THE RELATIONSHIP BETWEEN SEDENTARY BEHAVIOR AND HEALTH IN OLDER ADULTS

by

Elizabeth K. Grimm

A Dissertation Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

in Health Sciences

at

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ABSTRACT

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Elizabeth K. Grimm

The University of Wisconsin-Milwaukee, 2011
Under the Supervision of Professor, Scott J. Strath

Older adults have been shown to engage in high amounts of sedentary behavior. However limited information exists on whether this behavior relates to health and the details regarding sedentary behaviors. The primary purpose of this dissertation was to examine the relationship between time spent in sedentary behavior and risk factors for chronic disease development in older adults. The secondary purpose was to define the common sedentary behaviors and describe the characteristics of these behaviors. Seventy-three retired adults (65-90 years of age) wore accelerometers to measure their sedentary behaviors for seven days and completed a diary on three days of the week (two weekdays and one weekend day). Correlations and regressions were used to examine the relationship between sedentary behavior and health. Analysis of variance methods were used to compare sedentary behavior by gender and age, and across physical activity levels. Older adults spent 65% of their day being sedentary and this behavior was related for the group to waist circumference (r=.25) and triglycerides (r=.26), and individually for men and women with percent body fat (r=.32-.43), but sedentary behavior was not predictive of health. Sedentary behavior was significantly less for those meeting the physical activity recommendations compared with those who did not, 7% for the entire

group. Health outcomes (waist circumference, body fat percent, and triglycerides) were worse in the highest sedentary group compared to the moderately sedentary. There were five prevalent sedentary behaviors; watching television, using the computer, reading, eating, and transportation. There were also differences in the time spent in sedentary behaviors between gender with men napping and eating more than women. Differences also occurred for socializing, eating, reading, and talking on the telephone during the weekdays and weekend days. Being alone and eating were factors of being sedentary. Sedentary behavior was related to two risk factors for chronic disease development in older adults and the descriptions of sedentary behaviors are important findings for future studies for developing interventions to reduce this behavior in older adults.

Major Professor

August 11th 2011

Date

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CHAPTER I: INTRODUCTION

Background

As the baby boomer population reaches 65 years of age the number of older adults in the United States population is expected to increase substantially. By the year 2030, it is projected that the older adult population will make up 20% of the United States population with over 50% of older adults being retired (Wan, Sengupta, Velkoff, & DeBarrow, 2005; Center for Disease Control and Prevention [CDC], 2007). This change in age demographics has been coined the "graying" of America (CDC, 2007). This phenomenon is not just happening in the United States but globally as well. According to the World Health Organization (WHO, 2011), there are currently 600 million adults over 60 years of age and this number is expected to rise to 1.2 billion by the year 2025 and increase to 2 billion by the year 2050. The primary reasons for having prolonged life span are due to advancements in sanitation, nutrition, and medical care as well as infertility rates (WHO, 2007). These changes have shifted the leading causes of death from infectious disease and acute illness (e.g., influenza and pneumonia, tuberculosis, diarrhea and enteritis) to chronic disease and degenerative illness (e.g., heart disease, cancer, and stroke) over the past century (CDC, 2007).

Currently many older adults have chronic conditions (i.e., heart disease, cancer, type 2 diabetes, obesity, and stroke) that can ultimately lead to death (CDC, 2003). The development of chronic conditions and diseases is also related to lifestyle factors such as diet, smoking, and especially physical inactivity (Mokdad, Marks, Stroup, & Gerberding, 2000). Researchers suggest 35% of the leading causes of death in the United States are related to these lifestyle behaviors and approximately 400,000 of these deaths are

attributed to physical inactivity alone (Mokdad et al., 2000). Physical inactivity is when a person does not participate in the nationally recommended amount of physical activity that is necessary to achieve health benefits.

The amount of physical activity needed to promote and maintain health in older adults is a minimum of 30 minutes of moderate aerobic activity on five or more days of the week and/or a minimum of 20 minutes of vigorous aerobic activity on three or more days of the week (Nelson et al., 2007). Physical activity, across all age groups, is positively associated with a reduction in cardiovascular disease, stroke, hypertension, type 2 diabetes, osteoporosis, obesity, some cancers, and improvements in anxiety and depression (Haskell et al., 2007; Nelson et al., 2007). In older adults specifically, physical activity helps maintain physical function (Fielding et al., 2007), reduces fall risk and injury (Smulders et al., 2010) and is therapeutic for many chronic disease conditions (Hagberg, Montain, Martin, & Ehsani, 1989; Janssen & Joliffe, 2006; Kitzman, Brubaker, Morgan, Stewart, & Little, 2010). By modifying these behaviors, especially physical activity, many of the chronic conditions older adults are faced with can be prevented.

Sedentary behavior is another modifiable activity closely related to physical inactivity. This behavior is typically forgotten when thinking about lifestyle factors that impact health. Sedentary behaviors consist of activities that do not require a significant increase in energy expenditure above a resting level (i.e., 1-1.5 metabolic equivalents or METS, 1 MET = 3.5ml/kg/min oxygen) (Owen, Leslie, Salmon, & Fotheringham, 2000; Pate, O'Neill, & Lobelo, 2008). Activities that fall within this category include reading, lying down, sitting, or watching television and/or other forms of screen based entertainment. Older adults have been observed to be more sedentary than younger

adults and recently it was reported that older adults spend a significant amount of their day engaging in these behaviors, approximately nine or more hours per day (Matthews et al., 2008).

Over the last decade there has been a focus on sedentary behavior in the form of self-reported television viewing and its relationship with health, in primarily younger and middle aged adults. Research demonstrates a positive relationship between increased television viewing and chronic conditions (i.e., obesity, impaired fasting glucose, cardiovascular disease, and metabolic syndrome) (Hu, Li, Colditz, Willet, & Manson, 2003; Healy et al., 2007; Katzmarzyk, Church, Craig, & Bouchard, 2009; Dunstan et al., 2010). These studies suggest the more time an individual spends in front of the television the greater the likelihood of having a chronic condition(s). Other measures of sedentary behavior have been gleaned through diary recordings of leisure time activities (Bureau of Labor and Statistics, 2008). Despite the existence of this data for engagement in leisure activities from older adults little contextual knowledge exists about why they choose to participate in these behaviors (e.g., for social reasons or enjoyment).

Because sedentary behavior is so prevalent and a negative relationship to health exists in younger and middle aged adults, researchers began examining the reliability of measuring this behavior. Self-report measures are a practical and feasible method to gather information, but they rely upon recall and a person's perception of their behavior, which may not always be accurate. Self-report measures of activity have been demonstrated to have recall bias, challenges with comprehension of questions, and difficulty measuring the lower end of the physical activity spectrum (Tudor-Locke & Myers, 2001). The measures previously used in studies of sedentary behavior and health

have been reported to be reliable and valid tools to measure sedentary behaviors in younger and middle-aged adults, however there are very few studies examining their validity and use specifically in an older adult sample (McCormack, Giles-Corti, & Milligan, 2003; Marshall, Miller, Burton, and Brown, 2010). This could be due to the lack of information known about the sedentary behaviors of older adults.

To overcome some of the concerns with self-report measures, objective measures of sedentary behaviors have been used to quantify this behavior. To date, one of the most common objective methods to evaluate sedentary behavior has been via the use of accelerometry. Actigraph accelerometers (Pensacola, FL) are a valid and reliable tool for quantifying physical activity and recent research suggests they are accurate measures of quantifying sedentary behavior but may not necessarily differentiate between different types (e.g., watching television, reading, etc) or postures of sedentary behavior (e.g., sitting or standing), as well as, they cannot provide the descriptive information about sedentary behaviors that self-report methods can (Freedson, Melanson, & Sirard, 1998; Crouter, Clowers, & Bassett, 2006; Hart, McClain, & Tudor-Locke, 2010; Kozey-Keadle, Libertine, Lyden, Satudenmayer, & Freedson, 2011). However the use of multiple types of accelerometers with different functions can overcome the limitation to traditionally used accelerometry.

The results of research using accelerometry to quantify sedentary behavior found similar relationships to the self-report television viewing literature. These findings also suggest increased total time spent in sedentary behaviors are related to individuals having negative heath conditions (i.e., elevated cholesterol, high blood pressure, larger waist circumference) in younger and middle-aged adults (Healy et al., 2007; Healy et al.,

2008). Again suggesting the more time spent engaging in sedentary activities the greater the likelihood for having negative health condition(s).

Although the literature has been advancing with the use of objective monitors, to date specific to older adults, very few studies have quantified the total time spent in sedentary behavior or assessed the differences in the postures of sedentary behaviors (e.g., sitting versus standing). This information is important if surveys are compared to objective data or if research participants are multi tasking. It could be argued with self-report measures of television viewing the participants could be engaged in other types of sedentary activities that are not just sitting while the television is on. For example participants could be standing in place while conversing with a friend or standing in line. There are also physiological benefits to engaging in sedentary activities that are standing rather than sitting and monitors that assess posture could examine this more closely (Hamilton, Hamilton, Zderiec, 2007). Therefore combining objective postural assessment methods (i.e., activPal™, Glasgow, Scotland) with traditional accelerometers (i.e., Actigraph) that assess the intensity of our activities we could generate a better profile of sedentary behavior, reduce the recall error that can occur with sedentary behavior surveys, decipher between different types of behaviors with measures of posture, and better relate sedentary behavior to health in an older adult population. Until more rigorous methods are applied we will not fully understand whether a relationship between health and sedentary behavior exists in older adults.

Another area often overlooked with sedentary behavior is the descriptive aspect of this behavior. First, a majority of the literature assesses a specific sedentary behavior (e.g., television watching or overall sitting) and there is rarely an inquiry about other

sedentary behaviors (e.g., reading, socializing, traveling, sewing, and playing games) or an understanding about what motivates a person to engage in those behaviors. Because of this we do not have a clear understanding of this behavior in any population, and especially older adults: which sedentary behaviors are the most common (e.g., is it television, reading, or playing games?), when do people engage in sedentary activities (i.e., every day, time of day, etc.), and what motivates people to participate in these behaviors (i.e., enjoyment, social support, eating habits). Therefore much information has been overlooked on the topic of sedentary behavior. Therefore a need exists to identify a variety of sedentary behaviors that older adults engage in and learn about why they choose to engage in them.

By creating a study that examines health and explores the patterns and influences of sedentary behavior through the quantification of sedentary behavior objectively via acceleration and deceleration of postural allocation and self-report methodologies a more accurate depiction of the relationship between sedentary behavior and health in older adults can be determined. By doing so we can appropriately address the methodology concerns previously mentioned. This type of approach can examine sedentary behaviors by using both subjective self-report methods to capture the contextual components specific to sedentary behaviors along with using objective measures to accurately quantify this behavior in older adults. Therefore, the following study is a cross-sectional multi-method examination of the relationship between sedentary behavior and various cardiometabolic health outcomes as well as an exploration of the sedentary behaviors older adults participate in.

Statement of Purpose

This study has two purposes. The primary purpose of this study is to examine the relationship between objectively defined total time spent in sedentary behavior and the cardiometabolic risk factors associated with chronic disease development in older adults. The secondary purpose of this study is to define the common sedentary behaviors in which older adults regularly participate and the characteristics and context in which the behavior are performed (i.e., the timing of these events, if they participate with others or eat during these behaviors, and the enjoyment of engaging in sedentary activities).

Hypothesis

Regarding the above stated primary purpose, the following hypothesis is presented: total time spent in sedentary behavior independent of total time spent in moderate and vigorous physical activity will be positively related to waist circumference, total body fat percentage, systolic blood pressure, diastolic blood pressure, triglycerides, total cholesterol, fasting blood glucose, low-density lipoproteins, and will be negatively related to high-density lipoprotein cholesterol.

Delimitations

To adequately examine the relationship between sedentary behavior and cardiometabolic risk factors in older adults, this study is delimited to ambulatory retired (i.e., someone no longer working 40 hours at their primary profession) Caucasian individuals 65-90 years of age. The outcomes of this study cannot be generalized beyond this population.

Significance

As the United States demographic changes to having a greater prevalence of older adults there will also be more individuals with chronic health conditions. To combat

these health concerns older adults need to be more physically active and research suggests this age group engages in significantly more sedentary behavior than any other age demographic. In younger and middle aged populations, total time spent engaged in sedentary behaviors or increased time spent watching television is negatively related to a number of health conditions (i.e., impaired fasting blood glucose, obesity, elevated blood pressure and cholesterol values) (Hu et al., 2003; Healy et al., 2007; Katzmarzyk, Church et al., 2009; Dunstan et al., 2010). These health conditions are also risk factors for the development of chronic diseases like heart disease and type 2 diabetes. Therefore it is important to explore this relationship in a population like older adults who are at a greater risk for having these conditions.

Currently what is known about the relationship between sedentary behavior and health is determined from epidemiological studies assessing the self-reports of television watching and overall sitting time and a few studies examining the total amount of time spent engaged in sedentary behaviors measured with accelerometry. Very few studies have tried to identify and examine this relationship with other sedentary behaviors (i.e., reading, sewing, etc.) or determined the motivating factors for why people engage in sedentary behavior (Dunton, Berrigan, Ballard-Barbash, Graubard, & Attunes, 2009; Vandelanotte, Sugiyama, Gadriner, & Owen, 2009). Therefore much information about sedentary behavior is still unknown.

