical activity and sedentary behavior through the theory of planned behavior framework may provide useful insight to help address health issues in the population. The objective of this study was to evaluate the predictive value of the theory of planned behavior in explaining physical activity and sedentary behavior in young and middle-aged U.S. adults. Specifically, relationships between objectively measured physical activity and sedentary behavior over a 6-week period were examined using socio-demographic characteristics and theory of planned behavior constructs. A secondary objective was to measure stress dynamically and examine the relationship between stress and physical activity, and stress and sedentary behavior, over the same 6-week period. Methods: Participants (n=45, mean age=31 years, 70% female, 83% White) completed surveys that included sociodemographic information, theory of planned behavior constructs, and a weekly stress inventory. Participants also wore an activity monitor (i.e., Actigraph accelerometer or SenseWear Armband) for 6 weeks and completed the weekly stress inventory once weekly throughout the 6-week study period. Two longitudinal models were estimated to determine the relationship between TPB constructs, relevant socio-demographic characteristics, and perceived stress with sedentary behavior and physical activity over the 6-week study period. Results: Model fit indices supported the theory of planned behavior constructs in explaining physical activity and sedentary behavior. Model fit indices also supported a relationship between greater stress and less time spent being sedentary, but did not support a relationship between physical activity and stress in this sample. Conclusions: Results cautiously continue to support the use of the theory of planned behavior to explain physical activity and sedentary behaviors, though the constructs in this study explained less variance in intention and behavior when compared to previous research. More research should be conducted to understand the relationships between stress and physical activity, and stress and sedentary behavior. Researchers and practitioners should address physical activity, sedentariness, and stress in efforts to improve the health status of young and middle-aged adults.

Physical Activity, Sedentary Behavior, and Perceived Stress among Adults:
An Application of the Theory of Planned Behavior

by

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A Dissertation

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DEDICATION

To Dr. Rafer Lutz

"Rafer's life was one of unending service," as many have stated and was mentioned in his memorial service. This dissertation and Shana Walsh's experience through her doctoral work is a testament to these words. Not only was Rafer a strong Christian, committed to serving our Lord and lovingly dedicated to his family, he was also intentional about serving those around him through teaching, research, service, and mentorship. Rafer was my partner on this project, and even though he was not here in the flesh to serve on this committee or to co-chair Shana's dissertation alongside me, his presence has been with me, and thus us, throughout this process. Rafer's calm and patient character and his expertise and wisdom persisted through the words he originally wrote in the IRB application and his published articles that guided the methods and informed the research questions posed and answered in this dissertation. Moreover, his legacy of seeking truth, and my memory of his diligence and focus on helping others achieve success pervade this final product. Although we will never know exactly what thought provoking questions Rafer would have asked on February 29th, 2016 at her defense, I do know that he would have been proud of Shana and this achievement. Because of Rafer, those of us who knew him are continuously reminded that nothing "can separate us from the love of God." (Romans 8:38-39) This has been evident throughout Shana's dissertation journey, reflecting Rafer's presence far beyond the words he left with us.

- *Renée Umstattd Meyer*

CHAPTER ONE

Introduction

Purpose and Significance

Young and middle-aged adults aged 20-49 make up 41% of the U.S. population, accounting for approximately 127 million people (U.S. Census Bureau, 2013). At present, this population is experiencing high rates of chronic diseases resulting from lifestyle choices. More than one-third of all U.S. adults are obese and two-thirds of U.S. adults can be considered overweight or obese (Ogden et al., 2014). Approximately half of all U.S. adults have one or more chronic health condition (Ward, Schiller, & Goodman, 2014). Of the estimated 80 million American adults with cardiovascular disease, more than half are estimated to be 60 years of age or younger (Lloyd-Jones et al., 2010). Given this, determinants of health behaviors relating to lifestyle choices in this population are important to examine.

Additionally, young to middle-aged adulthood is also often a period of child-rearing (Matthews & Hamilton, 2014). Research suggests healthier parents have healthier children (Whitaker et al., 1997). Children in the U.S. are also currently experiencing unprecedented rates of obesity and related comorbidities (Ogden et al., 2014). Childhood obesity tracks into adulthood and is accompanied by an increased disease risk (Singh et al., 2008). Understanding and promoting healthy behaviors in young and middle-aged adults who are parents could therefore play an important role in improving the lives of adults while also improving the health status of their children, ultimately resulting in a healthier population.

Physical activity is a specific health behavior that is important to consider across the young and middle-aged adult population. Decades of scientific evidence strongly support a relationship between regular physical activity and a reduced risk of the chronic diseases present in high rates among American adults. This includes obesity, cardiovascular disease, type 2 diabetes, high blood pressure, and a variety of cancers (Centers for Disease Control and Prevention, 2014). Despite this, many American adults do not engage in sufficient levels of physical activity to achieve health benefits. Data from 2014 using a subjective measure of activity indicated just slightly over half of all adults (51.6%) engaged in the minimum amount of aerobic physical activity suggested by the guidelines (Centers for Disease Control and Prevention, 2014). Data resulting from objectively measured physical activity may have indicated different results and strengthened these findings. Given the negative health outcomes associated with low levels of physical activity and the modifiability of the behavior, it is important to continue to identify determinants of physical activity across this population.

Sedentary behavior has also recently emerged as a public health issue affecting the health of young and middle-aged adults (Owen, Bauman, & Brown, 2009). The term “sedentary behavior” is used to characterize activities that require little energy expenditure in the range of 1.0 to 1.5 metabolic equivalents of task (METs; Ainsworth et al., 2011; Owen et al., 2009). Common sedentary behaviors include watching television, sitting at a desk, and using a computer (Ainsworth et al., 2011). Sedentary behavior has been associated with cardiovascular disease, obesity, type 2 diabetes, premature mortality, and some cancers (Katzmarzyk, Church, Craig, & Bouchard, 2009; Hu et al., 2003; Ford et al., 2010; Howard et al., 2008; Gierach et al., 2009). These relationships have been found independent of physical activity levels. This means a person can participate in physical activity regularly while also being highly sedentary (e.g., an office employee who sits at a desk for 8 hours per day at work and watches television in the evenings, and also jogs for 30 minutes daily), and may still suffer negative health consequences from being sedentary (Owen, Healy, Matthews, & Dunstan, 2010). Objectively measured sedentary behavior data from the National Health and Nutrition Examination Survey revealed American adults spend more than 7 hours per day in sedentary pursuits (Matthews et al., 2008).

Additionally, young and middle-aged adults are also often a part of the working population. Work is a large source of sedentary behavior across many occupational sectors (Church et al., 2011). Researchers (Clemes et al., 2014) measuring sitting times in office employees found almost two-thirds of time at work was spent sitting. Given its prevalence and the negative health consequences caused by sedentariness, better understanding its determinants can lead to efforts to reduce it, ultimately improving the health of young and middle-aged adults.

In addition to physical activity and excessive sedentariness, stress levels also affect the health status of young and middle-aged adults. Stress is defined as “a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being” (Lazarus and Folkman 1984, p. 19). High stress levels are pervasive for American adults, with 47% reporting being concerned with the amount of stress in their lives (Stambor, 2006).

This is problematic because stress influences the body's immune response (Cohen & Williamson, 1991; Sergestrom & Miller, 2004), is related with heart disease (Pandya, 1998; Tennant, 2000), cancer (Kiecolt-Glaser et al., 1985), and an increase in unhealthy behaviors (Ng & Jeffery, 2002).

Evidence suggests that stress levels are related with both physical activity and sedentary behaviors. Researchers of a large-scale study with more than 32,000 participants reported those who are less physically active were twice as likely to report high stress levels (Aldana et al., 1996). A small but compelling amount of evidence has also supported a relationship between higher levels of stress and stress-related conditions and greater sedentary time (Sanchez-Villegas et al., 2008; Hamer et al., 2010).

Better understanding stress levels and the relationships between stress levels, physical activity, and sedentary behavior could lead to more multi-faceted approaches to combating the health issues facing young and middle-aged adults in the U.S. today.

Health behavior theories are often used to help explain influences on health behaviors, such as physical activity or sedentariness (Glanz, Rimer, & Viswanath, 2008). Specifically, the theory of planned behavior has been extensively applied to physical activity research and has recently begun to be applied to sedentary behavior research. The theory of planned behavior posits that a behavior is predicted directly by behavioral intention (e.g., a person's plan of action to engage in the behavior), and perceived behavioral control (e.g., factors outside an individual's control that may affect intentions or behaviors), and that attitude (e.g., a person's overall evaluation of performing the behavior and his or her beliefs about the outcomes or attributes of performing the behavior), subjective norm (e.g., a person's normative beliefs and their motivation to comply) and perceived behavioral control all influence behavioral intention (Ajzen, 1991). A meta-analysis of 72 studies conducted in 2002 by Hagger and colleagues examining the predictive value of the theory of planned behavior constructs in physical activity behaviors found the model to explain 27% of the variance in behavior and 45% of the variance in intention. A smaller but substantial body of literature supports the theory of planned behavior being used to help explain sedentary behaviors.

The purpose of this study was to examine correlates of physical activity and sedentary behavior across a population of young and middle-aged working adults. Specifically, relationships between objectively measured physical activity and objectively measured sedentary behavior over a six-week period were examined using socio-demographic characteristics, dynamically measured perceived stress levels, and theory of planned behavior constructs.

Research Questions

1. Are the theory of planned constructs of attitude, subjective norm, and perceived behavioral control associated with behavioral intention for physical activity?

2. How are theory of planned behavior constructs and socio-demographic characteristics related with objectively measured physical activity over a six-week period?

    2a. What is the unique contribution of perceived stress level measured once weekly over the same six-week period to the model?

3. How are the theory of planned behavior constructs of attitude, subjective norm, perceived behavioral control, and intention for physical activity and socio-demographic characteristics related with objectively measured sedentary time over a six-week period?

    3a. What is the unique contribution of perceived stress level measured once weekly over the same six-week period?

Study Overview

Adults aged 20-49 were recruited from local businesses, church congregations, and a university in a central Texas community to participate in this study. After giving their informed consent, participants completed surveys regarding socio-demographic information, stress level, and theory of planned behavior constructs. Participants were also given an accelerometer that they were asked to wear daily for six weeks (either an Actigraph GT1M accelerometer or a Sensewear MF-SW), and a stress inventory that they were asked to complete weekly over the same six-week period. As an incentive for participation, participants were compensated with $10 for every week that they completed the stress inventory and wore their accelerometers for 5 of the 7 days (4 weekdays and 1 weekend day, specifically). Thus, participants exhibiting complete compliance across the 6 weeks of the study were compensated with $60 total.

Limitations

There are several limitations to this study. First, data were collected from a convenience sample. The sample size was relatively small (n=48) and all participants were from the same geographic area (Central Texas). A larger sample size may have yielded different results, and it is possible that findings would differ across more varied locations. This limits the scope of generalizability of the results.

Additionally, only accelerometer data was used to measure physical activity and sedentary behavior. Although the accelerometers used in this study have been previously validated for measuring energy expenditure in adults (Actigraph: Alhassan et al., 2012; Sensewear armband: Jakicic et al., 2004), they do have several limitations. The models used in this study cannot be worn in water, and can only provide information about the duration and intensity of an activity bout but not identify the type of activity. Accelerometer data alone may therefore be over- or underestimating actual energy expenditure (Dishman, Washburn, & Schoeller, 2001).

Public Health Benefit

Low levels of physical activity and high levels of sedentary behavior are major public health concerns across the young and middle-aged adult population in the U.S. and world. Both behaviors contribute significantly to growing chronic disease rates, decreased quality of life, and burgeoning health care costs (Centers for Disease Control, 2014; Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). Regular physical activity participation and reduced time spent being sedentary, however, reduce a person's disease risk and improve quality of life, making these behaviors ideal focuses for public health promotion efforts. Research in which the determinants of these behaviors are explored, while accounting for known related factors, such as stress, can guide such efforts.

The results of this study will provide deeper insight into factors related with physical activity and sedentary behavior, and can be used by researchers, public health professionals, and interventionists. Findings can be used to direct the development and implementation of intervention strategies to promote healthier behaviors, ultimately leading to healthier people and a healthier population. Additionally, the application of the theory of planned behavior to research examining physical activity and sedentary behavior will provide additional information in explaining the behaviors. Although the theory of planned behavior has been applied extensively to physical activity research, few studies within the young and middle-aged adult population use objectively measured physical activity or longitudinally measured physically activity. By doing both, this study will add a meaningful contribution to current literature. Few researchers have used the theory of planned behavior in examining sedentary behavior, however those that have largely support its continued application. Further, to the best of the researcher's knowledge, the theory of planned behavior has not been studied with longitudinally measured sedentary behavior. Results from this study can therefore be used to answer previously unanswered questions, and to guide researchers, public health professionals, and interventionists to improve the health and the lives of young and middle-aged American adults.

CHAPTER TWO

Review of the Literature

Introduction

Population of Interest

Young and middle-aged adults aged 20-49 make up 41% of the total U.S population, or about 127 million people (U.S. Census Bureau, 2013) and thus their health needs are important to consider. Recent reports indicate this population is severely impacted by chronic conditions resulting from poor lifestyle choices (e.g., insufficient amounts of physical activity, poor diet, and smoking). Specifically, an estimated 81,100,000 American adults have one or more types of cardiovascular diseases and of these, 43,100,000 are estimated to be 60 years old or younger. Approximately 151,000 Americans who died of cardiovascular disease in 2006 were younger than 65 years of age, which is well below the average life expectancy of 77.7 years (Lloyd-Jones et al., 2010).

Data from 2011-2012 also indicates that more than one-third of all U.S adults (approximately 77 million people) are obese, and two-thirds of adults can be considered either overweight or obese (Ogden et al., 2014). Obesity-related conditions in adults include heart disease, stroke, several types of cancer, and type 2 diabetes, which are some of the leading causes of preventable death (Centers for Disease Control, 2014). Researchers estimate the direct medical cost of obesity to be $190.2 billion annually, which is equal to 20.6% of all U.S. national health expenditures (Cawley & Meyerhoefer, 2012). Trends project there will be 65 million more obese adults in the U.S. by the year 2030, and the medical costs associated with treatment of obesity-related illnesses are esimated to increase by $48-66 billion/year (Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). As of 2012, about half of all adults (approximately 117 million people) had one or more chronic health condition, and one in four adults had two or more chronic conditions (Ward, Schiller, & Goodman, 2014). Further, chronic diseases are responsible for 7 out of 10 deaths each year, and treating people with chronic diseases accounts for 86% of our nation's health care costs (Centers for Disease Control and Prevention, 2015).

Given that young and middle-aged adults make up a large percentage of the population and that they are experiencing high rates of chronic disease, better understanding relationships between modifiable risk factors and health outcomes in this population is particularly important to further disease prevention efforts. Additionally, the period of young and middle-aged adulthood is often a time of child-rearing. In 2006, first time mothers were on average 25 years old, though the average age is continually rising (Matthews & Hamilton, 2014). Evidence suggests healthier parents may have healthier children. For example, Whitaker and colleagues (1997) found that parental obesity more than doubled the risk for children (whether obese or non-obese) to become obese adults. The same study found that among children aged three to five, the chance of becoming an obese adult increased from 24% if neither parent was obese to 62% if at least one parent was obese.

Psychological Stress

Stress impacts the health status of middle-aged adults and is a risk factor of chronic disease (e.g., heart disease, obesity, metabolic syndrome, cancer; Chandola, Brunner, & Marmot, 2005; Tennant, 2000). A person's ability to reduce his or her physiological response to stress also influences overall physical and psychological health (Krantz & Manuck, 1984; Trieber et al., 2003). Stress is defined as "a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (Lazarus and Folkman 1984, p. 19). Although stress is relevant to a variety of academic disciplines and has been defined in various ways (Kinman & Jones, 2005), Lazarus and Folkman's definition is the most widely cited definition of stress. This definition captures the transactional emphasis of stress as well as the importance it places on the appraisal of events (Wagner, 1990).

Research suggests that more than half of working adults and 47% of Americans say they are concerned with the amount of stress in their lives, with 22% of people experiencing extreme stress in their lives (Stambor, 2006). Additionally, 39% of Americans have indicated that their stress has increased over the past year. An even larger percent of respondents said their stress has increased over the past 5 years (44%; American Psychological Association, 2011). Only 26% of respondents reported doing an excellent or very good job at preventing themselves from becoming stressed, and when stress does occur, only 29% of people indicated that they were doing an excellent or very good job at handling or reducing it. Work is cited as a significant source of stress, and is also cited as one of the leading causes of employee absenteeism. In the United Kingdom for example, stress has been estimated to cost approximately $5.8 billion (US) per year resulting from 11 million lost working days (Health & Safety Executive, 2010).

Stress and Health

Given the pervasiveness of stress among adults, understanding it's relation to health and health-related behaviors may be a key component in addressing the health needs of this population. The field of research demonstrating the effect of stress on health arguably began with the seminal work of Hans Selye, when he suggested the first ever model explaining the role stress plays in physical disease (Selye, 1975). Since then, the harmful effects of stress on the body have become well-documented and include an altered immune response (Cohen & Williamson, 1991; Sergestrom & Miller, 2004), heart disease (Pandya, 1998; Tennant, 2000), impaired DNA repair possibly related with cancer (Kiecolt-Glaser et al., 1985), overeating resulting in increased central adiposity (Stone & Brownell, 1994; Adam & Epel, 2007), an increase in unhealthy behaviors (e.g., consumption of energy dense foods, less frequent exercise, smoking; Ng & Jeffery, 2003), and poorer mental health status (e.g., anxiety, depression; World Health Organization, 2014). Work-stress specifically has been identified as having a positive dose-response relationship with the risk of metabolic syndrome, where employees with chronic work stress being more than twice as likely to have the syndrome than those without work stress (odds ratio: 2.25; Chandola, Brunner, & Marmot, 2005). It is also understood that the a person's ability to reduce their physiological response to stress plays an important role in their overall psychological and physical health (Krantz & Manuck, 1984; Trieber et al., 2003).

Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985). Examples of physical activity include walking, household or occupational activities, sports, conditioning, and all other activities requiring bodily movement performed by persons to sustain life. This differs from exercise, which is defined as a subset of physical activity that is planned, structured, repetitive, and has a final or intermediate objective of the improvement or maintenance of physical fitness (Caspersen et al., 1985). Physical activity is therefore more broadly defined, where all exercise is physical activity, but not all physical activity is exercise. Physical activity is strongly linked to health outcomes, and is specifically linked to risk reduction of the diseases and conditions presently impacting this population (e.g., obesity, cardiovascular disease, type 2 diabetes; U.S Department of Health and Human Services, 2008).

Physical Activity and Health

The study of the relationship between physical activity and health arguably began with the pioneering research conducted by Jeremy Morris and colleagues in the early 1950's. Morris tracked the heart attack rates of hundreds of employees of the London Transport Executive, comparing bus drivers with bus conductors of London's double-decker buses (Morris et al., 1953). Bus drivers sat for 90% of their shifts while bus conductors climbed up and down the steps of the bus throughout the majority of the workday, totaling approximately 600 steps per day. The results of this study determined that the more physically active employees experienced fewer than half of the heart attacks than employees with less active occupations, and had significantly lower rates of early mortality. This data provided some of the first evidence supporting the relationship between physical activity and health outcomes.

Morris' study was followed by a second landmark publication in the field of physical activity epidemiology, known as the 'Harvard Alumni Study' conducted by Ralph Paffenbarger (Paffenbarger, Wing, & Hyde, 1978). Paffenbarger mailed brief questionnaires to surviving male alumni of Harvard who had attended the school between 1916 and 1950. The questionnaires asked about activity level, tobacco use, parental disease history, and medical care for diagnosed conditions. A total of 16,936 men responded, and data analysis revealed a greater relative risk for men who climbed fewer than 50 stairs per day when compared to men who climbed more than 50 stairs per day, men who walked less than five city blocks daily when compared to men who walked more than five blocks, and for men who expended less than 2000 calories per week when compared to men with greater caloric expenditure.

In the 60+ years since these initial studies were conducted, the relationship between health and physical activity has become well established. Current research indicates regular physical activity can improve the health and quality of life of persons of all ages, regardless of the presence of a chronic disease or disability (U.S. Department of Health and Human Services, 2008). More specifically, strong evidence supports a relationship between adults participating in regular physical activity and a reduced risk of stroke, high blood pressure, adverse blood lipid profiles, type 2 diabetes, metabolic syndrome, colon cancer, breast cancer, coronary heart disease, and early death (U.S. Department of Health and Human Services, 2008). Regular physical activity participation among adults has also been strongly associated with improved cardiorespiratory and muscular fitness, weight gain prevention, weight loss (particularly when combined with caloric restriction), prevention of falls, reduced depression, and in older adults, improved cognitive function (U.S. Department of Health and Human Services, 2008).

In children and adolescents, regular physical activity participation improves health status, and is associated with higher levels of cardiorespiratory fitness, stronger muscles, reduced adiposity, stronger bones, and psychological benefits including increased self-esteem levels and reduced symptoms of anxiety and depression (U.S. Department of Health and Human Services, 2008). Additionally, healthy youth are more likely to have healthy adulthoods. Regular physical activity reduces the likelihood that risk factors for chronic diseases such as heart disease, hypertension, type 2 diabetes, and osteoporosis, will develop during adulthood (U.S. Department of Health and Human Services, 2008).

The physical activity levels of young and middle-aged adults with children influences the physical activity levels of the children. A 1991 study found that children with two active parents were 5.8 times more active than children with two inactive parents (Moore et al., 1991), indicating active parents may have more active children. Parental support for physical activity has also been shown to be a consistent correlate of child and adolescent physical activity (Biddle et al., 2005; Gustafson & Rhodes, 2006; Van Der Horst et al., 2007). Inactivity in childhood is a major cause of childhood obesity and is associated with a multitude of deleterious health outcomes including a higher risk for cardiovascular disease, development of diabetes, and cancer (Li et al., 2009). Childhood BMI also tracks into adulthood and is also accompanied by increased cardiovascular and metabolic risk, creating a perpetuating cycle of poor health outcomes (Singh et al., 2008; Juhola et al., 2011; Morrison et al., 2012). Therefore, in addition to the personal benefits received by adults themselves for engaging in healthy behaviors, understanding and increasing healthy behaviors in young and middle-aged adults who are parents could play a significant role in increasing healthy behaviors in children, ultimately resulting in healthier children and a healthier population.

Physical Activity Guidelines

Given the severity of the consequences associated with insufficient physical activity participation, the cost of the problem, and modifiability of the behavior, increasing physical activity levels across all populations is a public health priority. The abundance of evidence supporting the relationship between physical activity and postive health outcomes led to the first ever Surgeon Generals report addressing physical activity, called *"Physical Activity and Health: A Report of the Surgeon General"* (U.S. Department of Health and Human Services, 1996). This report was the most comprehensive review of physical activity and health at the time, and was designed to be a work of significance on par with the Surgeon General's historic first report on smoking and health. The primary message of the report was that Americans can substantially improve their health and quality of life by including moderate amounts of physical activity in their daily lives.

Since the publication of the Surgeon General's report, the U.S Department of Health and Human Services identified being physically active as one of the most important steps that Americans of all ages can take to improve their health, and issued the first-ever publication of national guidelines for physical activity in 2008 (the *2008 Physical Activity Guidelines for Americans*; U.S. Department of Health and Human Services, 2008). The guidelines state that in order to achieve substantial health benefits, adults should engage in a minimum of 150 minutes per week of moderate-intensity, or 75 minutes per week of vigorous-intensity aerobic physical activityperformed in bouts of at least 10 minutes and spread throughout the week (or the equivalent combination of moderate- and vigorous- intensity activity). Moderate activity refers specifically to activity between three and six metabolic equivalents (METs) while vigorous activity requires 6 or more METs. One MET is defined as the amount of oxygen consumed while sitting rest (Jette, Sidney, & Blumchen, 1990), and thus three METs equals three times more energy than what is required when sitting at rest. Examples of moderate activities in the three-to-six MET range include brisk walking, housework, dancing, and gardening (Ainsworth et al., 2011). Vigorous activities that require six or more times the amount of energy used at rest include running, bicycling, swimming, climbing stairs, and carrying heavy loads (Ainsworth et al., 2011). For additional and more extensive health benefits, the guidelines state adults should increase their aerobic physical activity to 300 minutes per week of moderate-intensity or 150 minutes per week of vigorous-intensity aerobic physical activity, or an equivalent combination of both. The guidelines also state that adults should engage in muscle-stengthening activities that are moderate- or high-intensity and involve all major muscle groups on two or more days per week, and that these exercises provide additional health benefits (U.S. Department of Health and Human Services, 2008).

Despite the public health emphasis on increasing physical activity levels, many Americans are enaging in insufficient amounts of activity to meet the guidelines. In fact, data from 2013 from the Centers for Disease Control and Prevention (2014) revealed only 20.6% of adults met the recommendations for aerobic physical activity and muscle-strengthening activity. Approximately half of all adults (51.6%) engaged in the minimum amount of aerobic physical activity suggested by the guidelines, and only 29.3% of adults performed muscle-strengthening activities on two or more days per week.

Physical Activity and Stress

In addition to the health benefits of regular participation in physical activity, such as reduced disease risk and improved quality of life, there is compelling evidence suggesting there is a reciprocal relationship between stress and physical activity, where physical activity may relieve stress, and stress levels are also related with physical activity behaviors.

Although anecdotal evidence long preceded scientific evidence (Alderman, 2004), results of meta-analyses concluded bouts of physical activity or exercise can buffer the effects of exercise and reduce the stress response (Alderman, Rogers, Johnson, & Landers, 2003; Crews and Landers, 1987). Specifically, the body responds to stress with a set of neuroendocrine responses (e.g., secretion of glucocorticoids and catecholamines) mediated by the hypothalamic-pituatary-adrenal axis and the sympathetic nervous system. The sum of the neuroendocrine response is to mobilize lipids from stored adipose tissue and glucose from gycogen stores to ensure the availability of adequate energy for the brain; a process also called the body's "fight or flight response." During ancient times, this specific stress response was vital for survival in the face of physical aggressions. Today's stressors, however, are largely psychological, are not associated with an increased metabolic demand, and yet elicit the same stress response by the body. Therefore the stress response occurs in anticipation of physical activity that, given today's stressors, never occurs.

Chronic overactivation of the stress-reponse system without being followed by physical activity results in the development of stress-related health conditions (e.g., heart disease, metabolic syndrome; Chandola, Brunner, & Marmot, 2005; Tennant, 2000). Researchers have therefore hypothesized that “physical activity should be the natural means to prevent the conseuqneces of stress (Tsatsoulis & Fountoulakis, 2006, p.196). Although the exact mechanism through which physical activity or exercise reduces stress remains unclear, the ability of exercise to reduce the sensitivity to stress and to influence metabolic functions, specifically insulin sensitivity, are thought to play a large role (Tsatsoulis & Fountoulakis, 2006). Given this, it should come as no surprise that those who participate in regular physical activity often report lower rates of stress-related disorders such as anxiety and depression and have a reduced stress response (Crews & Landers, 1987; Taylor, Sallis, & Needle, 1985).

Further, a review article reported a substantial amount of evidence supporting that even a single bout of aerobic exercise aids in resistance to the physiological and emotional consequences of psychological stressors and can have antidepressant and anxiolytic effects (Salmon, 2001). Another review paper published in 1998 concluded unequivocal evidence supporting the positive effects of regular physical activity on reduced psychological stress responses, depression, anxiety conditions, and an elevated mood state (Scully et al.).

Evidence also suggest that stress levels are related with physical activity behaviors. A large-scale study with more than 32,000 participants reported that those wo are less physically active were twice as likely to report high stress levels (Aldana et al., 1996). Another study with more than 12,000 participants reported a decrease in stress levels with increase in leisure-time physical activity (Schnohr, Kristensen, Prescott, & Scharling, 2005). Given the understanding of the related physiological effects that both stress and physical activity have on the body, and their reciprocal relationship, considering both variables provides an opportunity to more holistically examine health status of adults.

Sedentary Behavior

While the role of physical activity in health is well established, emerging evidence suggests time spent being sedentary is also related with deleterious health outcomes (Owen, Bauman, & Brown, 2009), and thus is important to include when examining health status of young and middle aged adults. Sedentary behavior is a term used to characterize activities that require little movement and correspondingly low levels of energy expenditure in the range of 1.0-1.5 metabolic equivalents (METs; Ainsworth et al., 2011; Owen et al., 2009). Sedentary behaviors include lying down and prolonged sitting at a desk at work, in transit, television viewing, computer use, eating at a table, and playing electronic games (Ainsworth et al., 2011). As indicated by its definition, sedentary behaviors are not the same as low levels of physical activity, but instead represent a distinct class of activities that can exist with or without physical activity participation.

Sedentary Behavior and Health

One of the first large-scale studies examing the specific relationship between sedentary behavior and mortality was conducted by Peter Katzmarzyk and colleagues in 2009. In this 12-year prospective cohort study of 17,013 Canadian adults aged 18-90 years, a progressively higher risk of mortality was found across higher levels of sitting time from all causes and cardiovascular disease (*p*<.01; Katzmarzyk, Church, Craig, & Bouchard, 2009), demonstrating a dose-response association between sitting time and mortality, independent of leisure time physical activity. In an even larger 14-year cohort study in the U.S. with 53,440 men and 69,776 women published in 2010, time spent sitting (measured as >6 hours per day vs. <3 hours per day) was associated with mortality in both men (relative risk = 1.17) and women (relative risk = 1.34), and associations were strongest for cardiovascular disease mortality (Patel et al., 2010). Authors of both studies recommended health professionals (physicians and public health practitioners) encourage physical activity participation in addition to reducing time spent being sedentary.

In exploring other relationships between sedentary behavior and health, it is important to note that television viewing is often used as the measure of sedentary time. This is not only because television veiwing is a sedentary behavior, but it is also the most prevalent leisure time activity among American, Australian and UK adults (Bureau of Labor Statistics, 2009; Dong, Block, & Mandel, 2004; Three Screen Report, 2009; Australian Bureau of Statistics, 2013), and is significantly associated with total sedentary time (Clark et al., 2011). In addition to premature mortality and cardiovascular disease, researcheres have also found time spent being sedentary while viewing television to be associated with an increased risk of type 2 diabetes and obesity (Ford et al., 2010; Hu et al., 2003; Katzmarzyk et al., 2009). In an 8-year prospective study examing the association between television viewing and the development of diabetes among 23,855 adults, greater time spent viewing television was associated with an increased likelihood of diabetes diagnosis (Ford et al., 2010). Relatedly, objectively measured time spent in sedentary pursuits predicts higher levels of fasting insulin, a precursor to diabetes and major characteristic of metabolic syndrome (*p*=.02; Helmerhorst et al., 2009). In a 6 year prospective study of 50,277 non-obese women, time spent watching television was positively associated with becoming obese (Hu et al., 2003). Specifically, this study reported a 23% increase in obesity for every additional 2 hours per day of watching television.

Time spent being sedentary has also been related with cancer. In an 8-year prospective cohort study of 488,720 men and women aged 50-71 from the National Institutes of Health- American Association of Retired Persons Diet and Health Study, a link between sedentary behavior and an increased risk of colon cancer was shown in men and endometrial cancer in women (Howard et al., 2008; Gierach et al., 2009). A 9-year prospective cohort study conducted study by Patel and colleagues (2006) also found a link between sedentary behavior (measured as >6 hours per day vs. <3 hours per day) and ovarian cancer among 56,695 postmenopausal women (hazard rate ratio = 1.55; *p*=.01).

As mentioned previously, evidence suggests the relationships between sedentary behavior and health outcomes are independent of physical activity levels. This means it is possible to meet current recommended physical activity guidelines and still suffer negative health consequences from time spent being sedentary (Owen, Healy, Matthews, & Dunstan, 2010). An example of this would be an office worker who jogs for 30 minutes most days of the week, but spends the workday sitting at a desk and a couple of hours in the evenings watching television (Owen et al., 2010). This type of person (previously referred to as an *Active Couch Potato*; Owen et al., 2010), who exhibits high levels of sedentary behavior while also meeting or exceeding the recommendations set forth by the national physical activity guidelines may still experience detrimental dose-response relationships between time spent being sedentary and health markers (e.g., waist circumference, systolic blood pressure, glucose; Healy et al., 2008).

Sedentary Behavior and Stresss

Given the prevalence of both stress and sedentary behaviors across young to middle-aged adults, and how both factors are burdensome to health, understanding relationships between the two may be important for understanding overall health status of this population. Considerable evidence supports a relationship between physical activity and stress and a relationship between sedentary behavior and health, but more limited evidence exists for the relationship between sedentary behavior and stress. The evidence that does exist indicates that stress and sedentary behavior may have a reciprocal relationship, where stress may be related with time spent being sedentary, and also that time spent being sedentary may be related with stress (Hamer et al., 2010; Sanchez-Villegas et al., 2008).

Specifically, a study conducted in 2008 found a 31% increased risk for developing a mental health disorder among persons who reported being sedentary for more than 42 hours per week when compared to those who reported being sedentary for less than 10.5 hours per week (Sanchez-Villegas et al.). Additionally, a systematic review of articles published between 1985 and 2010 concluded sedentarty behavior is associated with an increased risk of depression (Teychenne, Ball, & Salmon, 2010). Research also found time spent sitting in front of a screen (also called screen time; e.g., computer use or television watching) is associated with a greater liklihood of having a mental health disorder (Sanchez-Villegas et al., 2008), and is associated with higher stress levels

(Hamer et al., 2010). Contrastingly, a 2014 study of 1,104 Australian adults found overall sitting time was not associated with the severity of stress symptoms (Rebar et al.). A study published in the same year using the same sample, however, urged interventionists to consider the multifaceted behavioral-psychological profile of individuals that includes physical activity, sedentary behavior, and psychological stress (Rebar et al., 2014b).

Sedentary Behavior Guidelines

Given the deleterious health outcomes related with sedentary behavior, Canada became the first country to release evidence-based national sedentary guidelines in 2011, which exist in addition to the country's physical activity guidelines (Canadian Society for Exercise Physiology, 2012). The rationale for the independence of the sedentary guidelines from the physical activity guidelines was to emphasize that although the behaviors are related, sitting too much is not the same as engaging in minimal amounts of physical activity. The current guidelines are specifically for those aged 0-17, and do not currently address reducing sedentary time in adults. The Canadian sedentary behavior guidelines for persons 0-4 years of age state that caregivers should minimize the time infants, toddlers, and preschoolers spend being sedentary during waking hours. Examples of sedentary behaviors at this age include: prolonged sitting or being restrained (e.g., in a stroller or high chair) for more than one hour at a time. The guidelines further state that screen time (e.g., television, computer, electronic games) is not recommended for children under 2 years of age, and should be limited to under one hour per day for children aged 2-4. For children (aged 5-11 years) and youth (aged 12-17) the guidelines state that time spent being sedentary each day should be minimized, which may be achieved by 1) limiting recreational screen time to no more than 2 hours per day (with lower levels associated with additional health benefits), and 2) limiting sedentary motorized transport, extended sitting and time spent indoors throughout the day.

In 2014, the Australian government followed Canada's example and also released sedentary behavior guidelines (Australian Government Department of Health, 2014). Australia's guidelines state that children aged 0-2 should not spend any time watching television or using other electronic media, children aged 2-5 should be limited to less than one hour per day of watching television or using other electronic media, and all children up to 5 years of age should not be sedentary, restrained, or kept inactive for more than one hour at a time, with the exception of sleeping. For children aged 5-12 and young people aged 13-17, Australia's guidelines suggest minimizing time spent being sedentary everyday through limiting use of electronic media to no more than 2 hours per day, with lower levels being associated with reduced health risks, and breaking up long periods of sitting as often as possible. For adults aged 18-64, sedentary behavior guidelines suggest minimizing the amount of time spent in prolonged sitting, and breaking up long periods of sitting as often as possible.

The U.S. does not yet have a set of national sedentary behavior guidelines, however, there has been discussion surrounding the inclusion of sedentary behavior recommendations in the next physical activity guidelines (Hamilton et al., 2008; Owen et al., 2010). Sedentary behavior guidelines may be particularly important for the U.S population given high U.S. sedentary rates. In a study using data from NHANES, 6,329 participants >6 years of age wore activity monitors for an average of 13.9 hours/day, and 7.7 hours of the monitored time was shown to be spent in sedentary pursuits (Matthews et al., 2008). When stratified by age, the most sedentary groups were older adults aged 70-

85 (males: 9.5 sedentary hours per day; females: 9.1 sedentary hours per day) and older adolescents aged 16-19 (males: 7.9 sedentary hours per day; females: 8.1 sedentary hours per day). Children aged 6-11 were the least sedentary group in the U.S., with male children spending 6.0 hours per day in sedentary pursuits and females spending 6.1 hours per day being sedentary. Young adults aged 20-29 (males: 7.27 sedentary hours per day, females: 7.68 sedentary hours per day) were found to be less sedentary than older adolescents (males: 7.91 sedentary hours per day, females: 8.13 sedentary hours per day), and sedentary time increased by about 2 hours per day for adults aged 30-39 (males: 7.2 sedentary hours per day; females: 7.3 sedentary hours per day). When stratified by sex, females were more sedentary than males throughout youth and early adulthood, but this pattern was reversed after 60 years of age, where women were then less sedentary than men (p <.01 for interaction; only shown in Whites but not in Blacks or Mexican Americans).

In the young and middle-aged adult populations, work is a large source of sedentary behavior across a growing number of occupational sectors (Church et al., 2011). An analysis of energy expenditure by occupation using data from 2003-2006 revealed that less than 20% of all American jobs required at least moderate-intensity physical activity; decreasing from 50% in the 1960s (Church et al., 2011). Another recent study measuring step counts and sitting times in 72 office workers found almost two-thirds (65%) of time at work was spent sitting (Clemes et al., 2014). This is particularly important for the American adult population who spend approximately 7.4 hours per day working, or the equivalent of one-third of their lives (Organisation for Economic Co-operation and Development, 2014). Furthermore, research indicates that employees with sedentary job types do not compensate for their sedentary behavior at work by being more active outside of work (Clemes et al., 2014; Jans et al., 2007), and that sedentary behavior in one segment of life is related with sedentary time in other segments of life (Walsh et al., 2015).

Theory Use in Health Behavior Research

Because health behaviors, such as participation in physical activity and time spent being sedentary, play a major role in health outcomes, health behavior theories have been used by researchers to better understand and explain such behaviors. Theories are defined as interrelated concepts, definitions, and propositions that present a systematic view of events or situations by specifying relations among variables. Thus, theories can be used to explain and predict events or situations, help explain behavior, and can be used to suggest means to achieve behavior change (Glanz, Rimer, & Viswanath, 2008). A variety of theories have been used to help explain physical activity behaviors, but the three most prominent theories applied within the context of physical activity include the social cognitive theory (Bandura, 1986), the transtheoretical model (Prochaska & DiClemente, 1986), and theory of planned behavior (Ajzen, 1991; Buchan, Ollis, Thomas, & Baker, 2012), with the theory of planned behavior being cited as having consistently strong predictive value of physical activity-related behaviors (Godin & Kok, 1996).

The Theory of Planned Behavior

The theory of planned behavior has been used to help explain and predict a variety of health behaviors including: addictive behaviors (e.g., smoking, substance abuse; Harakeh et al., 2004; Zemore & Ajzen, 2014), eating behaviors (e.g., vegetable consumption, taking vitamin supplements; Madden, Ellen, & Ajzen, 1992; Emanuel et al., 2012), automobile-related behaviors (e.g., seat belt use, speeding; Tavafian, Aghamolaei, Gregory, & Madani, 2011), HIV/AIDs-related behaviors (e.g., using condoms; Montanaro & Bryan, 2014), screening behaviors (e.g., mammograms, breast self-exam; Browne & Chan, 2012; McCaul, Sandgren, O'Neill, & Hinsz, 1993), and physical activity behaviors (e.g., exercising; Madden et al., 1992). In a meta-analysis published in 1996 that examined 56 studies, theory of planned behavior constructs performed well in predicting a wide variety of health behaviors, with an average R^2 of .41 (range 0-1; higher values explain a greater proportion of the variance in the behavior; Godin & Kok, 1996).

The theory of planned behavior is concerned with intrapersonal factors that determine the likelihood of performing a behavior. It purports that four factors influence behavior: intention to perform a behavior, attitude, perceived behavior control, and subjective norm. In the model, behavior is most strongly predicted by intention to perform a behavior (defined as a person's plan of action to engage in the behavior; Ajzen, 1991) and it is therefore the most immediate determinant of perfoming the behavior. A strong intention has been demonstrated to be associated with an increase in the likelihood that the behavior will be performed. Intention to perform a behavior is directly influenced by the remaining three constructs in the model, each described below (Ajzen, 1991).

Attitude. Attitude describes a persons' overall evaluation of performing the behavior (behavioral beliefs) and his or her beliefs about the outcomes or attributes of performing the behavior (evaluations of behavioral outcomes). A positive attitude thus stems from favorable beliefs about the outcomes associated with performing the behavior and a negative attitude stems from unfavorable beliefs about the outcomes associated with performing the behavior (Ajzen, 1991). Positive and negative attitudes have been shown to directly influence intention to perform a physical activity-related behavior (Godin & Kok, 1996).

Subjective norm. Subjective norm refers to a person's normative beliefs and their motivation to comply. The theory of planned behavior distinguishes between two types of norms: injunctive and descriptive. Injunctive norms capture whether individuals believe that those who are important to them or society at large would approve or disapprove of their performing the behavior, while descriptive norms refer to perceptions a person has about others engaging in the behavior (e.g., amount of people who actually engage in the behavior, population groups that engage in the behavior; Ajzen, 1991). A person who believes those important to him or her would approve of the behavior and or are participating in the behavior will have a more positive subjective norm than a person who does not. A positive subjective norm has to date only been weakly associated with intention to perform a physical activity-related behavior (Godin & Kok, 1996, McEachan et al., 2011).

Perceived behavioral control. Perceived behavioral control is included in the theoretical framework to account for factors outside an individual's control that may affect intentions and behaviors. It refers specifically to the extent to which a person feels able to engage in the bejavior. The construct includes both external factors (e.g., availability of time and money) and internal factors (e.g., ability and skill). Perceived behavioral control is influenced by control beliefs, which refer to the presence or absence of facilitators and barriers to behavioral performance, and is weighted by perceived power of each control factor to facilitate or inhibit the behavior. It is important to note that perceived behavioral control is the only construct in the theory of planned behaviors that is considered to both indirectly (through intention) and directly influence behavior. This is because a person with a positive attitude and subjective norm may not perform the behavior if the behavior is not within his or her volition control (Azjen, 1991). Perceived behavioral control has been shown to directly influence both intention to perform a physical activity-related behavior, and the behavior itself (Godin & Kok, 1996).

Physical Activity and the Theory of Planned Behavior

Although the theory of planned behavior was developed as a universal model for the prediction of human social behavior, it has been used extensively in physical activity research (Ajzen, 2011). A large number of reviews have consistently reported strong relationships between theory of planned behavior constructs and physical activity (e.g., Blue, 1995; Godin, 1993; Godin, 1994; Hausenblas, Carron, & Mack, 1997). In 1996, a meta analysis was published including studies from 1985 to 1996 to determine the efficiency of the theory of planned behavior in explaining and predicting health related-behaviors (Godin & Kok, 1996). Eighteen of the included studies looked specifically at physical activity-related behaviors (called exercise in the study; Godin & Kok, 1996). Results indicated attitude and perceived behavioral control have strong predictive potential of behavioral intention, explaining between 5% and 30% and 6% and 60% of the variance in intention, respectively. Subjective norm, however, was not supported as playing a significant role in exercise intention, as it was only significant in 8 of the 18 studies. The use of injunctive versus descriptive norm within the subjective norm construct was not reported. Intention and perceived behavior control were both found to have strong predictive potential of behavior, explaining between 25% and 58% and 2% and 38% of the variance in behavior, respectively. Excluding subjective norm, the rest of the model was supported as an appropriate framework through which to view physical activity behaviors.

In 2002, Hagger and colleagues also conducted a meta analysis using 72 studies published between 1975 and 2001 examining the predictive value of the theory of planned behavior constructs in physical activity behaviors. Studies were included in the meta analysis if the target behavior was defined as physical activity, and if the authors reported at least one correlation between the behavior and constructs derived from the theory of planned behavior. The entire model across all studies explained 27% of the variance in behavior and 45% of the variance in intention. Perceived behavioral control (β=.28) and attitude (β=.20) accounted for the greatest variance in intention. Perceived behavioral control (β=.22) and intention (β=.05) also contributed significantly to behavior. In this analysis, subjective norm was shown to contribute a small but significant amount to intention (β=.09), which is similar to the findings from the meta-analysis conducted by Godin and Kok (1996). The use of injunctive versus descriptive norms within the subjective norm construct was not reported by the researchers.

In 2011, McEachan and colleagues conducted another meta-analysis examining the theory of planned behavior in studies published from their inception through 2010. Articles were selected for inclusion if they reported prospective test of health or health-risk related behaviors. Cross-sectional studies were thus excluded. Additionally, all studies were required to explicitly test the theory of planned behavior and measure all constructs. A total of 207 studies that included tests of the model were included in the meta analysis, of which 103 were categorized as measuring physical activity. Results revealed 24% of the variance in physical activity behavior was explained by the theory of planned behavior constructs, with this percentage increasing to 34% when including past physical activity behavior in the model. The strongest predictor of physical activity behavior was found to be intention, explaining a mean of 42% of the variance across all included studies. Perceived behavioral control explained a mean of 11% of the variance in behavior across the studies. Attitude was found to be the strongest predictor of intention (β=.39). Perceived behavioral control closely followed attitude (β=.33) and subjective norm was the weakest predictor of intention (β=.12) across the studies in this sample.

Given the smaller contribution of subjective norm to the prediction of intention when compared to attitude and perceived behavioral control, researchers have suggested subjective norm may not require further study as a construct in the theory of planned behavior (Courneya, Plotnikoff, Hotz, & Birkett, 2000). Other researchers, however, have since argued for the construct's continued inclusion in exercise and physical activity research, and for injunctive and descriptive norms to be assessed independently of one another within the construct (Okun, Karoly, & Lutz, 2002). Early research assessing the predictive value of subjective norm in physical activity behaviors often focused only on injunctive norms. Ajzen and Driver (1992) specifically recommended the following items for measuring subjective norm in leisure activity behaviors: "Most people who are important to me approve/disapprove of my engaging in jogging" and "Most people who are important to me think I should engage in jogging." After finding subjective norm to have less influence on intention than other constructs, Godin and Kok suggested descriptive norms also be measured within the construct to strengthen its predictive validity (1996). Okun, Karoly, & Lutz (2002) hypothesized that descriptive norms may play a larger role in intention than injunctive norms, and found descriptive norms related to friends to be a significant predictor of intention for physical activity in sample of college students. Continuing to explore the relationship between different types of norms, and continuing to disaggregate the construct into injunctive and descriptive component may help explain the best approach for evaluating norms within physical activity research.