One way to better understand the relationship between sedentary behavior and the risk factors for the health conditions seen primarily in older adults is to combine the methodologies of past studies. To date no studies have reported exploring sedentary behaviors with a combined methods approach of self-reported sedentary behaviors to

better understand the actual sedentary behaviors older adults engage in and their motivating factors as well as use objective monitor assessment to more accurately quantify this behavior in older adults. By examining this relationship with multiple methods we can better understand sedentary behavior and what aspects influence health. The objective monitoring can provide an accurate assessment of how much time is spent engaged in sedentary behavior as well as provide information on the total amount of time spent in sedentary behaviors that are sitting versus standing. The self-reports of sedentary behavior and factors relating to this behavior will provide necessary information to better inform future interventions that want to manipulate sedentary behavior.

Therefore by combining methodologies the information gleaned from this study can help researchers identify if this behavior is related to health which could lead to developing recommendations for the reduction of sedentary behavior, especially in older adults. Also the descriptive information will help guide the development of ways to manipulate this behavior and improve health. To better understand the relationship between sedentary behavior and health in older adults a review of the literature was conducted. The following chapter provides a background on the importance of this topic.

CHAPTER II: LITERATURE REVIEW

Introduction

Sedentary behaviors consist of activities that do not require a significant increase in energy expenditure like sitting and watching television or lying on the couch (Owen et al., 2000). Researchers suggest the participation in these behaviors negatively relate to health, independently of participation in health enhancing regular moderate to vigorous physical activity (Jakes et al., 2003). Currently, much of the work demonstrating this relationship uses self-report surveys or questionnaires of sedentary behavior (i.e., television viewing and daily/weekly sitting) and physical activity participation, determined by asking individuals to recall whether they participated in a certain amount of sedentary behavior or physical activity over a specific timeframe (i.e., week, month, year). Reports suggest sedentary behavior relates primarily to having a specific chronic condition, disease, or death (e.g., impaired fasting glucose, obesity, cardiovascular disease, cancer, and all cause mortality). Most of the literature to date examines populations ranging in age (i.e., 8-75 years of age) with no studies examining this relationship in older adults specifically.

The following chapter presents an in depth discussion of the importance of studying sedentary behavior in an older adult population. The beginning of the chapter will start with an introduction to the prevalence of older adults living within society and the health and economical implications related to the aging demographic. Then the physical activity, inactivity, and sedentary behavior profiles of older adults will be discussed. Then the health benefits older adults gain by engaging in more physical activity will be briefly highlighted. Lastly what is currently known about the relationship between

increased participation in sedentary behaviors and health (i.e., mortality, obesity, fasting plasma glucose, insulin and 2-hour post plasma glucose, and metabolic syndrome) in the general population and how sedentary behavior is currently measured will be discussed.

The Prevalence of Older Adults Living in Society and Their Health

The graying of America is predicted to take place over the next 30 years. The total number of older adults is expected to increase from 31 million in the year 2000 to 71 million by the year 2030 which is approximately 20% of the total American population, and an increase of roughly 8% (Wan et al., 2005). Causes for this significant increase in the number of older adults includes the increase in lifespan (by approximately 18.2 years) because of changes in health care and prevention and more significantly the baby boomer population (i.e., those born between 1946-1964) reaching age 65 by 2011 (WHO, 2007). The following section discusses the relationship between health and an aging society.

As these population changes occur, so will the health of our nation. Unfortunately there are a number of chronic disease conditions associated with increased age such as hypertension, end-stage renal disease, diabetes and some cancers that are not as prevalent in younger and middle aged adults (National Health Care Statistics [NHCS], 2010). According to data from 2006 (Heron, 2010), the top three leading causes of death in older adults were heart disease, cancer, and stroke accounting for approximately 29%, 22%, and 6.7% of all deaths, respectively. The most prevalent risk factors for the development of these conditions, for older adults, are high total cholesterol (15.3%), type 2 diabetes (18.4%), being overweight or obese (measured with BMI, 69.7%), and hypertension (70.3%) (CDC, 2003). Recently, type 2 diabetes was added to the top 10 leading causes of death for older adults, accounting for approximately 3% of all deaths (Heron, 2010).

The treatment of these conditions is going to be costly and the following discussion explains the shift in health care costs for older adults and why it becomes important to prevent these risk factors from occurring as the number of older adults in America is on the rise.

The Economical Impact of an Aging Society

Currently the United States spends more money per person than any other country on the use and cost of health care services, the high volume of health care resources, and the fact that our population is becoming older (NHCS, 2010). Health care costs are projected to increase 25% by the year 2030 due specifically to the increase in number of older adults (CDC, 2007). According to the Medical Expenditure Panel Survey (2005), health care is five times more expensive for those 65 years of age and older than those younger than 65 years of age, regardless of health status. For older adults, health care costs are double when one or more chronic health conditions are present, $1,156 versus $3,600-6,000 (Agency for Healthcare Research and Quality [AHRQ], 2005). This information is alarming when 80% of older adults self-report having at least one chronic condition and 50% report having two or more (CDC, 2003). If the projected trends in aging occur, our society will experience increases in the price to treat these health conditions or diseases.

Summary of Older Adult Prevalence, Health, and The Economical Impact

To review what is currently known about our aging society and its implication on health and the costs to treat these changes as the population ages there will be a concurrent increase in the incidence of chronic conditions and diseases. The primary outcome of this is staggering increases in the price of health care to treat these conditions

especially for older adults. Because of this snowball effect public health officials are in need of ways to break this cycle. One such method is through the promotion of physical activity and the following discussion presents information relating to the lack of physical activity participation by older adults.

Physical Activity Profiles of Older Adults

Physical activity is defined as any bodily movement that results in a substantial increase in energy expenditure above a resting state (Caspersen, Powell, & Christenson, 1985). There is a continuum of physical activity ranging from light activities (i.e., leisurely walking through the house) to moderate (i.e., activities increasing heart rate and breathing but allow you to speak comfortably), and vigorous activities (i.e., activities requiring a maximal all out effort). Older adults are encouraged to engage in at least 30 minutes of moderate intensity physical activity on five days per week and/or 20 minutes of vigorous intensity physical activity on three days per week to promote and maintain their health (Nelson et al., 2007). Unfortunately many older adults do not regularly engage in this volume of physical activity and choose to participate in activities requiring little to no increase in energy expenditure, sedentary behavior. This behavior is not a part of the physical activity continuum but is an independent behavior with its own impact on health (Jakes et al., 2003).

The following studies portray the moderate and vigorous physical activity of older adults from studies using self-report methods. When adults 65-74 years of age participated in the National Health Interview Survey 2000-03, 26.9% of the sample reported engaging in the recommended physical activity to promote health, with the lowest percentage (8.2%) in those over 85 years of age (Schoenborn, Vickerie, & Powell-

Griner, 2006). When participating in the Behavioral Risk Factor Surveillance System in 2005, slightly more men and women over 65 years of age reported meeting the physical activity recommendations, 44.5-36.3% respectively (Kruger & Kohl, 2007). This percentage of older adults meeting national physical activity guidelines is considerably lower when older adults wore physical activity monitors that objectively quantified their physical activity behaviors (Troiano et al., 2007).

The lower prevalence of physical activity is observed when participants wore accelerometers that objectively quantified the time spent in various physical activity intensities. When moderate and vigorous physical activity behavior was examined objectively with accelerometry in the National Health and Nutrition Examination Survey (NHANES) 2003-04, only 2.4% of individuals over 60 years of age engaged in the recommended amount of moderate physical activity and no one in this age group participated in enough vigorous physical activity to fulfill the recommendations (Troiano et al., 2007). The average adult 60 years of age and older spent approximately 12-16 minutes per day in moderate intensity physical activity with those over 70 years of age engaging in less moderate intensity physical activity, only 5-9 minutes per day (Troiano et al., 2007). Similar findings are reported in a sample of adults over 50 years of age. Only 3% of their entire day was spent participating in moderate intensity physical activity and $\leq$1% was spent in vigorous physical activity (Grimm et al., 2009). These values also decreased significantly with age, 50-59, 60-69, and 70+ years of age. Davis and Fox (2007) observed even less participation in moderate and vigorous physical activity with no older adults, over 70 years of age, meeting the physical activity recommendations when it was measured via accelerometry. However this sample of older adults spent

slightly more time (19.9 ± 16.3 minutes per day) in moderate and vigorous physical activity than the older adults in the NHANES 2003-04 study (Davis and Fox, 2007; Troiano et al., 2007). Overall these reports suggest older adults are engaging in some moderate and vigorous physical activity but not the recommended amount to promote health. In the following paragraphs a brief overview of the prevalence of sedentary behavior in older adults is discussed.

Sedentary Behavior Profiles of Older Adults

Sedentary behaviors are activities that do not increase a person's energy expenditure substantially above a resting level (Owen et al., 2000). These behaviors expend as little as 1-1.5 metabolic equivalents or METs of energy (one MET is equivalent to using 3.5 ml/kg/minute of oxygen) such as sitting/reclining/lying while watching television or movies, browsing the internet, traveling in a car/bus/train/airplane, reading, knitting, and writing (Owen et al., 2000; Pate et al., 2008). In a study examining what older adults spend their time doing, it is noted that many of their activities can be classified as being sedentary. The American Time Use Survey (Bureau of Labor Statistics [BLS], 2008) explores what older adults do throughout their day. On an average day, older adults describe spending a majority of their time watching television (54.5%), reading (12.5%), socializing with others (11%), relaxing (9%), participating in leisure time physical activity (3%), and other leisure activities like eating, shopping, etc (10%), With what is known about the definition of sedentary behavior it can be assumed that almost all of the activities reported in the American Time Use Survey are forms of sedentary behavior except that of leisure time physical activity. Despite this survey of daily activity there are no other studies to date examining older adult daily activities,

especially their sedentary behaviors. However a few studies objectively quantify and examine patterns of this behavior with accelerometers in older adult samples.

Currently there are four cross-sectional examinations of the total time spent engaging in sedentary behaviors in older adult populations. All four studies use accelerometry to quantify the amount of time spent in sedentary behaviors however slightly different methodologies are employed. The studies use different accelerometer criteria to determine sedentary behavior. Half of the studies use a cut-point for sedentary behaviors that is ≤100 counts/minute (cts/min) and the other studies use a range of ≤200-259 cts/min to determine sedentary behavior. Comparing the results of these studies becomes difficult when researchers use different criteria to measure the "same" behavior. Because of these differences the studies described in the following paragraphs are organized based on the different sedentary behavior criteria used.

The first examinations of sedentary behavior in older adults use higher criteria to demarcate sedentary behavior with accelerometry. In the first study, Davis and Fox (2007) analyzed data from the Better Ageing Project and observed the volume of sedentary behavior was different between older adults, ≥70 years of age and younger adults, ages 20-37. Sedentary behavior was measured as ≤200 cts/min and described in increments of bouts (a bout was ≥60 mins). The older adults spent more time in bouts of sedentary behavior in the evening than in the morning, and they engaged in two times as many bouts of sedentary behavior than the younger adults, and the older adult men engaged in significantly more of these bouts than the older adult women (Davis & Fox, 2007). Total time spent in sedentary behavior was not determined in this study. However in a study using ≤259 cts/min as sedentary behavior measured with

accelerometry total time spent in sedentary behavior was reported. Orsini and colleagues (2008) observed 151 women 56-75 years of age participating in the Swedish Mammography Study and they spent approximately 328.4 minutes per day or approximately 5.47 hours per day engaging in sedentary behavior (Orsini et al., 2008). This report of total time spent sedentary is substantially lower than in the following observations of this behavior when lower accelerometry cut points are used.

In the second group of studies assessing sedentary behavior the authors used ≤100 cts/min to quantify the sedentary behavior of older adults. Hagstomer et al. (2007) assessed the sedentary behavior levels of Swedish individuals across the age-span. Older adults, 65-79 years of age, spent 451 minutes per day or approximately 7.5 hours per day being sedentary (Hagstomer, Oja, & Sjostrom, 2007). There were no differences in sedentary behaviors across body mass index, age, or gender. An even higher amount of sedentary behavior is observed in older adults living in the United States. Matthews and colleagues (2008) reported the total time spent in sedentary behavior, across the age span, for individuals participating in the NHANES 2003-04 study. There were 229 men and 333 women between 60-69 years of age and 411 men and 392 women 70-85 years of age in this study. Those ≥70 years of age were the most sedentary, spending 546-570 minutes per day or approximately 9.1-9.5 hours per day out of the 13.9 hours they wore the monitor, in sedentary activities (Matthews et al., 2008). There were significant gender differences in those 60-69 years of age with the Caucasian men spending more time being sedentary (8.8±0.1 hours per day) than Caucasian women (8.1±0.1 hours per day) (Matthews et al., 2008). These gender differences mimicked those reported by Davis and Fox (2007) when sedentary behavior bouts were examined.

Summary of Physical Activity and Sedentary Behavior Profiles of Older Adults

Collectively these studies suggest an alarming number of older adults do not engage in the recommended amount of physical activity to promote and/or maintain health, less than 45% when it was self-reported and less than 2.5% when physical activity was monitored by accelerometry (Kruger & Kohl, 2007; Troiano et al., 2007). Instead of engaging in health promoting moderate and vigorous physical activity, older adults engage in large amounts of sedentary behaviors, up to nine or more hours per day (Matthews et al., 2008). Based on the results of these few studies, gender, increasing age, and potential cultural differences may influence the total time spent in sedentary behavior but more research is necessary. There is little evidence examining the health impact of this behavior specifically in older adults. The following chapter section will briefly discuss the benefits of engaging in regular physical activity for older adults and then what is currently known about the health impact of engaging in sedentary behavior will be presented.