Since the meta-analysis published by McEachan and colleagues in 2011, researchers have continued to employ the theory of planned behavior in physical activity research. To find and describe articles published between 2010 and 2015 using the theory of planned behavior in physical activity research examining samples of adults, a literature search was conducted using PubMed, psycINFO, and Web of Sciences databases. The search strings were "theory of planned behavior" AND "physical activity" OR "theory of planned behaviour" AND "physical activity." English language articles were selected for inclusion and discussed below if 1) a sample of adults was used; 2) at least one theory of planned behavior construct was measured, and 3) the sample was non-clinical (i.e., samples where all participants were diagnosed with chronic kidney disease or other were excluded). Intervention studies and cross-sectional studies were both included if they met all other inclusion criteria. Initial searches resulted in a combined total of 446 articles across the 3 databases. All titles and abstracts were reviewed. A total of 69 articles were selected for full-text review and that number was reduced to 47 after the removal of duplicates and triplicates.

Across the 47 articles selected for full-text review, 16 were excluded because they were not samples of adults (e.g., high school students), 11 did not measure at least one theory of planned behavior construct, and 4 studies used samples that were considered to be clinical populations. An additional article was excluded because, although it met all other criteria, an n-of-1 design was used and thus the data could not be compared to other studies included in this review (Hobbs et al., 2013). The article selection process resulted in a total of 14 articles, reporting on 13 unique sets of data. Characteristics and results of the 13 datasets are described below.

The majority of studies (86%) took place outside the United States (n=12) and included locations such as Canada (Casiro et al., 2011; Kirk & Rhodes, 2011; Plotnikoff et al., 2012; Rhodes et al., 2014), the Netherlands (Friederichs et al., 2013; Sassen et al., 2010), Sweden (Ganedahl et al., 2015), Australia (Hamilton et al., 2012; Hamilton & White, 2011; Hamilton & White, 2012), Iran (Saber et al., 2014) and the United Kingdom (Scott, Eves, Hoppe, & French, 2010). Of the remaining two studies that took place in the U.S., one took place in Oklahoma (Gwin et al., 2013), and the other among a Korean-American population, though no further geographic identifier was mentioned (Lee et al., 2011).

All articles included samples of adults. More specifically, three studies included sample of parents (Casiro et al., 2011; Hamilton et al., 2012; Hamilton & White, 2012) and four studies included samples of employees or trainees (Ganedah et al., 2015; Kirk & Rhodes, 2011; Sassen et al., 2010; Scott et al., 2010). One study measured a sample of housewives (Saber et al., 2014) and another measured clergymen (Gwin et al., 2013). Sample sizes ranged from n=120 to n=1,427 adults (Saber et al., 2014; Plotnikoff et al., 2012). Five studies had samples between n=100 and n=200 adults, four studies had samples ranging between n=201 and n=500 adults, one sample was of n=580 adults, and the remaining three studies had samples of over n=1,000 adults.

None of the studies included were interventions, and the majority employed a cross-sectional design (n=7). Three studies required participants complete questionnaires at baseline and then again one week later (Hamilton et al., 2012; Hamilton & White, 2012; Scott et al., 2010). Two studies used retrospective designs: a one-week retrospective (Lee, 2011), and a longitudinal retrospective (Kirk & Rhodes, 2011). One study required participants complete surveys at baseline, at six-months, and at one-year (Rhodes et al., 2014), and the last study asked participants to complete cross-sectional surveys twice, once in 1998 and once in 2003 (Plotnikoff et al., 2012).

Measurement of physical activity varied across studies. All but one study used subjective measures of physical activity (n=13). Subjective measures included the Godin Leisure Time Exercise Questionnaire (Casiron et al., 2011; Kirk & Rhodes, 2011; Lee, 2011), the International Physical Activity Questionnaire (Friederichs et al., 2013; Gwin et al., 2013; Saber et al., 2014), the Minnesota Leisure Time Physical Activity Questionnaire (Plotnikoff et al., 2012), the Short Questionnaire to Assess Health Enhancing Physical Activity (Sassen et al., 2010), the 7-day Physical Activity Recall questionnaire and interview (Scott et al., 2010), a single-item scale assessing number of days physical activity was performed in the previous week (Hamilton et al., 2012), a survey made up of items relating to the performance of meeting the current physical activity guidelines (Hamilton & White, 2012), and a survey using items to assess hours per week in various physical activity categories (Ganedahl et al., 2015). Only one study used an objective measure of physical activity (Actigraph accelerometer; Rhodes et al., 2014) to measure physical activity at baseline, 6 months, and 12 months throughout an intervention.

Per the inclusion criteria, all studies measured at least on theory of planned behvaior construct. Mirroring the structure of the tables presented in Godin & Kok's meta analysis (1996), Table 1 displays the correlation coefficients and regression coefficients when provided between intention and attitude, subjective norm, and perceived behavioral control. The amount of variance in intention (R^2) explained by the remaining three constructs is also included in the table when provided. Results indicated attitude was positively correlated with intention across all of the 15 tests where it was measured. Correlation coefficients ranged from .15 to .52. The correlation between subjective norm and intention was reported in 13 samples and coefficients ranged from .02 to .51, indicating a weaker correlation than what was found between attitude and intention. The correlation between perceived behavioral control and intention ranged from .01 to .45 across the 13 samples where it was measured. In four studies, attitude was disaggregated into two measures: affective attitude and instrumenal attitude (Casiro et al., 2011; Kirk & Rhodes, 2011; Rhodes et al., 2014; Scott et al., 2010). Measurement of subjective norm varied across studies. In five studies, the survey items used to measure subjective norm addressed only injunctive norms (Gwin et al., 2013; Hamilton et al., 2012; Hamilton & White, 2012; Plotnikoff et al., 2012; Scott et al., 2010). In three studies, injunctive and descriptive norms were assessed independently within the subjective norm construct

(Kirk & Rhodes, 2011; Lee et al., 2011; Sassen et al., 2010). In two studies, the measure of subjective norm included survey items that measured both injunctive and subjective norms (Casiro et al., 2011; Rhodes et al., 2013). In three studies, the measurement of subjective norm was unclear (e.g., survey items or example survey items used to measure the construct were not included in the article; Friedrichs et al., 2013; Ganedahl et al., 2015; Saber et al., 2014). In all cases, all coefficients were recorded and are reported in Table 2.1. The amount of variance in intention explained by attitude, subjective norm, and perceived behavioral control was measured in 10 samples and ranged from 21% to 55%.

Table 2.2 displays the correlation and regression coefficients between physical activity and the constructs of intention and perceived behavioral control when provided. The amount of variance in physical activity explained by the two constructs (R^2) is also included in the table when reported. Results indicate that intention was positively correlated with physical activity, with correlation coefficients ranging from .15 to .66 across the 12 study samples where it was measured. Perceived behavioral control was also positively correlated with physical activity across the 10 studies where it was measured (range: r= .12 - .41). The amount of variance explained in physical activity by intention and perceived behavioral control was measured in 9 samples and ranged from 9% to 31%. Scott et al. (2010) reported a variance of 4% in constrained physical activity (defined in this study as required team sport) and concluded the theory of planned behavior was effective at predicting volitional activities but ineffective in the prediction of constrained or required physical activities.

Table 2.1. *Prediction of Intention From Attitude, Subjective Norm, and Perceived Behavioral Control*

Study	Correlations			Regression Coefficients			
	Attitude	Subjective Norm	Perceived Behavioral Control	Attitude	Subjective Norm	Perceived Behavioral Control	R^2
Casiro et al., 2011	.44[a,c], .20[b,c] .30[a,d], .25b[,d]	.10[c] .35[d]	.43[c] .45[d]	-	-	-	-
Gwin et al., 2013	-	-	-	.41	.27	.29	.55
Hamilton et al., 2012	.46[e] .52[f]	.51[e] .31[f]	.41[e] .32[f]				
Hamilton & White, 2012; Hamilton & White, 2011	.45[e] .49[f]	.51[e] .27[f]	.43[e] .32[f]	.38[e] .46[f]	.30[e] .05[f]	.29[e] .27[f]	.45[e] .33[f]
Kirk & Rhodes, 2011	-	-	-	.31[a] .12[b]	.05[g] .10[h]	.39	.42
Lee et al., 2011	.56	.19[g] .14[h]	.34	.63	.13	.43	.43
Plotnikoff et al., 2012	.26[i] .31[j]	.25[i] -	.21[i] .43[j]	- -	- -	- -	.29 .21
Rhodes et al., 2014	.38[a,k] .15[b,k]	.10[k]	.37[k]	-	-	-	-
	.19[a,l] .15[b,l]	.02[l]	.32[l]	-	-	-	-
Saber et al., 2014	.15	.17	.01	-	-	-	-
Sassen et al., 2010	.47	.32	.39	.23	.17[h]	-	.39
Scott et al., 2010	-	-	-	.45[a,m], .02[b,m] .25[a,n], -.08[b,n]	-.04[m] .06[n]	.40[m] .57[n]	.43[m] .53[n]

Note. [a]Affective attitude; [b]Instrumental attitude; [c]Personal physical activity; [d]Intergenerational activity (e.g., physical activity with one's children); [e]Mothers only; [f]Fathers only; [g]Injunctive norm; [h]Descriptive norm; [i]Data from sample at time point 1 (in 1988); [j]Data from sample at time point 2 (in 2003); [k]Husbands only; [l]Wives only; [m]volitional physical activity; [n]constrained physical activity (e.g., required team sports); - information not provided

Table 2.2. *Prediction of Behavior From Intention and Perceived Behavioral Control*

Study	Correlations		Regression Coefficients		
	Intention	Perceived Behavioral Control	Intention	Perceived Behavioral Control	R^2
Casiro et al., 2011	.20[a] .25[b]	.35[a] .24[b]	-	-	-
Friederichs et al., 2013	.15	.20	.35	.17	.14
Ganedahl et al., 2015	-	.15[c] (n.s.)[d]	-	-	-
Gwin et al., 2013	-	-	.38	(n.s)	.14
Hamilton et al., 2012	.59[e] .58[f]	.23[e] .18[f]	-	-	-
Kirk & Rhodes, 2011	-	-	.48	.09	.28
Lee et al., 2011	.27	.35	.54	.30	.31
Plotnikoff et al., 2012	.29[g] .36[h]	.12[g] .28[h]	- -	- -	.09[g] .22[h]
Rhodes et al., 2013	.28[i] .37[j]	- -	- -	- -	- -
Saber et al., 2014	.16	-	-	-	-
Sassen et al., 2010	.66	.41	.47	-	.52
Scott et al., 2010	-	-	.38[k,m], .39[k,n] .15[l,m], .04[l,m]	.13[k,m], -.01[k,n] .14[l,m], .15[l,m]	.22[k,m], .20[k,n] .07[l,m], .04[l,n]

Note. [a]Personal physical activity; [b]Intergenerational physical activity; [c]Males only; [d]Females only; [e]Mothers only; [f]Fathers only; [g]Data collected at time point 1 (in 1988); [h]Data collected at time point 2 (in 2003); [i]Husbands only; [j]Wives only; [k]volitional physical activity; [l]constrained physical activity (e.g., required team sports); [m]Results from the Physical Activity Recall Questionnaire; [n]Results from the Physical Activity Recall Questionnaire and Interview; (n.s.) not significant; - information not provided

The results of review papers, meta analyses, and research published since 2010 examining the theory of planned behavior in the physical activity of adults support the predictive value of the theory of planned behavior constructs in physical activity intention and behaviors. The evidence provided from this large body of research, however, does have some limitations. First, the majority of studies use self-report measures of physical activity. In 2001, Armitage and Conner published data demonstrating that the theory of planned behavior explained less variance in objectively measured physical activity (R^2=.20) than it did in subjectively measured physical activity (R^2=.31), which may indicate subjective measures are overestimating the theory's predictive abilities. Despite this, only one of the articles published between 2010 and 2015 examining the theory of planned behavior in relation to physical activity among adult population used an objective measure of physical activity. Additionally, questions still remain unanswered regarding the utility of the subjective norm construct. Researchers of 8 of the 14 recent studies either measured injunctive norms only within the subjective norm construct or were unclear about their measurements of the construct. This evidence suggests subjective norm may still need to be investigated, particularly in research using objective measures of physical activity. Lastly, only two studies took place in the U.S.. Given the low levels of physical activity for American adults, further research in the U.S. is warranted. The theory of planned behavior remains a highly recommended framework to utilize in physical activity research and further research should be conducted to address these gaps in the literature.

Sedentary Behavior and the Theory of Planned Behavior

Because sedentary behavior has only recently emerged as a major public health issue, there are far fewer published studies examining the relationships between theoretical constructs and the behavior. To find and describe all published articles on the topic of sedentary behavior and its relationship to the theory of planned behavior, a literature search was conducted. The search terms “theory of planned behavior” AND “sedentary” OR “theory of planned behaviour” AND “sedentary” were searched in the PubMed, psycINFO, and Web of Science databases. These search terms yielded a combined total of 106 articles across the 3 databases. English language articles were selected for inclusion and discussed below if 1) at least one theory of planned behavior construct was measured, and 2) sedentary behavior was measured as an outcome variable. Intervention studies and cross-sectional studies were both included if they met all other inclusion criteria. All titles and abstracts were reviewed and 22 articles were selected for full-text review. That number decreased to 14 after the removal of duplicates and triplicates.

Full text review of the remaining articles 14 articles revealed the behavior of interest in 5 studies was physical activity instead of sedentary behavior, and 1 study did not include the theory of planned behavior in any capacity. The search and selection process thus yielded a total of eight articles reporting on sedentary behavior and applying the theory of planned behavior. Characteristics of this body of literature are described below. Table 2.3 presents a brief description of the scope of each of the 8 studies, including sample sizes and study designs.

Only two of the studies using the theory of planned behavior in sedentary behavior research took place in the United States (Ickes, 2011; Slawson et al., 2015). Other study locations included Canada (Lowe et al., 2015; Prapavessis et al., 2015; Rhodes & Dean, 2009), The Netherlands (Hume et al., 2010; Te Velde et al., 2011), and Australia (Hamilton, Thomson, & White, 2013). Half of the study samples were adolescents (Hume et al., 2010; Ickes, 2011; Slawson et al., 2015; Te Velde et al., 2011), and half of the samples were adults (Hamilton et al., 2013; Lowe et al., 2015; Prapavessis et al., 2015; Rhodes & Dean, 2009). Within the adult samples, one study specifically examined cancer patients with brain metasteses currently undergoing treatment (Lowe et al., 2015), one study examined mothers (Hamilton et al., 2013), and another researched a sample of both adults and undergraduate students (Rhodes & Dean, 2013).

Measurement of sedentary behaviors varied across studies. All but one study used a subjective measure of sedentary time. Subjective measures included a modified version of the Sedentary Behavior Questionnaire (Prapavessis et al., 2015), the Adolescent Sedentary Activity Questionnaire (Slawson et al., 2015), two items addressing time spent viewing television from the Activity Questionnaire for Adolescents and Adults (Te Velde et al., 2011), items addressing hours per day of screen time mother's allowed for their children (Hamilton et al., 2013), items measuring hours per day spent watching television (Hume et al., 2010), items measuring leisure time spent playing videogames, watching television, using a computer, or reading (Rhodes & Dean, 2009), and items measuring screen time (Ickes, 2011). The only study to use an objective measure of sedentary time was conducted by Lowe et al. (2011), and the ActivPAL accelerometer was used to measure time spent supine, sitting, standing, or stepping over a seven day period.

The body of literature on the topic of sedentary behavior and its relationship to the theory of planned behavior indicates that progress, largely in the last five years, has been made exploring the relationship between theoretical constructs and sedentary behavior. Despite this, only eight published articles on the topic signify the field is underdeveloped, and that there is great opportunity for research to be conducted that will fill in the gaps. Given the overwhelming empirical support of the predictive value of the theory of planned behavior in physical activity behavior, utilizing the same theory to examine the related, albeit distinct behavior of time spent being sedentary, may be prove to be useful in better understanding sedentary behaviors. Six of the seven published studies examining this relationship supported the continued use of the theory in understanding sednatariness. Research that takes place in the U.S., uses more diverse samples, objective measures of sedentary behavior, and designs other than cross-sectional are recommended.

Table 2.3. *Description of Studies Measuring Sedentary Behavior and the Theory of Planned Behavior (n=8)*

Study Citation and Purpose	*Brief Study Description*	*Results*
Hamilton et al., 2013 Purpose: to investigate TPB constructs that influence mother's decisions about limiting screen time for their children to less than one hour per day	Cross-sectional survey data were collected from 162 mothers about TPB constructs. One week later, mothers completed a follow-up telephone questionnaire assessing decisions they made regarding their child's screen time the previous week Hierarchical multiple regression was used to determine the variance explained by TPB constructs in mother's decisions about limiting screen time	Attitude (r=.73), subjective norm (r=.78), and PBC (r=.52) were positively and significantly correlated with intention to limit screen time PBC (r= .48) and intention (r=.65) were positively and significantly correlated with the behavior Attitude, subjective norm, and PBC accounted for an additional 23% of the variance in intention beyond demographic predictors; Attitude and subjective norm were independently significant Intention and PBC accounted for an additional 3% of the variance in the behavior, with intention but not PBC emerging as significant
Hume et al., 2010 Purpose: To examine association between TPB constructs and Dutch adolescents' TV viewing	Cross-section survey data were collected from 338 adolescents in schools about TPB constructs and time spent viewing TV during leisure Logistic regression analyses examined associations between variables and TV viewing	TPB constructs were not significantly associated with higher likelihood of exceeding TV viewing guidelines
Ickes, 2011 Purpose: To examine the extent to which TPB constructs predict sedentary behaviors	Cross-sectional survey data were collected from 318 middle school students about TPB constructs and screen time. Multiple regression and structural equation modeling was used to determine predictors of the behavior	Attitude (r=.05), subjective norm (.05), and PBC (r=-.02) were not correlated with intention. PBC (r=.22) was correlated with the behavior (total screen time) while Intention (r=-.07) was not. Total screen time was predicted by intention for normal-weight adolescents (R^2= .03) and for overweight adolescents (R^2=.31)

(continued)

Study Citation and Purpose	*Brief Study Description*	*Results*
Lowe et al., (2014) Purpose: To examine TPB correlates of objectively measured sedentary behavior in advanced patients with brain metastases	Cross-sectional survey data were collected from 31 advanced cancer patients diagnosed with brain metastases aged 18 and older about TPB constructs. Sedentary time was measured using the activPAL accelerometers for 7 days while undergoing palliative treatment Independent samples t-tests were performed to compare differences between groups in TPB constructs based on the cutpoint of 20.7 hours spent sitting or supine all day	Instrumental attitude (r=.63), affective attitude (r=.53), and PBC (r=.57) were significantly correlated with intention; Injunctive norm (r=.33) and descriptive norm (r=.18) were positively but not significantly correlated with intention PBC (r=-.15) and intention (r=-.32) were negatively correlated with sedentary behavior, where higher levels of TPB variables are correlated with lower levels of sedentary time Participants who recorded higher levels of sedentary behavior reported significantly lower instrumental attitude (p=.05) and affective attitude (p=.04) than those who reported lower levels of sedentary behavior; Differences between groups in PBC and intention were not significant (p=.08 and p=.12, respectively)
Prapavessis et al., (2015) Purpose: To provide preliminary evidence for factor structure and composition of sedentary derived TPB constructs and to determine the utility of these constructs in predicting sedentary intention and sedentary time	Cross-sectional survey data were collected from 372 adults using newly created items measuring TPB constructs and a modified Sedentary Behavior Questionnaire. Participants were randomized to one of three questionnaire packages: general, weekday, and weekend. Weekday and weekend packages included volitional (leisure) and less-volitional (work/school) activities resulting in 5 models Regression modeling was used to determine the variance explained in sedentary behavior by TPB variables	Attitude towards sitting 0-4 hours per day was correlated with intention in only one model, but was related to attitude towards sitting for half the day and attitude towards sitting for 12-16 hours per day in 3 models; Subjective norm was correlated with intention in 4 of the 5 models and PBC showed an association in only 1 model Intention was significantly correlated with sedentary behavior in all 5 models, but PBC was only correlated with behavior in 1 model Attitude towards sitting for half the day significantly predicted intention only in weekend leisure sedentary behavior, subjective norm was a significant predictor in 3 of the 5 models, and PBC was a significant predictor is weekday work/ school sedentary behavior; Variance in intention ranged from 9% in weekday leisure sedentary time to 58% in weekend work/school sedentary behavior Intention significantly predicted behavior in all 5 models and explained between 2% and 36% of the variance (weekday leisure sedentary behavior and weekday work/school sedentary behavior, respectively); PBC

(continued)

Study Citation and Purpose	*Brief Study Description*	*Results*
		significantly predicted behavior in weekday work/ school sedentary time only
Rhodes & Dean, 2009 Purpose: To apply the TPB constructs to understand the motives underlying 4 common sedentary leisure activities: television viewing, computer use, reading/music, and socializing	Cross-sectional survey data were collected from 206 adults and 174 undergraduate students. Surveys measured TPB constructs and self-reported leisure sedentary behavior in 4 categories: television viewing, computer use, reading/music, and socializing Ordinary least squares regression and a path analytic approach was used to explain the predictive value of TPB constructs of the 4 sedentary behaviors for adults and undergraduates separately	Adults: Attitude was significantly correlated with intention for all 4 sedentary behaviors: TV viewing (r=.65), computer use (r=.74), reading/music (r=.59), socializing (r=.75); Subjective norm was significantly related with intention for all 4 behaviors in the same order: r=.47, .44, .44, .70; PBC was significantly correlated with intention for reading/ music (r=.49) and socializing (.53), but not for TV viewing (r=.18) or computer use (r=.14) For TV viewing, attitude (β=.55) and subjective norm (β=.18) significantly predicted intention; Intention (β=.41) explained 18% of behavior. For computer use, only attitude (β=.69) significantly predicted intention; Intention (β=.60) explained 36% of behavior. For reading/music, attitude (β=.41) and PBC (β=.29) significantly predicted intention; Intention explained 8% of behavior. For socializing, attitude (β=.47) and subjective norm (β=.29) significantly predicted intention; Intention explained 9% of behavior. Undergraduates: Attitude was significantly correlated with intention for all 4 sedentary behaviors: TV viewing (r=.59), computer use (r=.64), reading/music (r=.31), socializing (r=.52); Subjective norm was significantly related with intention for all 4 behaviors in the same order: r=.42, .48, .23, .42; PBC was significantly correlated with TV viewing (r=.36), reading/music (r=.23), and socializing (r=.54) but not computer use (r=.20) For TV viewing, attitude (β=.48) and PBC (β=.22) significantly predicted intention; Intention (β=.41) explained 18% of behavior. For computer use, only attitude (β=.54) significantly predicted intention; Intention (β=.25) explained 6% of behavior. For reading/music, attitude (β=.23) predicted intention; Intention (β=.25) predicted 6% of behavior.