Importance of a Physically Active Lifestyle for Older Adults

There are number benefits for older adults who participate in regular physical activity. As a person ages there are many physiological changes that take place including the decline of aerobic capacity (5-10% each decade of life in those not engaging in regular activity) and the loss of muscle tissue, reducing strength (Sui et al., 2007). These changes can impact an older person's quality of life and their functional independence. Comprehensive reviews of the literature suggest participation in regular physical activity; especially structured exercise slows down these processes (Nelson et al., 2007; Vogel, Brechat, Lepretre, Kaltenbach, Berthel, & Lonsdorfer, 2009).

Physical Activity and Mortality in Older Adults

Over the past few decades there have been a number of studies reporting a relationship between increased participation in physical activity and a reduction in mortality rates in older individuals. There were observed reductions for overall mortality rates of 28-44% in older adults who regularly engage in weekly moderate and or vigorous physical activity (reported as weekly total kilocalories, 980 to ≥1890 kilocalories per week), participating in the longitudinal Cardiovascular Health Study, respectively (Fried, Kronmal, & Newman, 1998). When older adults ate healthy diets as well as engaged in regular physical activity (self-reported from the Morris physical activity questionnaire) they had significant reductions in overall mortality rates (37%) and death from cardiovascular disease (35%) and cancer (36%) (Knoops, de Groot, & Kromhout, 2004). There are similar findings of lower mortality rates for older adults when occasional physical activity (28%) and general walking (i.e., 1 or 2 times per week) habits were examined compared to those not engaging in physical activity (Sundquist, Qvist, Sundquist, & Johansson, 2004). Those engaging in more activity have lower mortality rates of 40-50% (Sundquist et al., 2004). Hakim and colleagues (1998) observed similar results in retired men participating in the Honolulu Heart Program. Mortality rates almost doubled for retired men walking less than one mile per day (40.5%) when compared to those walking two or more miles per day (27.4%) (Hakim, Petrovitch, & Burchfiel, 1998). The results from these studies suggested a positive relationship with increased physical activity participation, regardless of intensity or type of physical activity, and lower mortality rates in older adults.

Physical Activity and Changes in Body Composition in Older Adults

Regular participation in physical activity was also shown to reduce fat mass, from 1-4%, in an older adult population (Vogel et al., 2009). Postmenopausal women whose ages ranged from 50-75 years, engaging in 45 minutes of exercise on 5-days of the week lost 1.4 kilograms of body weight (95% CI: -2.5-0.3kg), 1% of total body fat (CI 95%: -1.6 - -0.4%), -8.6 g/cm^2 of intra-abdominal fat (95% CI = -17.8-0.9 g/cm^2) and -28.8 g/cm^2 of subcutaneous abdominal fat (95% CI = -47.5-10 g/cm^2) while participating in the Physical Activity for Total Health Study (Irwin, Yasui, & Ulrich, 2003). These studies demonstrated the positive benefits of engaging in regular exercise for improvements in body composition.

Physical Activity and Type 2 Diabetes in Older Adults

Engagement in regular physical activity was shown to be beneficial for both the prevention of type 2 diabetes as well as therapy for older adults with diabetes. In an intervention comparing the effects of exercise or medication on blood glucose values, when non-diabetic older adults with elevated fasting and post 2-hour plasma glucose values were randomized into either a placebo, lifestyle (engagement in physical activity for 150 minutes per week with a goal of a body fat reduction of 7%), or metformin medication groups, the lifestyle group had the lowest incidence rates of type 2 diabetes compared to the placebo (58%, 95% CI = 48-66%) and the medication group (39%, 95% CI = 24-51%) (Knowler, Barrett-Connor, & Fowler, 2002). Similarly, the incidence of type 2 diabetes was significantly lower in older adults engaging in 3.8 hours of physical activity compared to the lowest physical activity group engaging in 0.5 or less hours of activity per week (66% versus 48%) (Laaksonen, Lindstrom, & Lakka, 2005). Lower levels of activity (i.e., walking, gardening, and/or bicycling for 20 minutes per day) are

also beneficial in reducing diabetes incidence in older adult men. Lower concentrations of plasma glucose and lower prevalence of glucose intolerance was seen in older adults who cycled (63%), gardened (67%), and/or walked (8%) (Van Dam, Schuit, Feskens, Seidell, & Kromhout, 2002). Again these studies support the benefits of engaging in regular exercise or physical activity in the fight against developing type 2 diabetes in older adults.

Physical Activity and Hypertension in Older Adults

Engaging in physical activity can prevent or slow down the development of hypertension in older adults. Blood pressure values were reduced when previously sedentary older adults engaged in 6-months of either moderate (70% VO_2max) or vigorous (70-85% VO_2max) intensity aerobic exercise. Systolic blood pressure was lower after moderate or vigorous intensity exercise by 8 (moderate) and 9 mmHg (vigorous), and similar results were seen in diastolic blood pressure for both the moderate and vigorous exercise groups, 7 mmHg and 8 mmHg, respectively (Braith, Pollock, Lowenthal, Graves, & Limacher, 1994). Similar results were observed for adults over 80 years of age after participating in a moderate intensity exercise program for 6-months. There were lower systolic blood pressures (13 mmHg) but no changes in diastolic blood pressure (Vaitkevicius, Ebersold, & Shah, 2002). Even in older adults with normal blood pressure values, walking or swimming regularly for 6-months improved blood pressures compared to a control group, 4.4 mmHg (95% CI = 1.2-7.5 mmHg) and 1.4 mmHg (95% CI =-0.14-3.0 mmHg), respectively (Cox, Burke, Beilin, Grove, Blanksby, & Puddey, 2006). Improvements in blood pressure are observed in as little as 4-months when older adults engaged in exercise for 3.6 hours per week at 50-85% of maximal intensity. When

compared to a control group, both systolic and diastolic blood pressures are reduced 7.9 and 3.6 mmHg, respectively (Braith, Pollock, Lowenthal, Graves, & Limacher, 1994). Even walking as little as 3 kilometers or approximately 4300 steps per day beyond regular daily walking reduces blood pressure in post-menopausal women with borderline to stage 1 hypertension. These women lowered their resting systolic blood pressure by 6 mmHg after 12 weeks of additional walking and another 5 mmHg after 24 weeks of walking (Moreau et al., 2001). This literature suggests older adults can improve their blood pressure in four or more months, especially systolic blood pressure, by engaging in regular structured exercise programs or by increasing the number of daily steps walked.

Physical Activity and Fall Incidence in Older Adults

Evidence suggests a relationship with physical activity participation and fall incidence in older adults. In a randomized controlled trial lasting for 25 weeks, older adults participating in resistance and agility training lowered their fall risk score significantly by 47.5-57.3%, but no change was observed in the stretching group (Liu-Ambrose, Khan, Eng, Janssen, Lord, & McKay, 2004). Another randomized control trial found significant reductions in fall incidence in older adults after they participated in 12 months of weight bearing exercise for 1-hour two times a week. The exercise group reduced the number of falls by 22% compared to the control group (Lord, Castell, & Corcoran, 2003).

Other forms of activity, like Tai Chi, were also beneficial for reducing the number of falls in older adults. When older adults engaged in Tai Chi three times a week for 6-months, the control group fell 73 times during the 6-month follow-up period while the Tai Chi group fell only 38 times during follow-up (Li, Harmer, & Fisher, 2005). Also

when Tai Chi, endurance/resistance training group, and control groups were compared, the Tai Chi group fell significantly less (58%) compared to the endurance/resistance training group (72%) and control group (75%) after a 24-month follow-up period (Nowalk, Prendergast, Bayles, D'Amico, & Colvin, 2001).

Structured aerobic exercise, resistance training and activities like Tai Chi are beneficial for preventing falls in older adults. This literature supports the engagement in physical activity for the prevention of falls in older adults.

Summary of the Benefits of Physical Activity for Older Adults

Physical activity was observed to be beneficial for the overall health and the diseases and conditions prevalent in many older adults. The literature suggests physical activity helps reduce mortality rates, improves body composition, and reduces the incidence rates of hypertension, type 2 diabetes, and falls. Concern lies with the health of older adults who do not engage in enough daily physical activity to see these benefits. Therefore it is important to research the impact of a sedentary lifestyle on these same health issues that physical activity and exercise positively impact.

The Importance of Studying Sedentary Behavior

As the previous section demonstrated the benefits for older adults who engage in physical activity there is still concern about the impacts of not engaging in enough physical activity. As mentioned previously it is speculated that the increased participation in physical inactivity is due to the time spent engaging in sedentary behavior. It is thought that sedentary behaviors are what typically replace the desired physical activity (Owen et al., 2000). When there is increased time spent participating in sedentary behavior there is usually a reduction in total daily physical activity. Owen and

colleagues (2000) suggest that a replacement of sedentary behaviors for active ones occurs regularly throughout the day causing a large reduction in total daily energy expenditure. For example if someone substituted two hours per day of sedentary behavior instead of performing light physical activity there is a reduction of energy expenditure by approximately 2 MET hours per day or that associated with walking for 30 minutes per day (Owen et al., 2000). This is a large amount of health enhancing activity that is being potentially replaced by sedentary behaviors. This is significant because increased physical activity participation has numerous health benefits for older adults such as reducing the likelihood of developing cardiovascular disease, lowering blood pressure and cholesterol values, and preventing disability, loss of function and one's independence (Nelson et al., 2007).

Reasons for the increased participation in sedentary behavior are related to changes in the environment promoting a sedentary lifestyle, which differs from that of previous generations. Aspects of our work, home, ways we commute, and manipulations in public spaces have created environments that promote minimal physical activity and muscular activity (e.g., elevators are in all buildings so very few people take the stairs, people can drive through and get food instead of having to walk in and sit down for dinner, and transportation is very accessible and walking arguably can be inconvenient) (Hill, Wyatt, Reed, & Peters, 2003; Owen, Sparling, Healy, Dunstan, & Matthews, 2010). Over the past three decades there has been reductions in the number of active jobs. For example in 1970 only 2 in 10 people had desk jobs compared to the 4 in 10 people in the year 2000. A similar but inverse relationship existed with labor-intensive jobs (Brownson, Boehmer, & Luke, 2005; Owen et al., 2010). Watching TV has dramatically increased to four or

more hours per day being watched and one or more hours per day are spent driving or taking public transportation (Brownson et al., 2005; Owen et al., 2010). All of these changes have altered our behavior to engage in more sitting rather than physically moving (Brownson et al., 2005; Owen et al., 2010).

Another reason for examining sedentary behavior is an independent behavior and its own effects on health. These effects differ from even the lowest intensity physical activity, light physical activity. Light intensity activities have slightly higher energy expenditures between 1.6-2.9 METs and include activities like slow walking, cooking food, typing on the computer, and washing dishes (Pate et al., 2008). For example, there are variations in blood glucose values when sedentary behavior is compared to light intensity physical activity, independent of health enhancing moderate to vigorous physical activity (Healy et al., 2007). Light physical activity is beneficially related to plasma glucose whereas sedentary behavior is unfavorably associated (Healy et al., 2007). Adversely, health effects like this can contribute to the development of type 2 diabetes or compound other health conditions in an older adult population.

There is also emerging animal research on the damaging physiological effects of participation in sedentary behavior. When acute (1-8 hours) and chronic (11 days) sedentary behaviors (e.g., preventing mice from standing or doing ambulatory activity) are examined results show reductions in the lipoprotein lipase activity due to diminished muscle contraction (Hamilton et al., 2004; Hamilton, Hamilton, & Zderic, 2007). Lipoprotein lipase is one of the cellular regulators of the lipoprotein risk factors for many chronic conditions. In animals, when less lipoprotein lipase activity occurs because of engaging in sedentary behaviors triglyceride lipolysis and high-density lipoprotein

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cholesterol circulation in the blood is reduced (Bey & Hamilton, 2003; Hamilton et al., 2004; Hamilton et al., 2007). Having elevated triglycerides and low values of high-density lipoproteins are risk factors for heart disease in humans. When people have less lipoprotein lipase activity evidence suggests a relationship with elevated blood pressure, type 2 diabetes, and the metabolic syndrome (Hamilton et al., 2007). Therefore if these changes occur when people are sedentary this behavior should be examined as a possible risk factor for the development of chronic disease. The following section expands on this further and discusses the current literature relating sedentary behavior to health.

Mortality

All-cause Mortality

Research from the Australian Diabetes, Obesity, Lifestyle Study (AUSDIAB) and the Canada Fitness Survey reported a dose response relationship with self-reported time watching television and time spent sitting with all cause mortality. The AUSDIAB study is a prospective study of 8,800 adults' ≥25 years of age. Dunstan and colleagues (2010) reported an 11% increase in risk of death from all causes with each 1-hour increase in television viewing, from 0-6 hours per day, after adjusting for age, gender, waist circumference, and leisure time physical activity participation. When television watching of less than two hours per day was compared to 2-4 hours per day there was an additional 13% increase in risk of death from all causes (Dunstan et al., 2010). This percentage increased dramatically to 46% when television was watched for more than 4-hours per day (Dunstan et al., 2010).

The Canada Fitness survey includes 17,013 adults 18-90 years of age also examined the relationship between sedentary behavior and mortality (Katzmarzyk et al.,

2009). In this survey they used sitting time instead of television watching as a marker of sedentary behavior. Researchers quantified sedentary behavior by having participants self-report the amount of time they spend sitting per week (i.e., almost none of the time, ¼ of the time, ½ the time, ¾ the time, and almost all the time). A dose response relationship was observed for all cause mortality increasing from 11-54% when sitting was reported for more than ½ of the time, ¾ of the time and almost all of the time (Katzmarzyk, Church, Craig, & Bouchard, 2009). Therefore the individuals sitting the longest had a greater relative risk of all cause mortality. These results were independent of gender, age (e.g., younger ≤59 years of age versus older ≥60 years of age), smoking status, alcohol consumption, past health conditions, and leisure time physical activity participation (Katzmarzyk et al., 2009).