(continued)

Study Citation and Purpose	*Brief Study Description*	*Results*
		For socializing, attitude (β=.38) and PBC (β=.43) significantly predicted intention; Intention (β=.31) explained 9% of behavior.
Slawson et al., (2015) Purpose: To develop a peer-based health education program focused on establishing positive peer norms toward healthy behaviors including reducing sedentary time	Undergraduate students in health disciplines will be hired as peer facilitators to lead an intervention study guided by the TPB to students in 10 high schools in Southern Appalachia. Facilitators will teach the Team Up for Healthy Living curriculum (8 lessons; 40 minutes) to students in schools randomized to the intervention group. Control group will receive their regularly scheduled Lifetime Wellness curriculum. Outcomes including sedentary behaviors will be assessed at baseline and at 3 and 12 months post baseline	n/a
Te Velde et al., (2011) Purpose: To explore the association between home environmental variables and TV viewing, and the mediating pathways underlying this association	Longitudinal data was collected from 1,265 adolescents in The Netherlands at baseline and at follow-up 2 years later. Surveys included 2 items about TV viewing, family environmental variables, and TPB constructs Mediation analyses were conducted to determine whether the association between family environmental variables and TV viewing was mediated by the TPB constructs	Intention and attitude were significantly associated with having a TV in the bedroom (10.2 and 13.1 of percentage mediated, respectively) Intention, attitude, and subjective norm were significantly associated with parental modeling (5.4, 19.8, -8.3 of percentage mediated, respectively)

Note. TPB = Theory of Planned Behavior, PBC = Perceived Behavioral Control, n/a = not applicable

Conclusions

Young and middle-aged adults are currently experiencing pervasive stress, and are engaging in low levels of physical activity and high levels of sedentary behavior. Given the negative health consequences associated with such behaviors, better understanding factors related with physical activity and sedentary behavior may play an important role in addressing the health needs of this population. Because of the predictive potential of the theory of planned behavior, utilizing the framework may help to further explain the behaviors. The purpose of this study is to examine correlates of physical activity and sedentary behavior in a population young and middle-aged working adults. Specifically, associations between objectively measured physical activity and sedentary behavior over a six-week period were examined using measures of perceived stress, socio-demographic and health-related variables, and constructs from the theory of planned behavior.

CHAPTER THREE

Method

The purpose of this study was to examine correlates of physical activity and sedentary time in a working adult population. Specifically, associations between objectively measured physical activity and sedentary behavior over a six-week period were examined using measures of perceived stress, socio-demographic and health-related variables, and constructs from the theory of planned behavior.

Research Questions

1. Are the theory of planned constructs of attitude, subjective norm, and perceived behavioral control associated with behavioral intention for physical activity?

2. How are theory of planned behavior constructs and socio-demographic characteristics related with objectively measured physical activity over a six-week period?

   2a. What is the unique contribution of perceived stress measured once weekly over the same six-week period to the model?

3. How are the theory of planned behavior constructs of attitude, subjective norm, perceived behavioral control, and intention for physical activity and socio-demographic characteristics related with objectively measured sedentary time over a six-week period?

   3a. What is the unique contribution of perceived stress measured once weekly over the same six-week period to the model?

Hypotheses

1. Theory of planned behavior constructs subjective norm, perceived behavioral control, and attitude will be related with behavioral intention for physical activity while controlling for socio-demographic variables. Specifically, a more positive subjective norm, greater perceived behavioral control, and a more positive attitude will be associated with a higher score of behavioral intention for physical activity.

2. Theory of planned behavior constructs intention and perceived behavioral control will predict physical activity behaviors while controlling for socio-demographic variables. Specifically, greater perceived behavioral control and a higher score for behavioral intention will be associated with a higher level of physical activity.

   2a. The addition of perceived stress level measured over six-weeks will increase the amount of variance explained in physical activity behavior while controlling for theory of planned behavior constructs and socio-demographic variables. Specifically, a higher stress level will be associated with a lower level of physical activity.

3. Theory of planned behavior constructs of intention for physical activity, perceived behavioral control for physical activity, attitude, and subjective norm will predict sedentary behavior after controlling for socio-demographic variables. Specifically, a lower score for behavioral intention for physical activity, a lower score for perceived behavioral control for physical activity, a more negative attitude, and a lower score for subjective norm will be associated with a greater level of sedentary behavior.

   3a. The addition of perceived stress level measured over six-weeks will increase the amount of variance explained in sedentary behavior. Specifically, a higher stress level will be associated with a greater level sedentary behavior.

Participants and Recruitment

Adults aged 20-49 were recruited from local businesses, a university, and church congregations in a central Texas community to participate in this study. Researchers asked pastors at local churches for permission to recruit study participants from church service attendees and congregation members. Flyers and announcements with study information were then posted in churches where permission was granted. Worksite recruitment at both local businesses and the university occurred using flyers and emails through key contacts made with the researchers. An attempt was made to enroll males and females equally throughout the recruitment process. Participation in this study was strictly voluntary and all participants indicated their informed consent prior to participation. Institutional Review Board approval was obtained from the referent institution prior to recruitment (approval #238853-5).

Study Site

Initial participant contact, description of study methods, discussion explaining informed consent, initial survey completion, and instructional sessions took place in local churches, community sites (e.g. conference rooms at local businesses), and university classrooms. The remainder of the study took place in participants' free-living environments (i.e. their home, workplace, community, etc.).

Procedure

The primary investigator or a researcher explained the purpose of the study and covered all contents of the consent form to interested participants. For all participants who consented to participate, each completed a packet of questionnaires that included socio-demographic information, all theory of planned behavior variables, and the Weekly Stress Inventory. This survey took approximately 15-30 minutes to complete. Participants were then instructed in the use of the activity monitor that they were asked to wear it daily for the following 6 weeks. Participants were randomly assigned to one of three groups: 1) wearing an Actigraph GT1M monitor, 2) wearing a Sensewear MF-SW Armband, or 3) wearing both monitors. The instructions covered information regarding how to wear the device(s) assigned to the participant, when to wear the device, and how to charge the battery. Once weekly throughout the study participants were also asked to complete the Weekly Stress Inventory survey.

Incentive

As an incentive for participation, participants were compensated with $10 for every week that they completed the stress inventory and wore a physical activity monitor for at least five days (a minimum of four weekdays and one weekend day, specifically). Thus, participants exhibiting complete compliance across the 6 weeks of the study were compensated with $60 total.

Measures

Literature Review and Background

Measurement of psychological stress. Better understanding relationships between health outcomes and psychological stress is necessary to further the field and thus requires the measurement of stress. Historically, measures of stress evaluated major life events known to cause stress, such as the death of a family member, dismissal from work, or divorce (e.g., The Social Readjustment Rating Scale; Holmes & Rahe, 1967). While the number of major stressors a person was experiencing had a small but consistent relationship with the onset or exacerbation of disease conditions (Dohrenwend & Dohrenwend, 1974), findings were limited as response to minor stressors, such as getting stuck in traffic, having a confrontation with someone, or having household chores to do, were not included. To address this, researchers in the 1980's began developing measures that assessed the minor stressors to offer more insight into the relationships between stress and health outcomes. These scales included the Daily Hassles Scale (Kanner et al., 1981), the Inventory of Small Life Events (Zautra, Guarnaccia, & Dohrenwend, 1986), and the Daily Stress Inventory (Brantley, Waggoner, Jones, & Rappaport et al., 1987). Research that later compared measures of major stressors to measures of minor stressors revealed minor stressors better predicted physical and psychological responses than major stressors, and that this remained true even after controlling for major stressors (DeLongis, Coyne, Dakof, Folkman, & Lazarus, 1982; Lazarus & DeLongis, 1983; DeLongis, Folkman, & Lazarus, 1988; Brantley & Jones, 1993).

These measures were developed to evaluate minor stressors, however, they have been used to assess stress levels on either a daily or a monthly basis. Researchers Brantley and Jones (1989) felt that daily measures of stress may not be long enough to truly reflect a person's stress level, and monthly assessments may be too long for some study periods. Weekly stress measures, however, may meet that need, and thus a measure called the Weekly Stress Inventory (WSI) was developed (Brantley, Jones, Boudreaux, & Catz, 1997). Although the WSI can be used successfully in cross-sectional research, it is particularly appropriate for research requiring a repeated measures design in which sensitivity to weekly changes in stress is important (Brantley et al., 1997). Repeated administrations of the WSI can better capture a respondent's chronic stress level, and be used with more integrity to examine the relationships between patterns of stress and other health behaviors and health outcomes. Given the dynamic nature of stress, it's pervasivess, and it's relationship with health outcomes, measuring stress in a dynamic way may provide the stronger evidence necessary to draw conclusions.

Measurement of theory of planned behavior constructs. Theory of planned behavior constructs are typically measured via survey items. Because the theory of planned behavior can be applied to many behaviors, an important first step in creating a questionnaire is to identify and carefully define the specific behavior of interest (e.g., leisure-time physical activity). Attitude items are commonly developed using pairs of bipolar adjectives (e.g., opposites) across a 7-point scale following a single behavioral ‘stem.’ Using the example of leisure-time physical activity, a survey item measuring attitude might appear as follows:

Engaging in leisure-time physical activity is:

Pleasant 1 2 3 4 5 6 7 Unpleasant

Subjective norm is typically measured using 7-point scales with endpoints of “strongly disagree” and “strongly agree.” Items refer to the opinions of important people regarding the behavior in general, if important people engage in the behavior themselves, and if important people believe the person completing the questionnaire should engage in the behavior. An example item measuring subjective norm might appear as follows:

Most members of my family feel that I ought to engage in leisure-time physical activity at least three times a week.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

Perceived behavioral control is measured similarly to subjective norm. Survey items are commonly constructed with 7-point scales with endpoints of “strongly disagree” and “strongly agree.” Items address self-efficacy and controllability (i.e., whether performing the behavior is within a person’s control). An example survey item measuring perceived behavioral control might appear as follows:

Whether or not I engage in leisure-time physical activity is up to me.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

Like subjective norm and perceived behavioral control, survey items measuring behavioral intention are also commonly constructed with 7-point scales with endpoints of “strongly disagree” and “strongly agree,” though other endpoints can be used. An example survey item measuring intention could appear as follows:

I plan to engage in regular leisure-time physical activity in the next 6 weeks.

Not at all 1 2 3 4 5 6 7 Frequently

Measurement of physical activity. Physical activity measurement can be accomplished in a number of ways. Specific methods for physical activity measurement are commonly classified as subjective, objective, or observational. Observational methods, for example, can be used to count people on trails, sidewalks, or stairs through human observers or electronic monitoring (Sallis, 2010). Subjective and objective methods are described in detail below.

Subjective measures. Effectively measuring physical activity in free-living populations is crucial for progressing the fields of public health and health promotion. Historically, collecting activity data at the population level has involved the use of subjective, or self-reported measures such as questionnaires, logs or diaries, surveys, and interviews. The seminal research in the field of physical activity and health, including the studies conducted by Morris et al. (1953) and Paffenbarger et al. (1978) relied on such self-reported physical activity data to establish the associations between activity level and health status that research builds upon today. Popular subjective measures used in collecting physical activity data in adults include the Minnesota Leisure-Time Physical Activity Questionnaire (MLTPAQ; Taylor et al., 1978), the Stanford 7-Day Physical Activity Recall (7-DAR; Sallis et al., 1985; Blair et al., 1985) and the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003), among others. Each of these instruments have extensive evidence supporting their validity and reliability across a wide range of population groups (e.g., MLTPAQ: Jacobs, Ainsworth, Hartman, & Leon, 1993; Taylor et al., 1978; 7-DAR: Taylor et al., 1984; Dishman & Steinhardt, 1988; and IPAQ: Craig et al., 2003; Bauman et al., 2009).

In addition, having established validity and reliability, subjective measures are used frequently in scientific research because they are typically low in cost, can be used with large study samples, offer limited participant burden, are practical, and are generally accepted in the field (Dishman, Washburn, & Schoeller, 2001). Self-reports and other subjective measures have been used across a wide range of age groups and can be adapted to meet the needs of specific groups (Sallis & Saelens, 2000). Despite their various benefits, subjective measures possess several limitations. First, by nature of their subjectivity, they have the capacity to over- or underestimate actual physical activity levels. Additionally, they are subject to recall and response biases, such as inaccurate memory and social desirability (Ainsworth, Montoye, & Leon, 1994). Recalling physical activity is a cognitive task shown to be subject to memory decay and lack of motivation in memory recall (Baranowski, 1988). Social desirability bias refers to the tendency of respondents to overreport good behaviors, such as exercise and healthy eating, and underreport undesirable behaviors, such as smoking, when they are concerned about the social acceptability of their behaviors (Warnecke et al., 1997).

Objective measures. Although subjective measures can be useful for understanding physical activity levels in populations, objective or direct measures are becoming more commonly used. Objective assessments of physical activity measure and record the biomechanical or physiological result of engaging in physical activity (Trost & O’Neil, 2013). Historically, this occurred in the form of the measurement of energy expenditure and utilized methods of direct calorimetry, where the rate of heat loss from a person to calorimeter is measured, or indirect calorimetry, where oxygen consumption and or carbon dioxide production is measured (Levine, 2005). Neither method, however, captures physical activity in the free-living environment, which ideally should be measured over a period of time long enough to be representative of a person's habitual activity level and involve minimal discomfort to the participant (Plasqui & Westerterp, 2007). To fill this gap, a method called doubly labeled water was introduced. To use the doubly labeled water method, participant's ingest water where both the hydrogen and oxygen in the water have been labeled with stable, non-radioactive isotopes. When both the oxygen and hydrogen in the ingested doubly labeled water are labeled with known amounts of tracers at the same time, the differences in elimination rates of the tracers represent the elimination rate of carbon dioxide and corresponding energy expenditure (Levine, 2005). To date, the doubly labeled water method is considered to be the gold-standard of objective physical activity measures (Plasqui & Westerterp, 2007) and can measure energy expenditure over a 7-21 day period with an pproximate error rate of 6-8% (Levine, 2005).

Unfortunately, the doubly labeled water method is extremely costly and thus not possible or practical for many research projects or larger scale, epidemiological studies (Plasqui & Westerterp, 2007). However, more affordable methods for objectively measuring physical activity exist and include (1) heart rate monitors, (2) pedometers, and (3) accelerometers. Heart rate monitors record heart rate and thus can assess activity because of the linear relationship between heart rate and energy expenditure during steady-state exercise. In recent years heart rate monitors have become relatively inexpensive and have an increased storage capacity making them practical for field measures (Trost & O’Neil, 2013). Heart rate monitors, however, cannot acocunt for the known factors that influence the heart rate-oxygen consumption relationship, including age, body size, muscle mass utilization, stress, and cardiorespiratory fitness level, and may inaccurately reflect total physical activity in a person who spends the majority of their day in sedentary pursuits (Trost & O’Neil, 2013). Heart rate monitors therefore may be most effective at capturing the intensity of a specific bout of exercise as opposed to capturing habitual physical activity (Trost & O’Neil, 2013).

Pedometers detect number of steps walked per day. There are two main classes of pedometers: spring-levered and piezoelectric. Spring-levered pedometers have a pendulum arm that moves up and down with vertical acceleration when worn at the waist or hip to measure total number of steps. If the lever arm is sufficiently displaced, it makes an elecrical contact with a sensor to record a step (Melanson et al., 2004). Piezoelectric pedometers, which represent an advancement in technology from the pendulum mechanism (Hasson et al., 2009), generate an electrical charge in relation to a mechanical force (e.g., acceleration; Plasqui & Westerterp, 2007). When body acceleration exceeds a threshold, the device records a step (Trost & O’Neil, 2013).

Several models of pedometers have demonstrated validity and reliability across populations groups, including the following spring-levered models: Yamax SW-200 (Yamax, Tokyo, Japan; Schneider, Crouter, & Bassett, 2004), Accusplit Fitness Walker (San Jose, CA), and the Freestyle Pacer 798 (Camarillo, CA; Bassett et al., 1996), and the following piezoelectric models: Omron HJ-151 and HJ-720ITC (Omron Healthcare Europe B.V., The Netherlands; Holbrook, Barreira, & Kang, 2009; Kenz Lifecorder; Suzuken Company, Nagoya, Japan; Nakae, Oshima, & Ishii, 2008). Research indicates piezoelectric models more accurately measure step counts than spring-levered models (Melanson et al., 2004), especially in obese populations (Crouter et al., 2003) and when walking at slow speeds (Melanson et al., 2004). While pedometers are often the least expensive of the three objective measures described above, because they measure step counts only do not consider the energy expenditure associated with each step taken (i.e., run vs. walk). By measuring step counts only, pedometers can also not be used to accurately measure the energy expenditure associated with activities such as swimming, jumping, cycling, climbing stairs, or carrying heavy objects. Lastly, pedometers can only categorize step count totals as being associated with high or low levels of activity, but cannot capture time spent in physical activity or sedentary activities distinctly.

Accelerometers measure the acceleration of the body in varying planes (commonly the vertical, anteroposterious, and media-lateral places; Trost & O'Neil, 2013) to measure the mechanical work of the body that results in energy expenditure (Plasqui & Bonomi, & Westerterp, 2013) at a rate of 10-30 times per second (Trost & O'Neil, 2013). The body's acceleration is converted, often using a proprietary algorithm that varies across make and model, into a measure of activity intensity (Trost & O'Neil, 2013). Accelerometers are commonly worn on the hip, though newer models can be worn on the ankles, arms, wrists, and thighs (Actigraph: Actigraph, Pensacola, FL, USA; Sensewear: BodyMedia, Inc., Pittsburgh, PA, USA; ActivPAL; PAL Technologies Ltd, Glasgow, UK). Like heart rate monitors, accelerometers are also small and relatively inexpensive, and do not require the chest straps required by several models of heart rate monitors. Additionally, several models of accelerometers have been validated in measuring energy expenditure in children, adults, and special populations including

Actigraph (Alhassan et al., 2012; Lopes, Magalhaes, Bragada, & Vasques, 2009), Actical (Alhassan et al., 2012), Sensewear (Jakicic et al., 2004), ActivPAL (Davies et al., 2012), and the GENEActiv (Esliger et al., 2011). Accelerometers do have shortcomings, however, as not all models can be used in water, and many cannot accurately represent the energy expenditure of activities such as cycling or carrying objects. Despite this, accelerometers have become the most commonly used objective measurement of physical activity (Hildebrand et al., 2014). Further, the National Health and Nutrition Examination Survey (NHANES) in the U.S. which is used for data collection at the national surveillance level, incorporated accelerometers (specifically the Actigraph) into their collection methods in 2003. This was the first use of an objective measure of physical activity for a United States population study, and thus may have set a standard for the measurement of activity at a national level.

There are benefits and challenges associated with both objective and subjective measures of physical activity and despite the use of the inclusion of accelerometry by NHANES, a true "gold standard" measure of physical activity in the free living environment has not yet been established (Dishman et al., 2001). Objective measures, however, are not subject to the reporting and recall biases of subjective measures (Trost & O'Neil, 2013) but can typically only provide information about the duration of an activity bout and activity intensity and cannot identify the type of activity, or other qualitative information that could be included in a subjective measure (e.g., where and with whom the activity was performed; Trost & O'Neil, 2013). Additionally, objective measures cost significantly more than a subjective measure such a survey would, and require skill in interpreting the data. Further, a systematic review of 187 articles comparing subjective to objective measures of physical activity found low to moderate correlations ranging from -.71 to .96, and no clear pattern for the differences (Prince et al., 2008). Given this, researchers have made the following recommendations: (1) use a combination of objective and subjective measures to evaluate physical activity in research participants (Haskell, 2012), and (2) select measurement methods based on the research question and the limitations imposed by sample size, study budget, study timeline, and setting (Dishman et al., 2001).

Measurement of sedentary behavior. Like physical activity, the measurement of sedentary behavior can be accomplished using several methods. These are most commonly classified as subjective, observational, and objective. Subjective and objective methods of measuring sedentary behavior are described in detail below.

Subjective measures. Because sedentary behavior has only recently emerged as a public health issue, there are fewer validated measures assessing sedentary time than there are measures assessing physical activity. Subjective measures used in assessing sedentary behavior have most commonly been in the form of self-administered questionnaires, however, in-person and telephone interview formats have also been used (Atkin et al., 2012). Examples of questionnaires with established validity and reliability for assessing sedentary behavior including single-item measures such as the IPAQ short form (Craig et al., 2003; Rosenberg et al., 2008), as well composite measures across multiple domains of sitting (e.g., at work, in transit, watching television) including the Activity Questionnaire for Adults and Adolescents (AQuAA; Chinapaw et al., 2009) and the Sedentary Behavior Questionnaire for adults (SBQ; Rosenberg et al., 2010).

Subjective measures of sedentatry behavior are cost-effective and can be used in large scale studies. However, a ‘gold standard’ measure of sedentary behavior does not currently exist which places the results of validation studies of subjective measures in question (Dishman et al., 2001). Further, they are subject to the same biases as subjective measures of physical activity are, which include recall bias and social desirability (Ainsworth, Montoye, & Leon, 1994). To improve subjective measures of sedentary behavior, researchers have recommended research be conducted in examining the mode of questionnaire administration, response formats, and assessment timeframe of subjective measurements (Healy et al., 2011). Evaluating the use of the measures across more varied population groups (e.g., native languages other than English, individuals with low literacy levels, and those with less traditional schedules such as shift workers or parents of infants) has also been suggested (Healy et al. 2011).

Objective measures. Objective methods of measuring sedentary behavior have also been used in the literature. Accelerometers specifically, which have been used in national surveillance studies such as NHANES to measaure physical activity, can also be used to assess sedentary time. Accelerometers can measure total time spent in sedentary pursuits as well as the way sedentary behavior is accumulated (length of sedentary bouts; Atkin et al., 2012). Several models have established validity and reliability including the activPAL (PAL Technologies Ltd, Glasgow, UK; Kozey-Keadle et al., 2011), which is a device that adheres to the thigh and includes an inclinometer, the wristworn GENEActiv (Pavey, Gomersall, Clark, & Brown, 2015), and the Actigraph (model GT3X+; Rowlands et al., 2014).

Potential confounding variables. Socio-demographic variables including age, sex, race/ethnicity, annual household income, marital status, number of children under 18, body mass index, and years of education completed have been related with many health behaviors, including physical activity and sedentary behavior. Research indicates an association between lower levels of physical activity in aging populations (Sallis, 2000; Brownson, Eyler, King, Brown, Shyu, & Sallis, 2000), females when compared to males (Salmon, Bauman, Crawford, Timperio, & Owen, 2000a; Salmon, Owen, Bauman, Schmitz, & Booth, 2000b), non-white populations when compared to white/Caucasian populations (Brownson et al., 2000; King, Castro, Wilcox, Eyler, Sallis, & Brownson, 2000), lower-income populations (Brownson et al., 2000; Salmon et al., 2000a; Salmon et al., 2000b), persons with greater BMIs (Brownson et al., 2000; Sternfeld, Ainsworth, & Quesenberry, 1999), and persons reporting fewer years of education completed (Brownson et al., 2000; Salmon et al., 2000b). Although evidence associating physical activity and number of children remains inconclusive, related evidence suggests parents engage in significantly less physical activity than non-parents (Bellows-Riecken & Rhodes, 2008). Being married may also be related with lower levels of physical activity, though according to a review paper from 2002, only weak evidence exists supporting the relationship (Trost, Owen, Bauman, Sallis, & Brown).

Evidence similarly suggests that age and sex are both related to sedentary behavior, where sedentary behavior increases throughout the aging process (United States Centers for Disease Control and Prevention, 2014), and females report higher levels of sedentary behavior than males throughout adulthood (Matthews et al., 2008). Beyond this, there are fewer established relationships between socio-demographic variables and sedentary behavior. Although physical activity and sedentary behaviors are distinct classes of activities, they are related. Thus it is theoretically supported that socio-demographic characteristics related with physical activity may also be related with sedentary behavior.

Description of Study Measures

*Stress***.** Stress was measured using the Weekly Stress Inventory. The Weekly Stress Inventory consists of 87 events that commonly cause a stressful experience. Participants are asked to indicate if the event occurred during the previous week, and rate the amount of stress evoked by each event that occurred on a 7-point Likert scale ranging from 1 “happened, but not stressful” to 7 “extremely stressful.” Participants completed The Weekly Stress Inventory once weekly at the end of each week for the six-week study period. The instrument was selected instead of a daily stress inventory to reduce the monitoring burden placed on participants and to coincide with Stetson et al.’s (1997) procedures. Further, although The Weekly Stress Inventory is suitable for cross-sectional research, it is particularly well suited for longitudinal research assessing stress levels over a multiple-week time period (Brantley & Jones, 1989).

Two scores are derived from The Weekly Stress Inventory (WSI): the WSI-Event and the WSI-Impact. The WSI-Event is the sum of the total number of events that occurred in the previous week and the WSI-Impact is the sum of the total perceived stress ratings. The WSI-Event and WSI-Impact scores have concurrent validity with their counterparts on the Daily Stress Inventory-Event and Impact scales (r=.77 and r=..84, respectively; Brantley & Jones, 1989). Scores on the Daily Stress Inventory have demonstrated convergent validity with endocrine measures of stress (Brantley et al., 1988). The Weekly Stress Inventory has also shown predictive validity in college students (Brantley et al., 1997) and internal consistency in a sample of adult patients undergoing cardiac care (Mosley et al., 1996). Both the WSI-Event and the WSI-Impact scores will be used in analyses.

Theory of planned behavior constructs. All theory of planned behavior scales used in this study for measuring attitude, subjective norm, perceived behavioral control, and intention were created following Francis and colleagues' (2004) guidelines for constructing measures for use in theory of planned behavior research. All survey item formats for assessing attitude, subjective norm, perceived behavioral control, and intention have been used widely in previous theory of planned behavior research. Similar scales using the same behavior of interest (leisure-time physical activity) have demonstrated acceptable levels of reliability and validity (Okun et al., 2002, 2003) in samples of college students. Specifically, internal consistency reliability for attitude items as estimated by coefficient alpha were measured as .88 and .89 in the studies conducted by Okun et al., 2003 and 2004. Items measuring injunctive and descriptive norms were correlated to one another (r=.20 and .70, respectively; Okun et al., 2003). Perceived behavioral control items were correlated with one another in both studies (r=.37 and .32; Okun et al., 2003, 2004), and internal consistency reliability was measured as .53 (Okun et al., 2004). Items measuring intention were correlated with one another in both studies (r= .86, and .77; Okun et al., 2003, 2004) and internal consistency reliability was measured as .87.

Although all theory of planned behavior survey items were written specifically with the behavior of interest as leisure-time physical activity, items were also used to assess sedentary outcomes. Specifically, research question three will be used to determine if low scores for attitude, subjective norm, perceived behavioral control, and intention for leisure-time physical activity can predict greater time spent being sedentary. Although theory of planned behavior survey items could be useful in predicting sedentary outcomes, items developed for physical activity behaviors will be used in this study because of the relatedness between the two behaviors. While sedentary behavior and physical activity represent distinct classes of activities, sedentary behavior often replaces leisure-time physical activity in sedentary people. For this reason, it is hypothesized that using survey items designed to measure leisure-time physical activity may predict sedentary outcomes, and may possibly even serve as better predictors than items designed to measure sedentary activity.

Attitude. Twelve adjective pairs were used to assess attitude: useful/ useless, foolish/ wise, disagreeable/ agreeable, unpleasant/ pleasant, desirable/ undesirable, good/ bad, enjoyable/ unenjoyable, boring/interesting, harmful/ beneficial, strong/ weak, and passive/ active. All items were rated on a 7-point scale ranging from 1 to 7. Different anchor points were used for each item. For example, for the useful/ useless item, the anchor points were useful and useless. Items with negative endpoints on the right were recoded so that higher scores consistently reflected a positive attitude toward the target behavior. Internal consistency between items will be checked (i.e., scores on these items should correlate strongly with one another). Any items that do not indicate internal consistency will be omitted. The means of all item scores provides an overall attitude score. The means of only experiential or only instrumental attitudes can be used to provide a score for the respective component of the attitude measure.

Subjective norms. Subjective norms were measured with items that assessed both injunctive norms (i.e. what important people think a person should do) and descriptive norms (i.e. what important people actually do). Injunctive norms were related to friends, family, “group”, and co-workers, respectively, with one item devoted to each. For example, participants were asked the degree to which they believe their friends think they ought to engage in regular sport or exercise. Participants were asked to respond on a 7-point scale ranging from (1) “strongly disagree” to (7) “strongly agree.”

Descriptive norms related to friends and family. The measure of descriptive norm parallels the measure of subjective norm. Subjunctive norm was assessed with items related to co-workers, friends, family, and “group”, respectively, with one item devoted to each. For example, participants were asked to respond regarding whether their friends engage in leisure-time physical activity, rated on a 7-point scale, with anchor points of “strongly disagree” (1) and “strongly agree” (7). For both injunctive and descriptive norms, all items were formatted with negative endpoints on the left. Higher scores therefore consistently reflected a more positive subjective norm. The means of all item scores provides an overall subjective norms score. The means of only the four items measuring injunctive norm and the means of only the four items measuring descriptive norms can also be used separately to compute a score of the respective component of the subjective norm measure.

Perceived behavioral control. Perceived behavioral control was measured with 3 items. Participants were asked (a) whether they are able to "find time" to engage in leisure-time physical activity if they want to; (b) whether engaging in sport or exercise is "up to them", and (c) if it is "easy" for them to engage in leisure-time physical activity. The anchor points for the 7-point rating scales were strongly disagree (1) and strongly agree (7). Because all items were formatted with negative endpoints on the left, higher scores consistently reflect a greater control over the targeted behavior. The mean of the item scores is used to create an overall perceived behavioral control score.

Intention. Intention was measured with three items. Participants were asked: (a) whether they plan to engage in leisure-time physical activity during the next 6 weeks, (b) whether they will engage in leisure-time physical activity in the next 6 weeks, and (c) whether they will engage in vigorous leisure-time physical activity during the next 6 weeks. Ratings were made on a 7-point scale from (1) unlikely to (7) very likely. Because each item was formatted with a negative endpoint on the left, higher scores consistently indicated a higher score for intention to perform the behavior. The mean of the intention scores across the three items is the overall score for intention.

Physical activity and sedentary behavior. Two objective measures of physical activity and sedentary behavior were used by researchers in this study: The Actigraph accelerometer model GT1M (Actigraph, Pensacola, FL, USA) and the Sensewear Armband Model MF-SW (BodyMedia, Inc., Pittsburgh, PA, USA). As described in the methods, some participants were asked to wear Actigraph accelerometers while others were asked to wear SenseWear Armband MF-SW.

The Actigraph accelerometer is a small, portable, three-axis activity monitor worn on a belt at the right hip. It measures movement through acceleration and allows for an estimation of time spent engaged in physical activity at moderate and vigorous intensities. Actigraph accelerometers have been used extensively in scientific research as a means of measuring energy expenditure in free-living adults and children (Alhassan et al., 2012; Lopes, Magalhaes, Bragada, & Vasques, 2009). Actigraph devices have been validated against measured of oxygen consumption for treadmill walking (r=.64) and stair climbing (r=.74) in a sample of young and middle-aged adults (Slootmaker, Chin A Paw, Schuit, van Mechelen, & Koppes, 2009). All participants selected to wear Actigraph accelerometers were provided with oral instructions on how to properly wear the device (location on hip, direction the device faces, belt tightness, etc.), and when to wear the accelerometer (during waking hours except water activities such as swimming, showering, or bathing). Participants were given chargers and instructions on how and when to charge their devices. Participants were asked to wear the accelerometer daily for six weeks. Participants were also given printed instructions and contact information of an investigator they could reach if there were any issues with the device.

Prior to giving the device to participants, Actigraph GT1M accelerometers were initialized by an investigator. Initialization of the Actigraph GT1M involved entering the starting date and time for data collection as well as the data collection intervals. Data were collected at using 10-second epochs over the six-week data collection period. In concurrence with procedures described by Trost et al. (2005) and Matthews et al. (2002), data was considered to be sufficient if the device was worn for a minimum of 3 days over a one-week period and a minimum of 10 hours per day. At the conclusion of the six-week study period, accelerometers were returned to investigators and data was downloaded using ActiLife Software (Actigraph, Pensacola, FL, USA). ActiLife 6.12.0 Data Analysis Software was used to reformat Actigraph data into one-minute intervals. The cut points used to analyze the data in this study were the cut points published by Freedson, Melanson, and Sirard in 1998. These cut-points were selected because they have been widely used across adult populations (Healy et al., 2007; Schmidt, Freedson, & Chasan-Taber, 2003) and have established validity when compared to energy expenditure measured via oxygen consumption during treadmill exercise (Freedson, Melanson, & Sirard, 1998). Using Freedson's cut points, sedentary behavior was classified as fewer than 100 counts per minute (less than 1.5 MET; Matthews et al., 2008; Evenson, Buchner, & Morland, 2012; Freedson, Melanson, & Sirard, 1998). Moderate-to-vigorous physical activity was classified as 1952 counts per minute and greater (greater than and equal to 3.0 METs; McClain, Sisson, & Tudor-Locke, 2007; Freedson, Melanson, & Sirard, 1998). A weekly sum of minutes spent in sedentary activities and moderate-to-vigorous physical activities for each of the six weeks was used in data analyses.

Similar procedures were followed for participants selected to wear the SenseWear Armband Model MF-SW (BodyMedia Inc., Pittsburgh, PA, USA). The SenseWear Armband is a multisensor device worn on the upper left or right arm over the triceps muscle belly using an armband. Manufacturer information indicates Models MF-SW contain a tri-axial accelerometer measuring motion and can measure skin temperature, heat flux (i.e., the rate at which heat is dissipating from the body) and galvanic skin response (i.e., electrical conductivity as a function of sweat loss). SenseWear Armbands have been used extensively in published research to measure energy expenditure in free-living populations (Liden et al., 2002; Malavolti et al., 2007; Papazoglou et al., 2006; Fruin & Rankin, 2004) and have been successfully validated against doubly labeled water methods in healthy young and middle-aged adults (Intraclass correlation coefficient [ICC] = 0.85, 95% Confidence Interval = 0.92-0.76; Johannsen et al., 2010).

All participants selected to wear SenseWear Armbands were provided with oral instructions on how to properly wear the device (e.g., location on arm, armband tightness), and when to wear the accelerometer (during waking hours except water activities such as swimming, showering, or bathing). Participants were given chargers and instructions on how and when to charge their devices. Participants were asked to wear the device daily for six weeks. Participants were also given printed instructions and the contact information of an investigator they could reach if there were any issues with the device.

SenseWear Professional 7.0 Software (BodyMedia Inc.) was used to download the data and will be used to interpret the collected data. This software uses a proprietary algorithm to estimate physical activity data and provides minutes spent across activity categories. Specifically, a sum of minutes spent in various intensity levels can be computed using the SensWear Professional 7.0 Software, where the researcher specifies the MET-level desired for each. For this study a sum of weekly minutes spent in sedentary time was defined as 1.5 METs or lower (Ainsworth et al., 2011; Owen et al., 2009), and time spent in moderate-to-vigorous physical activity was defined as 3.0 METs or greater (Ainsworth et al., 2011). Both time spent in sedentary and moderate-to-vigorous activities were computed for each of the six weeks the device was worn by participants and used in analyses.

*Socio-demographic information: Potential confounding variables***.** Socio-demographic information was also collected from participants. These variables were used to describe the sample, and given the empirical evidence supporting the relationships between physical activity and possibly sedentary behavior and the socio-demographic variables described above, these variables were also be examined as potential confounding variables within the proposed research questions. Socio-demographic data were collected using selected items from the Behavioral Risk Factor Surveillance Survey (Centers for Disease Control, 2014) and included age, sex, race/ethnicity, yearly household income, marital status, number of children under 18, height, weight, and years of education completed. BMI was calculated through self-reported height and weight (weight [kg] / height [m^2]; American College of Sports Medicine, 2013) as a measure of weight status (e.g., underweight, normal weight, overweight, or obese). Socio-demographic information was used to describe the sample and the following variables were examined as potential confounding variables: age, sex, race/ethnicity, annual household income, marital status, number of children under 18 years of age, BMI, and years of education completed.

Analyses

To answer the proposed research questions, a series of regression models were developed and estimated. Table 3.1 displays the alignment between each regression model that was used in the study and the research questions.

Table 3.1. *Alignment Between Research Questions and Model Estimations*

Model Number and Associated Research Questions
Model 1
Research Question 1: Are the theory of planned behavior constructs of attitude, subjective norm, and perceived behavioral control associated with behavioral intention for physical activity?
Dependent Variable: Intention for physical activity
Independent Variables: Subjective Norm, Attitude, and Perceived Behavioral Control
Model 2
Research Questions 2 and 2A: How are theory of planned behavior constructs and socio-demographic characteristics related with objectively measured physical activity over a six-week period? What is the unique contribution of perceived stress level measured once weekly over the same six-week period to the model?
Dependent Variable: Physical activity
Independent Variables: [Step 1] Perceived behavioral control, intention, relevant socio-demographic characteristics; [Step 2] Perceived stress
Model 3
Research Questions 4 and 4A: How are theory of planned behavior constructs of attitude, subjective norm, perceived behavioral control, and intention for physical activity and socio-demographic characteristics related with objectively measured sedentary time over a six-week period? What is the unique contribution of perceived stress level measured once weekly over the same six-week period to the model?
Dependent Variable: Sedentary behavior
Independent Variables: Perceived behavioral control, intention, relevant socio-demographic characteristics

Descriptive Statistics

Descriptive statistics were computed using R statistical software version 3.0.1 (R Core Team, 2013). Mean, median, and standard deviation were calculated for each continuous variable, including physical activity and stress levels at each of the six time points. Frequencies and percentages were computed for categorical variables. A correlation matrix using Pearson product correlation coefficients for continuous variables and Point Biserial correlations for categorical variables were used to examine bivariate relationships. Further, scatterplots were created for all variables to assess the shape of the relationships.

Inferential Statistics

Model estimates were be computed using R statistical software version 3.0.1 (R Core Team, 2013). The three models described in Table 1 required varying techniques in regression, including standard regression modeling (Model 1), hierarchical regression analysis (Models 2 and 3), and multilevel modeling procedures (Models 2 and 3). Standard multiple regression techniques are used to evaluate relationships between the dependent variable and independent variables. Multiple regression was used to determine if the independent variables in a model can be used to explain the variance (R^2) in the dependent variable. In addition to producing a measure of variance explained, multiple regression analyses determine which independent variables have significant independent relationships with the dependent variable. In this study, standard multiple regression techniques were used to determine the amount of variance explained in the theory of planned behavior construct of intention for both physical activity and sedentary behavior using the predictor variables of subjective norm, attitude, and perceived behavioral control.

Hierarchical regression analysis builds upon standard multiple regression models by allowing researchers to determine the order in which variables are entered into a regression analysis. This in turn allows for the evaluation of the change in variance as variables or groups of variables are entered into the analysis (Cohen et al., 2002). The change in R^2 was used to determine the unique contribution and predictive ability of an additional independent variable when added to the model. In this study, hierarchical data structuring techniques were used in Models 2 and 3. Specifically, theory of planned behavior constructs and relevant socio-demographic characteristics (determined by correlations indicated in bivariate analyses) were entered into the model in the first block. The second block included perceived stress in an effort to determine the unique contribution of perceived stress in explaining physical activity.

In both standard and hierarchical regression analyses, the models assume that all data are normal and independent. To test the tenability of model assumptions, Q-Q plots of the studentized-residuals, histograms of the studentized residuals, and the variance inflation factor was be examined for violations. Values were considered outliers if they are outside of the 95% confidence interval of the Q-Q plot (Fox, 2008). Variance inflation factor values greater than four were be flagged as problematic. Prior to interpreting regression model parameter estimates, the tenability of the model assumptions will be verified. Researchers proceeded with the analysis pending no violations.

Multilevel models can be conceptualized as regression models occurring at different levels (Bell et al., 2013). Because of the dynamic nature of physical activity, sedentary behavior, and stress levels, measurement of these variables for each participant took place over six weeks, resulting in six data points for each participant. Standard regression techniques assume all observations are independent and cannot therefore properly account for the nesting of time within a person in this dataset. Multilevel modeling was thus selected as the method of analysis for models 2 and 3 to account for the hierarchical nesting of data given that data points within one person are correlated (Bell et al., 2013). Using multilevel modeling techniques, two longitudinal models were estimated. Model 2 was used to determine the relationship between intention, perceived behavioral control with subjective norm and attitude as mediators, relevant socio-demographic characteristics as determined by correlation coefficients in the bivariate analyses, and perceived stress with physical activity over the six-week study period. Model 3 was estimated to determine the relationship between intention, perceived behavioral control, relevant socio-demographic characteristics, and perceived stress with sedentary behavior over the six-week study period. In both models, time was nested within participants, where time is the level-1 units and participants are the level-2 units. Both models were estimated using the lme4 package in R.

Longitudinal model building. Longitudinal models are created through an iterative process where an unconditional model, or a model not conditioned on any predictors, is created, and is followed by models with added predictors. Although there are different methods of model building, the ultimate goal of each method is to estimate the most parsimonious model possible given the data. Model fit in this study was examined using Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). Across both AIC and BIC measures, smaller values represent a better fit.

Assumptions of multilevel models and model diagnostics. Before estimating the models, the tenability of model assumptions was examined. All data management procedures, data screening, checks for violations of assumptions took place using SAS statistical software. Linear multilevel models are assumed to have error terms that are normally distributed for both level-1 and level-2 variables, be independent, and homoscedastic. Multilevel models also assume normality, linearity, and homogeneity of variance. Model assumptions will be assessed in SAS using the MIXED_DX macro (Bell et al., 2010), which provides a comprehensive approach to assessing if any assumptions of a dataset have been violated. Visual (e.g., box plots, scatter plots, and histograms) and statistical information for both level-1 and level-2 residuals are given in the output. In the event of no violations, the model building process will follow.

Starting the process with the unconditional model allows for the calculation of the intraclass correlation coefficient. The intraclass correlation coefficient provides a measure of how much variation exists in the outcome variable across level-2 units. In this study, this refers to the variability in physical activity or sedentary behavior that is attributable to differences in participants as opposed to differences across time (the level-1 units).

The unconditional model takes the following form:

Level 1: $Y_{ti} = \pi_{0i} + e_{ti}$

Level 2: $\pi_{0i} = \beta_{00} + r_{0i}$

where, with physical activity as the outcome variable, Y_{ij} is the physical activity of time $_i$ for person $_j$, β_{oj} is the average physical activity at time point 1, and r_{ij} is the residual term. In addition to producing an intraclass correlation coefficient, this model also produces an AIC and BIC value that serve as a baseline to which successive models can be compared to determine model fit, and a fixed effect value, which provides an estimate of the activity level at the beginning of the data collection period.

The second model builds upon the unconditional model and will be conditioned on time. It appears as follows:

Level 1: $Y_{ti} = \pi_{0i} + \pi_{1i}a_{ti} + e_{ti}$

Level 2: $\pi_{0i} = \beta_{00} + r_{0i}$

$\pi_{1i} = \beta_{10}$

where β_{ij} refers to the change in physical activity levels of people across time, or the slope. In this model, the slope is treated as a fixed effect, indicating all participants will have the same slope (i.e., all participants will have the same increase or decrease in physical activity level across the six time points). Model AIC and BIC are also computed.

Model three includes the random effect for the slope. Because the previous model treated the slope as a fixed effect, estimating a model with the slope treated as a random effect is necessary to determine which model is most appropriate. Treating the slope as a random effect indicates there is variability in slopes (i.e., variability in the changes in physical activity level between participants across time). Model three appears as follows:

Level 1: $Y_{ti} = \pi_{0i} + \pi_{1i} a_{ti} + e_{ti}$

Level 2: $\pi_{0i} = \beta_{00} + r_{0i}$

$\pi_{1i} = \beta_{10} + r_{1i}$

where β_{ij} is the change in physical activity across time, β_{oj} is the average physical activity of all participants at time point 1 (i.e., slope), and μ_{ij} is the random effect, or the variability in slopes across participants. If the random effect value differs from zero, it will be necessary to include. Model AIC and BIC is also computed.

Model four includes level-2 (person-level) predictors as fixed effects. The level-2 predictors include perceived behavioral control, intention, and any relevant socio-demographic characteristics determined by bivariate analyses. Model four appears as follows:

Level 1: $Y_{ti} = \pi_{0i} + \pi_{1i} a_{ti} + e_{ti}$

Level 2: $\pi_{0i} = \beta_{00} + r_{0i}$

$\pi_{1i} = \beta_{10} + \sum_{m=1}^{M} \beta_{1m} X_{mi} + r_{1i}$

where model four includes the level-2 predictors listed above. The AIC and BIC from model four will be used to determine which model best fits the data, keeping in mind parsimony.

Summary

Model 1. Standard multiple regression techniques were used to determine the amount of variance explained in intention for physical activity by the three predictor variables: subjective norm, attitude, and perceived behavioral control.

Model 2. A longitudinal model with hierarchical data structuring was used to determine the amount of variance explained in physical activity (objectively measured over six week) using the following predictor variables: perceived behavioral control, intention, relevant socio-demographic characteristics. To determine the unique contribution of perceived stress to physical activity, perceived stress was added to the model in a second block.

Model 3. A longitudinal model was estimated to determine the amount of variance explained in sedentary behavior using the following predictor variables: perceived behavioral control, intention, relevant socio-demographic characteristics, and perceived stress.

Table 3.2 displays the anticipated timeline to complete the study.

Table 3.2. *Study Timeline*

Task	Completion Date
Data Collection	2011-2012
Recruitment	2011-2012
Participant enrollment	2011-2012
Data collection complete for all participants	2012
Data entry	2012
Dissertation Proposal	11/05/2015
Data Analysis	
Data cleaning	11/20/2015
Data analysis (descriptive and inferential statistics)	12/04/2015
Interpretation of results	12/11/2015
Manuscript Preparation	
First draft of manuscript 1	01/08/2016
Final draft of manuscript 1	01/29/2016
First draft of manuscript 2	01/15/2016
Final draft of manuscript 2	02/15/2016
Dissertation Defense	02/29/2016
Manuscript submission to journal	03/15/2016
Manuscript publication	03/15/2017

CHAPTER FOUR

Physical Activity and Perceived Stress Among Adults: An Application of the Theory of Planned Behavior

Abstract

Background: Young and middle-aged U.S adults engage in low levels of physical activity and experience high levels of stress. Examining physical activity and stress impact through the theory of planned behavior framework may provide useful insight to help address these health issues. The purpose of this study was to examine the predictive value of the theory of planned behavior in describing physical activity in a sample of U.S adults while accounting for stress. Specifically, we sought to examine relationships between objectively-measured physical activity over a 6-week period with a dynamically measured stress impact variable, sociodemographic variables, and constructs from the theory of planned behavior.