Cardiovascular Disease Mortality

The same studies assessing the relationship between sedentary behavior and all cause mortality also examined the relationship between sedentary behavior and cardiovascular disease mortality. In the AUSDIAB study researchers reported an 18% increase in risk of cardiovascular death with each 1-hour per day increase in television watching as well as a 19% increase in risk of cardiovascular death when 2-4-hours per day of television was watched (Dunstan, et al., 2010). When television was watched for greater than 4-hours per day the relative risk of death from cardiovascular disease quadrupled to 80% (Dunstan et al., 2010). This relationship existed independent of gender, age, smoking status, alcohol consumption, past health conditions and leisure time physical activity participation.

When sitting time was assessed in the Canada Fitness Survey the cardiovascular

mortality risk was similar to the results observed with television watching. The relative risk of cardiovascular related mortality was higher, 22-54% when participants self-reported sitting for ½ of the time, ¾ of the time or almost all of the time compared to almost none of the time or ¼ of the time (Katzmarzyk et al., 2009). There were similar results in a study examining cardiovascular event risk and overall daily sitting or lying down behaviors in 73,745 postmenopausal women ages 50-79 participating in the Women's Health Initiative (Manson et al., 2002). Manson et al. (2002) inquired about the number of hours per day spent in behaviors involving either sitting or lying down. These results were slightly higher than those of Katmarzyk and colleagues (2009) and suggested the risk for cardiovascular disease events when women reported total daily sitting or lying down time of 12-15 hours per day and ≥16 hours per day compared to those spending less than 4-hours per day in those positions, 38% and 68%, respectively (Manson et al., 2002). These results were independent of age and total physical activity energy expenditure.

Cancer Mortality

In both the AUSDIAB study and Canada Fitness Survey cancer mortality was examined. Dunstan and colleagues (2010) reported a 9% increase of all cancer type mortality risk for every 1-hour increase in television viewing but there were no significant relationships between television viewing lasting 2-4 hrs/d or greater than 4-hours per day. There were similar null findings reported by Katmarzyk and colleagues (2009) across sitting time throughout the week.

Risk Factors for Chronic Disease

General Cardiometabolic Health

Time spent watching television and overall time sitting are the primary assessments of sedentary behavior when comparing its effects to various cardiometabolic health outcomes. Studies demonstrated the more time spent in front of the television or spent sitting in general, negatively relates to different cardiometabolic biomarkers (Ching et al., 1996; Fung et al., 2000;Hu, Li, Colditz, Willet, & Manson, 2003). Also there is evidence that gender differences may arise between these relationships (Tucker & Friedman, 1989; Tucker & Bagwell, 1991). These negative health effects could result in or lead to the development of a cardiovascular event.

Researchers examined the relationship between self-reported television viewing (i.e., 1-2 hours per week up to ≥40+ hours per week) and various blood biomarkers (i.e., total cholesterol, triglycerides, high-density lipoproteins; low-density lipoproteins; apolipoprotien, APO-A1; insulin, C-peptide, and leptin) in a sample of 468 men aged 40-74 years participating in the US Male Health Professionals Follow-up Study. After adjusting for age, partial correlations resulted in very low but significant positive relationships between the average television hours viewed per week over time and body mass index (r = .13), C-peptide (r = .12), and leptin (r = .15) (Fung et al., 2000). In multivariate analysis sedentary behavior predicted lower high-density lipoproteins and APO-A1 and higher values of low-density lipoproteins (Fung et al., 2000). Additionally there was a significant increase in leptin levels of 1.29 ng/ml (95% CI = 0.3-2.3) for each 14-hour increase in television viewed per week (Fung et al., 2000). Across increasing tertiles of physical activity and television viewing, the most active men (37.1 MET/hours/week) watching the least amount of television per week (3.4 hours per week) had lower leptin values (5.1 ng/ml, 95% CI = -7.2 - -3.0) and higher high-density

lipoprotein cholesterol (12.8 mg/dL, 95% CI = -2.2-27.8) values compared to the least active men (1.43 MET/hours/week) watching the most television per week (18.1 hours per week) (Fung et al., 2000).

Thorp and colleagues (2009) reported similar findings to Fung et al. (2000) with linear regressions suggesting television viewing and/or sitting time predicts waist circumference, body mass index, blood pressure, triglycerides, high-density lipoproteins, and fasting and 2-hour plasma glucose and fasting insulin in 4,864 individuals ≥25 years of age participating in the AUSDIAB study (Thorp et al., 2009). Gender differences arose in these regressions with no association between television watching or sitting time and fasting plasma glucose and diastolic blood pressure in men (Thorp et al., 2009). Similar differences arose across increasing quartiles of television viewing for body mass index, diastolic blood pressure and triglycerides in women and 2-hour post load plasma glucose and fasting insulin in men (Thorp et al., 2009). However these gender differences did not occur in dose response relationships that existed between increasing quartiles of television viewing (<2 hours per day to >4 hours per day) and higher blood pressure, body mass index, waist circumference, hip circumference, waist to hip ratio, body fat percentage, total cholesterol, low-density lipoproteins, and triglycerides with lower high-density lipoprotein in those participating in the European Prospective Investigation into Cancer (EPIC) study. (Jakes et al., 2003).

In general this literature suggests increasing participation in sedentary behaviors negatively impacts a number of cardiometabolic risk factors for chronic disease development. These few studies also suggested that some relationships were stronger in men than women but further research is necessary before a conclusion can be drawn.

Obesity

There are few studies examining the relationship between sedentary behavior and the risk for becoming overweight or obese. In the following literature review sedentary behavior is described with self-report of television watching time, sedentary leisure activities (watching TV/videos, playing board games) and sedentary transportation (riding in a car), or by time spent in front of the computer. Obesity is reported by body mass index and percent fat measured by either bioelectrical impedance or skin fold assessment. All findings were independent of physical activity level, age, smoking status, and dietary factors. The following literature is organized in accordance to how obesity was measured.

Obesity Assessed by Body Mass Index

More time spent watching television was positively associated with overweight or obesity (Ching et al., 1996; Hu, Li, Colditz, Willet, & Manson, 2003). This was observed in both men (40-75 years of age) and women (35-50 years of age) participating in the Male Health Professionals Study and Nurses Health Study, respectively (Ching et al., 1996; Hu, Li, Colditz, Willet, & Manson, 2003). Men watching 2-5 hours of television per day had a greater likelihood of being overweight than men watching ≤1 hour per day, a relative risk of 1.42 (95% CI = 1.14-1.77) (Ching et al., 1996). This risk quadrupled to 4.06 (95% CI = 2.67-6.16) in men watching ≥41 hours of television per week or five or more hours per day of television (Ching et. al., 1996). In contrast, there was a lower relative risk of 1.23 (95% CI = 1.06-1.42) for women watching 2-5 hours of television and a relative risk of 2.00 (95% CI = 1.56-2.57) for those watching ≥40 hours of television per week (Hu, Li, Colditz, Willet, & Manson, 2003).

A 2-year follow-up study in the men participating in the Male Health Professionals Study reported those men originally watching ≥21 hours per week of television were 40% more likely to be overweight compared to those watching television for ≤1 hour per week (Ching et al., 1996). Linear regression analysis showed a 10-hour per week increase in television viewing resulted in a 0.05 increase in body mass index or 1/3 pound of body weight over that 2-year follow-up period (Ching et al., 1996). In the Nurses Health Study, their findings suggested a reduction in TV viewing by ≤10 hours per week along with being physically active could prevent 30% of obesity cases (Hu, Li, Colditz, Willet, & Manson, 2003). The results of both studies were independent of age, smoking status, and level of physical activity.

Interestingly, in the same data set from the Nurses Health Study previously discussed, there was no increase in the likelihood of becoming obese when women spent any duration (0-40+ hours per week) of time being sedentary, measured as sitting at work or away from home or while driving and/or sitting at home (reading, mealtime, or at a desk) (Hu, Li, Colditz, Willet, & Manson, 2003). In contrast, when other sedentary behaviors were examined, Dunton and colleagues (2009) observed from the 2006 American Time Use Survey significantly higher body mass index values when individuals sat for transportation ≥80 minutes per day compared to those who sat for ≤30 minutes per day. The same was reported for those reporting some versus no computer use and playing games (Dunton et al., 2009).

Sedentary behavior measured as computer usage also related to obesity levels for participants in the Physical Activity in Localities and Community Environments or PLACE study. Those individuals classified as high (>3 hours per week) computer and

Internet users were 1.46 (95% CI = 1.10-1.93) more times likely to be overweight and 2.52 (95% CI = 1.82-3.52) times more likely to be obese compared to those not using the computer during their leisure time (Vandelanotte, Sugiyama, Gadriner, & Owen, 2009). These relationships were also independent of physical activity participation; those who were high computer users were still 1.86 (95% CI = 1.21-2.88) more times likely to be overweight or obese despite being highly physically active when compared to those not using the computer (Vandelanotte et al., 2009). However, reading for leisure or personal interest was associated with significantly lower body mass index values (Dunton et al., 2009).

These results suggested some forms of sedentary behavior like television viewing and computer usage may have stronger relationships with the development of obesity as measured by body mass index than other forms of sedentary behavior (i.e., sitting for reading).

Obesity Assessed with Bioelectrical Impedance Analysis

Independent of physical activity participation, body fat percentage was positively related to sedentary behavior measured as either time spent watching television or heart rate. Similarly to the studies using body mass index values, as time spent watching television increased so did body fat percentage. The men and women participating in the EPIC study watching television for 2-hours per day had body fat percentages of 22.5-25.3% which was lower than those watching more than 4-hours per day with body fat percentages of 37.1-41.6% (Jakes et al., 2003).

Longitudinally, similar changes occurred when heart rate was used as an objective indicator of sedentary behavior. For those participating in the Medical Research Council

of Ely study both fat mass at baseline ($r=0.10$, $p<0.0001$) and fat mass ($r=0.19$, $p<0.0001$) and body weight ($r=0.19$, $p<0.0001$) after a six year follow-up positively related to the total time spent being sedentary (Ekelund, Barge, Besson, Sharp & Wareham, 2008). However, the total time spent being sedentary was not predictive of a change in body weight or fat mass over time when multiple linear regression equations were performed with each obesity indicator (body mass index, fat mass, and waist circumference) as predictor variables and the amount of sedentary time at follow-up as the dependent variable (Ekelund, Barge, Besson, Sharp & Wareham, 2008). However, baseline body weight ($\beta = 0.33$; 95% CI = 0.15-0.50), fat mass ($\beta = 0.59$; 95% CI = 0.11-0.40) and waist circumference ($\beta = 0.44$; 95% CI = 0.23-0.66) did predict the amount of time people were sedentary at follow-up (Ekelund, Barge, Besson, Sharp & Wareham, 2008). Therefore body size was a better predictor of future time spent in sedentary behaviors and not baseline sedentary behavior. These results were independent of gender, age, physical activity energy expenditure, baseline sedentary time, smoking, socioeconomic status, and follow-up sedentary time.

These studies suggested sedentary behavior, regardless of how it was assessed was positively related to an increase in body fat percentage. Therefore the more time spent being sedentary related to having more body fat. However sedentary time may not be the best predictor of obesity overtime and a person's baseline body size may be a better indicator of this behavior, but more research is necessary before definite conclusions can be made.

Obesity Assessed with Skin Fold Measures

There are two studies examining the relationship between television viewing and

obesity using skinfold assessment as the measure of obesity. In these two studies a man was considered obese if they had 21-30% body fat and a women was considered obese if they had more than 31% body fat (Tucker & Friedman, 1989; Tucker & Bagwell, 1991). The relative risk for being obese was 1.9 times (95% CI = 1.06-3.38) to 2.05 (95% CI = 1.48-2.84) greater in men (controlling for age, fitness, smoking, exercise and work) and 1.89 (95% CI = 1.37-2.61) to 2.15 times (95% CI = 1.15-4.01) greater in women (controlling for age, education, smoking, work week and exercise duration) when viewing television for 3-4 hours per day was compared with ≥4 hours of television viewing per day (Tucker & Friedman, 1989; Tucker & Bagwell, 1991). The relative risk of having more than 31% body fat was 2.34 (95% CI = 1.27-4.32) to 3.17 (95% CI = 1.47-6.83) greater for men watching 3-4 hours of television per day compared to ≥4 hours of television per day (Tucker & Friedman, 1989).

These studies concurred with the studies assessing body fat percentage with bioelectrical impedance. Therefore suggesting when television is watched for more than four hours per day individuals are twice as likely to be obese regardless of the assessment method.