Methods: Participants aged 20-49 [n=45, mean age=31, 70% female, 83% White] completed baseline questionnaires that included sociodemographic information, theory of planned behavior constructs, and a weekly stress inventory; and wore an objective measure of physical activity (e.g., Actigraph accelerometer or SenseWear Armband) for 6 weeks. Participants also completed the weekly stress inventory once weekly over the same 6 weeks that physical activity was measured. A longitudinal model was estimated to examine relationships between TPB constructs, sociodemographic characteristics, and stress over the 6-week study period.

Results: The addition of sociodemographic and theory of planned behavior covariates reduced the person-level error variance in physical activity by 3.8% and was supported by model fit indices (e.g., reduction of ~60 in AIC and BIC). This indicates that the theory of planned behavior had predictive value in explaining objectively- and longitudinally- measured physical activity in this sample. The inclusion of the stress impact variable was not supported by model fit indices, indicating stress level did not predict physical activity behavior in this sample.

Conclusions: The theory of planned behavior constructs consistently explain a smaller amount of the variance in objectively measured physical activity when compared to physical activity that is subjectively measured. Future research should explore relationships between theoretical constructs and objectively measured physical activity. Although not meaningful in this sample, future research should also examine the relationship between physical activity and stress in an effort to approach the health status of young and middle-aged adults more holistically.

Introduction

Decades of scientific evidence strongly support a relationship between regular physical activity (PA) and a reduced risk of the chronic diseases present in high rates among U.S. adults; such as obesity and cardiovascular disease (U.S. Department of Health and Human Services, 2008). Despite this, many American adults do not engage in sufficient levels of PA to achieve health benefits. In a Centers for Disease Control and Prevention (CDC) study, just over half of all adults (51.6%) engaged in the minimum amount of aerobic PA suggested by the national PA guidelines (2014). Because young and middle-aged adults aged 20-49 make up 41% of the total U.S. population, or about

127 million people (U.S. Census Bureau, 2013), the negative health impact of low levels of PA in this group are particularly important to consider. Of the estimated 81 million American adults that have one or more types of cardiovascular diseases, 43 million are estimated to be 60 years old or younger. Further, approximately 151,000 Americans who died of cardiovascular disease in 2006 were younger than 65 years of age (Lloyd-Jones et al., 2010). Given the persisting low levels of PA, high disease rates, and the modifiability of the behavior, it is important to continue to identify determinants of PA among the young and middle-aged U.S adult population.

Stress levels also impact the health status of young and middle-aged adults in the U.S., and high levels of stress are considered risk factors of many chronic diseases (e.g., heart disease, obesity, metabolic syndrome, cancer; Chandola, Brunner, & Marmot, 2006; Tennant, 2000). Evidence suggests U.S. adults routinely experience high levels of stress, with 47% of U.S. adults reporting concern with the amount of stress in their lives, and 22% reporting they are experiencing extreme stress in their lives (Stambor, 2006).

Evidence also suggests that stress levels are related with physical activity behaviors. A large-scale study with more than 32,000 participants reported those who are less physically active were twice as likely to report high stress levels (Aldana et al., 1996). Another study with more than 12,000 participants reported a decrease in high levels of stress with increasing leisure-time physical activity (Schnohr, Kristensen, Prescott, & Scharling, 2005). Research also indicates that stress levels change over time (Brantley, Jones, Boudreaux, & Catz, 1997), indicating cross-sectional research may not be the most appropriate way to assess relationships between stress and physical activity. Given that young and middle-aged report experiencing high levels of stress and low levels of physical activity, better understanding the relationship between stress and physical activity over time could lead to more multi-faceted approaches to combating some of the major issues faced by this population today.

Health behavior theories can help professionals better understand complex health behaviors and support efforts to promote positive behavior change. The theory of planned behavior (TPB), first developed by Ajzen in 1985, has demonstrated strong predictive value across a variety of health behaviors. The TPB postulates that a behavior is influenced by four factors: intention, perceived behavioral control (PBC), attitude, and subjective norm. Within the model, behavior is predicted directly by intention and PBC; and indirectly by the constructs of attitude, subjective norm, and PBC, with PBC therefore influencing behavior both directly and indirectly through intention.

The TPB has been used extensively in research describing and explaining PA (Ajzen, 2011). A large number of published literature reviews reported strong relationships between TPB constructs and PA (e.g., Blue, 1995; Godin, 1993; Godin, 1994; Hausenblas, Carron, & Mack, 1997). Results from two meta-analyses found TPB constructs to explain 27% and 24% of the variance in PA behavior and 45% and 42% of the variance in intention across the included studies (n = 72; Hagger et al., 2002; n = 103; McEachan et al., 2011, respectively). While the overall model has shown strong predictive value in explaining PA, there is mixed evidence supporting the utility of the subjective norm construct (Godin & Kok, 1996; Hagger et al., 2002). Some researchers have suggested subjective norm may not require further study as a construct of the TPB (Courneya, Plotnikoff, Hotz, & Birkett, 2000), while others have argued for the construct's continued inclusion, and for injunctive and descriptive norms to be assessed independently within the construct (Okun, Karoly, & Lutz, 2002).

To evaluate recent uses of the TPB in scientific literature, we conducted a literature search of the TPB in PA research in adult populations since 2010. Fourteen articles were identified where researchers reported on non-clinical samples of adults and measured at least one TPB construct. Results indicated: (1) the majority of recent TPB research took place outside the U.S. (n=12); (2) researchers mainly used subjective measures of PA (n=13); (3) employed cross-sectional designs (n=7) or examined PA over a one-week period at multiple time points (n=3); and (4) results support the continued use of the TPB to examine and explain PA behaviors, and the tendency to question the utility of the subjective norm construct.

Evidence from recent research and the overall body of literature on the TPB and physical activity has some limitiations. In 2001, Armitage and Conner reported that the TPB explained less variance in objectively measured PA (R^2=.20) than it did in subjectively measured PA (R^2=.31). Despite this, researchers have largely continued to use subjective measures of PA in their studies. Given that objective measures may be the stronger method of measuring PA as they are not subject to the reporting and recall biases of self-report measures, and that they provide different results, more research is needed using objective measures of PA in relation to TPB constructs. The vast majority of studies also employ cross-sectional designs. Results may differ when PA is measured in different study designs (e.g., study periods longer than one week). Questions also remain unanswered regarding the utility of the subjective norm construct, particularly in research using objective measures of PA. Lastly, recent research employing the TPB to explain

PA behaviors has largely taken place outside the U.S. Given the low levels of PA of American adults, further research in the U.S. is warranted.

The purpose of this study was to examine the predictive value of the TPB in PA intention and behaviors in a sample of U.S adults, and subsequently to examine the role of stress in this model. Specifically, we sought to examine objectively-measured PA over a 6-week period using sociodemographic variables and TPB constructs, followed by a dynamically measured stress impact variable to determine the unique contribution of stress in PA behavior.

Methods

Participants

Adults aged 20-49 were recruited from local businesses, a university, and church congregations in a central Texas community to participate in this study. Participation was strictly voluntary and participants indicated their informed consent prior to participation. Initial participant contact including initial survey completion took place in local churches, community sites (e.g. conference rooms at local businesses), and university classrooms. The remainder of the study took place in participants' free-living environments (i.e. home, workplace, community).

Procedures

Upon consent, participants completed a packet of questionnaires that included socio-demographic information, all TPB variables, and the Weekly Stress Inventory (WSI; Brantley & Jones, 1989). This survey took approximately 15-30 minutes to complete. Participants were also instructed in the use of the physical activity monitor that they were asked to wear daily for the following 6 weeks. Participants were randomly assigned to one of three groups: 1) wearing an Actigraph GT1M monitor, 2) wearing a SenseWear Armband MF-SW, or 3) wearing both monitors. The instructions included information regarding how and when to wear the device(s), and how to charge the battery. Once weekly throughout the 6-week study, participants also completed the WSI. As an incentive, participants were compensated with $10 for every week that they completed the WSI and wore their PA monitor for at least five days (a minimum of four weekdays and one weekend day, specifically). Thus, participants exhibiting complete compliance across were compensated with $60 total. Institutional Review Board approval from the referent institution was received prior to participant recruitment.

Measures

Sociodemographic characteristics. Survey items from the Behavioral Risk Factor Surveillance Survey (Centers for Disease Control, 2014) were used to ascertain age, sex, race/ethnicity, height, weight, annual household income, number of children, and marital status. Body mass index (BMI) was calculated through self-reported height and weight (weight [kg] / height [meters2]; American College of Sports Medicine, 2013).

Physical activity. Moderate-vigorous PA level was measured during waking hours over 6 weeks using the Actigraph accelerometer model GT1M (Actigraph, Pensacola, FL, USA) and the Sensewear Armband Model MF-SW (BodyMedia, Inc., Pittsburgh, PA, USA). The Actigraph accelerometer was worn by participants on a belt over the right hip. The device measures movement through acceleration and provides an estimation of time spent in physical activities at varying intensities. Actigraph accelerometers are widely used as objective measures of PA, have been validated against measures of oxygen consumption for treadmill walking (r=.64), and are used in the National Health and Nutrition Examination Survey (NHANES; Alhassan et al., 2012; Lopes, Magalhaes, Bragada, & Vasques, 2009, Troiano et al., 2008).

The SenseWear Armband is a multi-sensor device that includes an accelerometer and provides an estimation of time spent in physical activities at varying intensities. The SenseWear Armband model MF-SW was worn by participants in this study on the upper arm using an armband. SenseWear model MF-SW contains a tri-axial accelerometer measuring motion and also measures skin temperature, heat flux, and galvanic skin response. SenseWear Armbands have been used extensively in published research to measure energy expenditure in free-living populations (Liden et al., 2002; Malavolti et al., 2007; Papazoglou et al., 2006; Fruin & Rankin, 2004) and have been successfully validated against doubly labeled water methods in healthy young and middle-aged adults (Johannsen et al., 2010).

Data collected from Actigraph accelerometers were downloaded using ActiLife 6.12.0 Data Analysis Software (Actigraph, Pensacola, FL, USA). The cut points published by Freedson in 1998 were selected to interpret the data (e.g., moderate-vigorous PA was classified as 1952 counts per minute or greater). Nonwear and wear time intervals were classified using the algorithm developed by Choi et al. (2011), which has been validated against direct calorimetry. Data collected from SenseWear Armbands were downloaded using SenseWear Professional 7.0 Software, which uses a proprietary algorithm to estimate energy expenditure and provides minutes spent in varying activity categories. Moderate-vigorous PA was defined as 3.0 METs or greater in this study.

Based on previous research (Matthews et al., 2002; Trost et al., 2005), a minimum of 3 days with 10 hours of wear time per day was considered sufficient for inclusion. Participant data were included in the final dataset if they met the above criteria for at least 4 weeks over the 6-week study period. An average daily sum of minutes spent in physical activities for each of the 6 weeks was used in final analyses.

Because both SenseWear Armbands and Actigraph accelerometers were worn by participants in this study, steps were taken to determine the best way to use the data for analysis purposes. First, we estimated two separate models; one using data from SenseWear devices only (n=33) and one using data from Actigraph accelerometers only (n=21), where both models included the respective data from the 9 participants who wore both devices for the 6 week period. Estimates from both models were similar (e.g., a correlation between fixed effect estimates of .70) and the conclusions we drew about effects were the same. Therefore, to maximize the sample of this study, we used the data collected from both devices in the same model. Specifically, we developed a formula using the data from participants who wore both monitors (n=9) to convert data output from SenseWear Armbands to data output from Actigraph accelerometers. That is, the Actigraph acceleromter data were regressed onto the SenseWear Armband data. The resulting regression equation was then used to find the predicted number of minutes of PA for those who wore only SenseWear Armbands had they worn Actigraph accelerometers instead. The formula was as follows: $Y = 8.76631 + (.37388*X)$, where X = SenseWear data and Y = predicted Actigraph output. Despite evidence supporting the validity of both measures, Actigraphs were selected as the primary measure to which SenseWear data would be converted. This is due to the extensive body of research on

Actigraph accelerometers, the non-proprietary algorithm, and the facts that Actigraphs are used in national surveillance studies such as the NHANES (Troiano et al., 2008), and research specific SenseWear Armbands are no longer produced or supported by the company (acquired by Jawbone, San Francisco, CA, USA).

Stress impact. Stress was measured using the Weekly Stress Inventory (WSI; Brantley & Jones, 1989). The WSI is a self-report survey consisting of 87 events that could be possible sources of stress. The survey is scored in two ways: WSI-Event and the WSI-Impact. WSI-Event refers to the total number of stressful events selected by a particiant, and the WSI-Impact refers to the amount of stress evoked by each event as indicated on a 7-point Likert scale. Participants completed the WSI at baseline and once weekly at the end of each week for the 6-week study period. The WSI was selected instead of a daily stress inventory to reduce participant burden, and because it is particularly well-suited for research assessing stress levels over a multiple-week period (Brantley & Jones, 1989). Consistent with Ledoux et al.'s (2012) procedures, only the WSI-Impact scores were used in analyses.

Theory of planned behavior constructs. A TPB-based PA survey was created to measure each construct of the TPB (i.e., attitude, subjective norm, PBC, and intention). The survey was completed by participants during baseline data collection only, and included 26 items. All items were written with leisure time PA as the behavior of interest following Azjen's guidelines for developing TPB surveys (2006).

Attitude towards PA was assessed using 11 opposite adjective pairs anchored on a 7-point scale (e.g., useful/useless, unenjoyable/enjoyable; cronbach's α=.82). An overall mean attitude score was computed for analyses. Measurement of subjective norm included four items that addressed injunctive norms (i.e. what important people think a person should do; cronbach's ɑ=.84) and four items that addressed descriptive norms (i.e. what important people actually do; cronbach's ɑ=.78). All items were related to friends, family, "group", and co-workers, respectively. Mean scores were computed for injunctive and descriptive norms separately per the reccommendation of Okun, Karoly, & Lutz (2002). PBC was measured with 3 items on a 7-point Likert scale ranging from (1) strongly disagree to (7) strongly agree that addressed a person's ability to "find time" to engage in PA, whether or not the behavior is "up to them," and if it is "easy" to engage to PA. A mean score was computed to create an overall PBC score (cronbach's ɑ=.74). Intention was measured with three items using a 7-point scale ranging from (1) unlikely to (7) very likely, that assessed participant's intention to engage in PA in the next 6 weeks (cronbach's ɑ=.91) . The mean of the three items is the overall score for intention.

Data Analyses

All data analyses were conducted using R (version 3.0.1, R Core Team, 2013). Descriptive statistics were computed for each variable of interest. Two correlation matrices using Pearson product correlation coefficients for continuous variables and Point Biserial correlations for categorical variables was used to examine bivariate relationships between (1) weeks of PA data and (2) relationships across variables.

To answer the research questions of interest, two regression models were estimated. Research questions were as follows: 1) Are the TPB constructs of attitude, subjective norm, and PBC associated with behavioral intention for PA? 2) How are TPB constructs and socio-demographic characteristics related with objectively measured PA over a six-week period? and (3) What is the unique contribution of stress on the model?

Two regression models were estimated to examine the predictive ability of the TPB contsructs in explaining PA. The first model used standard regression techniques to answer the question: “are the TPB constructs of attitude, subjective norm, and PBC associated with behavioral intention for PA?” as is supported by the TPB. The second model used multilevel modeling and hierarchical procedures to further examine the predictive ability of the TPB to answer the question: “are the TPB constructs related with objectively measured PA over a six-week periof of time?”. This second model was also estimated to examine the secondary objective of this study and answer the question “does stress (measured dynamically) further explain physical activity behavior in this model?”. Multilevel models can be conceptualized as regression models occurring at different levels (Bell et al., 2013). Because of the dynamic nature of PA behavior and stress impact, measurement of these variables took place over 6 weeks, resulting in 6 weekly data points for each participant. Standard regression techniques assume independence and cannot therefore properly account for the nesting of time within a person in this dataset. Multilevel modeling can account for the hierarchical nesting of data given that data points within one person will be correlated (Bell et al., 2013). Using multilevel modeling techniques, a longitudinal model was estimated to determine the relationship between TPB constructs and relevant socio-demographic characteristics with PA over the 6-week study period. Using hierarchical methods, the stress impact variable was entered into the model independently to determine its unique contribution. The model was estimated using the lme4 package in R.

Prior to estimating regression models, diagnostic assessments were conducted. Multilevel models assume that error terms are normally distributed for both level-1 and level-2 variables, independent, and homoscedastic. To test these assumptions, the MIXED_DX SAS® macro (Bell, Schoeneberger, Morgan, Ferron, & Kromrey 2010) was used. For level-1 (i.e., time), the following output was examined: (1) normality summary statistics for the level-1 residuals overall and for each person, (2) plots of the variance of the level-1 residuals, (3) Levene's test for the homogeneity of variance of level-1 residuals, (4) box plots of the level-1 residuals, (5) histogram of the variance of all level-1 residuals, and (6) scatterplot of the level-1 residuals and predicted values. For level-2 (i.e., person), the following output was examined: (1) plots for level-2 residuals for each level-2 predictor, (2) multivariate normality and outlier summary statistics, (3) Mahalanobis distances values for the level-2 units, (4) histograms of the Mahalanobis distances for all people, and (5) table of ranked influence diagnostics. For detailed discussion of these assumptions and evaluation of diagnostic output, see Raudenbush and Bryk (2002) and Bell and colleagues (2010). Taken together, no violations were detected at either level, and the model estimation and model building processes began.

Results

Sample Characteristics

Based on recruitment efforts, 59 participants were enrolled in the study. Forty-five participants met inclusion criteria based on measurement completeness described above and were retained for these analyses. Prior to conducting analyses, simulations were conducted using SAS/IML software to examine power (SAS Institute Inc., 2012).

The simulations returned power of .7-.8 with a sample size of 45 using very liberal model parameters and random slopes. Since the current study used simpler models by not including random slopes, the observed power in the study likely exceeded the recommended value of .8. Table 4.1 displays the socio-demographic characteristics of the sample. Participants in this sample were mostly female, approximately 31 years of age, overweight, married, and identified their race as White.

Table 4.1. *Descriptive Statistics (n=45)*

Variables	Mean/Count *(range)*	SD/%
Sex		
Female	32	69.6%
Male	13	28.3%
Age	30.61 *(20-50)*	8.11
Race		
White	38	82.6%
African American	4	8.7%
Hispanic	4	8.7%
BMI	26.04 *(16.4-57.6)*	6.4
Number of children	.84 *(0-4)*	1.2
Marital Status		
Married	29	63%
Non-married	17	37%
Income		
<$19,000	11	23.9%
$20,000 - $39,000	12	26.1%
$40,000 - $59,000	8	17.4%
$60,000 - $79,000	7	15.2%
$80,000 - $99,000	3	6.5%
$100,000 or greater	4	8.7%
WSI-Impact	62.89 *(15.71-119.86)*	27.60

Note. WSI = Weekly Stress Inventory

Physical Activity

Table 4.2 displays the average daily minutes spent in PA for each of the 6 weeks participants wore activity monitors. Participants engaged in an average of 30-40 minutes per day of moderate-vigorous PA. Large standard deviations and ranges indicate variability in PA levels across participants.

Table 4.2. *Time Spent in Physical Activity*

Week	Physical Activity[a]			
	Mean	*SD*	*Median*	*Range*
Week 1	37.80	17.44	36.56	12.08 – 112.54
Week 2	34.55	15.86	30.77	14.5 – 70.83
Week 3	35.33	17.00	33.14	10.72 – 80.27
Week 4	37.17	16.09	35.61	14.75 – 73.88
Week 5	39.64	19.40	37.55	11.15 – 91.83
Week 6	36.49	19.80	29.02	14.60 – 82.79

[a]Physical activity is measured in average daily minutes over a one-week period

Bivariate Analyses

Correlations between weeks of PA are shown in Table 4.3. As expected, results indicate a strong correlation between weeks of PA measures (range: *r* =.441[week 1 and week 6] to *r* =.897 [week 4 and week 5]). Given that week 1 was most weakly correlated with all other weeks, researchers excluded it from further analyses to more accurately reflect what is presumed to be habitual physical activity levels. Only the last 5 weeks of physical activity were retained for final analyses.

Bivariate analyses examining associations between variables of interest are shown in Table 4.4. Significant relationships between the following TPB constructs were observed: (1) injunctive and descriptive norms, (2) both injuctive and descriptive norms and PBC, (3) both injunctive and descriptive norms and intention, (4) PBC and intention, and (5) intention and PA. Stress impact was significantly and negatively related with attitude towards PA. No relationship was found between PA and stress impact.

Table 4.3. *Correlation Coefficients Across 6 Weeks of Physical Activity (n=45)*

Week	1	2	3	4	5	6
1	-					
2	.495					
3	.488	.648				
4	.529	.728	.809			
5	.535	.755	.799	.897		
6	.441	.635	.703	.820	.800	-

Regression Analyses

Results from regression models are displayed in tables 4.5 and 4.6. In the first regression model, 70.5% of the variance in intention for PA was explained by the 4 independent variables representing the remaining TPB constructs (i.e., attitude, PBC, and injunctive and descriptive norms included separately). PBC and injunctive norm had significant, independent relationships with intention. Attitude and descriptive norm were not significantly related with intention for PA.

The longitudinal model examining relationships between sociodemographic characteristics, TPB constructs, and stress was estimated next. Longitudinal models are created through an iterative process where an unconditional model, or a model not conditioned on any predictors, is created, and is followed by models with added predictors. The ultimate goal of the process is to estimate the most parsimonious model possible given the data. Model fit was examined using Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). Across both AIC and BIC measures,

Table 4.4. *Correlation Coefficients for Associations Between Variables (n=45)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Age	-												
2 Sex	.155												
3 BMI	.256	-.032											
4 Income	.538**	.144	-.122										
5 Marital Status	-.115	.075	.058	-.271									
6 Number of Children	.410**	.159	.222	.293	-.277								
7 Attitude	.009	.142	.180	.018	.157	.004							
8 SN-Injunctive	.111	.013	.045	.151	-.079	.190	.091						
9 SN-Descriptive	.012	-.071	-.172	.285	-.015	.151	-.040	.698**					
10 PBC	.009	.051	-.314*	.171	.195	.001	.119	.332*	.306*				
11 Intention	.028	.062	-.359*	.210	.212	.008	-.066	.567**	.505**	0.745**			
12 Physical Activity[a]	.011	-.237	-.226	.101	.220	-.299*	-.153	.088	.222	.200	.314*		
13 Stress[a]	-.163	.044	-.159	.108	-.125	-.038	-.302*	-.075	.053	-.128	-.060	.114	-

Note. *Correlation significant at the .05 level; **Correlation significant at the .01 level; [a] PA average across 6 weeks; BMI = body mass index; SN = subjective norm

Table 4.5. *Intention for PA with Attitude, PBC, and Subjective Norm as Independent Variables*

Independent Variables	Intention			
	β	SE	*p*	95% *CI*
Attitude	-0.22	0.11	0.06	[-.44, .00]
Subjective Norm- Descriptive	0.11	0.15	0.48	[-.19, .41]
Subjective Norm- Injunctive	0.37	0.15	0.02	[.07, .67]
PBC	0.89	0.13	<0.001	[.62, 1.14]
R^2	0.705			

Note. β = Standardized beta weight; SE = Standard error; *p* = *p*-value; *CI* = Confidence interval

smaller values represent a better fit. Results from the model building process are shown in Table 4.6.