Fasting Plasma Glucose, 2-hour Post Plasma Glucose, and Fasting Insulin

The following studies examined the relationship between the total time spent in sedentary behavior and fasting plasma glucose, 2-hour post plasma glucose levels, and fasting insulin. In two studies using data from the AUSDIAB study, sedentary behavior was either assessed by self-report of television viewing (i.e., ≤1 to ≥4 hours per day) or objectively with accelerometry. A significant positive relationship between television viewing and fasting plasma glucose existed in both men and women (Dunstan et al.,

2007). For every one hour per day increase in television viewing, fasting plasma glucose increased 0.02 mmol/L (95% CI = 0.001-0.04, p=0.04) in men and 0.04 mmol/L (95% CI = 0.02-0.06, p=0.001) in women (Dunstan et al., 2007). A significant positive relationship existed between 2-hour post load plasma glucose level in women and sedentary behavior indicated by television viewing, for every 1-hour per day increase in television viewing there was an increase in 2-hour plasma glucose of 0.16 mmol/L (95% CI = 0.08-0.25, p=0.001) (Dunstan et al., 2007). When sedentary behavior was measured with accelerometry (≤100 cts/min), sedentary time was positively related to 2-hour post plasma glucose (β=0.29, 95% CI = 0.11-0.48, p=0.002) (Healy et al., 2007). A similar relationship occurred across quartiles of waking hours spent being sedentary. These quartiles increased from 51% of the day being sedentary to 64% of the day being sedentary. As these quartiles increased, 2-hour post plasma glucose increased from approximately 5 mmol/l to 6.5 mmol/l (Healy et al., 2007). Results of both studies remained after adjusting for age, waist circumference, diet and physical activity variables.

When the relationship between fasting insulin and sedentary behavior indicated as television viewing was examined gender differences arose suggesting higher fasting insulin levels in women watching 3 to ≥4 hours of television per day (β=.473, 95% CI = .06-.88, β=.501, 95% CI =.12-.88, respectively) (Dunstan et al., 2007). In a longitudinal study combining both objective measures of sedentary behavior with accelerometry and self-reported television viewing there were significant positive associations between television watching and insulin resistance (β=.01, 95% CI = .004-.019, *p*=.002) and fasting insulin (β=0.01, 95% CI = 0.004-0.017) but not with sedentary behavior measured with accelerometry (Ekelund, Brage, & Wareham, 2009). However when these variables

were re-examined one year later the only variable related to sedentary time (measured with accelerometry) was fasting insulin (β=.01, 95% CI =-.0013-.00005). Both of these study results were independent of physical activity level, sex, age, smoking status, and waist circumference.

Difference in results were observed for measures of insulin sensitivity and beta cell function compared to sedentary behavior measured as television viewing (Healy et al., 2007). There was an inverse relationship between television viewing and insulin sensitivity in women watching 3 and ≥4 hours per day (β=-.083, 95% CI =-.14 - -.03, β=-.097, 95% CI = -.18 - -.01, respectively) (Healy et al., 2007). This relationship was not observed across hours of television watching for beta cell function (Healy et al., 2007).

These study results suggested that increasing time being sedentary behavior as measured subjectively with self-report of television watching or with objective measures with accelerometry negatively impacted fasting plasma glucose, 2-hour post plasma glucose, and fasting insulin. This relationship is important because over time insulin resistance and elevated plasma glucose and 2-hour post glucose can lead to the development of type 2 diabetes or other metabolic health conditions.

Metabolic Syndrome

The Metabolic Syndrome is a combination of lipid and non-lipid risk factors with metabolic origins ("Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002). A person diagnosed with the Metabolic Syndrome has three or more of the following risk factors; abdominal obesity, low high-density lipoproteins, hypertension, high triglycerides and high fasting plasma

glucose. Similar relationships existed between time spent being sedentary and the risk of developing the Metabolic Syndrome as previously discussed with obesity, cardiovascular disease, and all-cause mortality.

The risk of having the Metabolic Syndrome increased from 12-23% for every 1–hour per day increase in television watched and this increase doubles for individuals watching ≥2 hours of television per day (Bertrais, Beyeme-Oudoua, Czernichow, Galan, Hercberg, & Oppert, 2005; Dunstan et al., 2005; Chang et al., 2008). These results remained when researchers controlled for participation in regular physical activity.

Positive relationships also existed with the individual variables associated with the Metabolic Syndrome. For example when sedentary behavior was measured with accelerometry and broken into quartiles of the percentage of waking hours spent in sedentary time there was increased waist circumference, triglyceride values, and clustering of metabolic risk scores between the lowest percent of day in sedentary behavior and the highest quartile of sedentary behavior (Healy et al., 2007). A dose response relationship was also observed with increasing hours of television viewed and body mass index, waist circumference, systolic blood pressure, fasting plasma glucose, and triglyceride values (Chang et al., 2008). There may also be gender differences similar to what was observed with the previous discussion on fasting blood glucose and fasting insulin. Women were more likely to have type 2 diabetes, impaired fasting blood glucose, and higher 2-hour post glucose than men when watching ≥14 hours per week of television (Dunstan et al., 2005).

A relationship was observed across the literature with increased participation in sedentary behavior being related to having the risk factors for the Metabolic Syndrome,

ultimately increasing the likelihood of developing the Metabolic Syndrome up to 23% (Bertrais et al., 2005; Dunstan et al., 2005; Chang et al., 2008).

Summary of the Impact Sedentary Behavior Has on Health

To reiterate the previous literature reviews there were dose response relationships between increased television viewing (one or more hours per day) and the risk of death (9-23%) from all causes, cardiovascular disease, cancer, and the Metabolic Syndrome. Collectively there was a 20-40% increase in risk for becoming overweight or obese when individuals watched more then 2-hours per day of television. There were also elevated blood biomarkers (fasting glucose, 2-hour plasma glucose, and insulin) for the development type 2 diabetes and the Metabolic Syndrome with increases in sedentary behavior measured as television watching or as a lower heart rate. These cardiometabolic risks and changes in blood biomarkers increased further with greater than 2-hours of television viewing per day.

Similar negative health relationships were also observed between increases in sitting time and body mass index, triglycerides, body fat percentage, blood pressure, low-density lipoproteins, high-density lipoproteins, and total cholesterol. All studies observed these relationships independent of physical activity participation, diet when measured, smoking status, gender, and age. These studies also focused on populations ranging in age (i.e., 18-75 years) as much as 57 years or as little as 10 years, with mean ages between 45-50 years. As these results were reported for individuals who have at least 15-20 years before they become classified as older adults these relationships become important when we begin to think about the developing health of these individuals. If we can prevent or reduce the negative health relationships caused by sedentary behavior in

the younger generations the progression of chronic disease development in older adults can be reduced.

There are still areas within the literature in need of scientific exploration. For instance, gender differences arose across some health variables; very few studies objectively measured sedentary behavior or describe the types of sedentary behaviors their population samples were engaging in, and no studies explored the reasons why these individuals were participating in these behaviors. Lastly and most importantly none of these studies examined the relationship between sedentary behaviors and health in an older adult population specifically. Because of these limitations future studies need to improve the methods for measuring and assessing sedentary behavior. The following section discusses the methodologies used in most of the studies assessing sedentary behavior.

Measurements of Sedentary Behavior

Self-report Measures of Sedentary Behavior

Traditionally, measurements of physical activity participation are self-report measures such as surveys or questionnaires where individuals answer questions relating to what physical activities they engage in and how much activity they do in a day or over a week. This information is then translated into whether or not a person participates in enough activity to meet the physical activity recommendations (i.e., Behavioral Risk Factor Surveillance Survey, Health Interactive Survey). If they did not meet the physical activity recommendations researchers describe these individual's as being physically inactive or sedentary, but specific sedentary behaviors were rarely inquired about within the survey or questionnaire. Surveys that assess physical activity and sedentary

behaviors specifically for older adults include the CHAMPS Physical Activity Questionnaire for Older Adults (Stewart, et al., 2001) and the Yale Physical Activity Survey (Dipietro, Caspersen, Ostfeld, & Nadel, 1993), but to date no surveys have been developed that inquire about the participation in sedentary behavior specifically for this population.

Researchers assessing sedentary behaviors with surveys typically focused on age groups spanning from 18-65 years of age and assessed only one or two types of sedentary behaviors, primarily television viewing and more recently the addition of computer use. Most studies observed a moderate to high reliability (ICC = 0.3-0.9) for the use of questionnaires to assess these sedentary behaviors. Television was used as the primary assessment of sedentary behavior because it is a common activity for people to engage in and it has a lower metabolic cost compared to other types of sedentary behaviors like reading, writing, and driving a car (Ainsworth et al., 2000).

The Australian Physical Activity Taskforce examined habitual incidental physical activity and they included three items measuring sitting on weekdays, Saturdays, and Sundays (i.e., "During a typical weekday, how much time do you spend sitting?") and two items measuring the amount of time spent watching television or using a computer both in and outside the workplace (i.e., "On average how many hours per week do you spend watching TV or using a computer?") (McCormack, Giles-Corti, & Milligan, 2003). The reliability of these questions over a 10-day period was moderate to high for measuring sitting on the weekdays and weekends (ICC = 0.65-0.77) as well as watching television or using the computer (ICC = 0.88-0.93) (McCormack et al., 2003).

A similar survey showed lower reliability assessing sedentary behavior over a 16-

day timeframe. The questions were modified from the NHANES and asked respondents "In a usual week, how many hours or minutes do you spend sitting or lying down and watching television or videos?" and "In a usual week, how many hours or minutes do you spend using a computer outside of work?" Reliability of the sedentary behavior questions for watching television and using the computer were ICC = 0.32 (95% CI =.14-.48) and ICC = 0.69 (95% CI =.57-.78), respectively (Evenson & McGinn, 2005). When Pettee, Ham, Macera, and Ainsworth (2009) examined the reliability of 1-question to assess television viewing (i.e., "In a usual week, how many hours do you spend watching television while sitting or lying down?") every seven days for 4-weeks, the reliability of the television viewing question declined slightly over the 1-month timeframe from one week (ICC =.55, 95% CI =.39-.68, p <0.001) to three weeks (ICC =.42, 95% CI =.23-.58, $p < 0.001$) (Pettee et al., 2009).

One study observed the reliability of a question taken from the Flemish Physical Activity Questionnaire in a sample of retired men and women and compared the results to those of younger adults. This question inquired about television viewing or playing computer games, "How many hours did you spend watching television or playing computer games over the past seven days." During a 2-week period, the reliability of the question ranged from 0.76 (95% CI =.49–.89) in men to .89 (95% CI =.72–.96) in women (Matton, et al., 2007). There was no difference in reliability between the retired older adults and the younger adults.

These studies suggested individuals, middle to older age are able to assess their sedentary behavior moderately week to week, but there are differences based on the type of sedentary behavior (i.e., television versus computer usage). Because of these

inconsistencies researchers need to further examine if these relationships occur because people have difficulty accurately recalling these types of behaviors or if it is because sedentary behaviors vary from week to week or day to day.

As Pettee and colleagues (2009) inquired about television viewing over a 4-week period they noted that individuals were able to consistently report watching television 7-8 hours per week but it differed significantly with what was reported in that year's Nielson's report 2004-05, suggesting televisions were on for an average of eight or more hours a day (Pettee et al., 2009). However, when another group of researchers monitored the actual hours a person's television was on and then asked participants to self-report how many hours they watched, minor inconsistencies existed. A small sample of overweight and obese individuals participated in a 4-week study that involved their television watching to be monitored by an electronic television monitor. Those values were compared to a survey question that was asked in the beginning of the study, "How many hours do you watch television per day, on average?" Results from this study found no significant differences between self-reports of television watching and the results from the objective monitoring of television, respectively (4.3±1.3 hours per day, range 3.0-8.0 hours per day versus 4.9±2.6 hours per day, range .8-13.3 hours per day) (Otten, Littenberg, & Harvey-Berino, 2009). The participants underestimated their television viewing by only .6±2.3 hours/day (95% CI = -1.34-.13) or approximately 4.3 hours per week (Otten et al., 2009). Despite this underestimation, 47.5% of the sample estimated their viewing time within 1 hour/day and 72.5% within 2 hours per day of the recorded television monitor (Otten et al., 2009). This study suggested that individuals can reasonably estimate how much television they view.

Since there is reasonable evidence suggesting that reliable surveys exist to estimate the amount of television watched in individuals under 65 years of age, researchers have tried to determine if television viewing alone is a broader marker or pattern of overall sedentary behavior. Sugiyama and colleagues (2008) examined this by comparing the answers to the following questions, "On how many days did you do the activity in the past 7-days?" and "On average, how many minutes did you do the activity on the days that you did it?" for the following six sedentary behaviors: television or video watching, computer/Internet use for leisure, video game use, reading, sitting and talking with friends, and driving or riding in a car. Reliability for these questions was moderate to high, ranging from .6-.8 (television of video watching ICC =.82, 95% CI =.75-.87; computer/Internet use for leisure ICC =.62, 95% CI =.48-.73; reading ICC =.78, 95% CI =.68-.84; sitting and talking ICC =.76, CI 95% =.66-.82; driving or riding in a care ICC = .85, 95% CI =.79-.89) (Salmon Owen, Crawford, Bauman, & Sallis, 2003). Results suggested for women, the more time reported watching television meant they spent more time in other leisure-time sedentary behaviors and less time in leisure-time physical activity and therefore television viewing may be a stronger marker of a sedentary lifestyle (Sugiyama, Healy, Dunstan, Salmon, & Owen, 2008). On average individuals 20-65 years of age reported 235 minutes per day engaging in various sedentary behaviors with 111 minutes per day (47%) spent watching television (Sugiyama et al., 2008). This study demonstrated television viewing to be a broader marker for sedentarism for women but not men. Because of these gender differences researchers have tried to capture domain specific sedentary behaviors to gauge if other types of sedentary behavior result in a more accurate picture of sedentary behaviors for some people.