The unconditional model was first estimated to (1) provide a baseline to which successive models can be compared to determine model fit, and (2) to compute the intraclass correlation coefficient (ICC). The ICC is used to determine how much variance exists in the outcome variable across level-2 units (i.e., variability in PA attributed to differences in participants). In this sample, the ICC indicated 74.86% of the variance in PA was explained by the person. Time should therefore still be considered a factor, and therefore time was nested within person.

Models 2 and 3 built upon the unconditional model to be conditioned on time, where slope was treated as a fixed effect in Model 2 (i.e., all participants have the same increase or decrease in PA level across the 6 time points) and a random effect in Model 3. The variance estimate of the random effect for time differed from zero, indicating time should be included as a random effect in the model.

Models 4 and 5 included level-2 (person-level) predictors as fixed effects. Predictors in Model 4 included age, sex, BMI, and TPB constructs. Despite a significant bivariate correlation between number of children and physical activity, number of children was not included as a predictor in the model because of the prevalence of missing data (n=10), and limited variability within the sample. Given that these predictors were at level-2, level-2 residual variances were compared to determine what percentage of the level-2 variance was explained by these predictors. That is,

$$\frac{\tau_{00,Model\ 3} - \tau_{00,Model\ 4}}{\tau_{00,Model\ 3}}.$$

These variables accounted for about 4% of the variability attributable to the person-level effects. None of the person-level variables were significantly independently related with the outcome. Model 5 built upon Model 4 by including the stress impact variable by itself, to determine its unique contribution to explaining PA. Stress was entered as a time-varying covariate, and the level-1 residual variances were compared to determine the unique contribution of stress to PA. That is:

$$\frac{\sigma^2_{Model\ 4} - \sigma^2_{Model\ 5}}{\sigma^2_{Model\ 4}}.$$

The reduction in residual variance is used as an indication of the percentage of variance explained by the additional parameters in Model 5. In this case, stress uniquely accounted for an additional 2.5% of the within-person variability.

Model selection. Model 4 was selected as the best fitting model, keeping parsimony in mind. The level-2 predictors reduced the AIC and BIC substantially, and the inclusion of model covariates reduced the person-level error variance in the model marginally (i.e., 3.8%). TPB constructs and sociodemographic characteristics helped to explain PA behaviors in this sample. The addition of the stress impact variable further reduced the person-level variance in the model, although only slightly (i.e., 2.5%) and was not supported by model fit indices (i.e., AIC and BIC increased).

Table 4.6. *Estimates From Multilevel Model Predicting PA*

	Model 1 *(Unconditional)*	Model 2 *(Time as a fixed effect)*	Model 3 *(Time as a random effect)*	Model 4 *(level-2 variables)*	Model 5 *(stress variable)*
Fixed Effects					
Intercept (SE)	36.66 (2.22)	35.88 (2.40)	35.81 (2.15)	34.28 (19.76)	29.02 (20.15)
Time		.33 (.39)	.39 (.53)	.42 (.56)	.64 (.58)
Age				-.11 (.26)	-.10 (.36)
Sex[a]				6.14 (4.55)	6.01 (4.53)
BMI				-.10 (.57)	-.06 (.57)
PBC				-.37 (2.82)	-.44 (2.81)
SN-I				-3.14 (2.46)	-3.15 (2.46)
SN-D				1.71 (2.35)	1.59 (2.35)
Intent				3.92 (2.42)	4.24 (2.43)
Attitude				-1.22 (1.81)	-1.05 (1.80)
Stress					.03 (.02)
Error Variance					
Level-1(SE)	103.95 (10.19)	104.09 (10.23)	80.63 (8.78)	80.45 (8.81)	80.42 (8.83)
Intercept (SE)	202.17 (47.05)	202.17 (47.06)	163.33 (41.75)	147.07 (42.74)	146.54 (42.61)
Time (SE)			7.39 (2.64)	8.23 (2.86)	8.10 (2.83)
Model Fit					
AIC	2003.8	2003.2	1985.0	1924.4	1928.3
BIC	2007.4	2006.8	1990.4	1929.8	1933.7

Note. BMI = body mass index, PBC = PBC, SN-I =subjective norm, injunctive; SN-D = subjective norm, descriptive; [a]males reported greater PA than females

Results from the final model also indicated a reduction in PA with greater BMI, greater PA for males, and greater levels of PA participation with increasing age. Higher scores for PBC were associated with lower levels of PA participation. Higher scores for intention for PA were associated with higher levels of PA participation.

Discussion

Despite an abundance of PA research in U.S. adult populations, low levels of PA engagement (Centers for Disease Control and Prevention, 2014) and high levels of chronic disease (Lloyd-Jones et al., 2010) persist in this group. Continued efforts and research that explores the behavior in unique ways is therefore warranted. The primary objective of this study was to examine the predictive value of the TPB in PA using objectively- and longitudinally-measured PA data in a sample of U.S. adults. Major findings supported the use of the TPB in predicting intention for PA (R^2 = .71) and cautiously support the predictive value of PBC and intention in explaining longitudinally measured PA behaviors. A secondary aim of the study was to determine if the addition of a dynamically measured stress impact variable offered a unique contribution to the model, given the established relationship between PA and perceived stress. The stress impact variable was not supported by model fit indices and we concluded perceived stress did not influence PA in this sample.

To test the models, descriptive data were first analyzed and revealed that, on average, participants engaged in 30-40 minutes of PA per day over the 6-week study period. Large standard deviations and ranges indicated variability within the sample. Overall, however, the study sample was active and meeting national PA guidelines and therefore not representative of the U.S. adult population. Given that only about half of all U.S. adults meet the PA guidelines, relationships between behavior and theoretical constructs may have been impacted by this routinely active sample.

A correlation matrix examining the relationship across weeks of PA was also created. As expected, weeks that were further apart (i.e. week 1 and week 6) had the lowest correlations (r =.441), and weeks that were closer together (i.e. week 3 and 4 and week 4 and week 5) had stronger correlations (r = .897 and .809, respectively). Because week 1 has the weakest correlations with all other weeks and the longest single bout of PA across the entire study, week 1 was excluded from final analyses, given that it may be the result of an observer effect. Although support for one week of assessment of physical activity exists in the literature (Trost et al., 2005; Matthews et al., 2002), data from this study indicates the first week of activity measurement may not be representative of habitual PA. Future researchers could consider collecting PA data for two weeks, and possibly discarding the data from the first week if it is not strongly correlated to the second. This could eliminate the possibility of an observer effect. Strong correlations across weeks 2-5 in this study, however, indicate that 6 weeks of data, while interesting, may not be necessary in future research.

A second correlation matrix examining relationships across all study variables was created. In addition to expected relationships between TPB variables (e.g., r = .745 for PBC and intention; r = .314 for intention and PA; r = .698 for injunctive and descriptive norms), other correlations between sociodemographic variables and TPB variables were significant. For example, both PBC and intention for PA were negatively related with BMI (r = -.314 and -.359, respectively). In working with overweight or obese populations, special attention to increasing PBC and intention for PA may be helpful in increasing PA levels. Additionally, a negative association was found between PA participation and number of children (r = -.299). This is consistent with research that suggests parenthood is a risk factor for inactivity (Bellows-Riecken & Rhodes, 2008). Despite evidence supported in the literature (Adamo, Langlois, Brett, & Colley, 2012;

Bellows-Riecken & Rhodes, 2008) and support from bivariate analyses, number of children was not included in the final multilevel model because of the prevalence of missing data in this sample (n=10), and limited variability. Future research should continue to investigate the relationships between physical activity level and parenthood when possible. Special attention should also be paid to parents in health promotion efforts designed to increase PA participation.

In the regression model examining intention, the TPB constructs of attitude, PBC, injunctive norm, and descriptive norm explained 70.5% of the variance in intention for PA. Previous research supports a large amount of the variance in intention being explained by TPB constructs (e.g., 45% in a meta-analysis conducted by Hagger et al., 2002). However, TPB constructs had particularly strong associations with intention for PA in this sample. PBC had a significant, independent relationship with intention (β = .89) while attitude did not (β =-.22). Previous research shows a consistent positive association for PBC with intention (Hagger et al., 2002; McEachan et al., 2011). Attitude has also been previously reported to be positively associated with intention in large meta-analyses (Hagger et al., 2002; McEachan et al., 2011), making the direction of the relationship and lack of significance between the two variables in this sample surprising. It is possible that attitude was not related to intention because of the specific characteristics of this sample, or how active the sample already was. It is possible that attitude may play a smaller role in intention for PA when PA is already habitual.

Researchers have previously reported mixed evidence supporting associations between subjective norm and intention (Godin & Kok, 1996; Hagger et al., 2002), consistent with the findings from this study. In this sample specifically, injunctive norm was independently related with intention for PA (β = .37) while descriptive norm was not. While some researchers (Courneya, Plotnikoff, Hotz, & Birkett, 2000) have suggested removal of the construct in PA research, others (Okun, Karoly, & Lutz, 2002) have called for the separate assessment of injunctive and descriptive norms within the construct. Early research assessing the relationship between subjective norm and intention focused only on injunctive norms (Ajzen & Driver, 1992). After consistently finding subjective norm to contribute the least to intention when compared to attitude and PBC, Godin and Kok suggested descriptive norms also be measured within the construct to strengthen its predictive value (1996). Godin and Kok (1996) and Okun, Karoly, and Lutz (2002) hypothesized that descriptive norms may play a larger role in intention than injunctive norms, and Okun, Karoly, and Lutz (2002) found descriptive norms related to friends to be significantly related with intention for PA in a sample of college students. Despite this, researchers of recent studies continue to evaluate only injunctive norms within the subjective norm construct (Gwin et al., 2013; Hamilton et al., 2012; Hamilton & White, 2012; Plotnikoff et al., 2012; Scott et al., 2010). Evidence from this study indicated descriptive norms were not relevant, which differs from previous hypotheses. Research that continues to independently assess injunctive and descriptive norms is recommended and may help explain the best approach for evaluating norms, if at all, within PA research.

Results from the multilevel model examining predictors of PA indicated that the inclusion of TPB constructs intention and PBC and sociodemographic variables reduced the person-level error variance by 3.8 %. These results are consistent with previous evidence that supports the predictive value of the TPB in explaining PA behaviors. The amount of person-level error variance in this study, however, is notably lower than the comparable R^2 found in previous research. In a meta-analysis that included 72 studies published between 1975 and 2001, Hagger and colleagues (2002) found the entire TPB model across all studies explained 27% of the variance in PA behaviors. In 2011, McEachan and colleagues conducted another meta-analysis examining the relationship between TPB constructs and prospective tests of health-related behaviors (e.g., excluding cross-sectional designs). Results revealed 24% of the variance in PA behavior across 103 studies was explained by including TPB constructs intention and perceived behavioral control.

The lower amount of variance explained by TPB constructs in this study may be due to our use of an objective measure of PA and the measurement of PA over 5 weeks. Data from 2001 published by Armitage and Conner demonstrated that TPB constructs explained a smaller amount of the variance in objectively measured PA (R^2 =.20) than they did in subjectively measured PA (R^2 =.31). Armitage and Conner suggest this may be attributed to greater bias in subjective measures. In their meta-analysis published in 2011, McEachan and colleagues reported similar findings: only 12.1% of the variance in objectively measured PA was predicted by TPB constructs when compared with 25.7% of the variance in subjective PA. It is worth noting, however, that researchers of only 14 of the studies used data from objective measures, while 91 studies were based on subjective measures of PA. Despite this new information, researchers have largely continued to rely on subjective measures of PA in TPB research within the last 5 years. We recommend more objective measures of PA be used in TPB research, especially given that objective measures are not subject to the same recall and response biases that self-report measures are, and thus may provide a more accurate assessment of PA behavior.

Neither of the TPB constructs in the final model were significant, independent predictors of PA. The direction of the relationships, however, is still worth noting. Consistent with previous literature (Hagger et al., 2002; McEachan et al., 2011), higher scores for intention for PA were associated with higher levels of PA participation. The relationship between intention and PA in this sample was also supported in bivariate analyses (r= .314). Even though bivariate analyses supported the expected positive relationship between PA and PBC (r=.200), although not statistically significant, greater PBC was unexpectedly associated with lower levels of PA participation in the final model. The reason for the change in relationship direction is likely the result of a suppressor effect between PBC and intention, where PBC is the suppressor, strengthening the R^2 value in predicting intention, while being a weak predictor by itself in the full model (Cohen, Cohen, West, & Aiken, 2003).

In addition to TPB constructs, sociodemographic variables were also included in the multilevel model and demonstrated relationships with PA. Researchers have previously reported an association between lower levels of PA in females when compared to males (Sallis, Salmon, Bauman, Crawford, Timperio, & Owen, 2000; Salmon, Owen, Bauman, Schmitz, & Booth, 2000), and persons with greater BMIs (Brownson et al., 2000; Sternfeld, Ainsworth, & Queensberry, 1999); findings that were supported in this sample. Previous research also supports a relationship between lower levels of PA with increasing age (Sallis, 2000; Browson, Eyler, King, Brown, Shyu, & Sallis, 2000); a finding not supported in this sample. This is possibly due to the fact that all participants were young and middle aged adults, with the oldest participants being 50 years of age. Trends in decreasing levels of PA with age have been shown to occur after age 50 (Troiano et al., 2008). If this sample included adults of all ages, our findings may have been different.

Model 4 was selected as the final model in this study, meaning stress impact was not included. The addition of stress did reduce the person-level error variance by 2.5%, but its addition was not supported by the model fit indices (i.e., AIC and BIC measures). A relationship between stress and PA, however, does exist. Results of meta-analyses concluded bouts of PA or exercise can buffer the effects of exercise and reduce the stress response (Alderman, Rogers, Johnson, & Landers, 2003; Crews and Landers, 1987). Further, those who participate in regular PA often report lower rates of stress-related disorders such as anxiety and depression and have a reduced stress response (Crews & Landers, 1987; Taylor, Sallis, & Needle, 1985). Despite this, a relationship between stress and PA was not evident in this sample. More research examining the complex relationship between PA behavior and stress impact among all population groups in addition to U.S. adults is still recommended.

There are several limitations to this study. First, data were collected from a convenience sample. The sample size was relatively small (n=45) and all participants were from the same geographic area (Central Texas); although simulations fully supported adequate power for the proposed analyses. It is possible that a larger sample size may have yielded different results, and that findings could differ across more varied locations. Additionally, PA data indicated that the average study participant was regularly active. More variety in activity levels in this sample may have also yielded different results. Two different accelerometers were used to assess physical activity in this study (i.e., SenseWear Armband devices and Actigraph accelerometers). A formula was developed, however, to regress SenseWear data to Actigraph data, thereby eliminating issues in measurement across the devices. Although the use of an objective measure of PA is a strength of this study, accelerometers do have several limitations. First, the models used in this study cannot be worn in water, and second, they can only provide information about the duration and intensity of an activity bout but not identify the type of activity. Despite this, accelerometers have still been widely used in research, including national surveillance studies, and are recommended by researchers for continued use assessing physical activity (Troiano et al., 2008; Alhassan et al., 2012; Lopes, Magalhaes, Bragada, & Vasques, 2009).

Conclusions

Although the TPB has been applied extensively to PA research, few studies within the young and middle-aged adult population use objectively measured PA or longitudinally measured PA, and few studies, if any, include a measure of the potential impact of dynamic stress. By doing both, the objective of this study was to add a meaningful contribution to the body of literature and to provide deeper insight into factors related with PA. Findings from this study indicated that TPB constructs have predictive value over longitudinally and objectively measured PA, but that they explain a smaller amount of variance in objectively measured PA than previous reports using subjective measures. Future research applying the TPB to objectively measured PA, and assessing injunctive and descriptive norms independently is needed. Results from this study also indicated that stress was not related with PA levels in this sample after accounting for TPB constructs and sociodemographic variables. Despite this, we suggest continued research examining the relationship between stress levels and PA participation. Because both high levels of stress and low levels of PA have negative health consequences and are pervasive among U.S. adults, better understanding both variables and the direction of the relationship that exists between the two can provide an opportunity to more holistically examine the health status of adults.

CHAPTER FIVE

Sedentary Behavior and Perceived Stress Among Adults: An Application of the Theory of Planned Behavior

Abstract

Objective: The purpose of this study is to evaluate the predictive value of the theory of planned behavior in sedentary behavior of young and middle-aged U.S. adults. Specifically, relationships between objectively measured sedentary behavior over a 6-week period was examined using socio-demographic characteristics and theoretical constructs consistently related with physical activity. A secondary objective was to measure stress dynamically and examine the relationship between stress and sedentary behavior during this time.

Methods: Participants (n=45, mean age= 31 years, 70% female, 83% White) completed surveys that included sociodemographic information, theory of planned behavior constructs, and the weekly stress inventory. Participants also wore an activity monitor (i.e., Actigraph accelerometer or SenseWear Armband) for 6 weeks and completed the weekly stress inventory once weekly throughout the 6-week study period. A longitudinal model was estimated to determine the relationship between TPB constructs, relevant socio-demographic characteristics, and perceived stress impact with sedentary behavior over the 6-week study period.

Results: Model fit indices supported the theory of planned behavior constructs in explaining sedentary behavior. Model fit indices also supported a relationship between greater stress and less time spent being sedentary.

Conclusions: Results support the use of the theory of planned behavior to explain sedentary behavior. More research should be conducted to understand the relationship between sedentary behavior and stress. Researchers and practitioners should address both stress and sedentariness in efforts to improve the health status of young and middle-aged adults.

Introduction

Young and middle-aged adults aged 20-49 make up 41% of the U.S. population, accounting for approximately 127 million people (U.S. Census Bureau, 2013). At present, this population is experiencing high rates of chronic diseases resulting from poor lifestyle choices. The consequences associated with escalating chronic disease rates are compounded when considering the high stress levels reported by young and middle aged adults (Stambor, 2006), the relationships that exist between stress and chronic disease (Pandya, 1998; Tennant, 2000; Kiecolt-Glaser et al., 1985), and between stress and modifiable chronic disease risk factors (e.g., physical activity and eating behaviors; Ng & Jeffery, 2002). Additionally more than half of the estimated 80 million American adults with cardiovascular disease are middle-aged to 60 years of age or younger (Lloyd-Jones et al., 2010). Further, young to middle-aged adulthood is also often a period of child-rearing (Matthews & Hamilton, 2014) with evidence indicating healthier parents have healthier children (Whitaker et al., 1997). As would be expected with adults in child-rearing years having high rates of chronic disease, children in the U.S. are also currently experiencing unprecedented rates of obesity and related comorbidities (Ogden et al., 2014). Understanding and promoting healthy behaviors in young and middle-aged parents could therefore play an important role in improving the lives of adults while also improving the health status of their children, possibly resulting in a healthier population.

Sedentary behavior has recently emerged as an independent public health issue affecting the health status of the adult population (Owen, Bauman, & Brown, 2009). The term “sedentary behavior” characterizes activities that require little energy expenditure in the range of 1.0 to 1.5 metabolic equivalents of task (METs; Ainsworth et al., 2011; Owen et al., 2009). Common sedentary behaviors include watching television, lying down, sitting at a desk or in transit, using a computer, playing electronic games, and other forms of screen time (Ainsworth et al., 2011). Sedentary behavior has been associated with a number of chronic conditions including cardiovascular disease (Katzmarzyk, Church, Craig, & Bouchard, 2009), obesity (Hu et al., 2003), type 2 diabetes (Ford et al., 2010), premature mortality (Patel et al., 2010), and some cancers (Howard et al., 2008; Gierach et al., 2009).

Notably, the impact of sedentary behavior on chronic disease is independent of physical activity levels. This means a person can participate in regular physical activity while also being highly sedentary (e.g., an office employee who sits at a desk for 8 hours per day at work and watches television in the evenings, and also jogs for 30 minutes daily) and therefore experience negative health consequences. This type of person has been referred to as an *Active Couch Potato* (Owen, Healy, Matthews, & Dunstan, 2010). Objectively measured sedentary behavior data from the National Health and Nutrition

Examination Survey has revealed American adults spend more than 7 waking hours per day in sedentary pursuits (Matthews et al., 2008).

Because health behaviors, such as participation in physical activity and time spent being sedentary, play a major role in health outcomes, health behavior theories have been used by researchers to better understand and explain such behaviors. Although physical activity and sedentary behavior are distinct (Owen et al., 2010), they are related, and theories that have shown strong predictive value in physical activity behaviors may also be useful for explaining sedentary behavior. The theory of planned behavior (TPB; Ajzen, 1991) has been extensively applied to physical activity research with more recent researchers exploring topics relating the theory to sedentary behavior, though the understanding of this relationship is in nascent stages.

The TPB posits that a behavior is predicted directly by behavioral intention (a person's plan of action to engage in the behavior) and perceived behavioral control (factors outside an individual's control that may affect intentions or behaviors), and indirectly by the relationships between intention and attitude (a person's overall evaluation of performing the behavior and his or her beliefs about the outcomes or attributes of performing the behavior), subjective norm (a person's normative beliefs and their motivation to comply) and perceived behavioral control (Ajzen, 1991). The predictive ability of TPB to explain physical activity is well established (Hagger et al., 2002). Although physical activity and sedentary behaviors are distinct (Owen et al., 2010), they are still related, and therefore a framework with strong predictive value of physical activity may also be useful in explaining sedentary behaviors.

Although TPB items can be written for any health behavior, items in this study were developed with leisure-time physical activity as the behavior of interest. While sedentary behavior and physical activity represent distinct classes of activities (Ainsworth et al., 2011), sedentary behavior often replaces leisure-time physical activity in persons exhibiting high levels of sedentariness (Owen et al., 2010), and may or may not be planned to the extent that physical activity behaviors are planned (e.g., intentions are weaker in predicting volitional sedentary activities when compared to non-volitional activities; Prapavessis et al., 2015). For this reason, the authors hypothesized that survey items designed to assess leisure-time physical activity may predict sedentary outcomes (i.e., through inverse relationships between TPB constructs for PA and sedentary behavior), and may serve as better predictors than items designed to measure sedentary activity.

To examine the use of the TPB in sedentary behavior research, a literature search was conducted by the authors. Results revealed only a total of eight published articles about TPB constructs in relation to sedentary outcomes, all using cross-sectional designs, and seven using self-report measures of sedentary behavior. Across the eight articles, two occured in the U.S (Ickes, 2011; Slawson et al., 2015), four focused on adolescents (Hume et al., 2010; Ickes, 2011; Slawson et al., 2015; Te Velde et al., 2011), and four focused on adults (Hamilton et al., 2013; Lowe et al., 2015; Prapavessis et al., 2015; Rhodes & Dean, 2009). TPB construct survey items were written with sedentary behavior as the behavior of interest in all but one study (Lowe et al., 2015). All but one of the completed studies (Hume et al., 2010) supported the continued use of the theory in understanding sedentariness.While this body of literature indicates that TPB could be a useful framework in understanding sedentary behavior, the field is underdeveloped and additional research is needed to deepen our understanding.