Marshall et al. (2010) created a recall questionnaire inquiring about sitting on the weekends and weekdays while traveling to/from places, at work, watching television, using a computer at home and for leisure, not including television. Reliability was assessed within an 11-day period and validity was compared to information reported in logs as well as sedentary data from accelerometers. The sedentary behavior recall had similar moderate to high reliability results as the television viewing questions discussed previously, highest reliability was for weekday sitting at work, watching television, and using a computer at home (r=0.84-0.78) and lower reliability for weekend days across all five sitting domains (r=0.23-0.74) (Marshall, Miller, Burton, and Brown, 2010). Similar results were observed for the validity of the questionnaire. The highest validity coefficients were for weekday sitting time at work and using a computer at home (0.69-0.74) with the weekend day validity lower for both men and women except for computer use and watching television for women (Marshall, Miller, Burton, and Brown, 2010). Gender differences still arise when domain specific sedentary behaviors were examined but this survey was still able to capture consistent reports of engagement in different sedentary behaviors.

What is still unknown is whether older adults engage in similar sedentary behaviors as younger adults or do they engage in others sedentary behaviors, for example playing cards or working on puzzles? To date there are no studies examining various domains of sedentary behaviors in an older adult poplation. This could be related to the fact that no diaries or logs have been created for older adults to capture a variety of sedentary behaviors. However some literature exists on this topic studied in a general population of various ages.

Salmon and colleagues (2003) investigated three constructs (barriers, enjoyment, and preference) related to the environment and individual factors of the Behavioral Choice Theory, in regards to participating in both physical activity and sedentary behaviors, in Australians 18 years of age and older. A one-week recall measure to assess leisure time physical activity was used as well as measuring the time spent in nine sedentary behaviors gleaned from information on the time-use surveys. The sedentary behaviors they tried to capture included computer use, hobbies, television viewing, sitting and socializing, reading, sitting or lying down listening to music, talking on the telephone, going for a recreational drive, and relaxing, thinking, and resting. Participants rated environmental barriers to PA (1 = not a barrier to 5 = very much a barrier), enjoyment (1 = no enjoyment to 5 = very enjoyable), and preference for sedentary behavior or physical activity with questions like "In the morning before work or other commitments, which one of the following would you most prefer to do if you had your choice?" followed by the choices of vigorous physical activity, moderate physical activity, or inactive recreational pastimes (Salmon et al., 2003). This study reported high levels of enjoyment and the cost of participating in physical activity to be related to high participation in television viewing (≥14 hours per week), reading for ≥5 hours per week, and sitting while socializing for ≥8 hours per week (Salmon et al., 2003). Poor weather was also associated with a 50% increased likelihood of participating in sedentary behavior as well as feeling tired (Salmon et al., 2003).

To review self-report measures of sedentary behavior, there are a number of reliable questions pertaining to television viewing as a marker of sedentary behavior in younger populations but only a few were validated with objective measures and almost

none were developed in an older adult population. There is also no consensus of whether television is a broader indicator of sedentary behavior. There are also assessments of different domains of sedentary behavior and still no consensus of whether these behaviors are regularly engaged in by all individuals, especially older adults. Lastly there is insufficient research on the determinants of sedentary behavior to fully understand why people engage in this behavior. Therefore more exploration of this topic is needed, especially in older adults. The following discussion revolves around objectively quantifying sedentary behavior and how there is a need to combine self-report measures with objective measurement to more thoroughly understand the participation of sedentary behavior in an older adult population.

Objective Measures of Sedentary Behavior

Over the past decade self-report assessments of sitting and television viewing have been used as a crude estimate of sedentary behavior. As previously discussed there is literature suggesting increased participation in sedentary behavior leads to a number of adverse health outcomes. However with any self-report measures there are concerns about recall ability and accuracy of self-report, which has lead to the recent assessment of sedentary behavior with more objective measures, such as with the use of accelerometry. These devices quantify the intensity of physical activity (sedentary, light, moderate, and vigorous) and activPal™ accelerometers measure sitting/lying and standing postures. Accelerometers more accurately determine whether individuals engage in the recommended amount of physical activity and more accurately quantify sedentary behaviors.

Accelerometers are typically small, lightweight devices worn on a belt around the

waist or attached to a limb, such as the arm or leg. They are able to measure body movements in the form of accelerations, which are used to estimate both physical activity intensity and/or lack of activity or sedentary behavior (Chen and Bassett, 2005). These monitors have the ability to capture the frequency, intensity, and duration of both physical activity as well as sedentary behavior, however they are unable to provide contextual information regarding these behaviors, the reasons why people engage in such behaviors, and what activities they are doing like a diary or survey is able to capture (Matthews, 2005). They have been used in the validation of physical activity and sedentary behavior surveys, as outcome measures in intervention studies, and in projects examining correlates of physical activity behavior (Matthews, 2005).

Accelerometers have been recently added to population studies like the NHANES to more accurately quantify physical activity as well as sedentary behavior. Matthews and colleagues (2008) reported the overall time spent being sedentary in a nationally representative sample of individuals. These researchers observed the entire sample (N=6329) to spend more than 54% of their day engaging in sedentary behaviors, with older adults, over 60 years of age, spending more than 60% of their day being sedentary when quantified by accelerometers (Matthews et al., 2008). Similar findings were reported when accelerometry was used to quantify this behavior in only older adult samples, suggesting they engaged in anywhere from 5.5-9.5 hours per day in sedentary behaviors (Davis & Fox, 2007; Hagstromer et al., 2007; Matthews et al., 2008; Orsini et al., 2008). Accelerometers have also been used in studies examining the relationship between health outcomes related to type 2 diabetes development and sedentary behavior; with results supporting the self-report literature that suggested the more time spent in

sedentary behavior the greater likelihood of developing adverse health outcomes (i.e., higher glucose values) (Healy et al., 2007). Because these monitors were originally designed to capture bodily movements they are considered to be an indirect measure of sedentary behavior, and because of this, to accurately capture this activity more sophisticated devices need to be used to directly measure sedentary behavior (Hart, McClain, & Tudor-Locke, 2011).

The activPal™ is a newer type of accelerometer designed to directly assess sedentary behavior. It is able to detect both static and dynamic accelerations and is worn on the thigh, allowing the detection of postural changes in behavior (i.e., standing or sitting/lying down postures). It was originally developed to assess postures and inactivity of clinical populations and recently has been demonstrated to be a reliable and accurate assessment of walking and sedentary behavior (Grant, Ryan, Tigbe, & Granat, 2006; Ryan, Grant, Tigbe, & Granat, 2006). There are other devices (i.e., IDEEA) created to assess postures during activity but they are cumbersome for participants and require wearing numerous sensors on different parts of the body (Hart, McClain, & Tudor-Locke, 2011). Because of these sensors, activity can be limited and participants may be less compliant to wearing the device (Grant et al., 2006). The activPal™ has been compared to more cumbersome devices and shown to accurately record the same sitting postures (Hart, McClain, & Tudor-Locke, 2011).

Because the activPal™ is a newer device, to date no studies have quantified sitting/lying down behavior with health outcomes like what has been carried out with the preferred other accelerometers. Other accelerometers do not have the accurate postural features of the activPal™, therefore a combination of both devices could provide an

accurate quantification of the duration, frequency, intensity, and patterns of not just physical activity but more importantly, sedentary behavior. Additionally, use with a self-report diary of sedentary behaviors could capture the contextual information lost when only objective monitors are used to quantify sedentary behaviors.

Summary of Sedentary Behavior Measures

There are a number of self-report questions for quantifying time spent in specific sedentary behaviors, like television viewing, but very few captured a variety of sedentary behaviors, and almost no surveys exist examining this behavior in older adults. This could be problematic when examining the relationship between these behaviors and health if individuals engaged in a variety of sedentary behaviors and not just television viewing. Due to concerns with the accuracy of these questionnaires, researchers used accelerometry to more accurately quantify sedentary behavior. However these objective monitors did not provide descriptive information about what behaviors made up the total time being sedentary. Also to date these monitors do not provide any postural information. Therefore a multi-method approach is necessary to best capture the sedentary behaviors older adults engage in. This approach will also be insightful when examining the relationship between sedentary behaviors and health.

Chapter Summary

It is important to examine the relationship between health and sedentary behavior in older adults. As the "Graying of America" occurs there will be significant changes in our demographics with older adults making up 20% of the population by the year 2030 (Wan et al., 2005). As this occurs the number of health conditions and the costs associated to treat these ailments will rise. Many older adults, 18-70%, have risk factors for chronic

disease development such as type 2 diabetes, high total cholesterol, high blood pressure, and are overweight or obese (CDC, 2003). These risk factors lead to the development of chronic disease conditions (heart disease, cancer, and stroke) that can lead to early death. Because of these changes in demographics and health, the costs of health care are expected to increase 25% (CDC, 2007). However, one of the most cost effective ways to change the health status of older adults is through a reduction in their sedentary behavior and increases in their physical activity participation. Martinson and colleagues (2003) report adults over 50 years of age to lower their average annual health care costs by approximately $2,202 when they increased their physical activity participation from 0-1 days to 3+ days per week.

Even though we know the positive impact physical activity has on older adults (i.e., reductions in mortality, prevention of weight gain, prevention of type 2 diabetes and hypertension, and falls) they still engage in significantly more sedentary behavior than physical activity (Nelson et al., 2007; Matthews et al., 2008; Vogel et al., 2009). As previously mentioned, older adults in the United States engaged in up to nine hours per day of sedentary behavior with very few participating in enough moderate and vigorous physical activity to meet the national recommendations to improve health (Matthews et al., 2008). Despite knowing that older adults participate in large amounts of sedentary behavior, little information is known about the quality of this behavior (i.e., are they sitting/lying), when do they engage in this behavior the most, why do they engage in this behavior (i.e., is it purposeful?, do they enjoy these behaviors?, do they do them with others or alone?), and what sedentary behaviors they actually engage in (i.e., reading, television viewing, playing card games). Before interventions can be conducted to

reduce this behavior more information is needed. Therefore a multi-method approach (i.e., use of self report diaries of sedentary behavior and objective assessment with accelerometry) to assess sedentary behavior is needed to answer these questions. Twenty-four hour self recorded diaries will provide contextual information about sedentary behaviors while the accelerometers will accurately quantify sedentary behavior. Once this information is captured researchers will be more informed and interventions to reduce sedentary behavior can be conducted. The following chapter discusses the methods for a cross-sectional examination of sedentary behavior and health in an older adult population that will examine these questions.

CHAPTER III: METHODOLOGY

The following section describes the experimental design of the study and further describes the participants, the instrumentation, protocol procedures, and statistical analysis.

Study Design

This study uses a multi-method, cross-sectional design with two data collection time points to understand the relationship between sedentary behavior and the cardiometabolic risk factors in older adults.

Independent Variables

Total time in sedentary behaviors measured by accelerometry (i.e., ≤50 cts/min) and total sitting/lying posture measured by the activPal™ accelerometer are the independent variables.

Dependent Variables

The dependent variables for this study are body mass index, waist circumference, total body fat percentage, systolic and diastolic blood pressure, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, fasting blood glucose, and the outcome of having the Metabolic Syndrome based on participant risk factor profiles.

Participants

Seventy-five Caucasian individuals, 65-90 years of age participated in this study. Ninety-five individuals were screened and 28 did not qualify or were not interested in participating. Of the participating sample, two men dropped out of the study after the first visit was completed. The participants were stratified by their physical activity

participation via a telephone screening. The participants were asked to describe their daily physical activity habits to determine their physical activity level. This stratification of the sample permits a broad sample to be recruited, based upon physical activity level. This information was used to determine if the participants engaged in no leisure time physical activity (0-9 minutes per day of moderate to vigorous physical activity), an insufficient amount of physical activity (10-29 minutes per day of moderate to vigorous physical activity) or if they met the current health enhancing physical activity recommendations for older adults (participating in at least 30 minutes of moderate intensity physical activity on five or more days of the week and/or at least 20 minutes of vigorous intensity physical activity on three or more days of the week or any combination of the two) (Nelson, et al., 2007).

The recruitment of participants was from word of mouth and the posting of flyers and ads around the community and at local senior centers across the greater Milwaukee area (see Appendix C and D for recruitment flyer and ad). Participants were included in the study if they were retired (i.e., no longer working in one's primary profession), spoke English as their primary language, and were able to ambulate without an assistive walking device. Individuals were excluded from participation if they were wheel chair reliant or used a walker or cane, had an orthopedic limitation that impaired their walking gait, or had a lower limb amputation (see Appendix B for participant screening form). Participation was not based on health status or medication usage except if individuals had a life threatening condition such as end stage renal disease or stage four cancers.

Protection of Human Participants

The University of Wisconsin-Milwaukee Institutional Review Board (IRB) approved all study procedures to ensure the safety and protection of each participant (see Appendix A for IRB documentation).

Instrumentation

To better understand the participation in sedentary behavior both objective measures of sedentary behavior and physical activity and self-report of sedentary behavior were utilized in this study. Sedentary behaviors were monitored objectively using two triaxial accelerometers and self-reported with a sedentary behavior diary on three-days.

Actigraph GT3X Accelerometer

The Actigraph GT3X (Actigraph, LLC, Pensacola, FL) accelerometer is a small (3.8 x 3.7 x 1.8 cm), lightweight (27 g) triaxial accelerometer. As a person wears the accelerometer their body movements are detected and the accelerations and decelerations of their movements are captured. These bodily movements were measured in magnitudes of 0.05 to 2 Gs. A twelve-bit analog to digital convertor assessed the output produced by the accelerometer at a rate of thirty times per sec or 30 Hertz, thereby digitizing the accelerations. Next the signals generated pass through a filter that band-limits the accelerations within a frequency range of 0.25-2.5 Hertz. This frequency rate is then able to distinguish human movements by filtering out environmental vibrations such as those experienced while driving in a car, therefore only detecting the motions of the participant. Those accelerations measured by the accelerometer are used to assess the intensity of physical activity assess the lack of movement or sedentary behaviors over a user specified time interval or epoch. The epoch length used in this study was 15 seconds and

all three planes of motion (i.e., vertical, medial-lateral, and anterior-posterior) were used so the Actigraph data can be compared to the second accelerometer, the activPal™, which is discussed in the next section.

The Actigraph accelerometer is a valid and reliable device to measure physical activity intensity in both laboratory and field settings across the age-span. The Actigraph accelerometer is a valid instrument in predicting energy expenditure in treadmill walking and running at speeds of 3.0, 4.0, 5.0, and 6.0 miles per hour in younger adults (Freedson et al., 1998; Melanson & Freedson, 1995; Welk, Blair, Wood, Jones, & Thompson, 2000). These energy expenditures positively correlated to oxygen uptake (r=0.82-0.91) (Freedson et al., 1998; Melanson & Freedson, 1995; Welk, Blair, Wood, Jones, & Thompson, 2000). Similar associations are observed in individuals across the age span (20-69 years of age) during walking or running on a treadmill at speeds ranging from 2-8 miles per hour (whole group, r=0.90; across age span r=0.79-0.94) (Miller, Strath, Swartz, & Cashin, 2010). When self-paced moderate to vigorous walking and activities of daily living are examined similar positive correlations are reported for estimating energy expenditure in middle-aged adults (r=0.76) (Hendelman, Miller, Baggett, Debold, & Freedson, 2000). When reliability of these walking trials and activities of daily living are examined the Actigrpah accelerometer results of both trials are positively correlated for walking (r=0.78 trial 1 and r=0.78 for trial 2) and activities of daily living (r=0.58 for trial 1 and r=0.65 for trial 2) (Hendelman, et al., 2000). Using intraclass correlations Welk and colleagues (2004) observed the Actigraph accelerometer to be the most reliable compared to three other accelerometer brands when worn by college aged men and women (r=0.80). When different physical activity intensities are examined, in younger

adults, between left and right hip worn accelerometry for sedentary, light, moderate, vigorous, and moderate to vigorous free-living activity intraclass correlations are high for all intensities (r=0.98-0.99) (McClain, Sisson, & Tudor-Locke, 2007). Collectively, these studies demonstrate moderate to high validity and reliability for the Actigraph accelerometer for use in both laboratory and field studies across the age span although most study samples are in young adults.

activPal™ Accelerometer

The activPal™ (PAL Technologies Ltd., Glasgow, UK) triaxial accelerometer is a small (35 X 53 X 7 mm) lightweight device that is attached centrally on the anterior aspect of the thigh half way between the patella and inguinal crease of the hip. This device can be worn on either leg. This is a piezo-resistive device making it more sensitive to capturing movements compared to more traditional piezo-electric accelerometer and allows acceleration detection down to zero hertz. Therefore the activPal™ is sensitive to both dynamic and static movements. It measures the posture of an activity based on the single axis of the thigh. Proprietary software generates a signal based on the position of the thigh to determine a sitting/lying, standing or walking posture and activity. The activPal™ measures accelerations in magnitudes of 0.01 to 2.00 G's at a sampling rate of 10/sec (10 Hertz) which are summed over a 15 sec epoch. The postural data is sampled at a pre-determined 0.1 sec/sample. The number of steps recorded by the activPal™ is determined by the number of gait cycles or when two steps, left and right foot, are taken. The device records these gait cycles in a range of 0.5 seconds for sprinting to 2 seconds for walking very slowly.

The activPal™ is a reliable and valid device to use for the detection of posture and movements occurring during activities of daily living in both younger and older adults. Grant and colleagues (2006) examine the validity of the sit to stand and stand to sit transitions between the activPal™ and an observer. The activPal™ detected the same total number of sit to stand and stand to sit transitions as the observer did during all tests. When the Bland Altman technique is used the percentage difference for the overall time spent sitting and time spent upright during both the treadmill walking and activities of daily living is <0.3% (Grant et al., 2006). The percentage increases slightly to 1.4% and 2% when the difference for total time spent standing and total time walking is examined (Grant et al., 2006).

Grant and colleagues (2006), also examine the reliability and validity of the activPal in measuring steps and cadence during controlled treadmill walking at five different treadmill speeds (2, 2.5, 3, 3.5, and 4 miles/hr in younger adults and 1.5, 2, 2.5, 3, and 3.5 miles per hour in older adults) and during slow, normal, and fast self-paced track walking (Grant et al., 2008; Ryan et al., 2006). To determine the level of agreement the Bland Altman technique was used between the observer and activPal™ for walking speeds and cadence on both the treadmill and track walking. The difference in cadence for all treadmill speeds and outdoor walking was ≤1.0% and ≤1.1% respectively, and ≤3 steps or 0.6% and ≤1 step for younger and older adults, respectively (Grant et al., 2008; Ryan et al., 2006). Using intraclass correlations, Ryan et al. (2006) found high inter-device reliability among multiple activPals™ for the number of steps taken and cadence (r=>0.99 and r=>0.99, respectively) when they were worn during treadmill walking. Collectively these studies suggest the activPal™ accelerometer to be an accurate and

reliable tool for measuring activity posture, steps, and cadence in both younger and older adults.

Sedentary Behavior Diary

A sedentary behavior diary was provided to each participant to gain a better understanding of what types of sedentary behaviors older adults engage in regularly (See Appendix E for the sedentary behavior diary). The diary was specifically created to explore the sedentary behaviors older adults engaged in. It was originally developed and used in a pilot study to determine if it was an appropriate tool to assess sedentary behavior in older adults. A total of 12 retired older adults between 65-90 years of age participated in the pilot project. Six men and six women completed a total of three diaries on specific days assigned by the researcher (two during the week and one a weekend day) over a one-week assessment period. Originally participants were asked to write down the primary behaviors that took place during every 60-minute period continuously throughout each 24-hour day. Participants were also instructed to circle the position they were in (standing, sitting, lying, or moving), if they were alone (yes/no), and to rate their enjoyment (1 low-5 high) of each behavior reported. One week later participants returned and participated in a 30-minute interview that included a modified cognitive walk-through of the diary.

The results of this pilot study showed that older adults engaged in 12 general behaviors with eight of them being sedentary behaviors. For all three-days, the most common sedentary behaviors were watching TV/movies, eating and reading and the least commonly reported sedentary behaviors were attending appointments and religious services, sitting at the computer, and transportation. More than 50% of the sample

primarily participated in sedentary behaviors between the hours of 8-11am, 12-1pm, and 3-10pm.

During the interview process participants suggested that one-hour was too long of a timeframe to report only one behavior and one primary body position. This information was apparent upon reviewing the diaries and observing participants writing down multiple behaviors and circling multiple positions. With this information a new diary was created for this research project. The new version broke down the one-hour increment periods into shorter 30 minute timeframes with more thorough and specific directions emphasizing writing down just one behavior, circling only one position which was limited to either moving or sitting/lying, circling if they were enjoying the behavior, if they were alone during the behavior, and if they were eating during the behavior. The revised diary was used for this research project to capture information about the types of sedentary behavior older adults engage in and why.

Study Procedures

Information Provided to the Participant

During initial telephone contact the potential participants were provided a brief overview of the study. They were informed that the study was being conducted to understand the relationship between sedentary behavior and health. They were informed that the study consisted of two visits and each visit was to last approximately 30-60 minutes with both visits being conducted within a 2-week period. Participants were informed that they were going to wear two activity monitors that measure the intensity of their daily activities and the posture of their activities for one-week and complete a

sedentary behavior diary on three separate days during that timeframe and undergo a fasting blood draw and body composition assessment.

If the participant still expressed an interest in the study they were screened over the telephone or in person to determine if they met the studies inclusion and exclusion criteria. If the participant met the criteria they were asked to come to the Physical Activity and Health Research Laboratory.

Study Setting

The study procedures took place at the Physical Activity and Health Research Laboratory at the University of Wisconsin-Milwaukee.

Study Protocol

Interested participants read and signed an informed consent document, answered demographic and health information, had anthropometrics and blood pressures measured and underwent a blood draw. Afterwards they were provided instructions on wearing the activity monitors and completing the sedentary behavior diary. One to two-weeks later the participants returned to the laboratory with their monitors and diaries. Then the participant underwent blood pressure reassessments, a body composition assessment, and then received their results of the health variables measured and the blood draw analysis from the previous visit. These procedures are described below in detail.

Testing Procedures – Visit One

When the potential participant expressed interest in the study, they were asked to read and sign the study's informed consent (see Appendix A for the informed consent document). Once this was completed a demographics and health history questionnaire

was completed by the participant. This questionnaire was used to assess demographics, current health status, risk factors for chronic disease, and use of medication.

Cardiometabolic Risk Factor Assessment - Anthropometrics

Next, anthropometrics, blood pressures, and a fasting blood draw was taken to assess the cardiometabolic risk factors related to the development of chronic disease. Anthropometric assessments included measures of height and body mass following standard procedures (American College of Sports Medicine [ACSM], 2006). Body height (cm) and mass (kg) was assessed using a calibrated physician's scale and stadiometer (Detecto, Kansas City, MO). Body height was measured to the nearest 0.1 cm and body mass was measured to the nearest 0.01 kg. Participants wore minimal clothing and no shoes. Body mass index (BMI) was determined by dividing the participant's body mass (kg) by body height in meters squared (m^2). Waist circumference (cm) was determined by using a constant tension tape measure. This measurement was taken around the narrowest part of the torso between the lowest rib and iliac crest according to standard procedures (Lohman, 1988). Waist circumference measures ware taken to the nearest 0.1 cm. All anthropometric assessments were taken at least twice to ensure accuracy. Both of the measures were acceptable if they differed by ≤0.5cm but if either measure was outside this range additional measures were taken until two measures met those criteria.

Cardiometabolic Risk Factor Assessment – Blood Pressure

During both visits blood pressure was assessed on both right and left arm a minimum of two times in accordance with standard procedures (Pickering, et al., 2005). The participant was asked to sit with their feet flat on the floor and their back supported

by a chair. Then the participant was asked to extend their left arm with their palm facing upwards. The researcher then placed the correct size blood pressure cuff (width ≥40% of the arm circumference and length ≥80% of the arms circumference) approximately one inch above the antecubital space over the brachial artery. The researcher then held the participant's arm, which was slightly bent at heart level and took the measurement. A mercury sphygnamometer and stethoscope was used to measure the blood pressure. The blood pressure cuff was inflated approximately 20-30 mmHg above the blood pressure if it was known or to 160-180 mmHg, then the cuff was deflated slowly approximately 2-3 mmHg per second. Simultaneously, the stethoscope was placed over the brachial artery and the 1st and 5th Korotkoff sounds were used to determine the blood pressure values. Each participant had there resting blood pressure taken twice on each left and right arm with the highest arm average systolic/diastolic mmHg recorded as his or her blood pressure. There was at least one minute between each blood pressure measurement. If the first two blood pressures on either arm differed by more than six mmHg systolic and/or four mmHg diastolic then a third blood pressure was taken. This procedure is according to the procedures of the American Society of Hypertension for arm sphygmomanometry (Pickering et al., 2005).

Cardiometabolic Risk Factor Assessment – Blood Draw

According to Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III), to determine a person's risk factors for chronic disease the following fasting blood profile must be taken: total cholesterol, low-density and high-density lipoprotein cholesterols, plasma glucose, and triglycerides

("Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report," 2002).

Participants were asked to fast or refrain from food and caffeinated beverages for 8-12 hours prior to the first visit. During the first visit, after the blood pressure readings, the blood draw procedures were conducted. An evacuated tube method was used to draw five ml of blood into a serum separator/preservative free tube (Vacuette Greiner Bio-One, Monroe NC). Immediately following the blood draw, the blood tube rested for 30 minutes and was centrifuged for 15 minutes. After the serum separated, it was removed and stored in a refrigerator until analyzed by a certified laboratory, Dynacare Laboratories (Milwaukee, WI).

An OLYMPUS® System (Beckman Coulter, Inc.) was used to analyze all blood lipids. Assays of total cholesterol were measured using a reagent that is a combination of esterase and oxidase. The coefficient of variation for the deamination of cholesterol was 1.8% for the low (116.3 mg/dL) to 2.1% for the high values (265.5 mg/dL). When the triglycerides were measured a series of coupled enzymatic reactions were used and the absorbance change was proportional to the concentration of triglyceride. The coefficient of variation for this method was 2.5% for the low (100 mg/dL) to 1.2% for the high (250 mg/dL) values. A two reagent homogenous system was used to assess both the low-density and high-density lipoprotein cholesterols. The coefficients of variation were 3.39% for the low (51.99 mg/dL) to 3.84% for the high (121.79 mg/dL) low-density lipoprotein cholesterol. When high-density lipoprotein cholesterols were analyzed with this methodology the coefficients of variation were 3.43% and 3.8% for the low (38.59

mg/dL) to high (85.09 mg/dL) values, respectively. Glucose was analyzed using the hexokinase G-6-PDH method and the coefficient of variation for glucose was 1.4% for the low (65 mg/dL) to 1.2% for the high (268 mg/dL) value.

Instrument and Sedentary Behavior Diary Directions

Lastly at the end of the first visit, each participant received directions and the equipment for wearing the accelerometers and completing the sedentary behavior diaries. Everyone was provided an adjustable elastic belt with the Actigraph accelerometer already attached to it. Step by step directions and additional information about wearing the devices was provided (see Appendix F for accelerometer directions). Specifically, the participants were instructed to wear the devices for the next seven consecutive days, all day long from when they awoke to before just before falling asleep for the night and to return the devices on their second visit. They were also instructed to wear the elastic belt, at waist level with the Actigraph accelerometer over the right hip on the anterior midline of the thigh. Lastly, the participants were informed that the monitor is not to be worn in the shower or while participating in water activities because it is not water resistant. The researcher had the participant demonstrate how to wear the belt and it's positioning before leaving the laboratory.