No studies to date have been conducted applying the TPB to longitudinally measured sedentary behavior and the interaction of longitudinally measured sedentary behavior with a measure of stress. Therefore, the purpose of this study was to evaluate potential relationships between sedentary behavior and physical activity focused TPB constructs and stress in young and middle-aged U.S. adults. Specifically, relationships between objectively measured sedentary behavior over a 6-week period was examined using socio-demographic characteristics, physical activity TPB constructs, and perceived stress. The authors hypothesized that lower scores for TPB constructs attitude, subjective norm, PBC, and intention will be associated with greater sedentary behavior (e.g., an inverse relationship between TPB constructs written for PA and sedentary behavior). The authors also hypothesized that higher stress levels would be associated with higher levels of sedentary behavior, given that previous research has linked higher levels of sedentary behavior to an increased likelihood of the development of a stress-related mental health condition (e.g., depression; Sanchez-Villegas et al., 2008; Teychenne, Ball, & Salmon, 2010).

Method

Procedures and measures of this study have been previously reported (Walsh et al., unsubmitted manuscript), although a brief summary is provided here:

Procedures

Adults aged 20-49 were recruited to participate in this study. After giving their informed consent, participants completed baseline surveys regarding socio-demographic information, stress level, and TPB constructs. Participants were also instructed to wear a device that objectively measures activity daily during waking hours for six weeks (either an Actigraph GT1M accelerometer; Actigraph, Pensacola, FL, USA; or a Sensewear MF-SW Armband; BodyMedia Inc., Pittsburgh, PA, USA), and complete the Weekly Stress Inventory (WSI; Brantley et al., 1997) once weekly over the same six-week period. Institutional Review Board approval from the referent institution was received prior to participant recruitment.

Measures

Baseline surveys included sociodemographic items (e.g., age, sex, height, weight), TPB construct items (e.g., attitude, subjective norm [injunctive and descriptive norms evaluated separately], PBC, and intention; all worded for leisure-time physical activity behaviors), and the WSI. All TPB survey items were created following Francis and colleagues' (2004) guidelines for constructing measures for use in TPB research. Means of all survey items for each construct were used in final analyses. The WSI asks participants to rank 87 events that commonly cause a stressful experience on a 7-point Likert scale. The WSI-Impact score is the sum of the total perceived stress ratings and was used in final analyses.

Sedentary behavior data was collected via two objective measures. Data collected from Actigraph accelerometers were analyzed using cut points developed by Freedson in

1998 (e.g., sedentary behavior was classified as fewer than 100 counts per minute; the equivalent of less than or equal to 1.5 METs; Matthews et al., 2008; Evenson, Buchner, & Morland, 2012; Freedson, Melanson, & Sirard, 1998). Non-wear and wear time intervals were classified using the algorithm developed by Choi et al. (2011). Data collected from SenseWear Armband devices were downloaded and analyzed using SenseWear Professional 7.0 Software (BodyMedia Inc.). Minutes spent in sedentary time were defined as 1.5 METs or lower (Ainsworth et al., 2011; Owen et al., 2009) for analysis purposes.

Because two monitors were worn by participants in this study, model estimates were first computed separately; one model using only data collected from Actigraph accelerometers (n=21) and one model using only data collected from SenseWear Arbands (n=33), where each model included the respective data collected from the 9 participants who were asked to wear both devices. Estimates from both models were similar (e.g., a correlation between the fixed effect estimates of .93). Given this, and to use the largest sample possible, we proceeded by estimating only one model that included data collected from both devices (n=45). To do this, data from the Actigraph accelerometers were regressed onto data from SenseWear Armbands. The regression equation was used to find the predicted number of sedentary behavior for those who wore only SenseWear Armbands had they worn Actigraph accelerometers instead. The equation used is as follows: Y = 389.492 + (.56203*X), where X = SenseWear day and Y = predicted Actigraph output. While evidence from validity studies demonstrates both devices are valid in measuring energy expenditure, Actigraph accelerometers have been more widely used by researchers, and are used in national surveillance studies such as NHANES

(Troiano et al., 2008), and thus were selected as the primary measure to which Sensewear data were converted. Additionally, research specific SenseWear Armbands are no longer produced or supported by the company (i.e., BodyMedia has been acquired by Jawbone, San Francisco, CA, USA). An average daily sum of minutes spent in sedentary activities for each of the six weeks was used in data analyses.

Data Analyses

Data analyses were computed using R (version 3.0.1, R Core Team, 2013). Descriptive statistics included means and counts of sociodemographic variables and bivariate correlation matrices examining relationships between variables of interest. A multilevel model was estimated to answer the proposed research question. Because of the dynamic nature of sedentary behavior and stress levels, measurement of these variables for each participant took place over six weeks, resulting in six data points for each participant. Since multilevel models do not assume independence they were selected as the method of analysis to account for the hierarchical nesting of data. A longitudinal model was estimated to determine the relationships between sedentary behavior and TPB constructs, relevant socio-demographic characteristics, and perceived stress over the six-week study period. Time was nested within participants, where time is the level-1 unit and participants are the level-2 units. The model was estimated using the lme4 package in R (Bates, Maechler, Bolker, & Walker, 2015).

First, an unconditional model (i.e., a model not conditioned on any predictors) was estimated. The unconditional model provides baseline values of Alkaike's information criterion (AIC) and Bayesian information criterion (BIC), measures of model fit, and is used to compute the intraclass correlation coefficient (ICC). Across AIC and BIC measures, smaller values represent better fit. The ICC provides an estimate of the amount of the total variability in sedentary behavior that is attributable to differences in people (level-2 units) as opposed to differences across time (level-1 units). The following two models (Models 2 and 3) build upon the unconditional model to be conditioned on time, where time is first treated as a fixed effect and then as a random effect. Model 4 includes level-2 predictors (e.g., TPB constructs, sociodemographic characteristics). The final model (Model 5) includes the stress impact variable by itself to determine its unique contribution. The goal of the model building process is to estimate the most parsimonous model possible given the data.

Diagnostic assessments were conducted prior to model estimation using the MIXED_DX SAS macro® (Bell et al., 2010). Additional details regarding diagnostic assessments are provided elsewhere (Walsh et al., unsubmitted manuscript). No violations were detected in level-1 or level-2 variables. Additionally simulations were conducted using SAS/IML software to examine power (SAS Institute Inc., 2012). The simulations returned power of .7-.8 with a sample size of 45 using very liberal model parameters and random slopes.

Results

Descriptive Statistics

Sociodemographic characteristics of the study sample have been described previously (Walsh et al., unpublished manuscript). Overall, the majority of participants (n=45) were female (70%), identified their race as White (83%), were married (63%), and were overweight (BMI mean = 26.04, SD = 6.4).

Table 5.1 displays the average daily minutes spent in sedentary behaviors for each of the 6 weeks participants wore activity monitors. Only wear-time was included in analyses and showed participants spent, on average, 11 waking hours per day in sedentary pursuits.

Table 5.1. *Time Spent in Sedentary Behavior*

Week	Sedentary Behavior[a]		
	Mean	*SD*	*Range*
Week 1	10.76	1.42	6.97 – 13.40
Week 2	10.50	1.41	7.03 – 13.51
Week 3	10.65	1.43	6.40 – 13.44
Week 4	10.76	1.29	7.18 – 13.12
Week 5	10.78	1.54	7.08 – 15.08
Week 6	10.73	1.34	7.99 – 13.63

[a]Sedentary behavior is measured in average daily hours over a one-week period

Correlation analyses of sedentary behavior across the 6 weeks are shown in Table 2. A strong correlation between data points of sedentary behavior across the 6 weeks of the study period was found in this sample (range: r =.502 [week 1 and week 6] to r =.841 [week 2 and week 3]).

Table 5.2. *Correlation Coefficients Across 6 Weeks of Sedentary Behavior (n=45)*

Week	1	2	3	4	5	6
1	-					
2	.719					
3	.563	.841				
4	.513	.742	.803			
5	.523	.643	.537	.699		
6	.502	.740	.683	.775	.758	-

Complete results of bivariate analyses are reported elsewhere (Walsh et al., unsubmitted manuscript). Only relationships between study variables with sedentary behavior are shown in Table 5.3. None of the relationships were statistically significant. Lower levels of sedentary behavior, however, were related with a greater score for intention for physical activity (r=-.153) and a greater score for perceived behavioral control (r=-.226). Higher scores for injunctive and descriptive norms were related with lower levels of sedentary time (r=.118 and .200, respectively). Stress was slightly negatively related with sedentary behavior (r=-.064)

Inferential Statistics

A multilevel model was estimated to examine the predictive value of TPB constructs, sociodemographic characteristics, and stress impact on sedentary behavior across the 6-week study period. Results of the model building process are shown in Table 5.4.

Model Interpretation and Selection

The ICC computed from the unconditional model was .67, indicating 67% of the variance in sedentary behavior was explained by person-level differences. Time was thus nested within person in the proceeding models. Model 2 estimated the impact of time, and indicated a fixed effect value of .70. With every week that passed, participants, on average, increased their time spent being sedentary by .70 units. In order to determine if the average change in sedentary behavior varied across participants, Model 3 provided an estimate where time was treated as a random effect. The variance estimate of the random effect for time differed from zero indicating the average change in sedentary behavior did differ across participants. Time was treated as a random effect in proceeding models. Model 4 included level-2 predictors (e.g., sociodemographic characteristics, TPB constructs). Level-2 residual variances were compared between models 3 and 4 to determine the percentage to which the level-2 variance was reduced with the inclusion of covariates using the following equation:

$$\frac{\tau_{00,Model\ 4} - \tau_{00,Model\ 3}}{\tau_{00,Model\ 4}}.$$

TPB constructs, Age, Sex, and BMI accounted for 2.3% of the variability attributable to the person-level effects. The inclusion of the person-level predictors reduced the AIC and BIC in the model substantially. Model 5 included the stress impact variable by itself in an effort to determine its unique contribution to sedentary behavior. Stress was included as a time-varying covariate, and the level-1 residual variances were compared to determine the impact of stress to sedentary behavior using the following equation:

$$\frac{\sigma^2_{Model\ 5} - \sigma^2_{Model\ 4}}{\sigma^2_{Model\ 5}}.$$

The additional parameter of stress impact accounted for an additional 1.4% of the within-person variability in this sample. The AIC and BIC were further reduced, and Model 5 was selected as the best fitting model.

Results also indicated an increase in sedentary behavior with age, and that females engaged in more sedentary time than males in this sample. Greater scores for perceived behavioral control and behavioral intention for physical activity were related with a decrease in time spent being sedentary.

Table 5.3. *Correlation Coefficients for Associations Between Variables (n=45)*

Variables	Age	Sex	BMI	Income	Marital Status	Children	Attitude	SN-I	SN-D	PBC	Intent	Stress
Sedentary Behavior	.049	-.060	.135	.078	-.063	-.048	.040	.118	.200	-.226	-.153	-.064

Note. *Correlation significant at the .05 level; **Correlation significant at the .01 level; BMI = body mass index; SN-Injuctive = Injunctive norm; SN-Descriptive = Descriptive norm

Greater scores for injunctive and descriptive norms were related with greater time spent being sedentary. A more positive attitude towards physical activity was also associated with greater time spent being sedentary.

Discussion

Given the negative health consequences and persisting high levels of sedentary behavior among U.S. adults, better understanding determinants of sedentary behavior can lead to more targeted efforts to reduce it. The primary objective of the present study was to evaluate the predictive value of physical activity related TPB constructs in examining sedentary behavior. Results indicated that the TPB may be an effective framework through which to view sedentary behavior, as evidenced by substantial reductions in measures of model fit (i.e., AIC and BIC). The inclusion of TPB and sociodemographic covariates in explaining sedentariness reduced the person-level error variance within this sample; albeit only by 2.3%. A secondary aim of this study was to determine if the addition dynamically measured stress contributed to the model given the documented relationship between sedentary behavior and stress. The inclusion of the stress variable was supported by model fit indices, although it only reduced person-level error variance by 1.4%.

Results from the final model indicated the following expected relationships in TPB constructs: (1) less time spent being sedentary was associated with greater perceived behavioral control for physical activity and (2) greater behavioral intention for physical activity; and the following unexpected relationships: (1) greater injunctive and descriptive norms were related with more time spent being sedentary; and (2) more

Table 5.4. *Estimates From Multilevel Model Predicting Sedentary Behavior*

	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed Effects					
Intercept (SE)	640.03 (10.72)	638.37 (11.58)	638.98 (11.35)	648.68 (109.87)	649.16 (112.91)
Time		.70 (1.85)	.35 (2.36)	.39 (2.40)	.31 (3.66)
Age				1.04 (1.46)	.99 (1.47)
Sex				-0.55 (25.20)	-3.76 (25.42)
BMI				-.58 (3.16)	-.33 (3.19)
PBC				-14.18 (15.62)	-15.94 (15.74)
SN-I				2.52 (13.69)	1.66 (13.78)
SN-D				19.14 (13.05)	19.89 (13.15)
Intent				-9.84 (13.43)	-8.76 (13.59)
Attitude				3.14 (10.03)	3.32 (10.12)
Stress					-.02 (.17)
Error Variance					
Level-1(SE)	2360.09 (231.40)	2730.11 (232.94)	1935.90 (217.90)	1918.50 (214.69)	1923.69 (217.92)
Intercept (SE)	4744.71 (1102.20)	4740.27 (1101.67)	4733.54 (1163.51)	4845.77 (1309.70)	4912.79 (1327.08)
Time (SE)			121.00 (53.15)	129.36 (54.92)	130.41 (56.33)
Model Fit					
AIC	2792.0	2788.8	2780.4	2725.5	2687.4
BIC	2795.7	2792.4	2785.8	2730.9	2692.8

Note. BMI = body mass index, PBC = perceived behavioral control, SN-I =subjective norm, injunctive; SN-D = subjective norm, descriptive positive attitudes towards physical activity were associated with greater time spent being sedentary. Bivariate analyses also supported the inverse relationships between sedentary behavior and physical activity intention (r = -.226) and perceived behavioral control (r = -.153), albeit both were insignificant. Unexpected relationships may be the results of the unique characteristics of this sample, or the use of an objective measure of sedentary behavior over a 6-week period.

A unique aspect of this study is that sedentary outcomes were predicted using survey items developed for leisure-time physical activity. Previous research exploring the relationship between TPB constructs and sedentary behavior has largely relied on survey items designed specifically to predict or explain sedentary behavior as the behavior of interest (e.g., attitude towards sitting 0-4 hours per day; Prapavessis et al., 2015; intention for television viewing; Rhodes & Dean, 2009). However one other study (Lowe et al., 2015) was identified that examined sedentary outcomes using TPB-based survey items worded for physical activity.

In the study conducted by Lowe et al. (2014), bivariate analyses indicated less time spent in sedentary behavior was related with higher perceived behavioral control scores and with greater intention scores in their sample of 31 adult patients with advanced brain cancer. These findings are consistent with the findings of the present study. Lowe et al. also reported instrumental and affective attitude to be the strongest correlates of objectively measured sedentary levels (r=-.42 and -.43, respectively). This differs from the findings of this study, where a more positive attitude toward physical activity was surprisingly related with an increase in sedentary behavior, and bivariate analyses revealed no relationship between the variables (r=.04). Future research should continue to explore the relationships between attitude towards both physical activity and attitudes towards sedentariness with sedentary behavior.

The relationships between sedentary behavior and physical activity related TPB constructs in this study indicate that survey items designed for physical activity may be effective in examining sedentary outcomes. Relationships between attitude, perceived behavioral control, and subjective norm with intention for sedentary behavior, however, could not be assessed when using language surrounding physical activity. Research comparing the predictive ability of TPB items written with sedentary behavior stems or physical activity stems in explaining sedentary behavior is recommended.

Because TPB-based survey items in this study were written about physical activity, it is difficult to compare results across studies that used sedentary-based TPB items. A study conducted by Prapavessis et al. (2015), for example, found TPB constructs to explain between 8 and 43% of the variance in sedentary behavior across five different contexts (e.g., weekday leisure, weekend work), and reported that intention for sitting was the strongest predictor of sedentary time in their sample. In another study examining the TPB and sedentary behavior in a community sample of adults and undergraduate students, Rhodes and Dean (2009) concluded sedentary behavior was intentional and associated with attitude, but not associated with perceived behavioral control. Rhodes and Dean (2009) also supported the use of the framework in future research examining sedentary behavior.

In this study, injunctive and descriptive norms were assessed independently of one another within the subjective norm construct. In physical activity research, there has been mixed evidence supporting the use of the subjective norm construct in explaining physical activity behaviors (Godin & Kok, 1996; McEachan et al., 2011). Some researchers (Courneya, Plotnikoff, Hotz, & Birkett, 2000) have argued for the removal of the construct from the model when assessing physical activity, while others (Okun, Karoly, & Lutz, 2002) have called for researchers to assess the two distinct components (injunctive and descriptive norms) independently. Early research measuring subjective norm in physical activity intention typically only assessed injunctive norms (Ajzen & Driver, 1992), and researchers have since hypothesized that descriptive norms may strengthen the predictive value of the construct (Godin & Kok, 1996; Okun, Karoly, & Lutz, 2002). Following the suggestion of Okun, Karoly, and Lutz (2002) and applying it to sedentary outcomes, injunctive and descriptive norms were entered into the model independently. Results were consistent with findings reported in physical activity research, questioning the utility of the construct. In the study conducted by Prapavessis et al., (2015), however, subjective norm played a significant role in explaining sedentary behaviors. Given the mixed evidence in this small field, it is suggested that future research continue to include the subjective norm construct in examining sedentary behavior, and continue to include items that assess both injunctive and descriptive norms within the construct.

The secondary objective of the present study was to examine the unique contribution of stress with regards to sedentary behavior, measured dynamically. Given the prevalence of both stress and sedentary behaviors across young and middle-aged adults, and how both factors are burdensome to health, understanding relationships between the two may be important for understanding overall health status of this population. Model fit indices supported the inclusion of stress impact in explaining sedentariness, and the person-level error variance was reduced; though only by 1.4%. Our results, however, indicated that a decrease in sedentary behavior was surprisingly associated with an increase in stress; the opposite of the expected relationship. Previous research indicates that high levels of stress are associated with an increase in unhealthy behaviors (e.g., consumption of energy dense foods, less frequent exercise, smoking; Ng & Jeffery, 2003), and it was hypothesized that the results of this study may have indicated sedentary behavior could be added to that list. It was not the case in this sample, however.

Other researchers have previously reported mixed evidence regarding the relationship between sedentary behavior and stress. Hamer and colleagues (2010) reported time spent sitting in front of a screen (e.g., screen time; computer use or television) to be associated with higher stress levels in a sample of 3,920 Scottish adults, while Rebar and colleagues (2014) found overall sitting time was not associated with the severity of stress symptoms in a sample of 1,104 Australian adults. These findings combined with the results from this study indicate that there is a need for better understanding the relationship between stress and sedentary behavior.

Other results from this study revealed the following relationships: (1) sedentary behavior was higher in females than males and (2) sedentary behavior was shown to increase with increasing age. Both of these findings are consistent with previous research. Data from NHANES showed females spent significantly more hours per day in sedentary pursuits than males (8.51 hours compared to 8.37 hours; Healy et al., 2011). Females are also less likely than males to meet physical activity guidelines, placing them at an increased risk for the health consequences associated with both high levels of sedentary behavior and low levels of physical activity. Given this, we recommend focusing on female populations when planning initiatives to reduce sedentary time. Although the entire sample in this study consisted of young and middle aged adults aged 20-50, sedentary behavior was still shown to increase with age. This is consistent with the well-established evidence suggesting physical activity declines with age (Sallis, 2000), and that sedentary behaviors increase as one ages (CDC, 2014). The relationship shown in this sample may be indicative of the beginning of this trend. In addition to females, special attention should also be paid to aging populations in efforts to reduce sedentary time. Number of children was not related with sedentary time in this sample and was thus not included in the final model as a person-level predictor. Although current research supports a relationship between parenthood and lower levels of physical activity participation (Bellows-Riecken & Rhodes, 2008), there is a need to better understand children's influence on the sedentary time of parents. Walsh et al. (2015) previously reported having fewer children to be associated with greater sedentary time in a sample of 156 working women. Future research to better understand the relationship between sedentary behavior and number of children for both parents, not just mothers, is needed.

Descriptive analyses revealed higher levels of sedentary behavior in this sample than what has been reported in other samples (i.e., ~11 hours per day compared to ~8 hours per day in NHANES data; Healy et al., 2011; Matthews et al., 2008) despite identical minimum wear time criteria (i.e., 10 hours of wear time per day). This difference could be caused by participants in this study wearing their monitors for more hours per day overall than in previous research. Regardless, the finding provides evidence that sedentary behavior is pervasive in this population. Given the negative health consequences associated with sedentary behavior, the descriptive results of this study substantiate the need for immediate and effective interventions to reduce sedentary time among U.S. adults. For working adults with sedentary occupation types, examples of successful sedentary-reduction interventions include the use of standing desks or sit-stand workstations (Pronk et al., 2012), active workstations (e.g., treadmill desks; Tudor-Locke et al., 2013), walking meetings (Mackey et al., 2011), and email prompts to encourage employees to take stair walks with colleagues (Andersen et al., 2013). In addition to workplace interventions, reducing sedentary time during leisure is also important. Encouraging the replacement of common leisure sedentary activities (e.g., computer use, television watching) with physical activities is one suggestion. Implementing lifestyle activities, such as taking the stairs and parking the car farther away from a destination, are also recommended.

Despite a few limitations, this study has several strengths. First, an objective measure of sedentary behavior was used. Although subjective measures can be used to assess sedentary levels, objective measures remove some of the biases and recall issues associated with self-reported measures. Additionally, sedentary behavior was measured over a 6-week period instead of the more commonly used one-week period to examine participants' sedentary behavior over a longer time period. Although high correlations across weeks of activity indicate that 6 weeks of measurement may not be necessary to assess habitual activity, it was a strength of this study. Lastly, a dynamic measure of stress was used. Although a relationship other than the one that was expected was found in this sample, using a weekly measure of stress that was taken by participants weekly for 6 weeks strengthens our data. A few additional limitations to note include was the relatively small sample size (n=45), although simulation studies supported adequate power for the proposed multivariate analyses. Additionally, the sample was made up of mostly White, married women from the same geographic area. It is possible that different findings could appear in less homogenous groups, and that the findings of this study may not be generalizable to other populations. Lastly, although using an objective measure of sedentary behavior is a strength of this study, issues remain in using objective measures to evaluate sedentary outcomes (e.g., differentiating between sitting and standing behaviors given the similarly low levels of energy expenditure; Ainsworth et al., 2011). More finite measures of objectively measuring sedentary behavior are necessary to advance the field.

Although the TPB has been applied extensively to physical activity research, its application to sedentary behavior represents a new field of study. This study used physical activity related TPB constructs to examine objectively measured sedentary behavior over a 6-week period and included a dynamically measured stress impact variable. In doing so, the objective of the study was to enrich our understanding of determinants of sedentary behavior that could be used to guide future initiatives to reduce it; thereby improving the health status of young and middle-aged U.S. adults. The results of this study indicate that the TPB may be an effective framework through which sedentary behavior can be viewed, and that more work is needed in understanding the relationship between stress and sedentariness. Future research should continue to explore theoretical determinants of sedentary behavior and include more diverse populations. Given that both stress and sedentary behavior are independently associated with negative health consequences, and exist in high levels in young and middle aged adults, researchers and public health professionals are urged to consider both stress and sedentary behaviors in any efforts to improve the health status in this population.

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