Participants also were provided with directions for wearing the second accelerometer, the activPal™. Participants received an activPal™ accelerometer and a roll of hypoallergenic adhesive tape that is waterproof and directions were provided to these participants in the same manner as the Actigraph. Specific instructions for the activPal™ included having the participant place the device on the anterior midline of the

thigh half way between the patella and the inguinal crease and to secure with the tape provided. Either leg could be used during the study period.

Once the accelerometers were explained the sedentary behavior diaries were shown to each participant. Participants were instructed to complete a 24-hour sedentary behavior diary on three specific days, which were assigned by the researcher during the same week the accelerometers were worn. The researcher assigned each participant two weekdays and one weekend day to complete the diaries. Then each participant was shown an example of how to complete the sedentary behavior diaries. Specifically, participants were asked to record the specific behavior they did during the majority of each half hour and then to circle whether they were sitting/lying or moving, if they were alone during the behavior (yes/no), if they were eating during the behavior (yes/no), and to rank the enjoyment level of the behavior [1 (highly enjoyable) to 7 (least enjoyable)].

Testing Procedures - Visit Two

Prior to the second visit participants received the following directions. They were asked to wear minimal clothing and to be euhydrated. During the second visit the participant's weight was taken prior to the scanning to ensure there were no weight changes from the first visit. Then the procedure was explained to the participant before they were situated on the DXA scan. They were asked to refrain from talking and moving during the scan. After the DXA scan, the regions of interest were adjusted if necessary to ensure precise results.

Upon returning from the one-week monitoring period the participants returned their monitoring devices and their sedentary behavior diaries. At this point, the researcher reviewed the diaries to ensure their completion and downloaded the accelerometer to

ensure it was worn for at least five days for ≥10 hours per day. If either the diaries or the accelerometer were incomplete or not worn the participant was asked to complete three more diaries and wear the accelerometers for an additional week. If they were not interested in repeating these study procedures they were dropped from the study and their data was used up until that point. After the review of accelerometers and diaries the participants had their blood pressures taken again in the same manner as during visit one. Additionally participants underwent a body composition assessment. Afterwards participants were provided with a summary of the anthropometrics, blood pressure, their total body fat percentage, and blood lipid panel results.

Cardiometabolic Risk Factor Assessment – Body Composition

Body composition tests were conducted using the Dual Energy X-ray Absorptiometry (DXA; Lunar Prodigy, General Electric Lunar Corporation, Madison, WI). For this research project, total body fat percentage was used to estimate body fatness. The total bodyscan lasted anywhere between 6-11mins depending on the participant's height, weight, and body thickness. The total amount of radiation the participants were exposed to was approximately 0.00004 mrem units of radiation. This was significantly less than traveling across the country by plane or receiving a chest x-ray in which participants are exposed to 0.01 mrems. However this exposure was added to their yearly exposure of 0.3 mrems and their total lifetime exposure. Participants were informed of the radiation exposure during the informed consent.

This procedure provided an estimate of a three-compartment model of body composition (i.e., fat mass, bone mineral, and mineral free lean tissue). The DXA uses pencil beam x-ray technology. Each participant lay supine on a padded table and a

mechanical scanner arm moved slowly down the length of the body making one cm transversus scans. The x-ray source is underneath the padded table and the x-rays passed up through the participant. During this time a detector within the scan arm captured and measured the energy transfer of the x-rays. Based on the absorption of this energy by the soft tissue body composition was determined for the entire body. Therefore a greater absorbance equated to a higher body fat percentage and a lower absorbance equated to a lower body fat percentage.

The DXA was observed to be an accurate and precise measurement tool when compared to a four-compartment model of body composition as the gold standard, underwater weighing, and total body water in an older adult sample (Goran, Toth, & Poehlman, 1998). The DXA accounted for approximately 73-78% of the variance in body fat by the four-compartment model and this percentage was lower compared to the other techniques (Goran, Toth, & Poehlman, 1998). However when the Bland-Altman analysis was conducted the DXA did not demonstrate to over or underestimate fat mass in men or women as the other techniques did, the *r-value* was non-significant. These studies supported the validity and reliability of using the DXA to assess body composition.

Data Reduction

Accelerometry Data

The Actigraph and activPal™ accelerometer data were downloaded to a computer through a USB 2.0 connection. Then the data was downloaded and converted into a Microsoft Excel file. To ensure validity and reliability of the Actigraph standardized data quality procedures were conducted (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005).

To date there are no standardized data quality procedures for the activPal™ so similar procedures as the Actigraph were followed. Data considered being both valid and reliable according to the following procedures were used for this analysis. Any block of time ≥ 60 minutes where the activity count is equal to zero was considered time when the monitor was not worn and only days during which the accelerometers were worn for ≥600 minutes was counted as valid days of data (Masse et al., 2005). While participants were asked to wear the accelerometers for seven consecutive days, some participants did not wear them for the full week. Only participants who had at least five complete days of valid accelerometer data were included in this analysis. This number of days ensures at least 80% reliability of activity counts and minutes of moderate to moderate plus vigorous physical activity (500-5724 cts/min) measurement increasing to 90% if worn for seven days with similar results for inactivity (≤499 cts/min) (Matthews, Ainsworth, Thompson, & Bassett, 2002).

Participant's Actigraph accelerometer physical activity was described according to cut point ranges in cts/min, measured by the accelerometer, time spent in sedentary behavior = ≤ 50 cts/min, light intensity physical activity 51-759 cts/min, moderate lifestyle intensity physical activity = 760-5724 cts/min, moderate walking intensity physical activity = 1952-5724 cts/min, and vigorous intensity physical activity = ≥ 5725 cts/min (Freedson et al., 1998; Matthews, 2005; Crouter et al., 2006). Cut points were developed from the use of regression formulas to predict the intensity of physical activity from cts/min achieved by accelerometer. These equations were developed to predict energy expenditure and were derived from various treadmill activities (i.e., walking and running) as well as lifestyle activities (i.e., sitting, standing, washing dishes, vacuuming,

mopping). Depending on which equation is used many of the activities energy expenditure can be under or over predicted with accelerometry. Crouter and colleagues (2006) observed most sedentary behaviors were commonly over predicted and clumped together with light activities or those with a MET value up to 2.5. They also noticed that most sitting and lying behaviors measured as ≤50 cts/min with accelerometry coinciding with a MET value of 1.0 and more accurately depicted sedentary behavior (Crouter et al., 2006).

The most common cut points used for light, moderate and vigorous physical activity intensities are those developed by Freedson, Melanson and Sirard (1998). Individuals were asked to walk and then run on a treadmill at various speeds corresponding to light, moderate, hard (vigorous) and very hard intensities. A regression equation was developed to correspond with oxygen consumption allowing the development of accelerometer count ranges or cut point's equivalent to physical activity intensity measured in METs. There was a positive linear relationship between the accelerometry counts and MET values determined by measuring oxygen consumption (r=.88) with increased variability at MET values greater than seven when compared to moderate activity MET values of 3-6 (Freedson et al., 1998). When the cut points were examined for prediction of MET values corresponding to light, moderate, hard (vigorous) and very hard physical activity there was a strong shared variance (R^2=.82) (Freedson et al., 1998).

Despite the use of the Freedson and colleagues (1998) cut points for various physical activity intensities there is still some skepticism surrounding other activities of daily living (i.e., washing dishes and vacuuming) that are metabolically a moderate work

load that is not captured by the above moderate intensity cut points of 1952-5724 cts/min. To overcome this concern Matthews and colleagues (2005) have a cut point range of 760-5724 cts/min, which captured a wider range of moderate intensity activities. This value was developed through a combination of accelerometry data cts/min collected during six light and six moderate activity tasks. Researchers created upper and lower cts/min range and used the intermediate value as the criterion cts/min (i.e., 690 cts/min) (Matthews, 2005). This value was cross-validated with cts/min 10% above and below the criterion cts/min (i.e., 575, 690, and 760 cts/min) (Matthews, 2005). This information was then compared to time spent in moderate intensity free-living physical activity that was determined by both oxygen consumption and 24-hour physical activity recall surveys. When all three cts/min ranges were cross-validated with the time spent in free living moderate physical activity, the 760-5724 cts/min range provided the best estimate of time spent in moderate lifestyle physical activity compared to the other cts/min with a difference of 7.4 measured minutes compare to 21.3 minutes and 11.8 minutes from the 575-5724 and 690-5724 cts/mins, respectively (Matthews, 2005). Collectively these studies support the examination of these various cts/min ranges that was used in the current study (i.e., sedentary behavior = 0-50 cts/min, moderate general = 760-5724 cts/min, moderate walking = 1952-5724 cts/min, and vigorous = ≥5725 cts/min).

Sedentary Behavior Diary

All sedentary behavior diaries were examined for missing data. All activities were entered into the database. This information was used for descriptive analysis. The average time spent in all sedentary behaviors were reported and frequencies of the most

prevalent sedentary behaviors were determined. Independent *t*-tests were used to examine gender and week-day versus weekend day differences in sedentary behaviors.

Cardiometabolic Risk Factor Analysis - Metabolic Syndrome

Metabolic Syndrome is a combination of lipid and non-lipid risk factors with metabolic origins (NCEP, 2002). To determine whether a participant had the Metabolic Syndrome, the researcher used the criteria from the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) and the International Diabetes Federation (IDF). The participant must have three or more of the risk factors shown below in Table 1 (Clinical Identification of the Metabolic Syndrome) to be classified as having Metabolic Syndrome. The blood pressures from the left and right arm were averaged on visit one and two, and these results were used to assess the blood pressure as a risk factor. The blood pressure on both visits needed to meet the criteria to be determined as having the risk factor for high blood pressure.

Table 1

Clinical Identification of the Metabolic Syndrome

Risk Factor	Defining Level
Abdominal Obesity	Waist Circumferences
Men	≥ 102 cm (> 40 in)
Women	≥ 88 cm (> 35 in)
Triglycerides	≥ 150 mg/dL or specific treatment of this abnormality
HDL cholesterol	
Men	≤ 40 mg/dL or specific treatment of this abnormality
Women	≤ 50 mg/dL or specific treatment of this abnormality
Blood Pressure	≥ 130 mmHg systolic and/or ≥85 mmHg diastolic or treatment of previously diagnosed hypertension
FBG	≥ 100 mg/dL

Note. Adapted from Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) and the International Diabetes Federation. HDL = high-density lipoprotein cholesterol; FBG = fasting blood glucose. ACSM, 2006.

Data Analysis

Statistical Analysis

A power analysis was conducted to determine the number of participant's necessary to achieve 80-90% power using linear regression analysis. Based upon the regressed relationship between sedentary behavior measured by the Actigraph accelerometer and the cardiometabolic risk factors (i.e., waist circumference, body mass index, triglycerides, high density cholesterol, systolic blood pressure, diastolic blood pressure, fasting plasma glucose and 2 hour plasma glucose) for chronic disease in a sample of overweight (BMI 27.2 ± 4.7) adults (53.4 ± 11.8 years of age) demonstrated in the literature (Healy, Dunstan, Salmon, Cerin, et al., 2008), a R^2=0.26 was used to determine a sample size of 57-69 participants to yield a power of 0.80-0.90. To adjust for potential dropout rates, equipment malfunctions, or missing data values, there were an additional 20% of individuals recruited for a range of 68-83 participants to achieve a minimum power of 0.80.

For this study's statistical analysis SPSS® 18.0 for Windows (SPSS Inc., Chicago, IL) was used to conduct all analyses. The significance for all statistics was set at a level of $\alpha = 0.05$, two-tailed, unless otherwise stated. All data analyzed was checked for errors or out of range data points in both data collection and entry into SPSS. If errors were identified they were corrected. Violations of the assumptions for all statistical analyses were tested and the appropriate data transformations and adjustments were made prior to conducting any analysis if violations existed.

First descriptive statistics were calculated for all demographic, accelerometry, cardiometabolic risk factor variables, and the types of sedentary behaviors reported in the

diaries. The information from the behavior diary was analyzed with frequencies. The descriptive statistic variables and the sedentary behavior, alone, eating, eating while alone, and enjoyment levels were compared between genders or weekend and weekdays with independent *t*-tests with the significance set at a level of $\alpha = 0.05$, two-tailed.

One-way analysis of variance was used to examine differences in sedentary behavior across levels of physical activity participation and to assess differences in health variables across levels of sedentary behavior. Physical activity levels were determined by dividing the groups into three equal percentages. Two-way analysis of variance was used to explore differences in sedentary behavior between gender and across age categories. Both analyses were conducted using each accelerometer measured sedentary behavior. The following assumptions were examined, normality, homogeneity of variance and independence of observation.

Next partial correlations and Pearson correlations were generated to determine the strength of the relationships between total time (mins/d) spent in sedentary behavior measured by the Actigraph accelerometer and the total time (mins/d) spent in sitting/lying down postures measured by the activPal™ with each of the measured cardiometabolic risk factors for chronic disease with total time spent in moderate to vigorous physical activity being statistically controlled. The significance for the partial correlations was set at a level of $\alpha = 0.05$, one-tailed and the significance for the Pearson correlations was set at a level of $\alpha = 0.05$, two-tailed. Normality, linearity, and homogeneity of variance of the predictor and control variables were tested for violations of assumptions.

Linear regression analysis was conducted to determine if total time (mins/d) spent in sedentary behavior measured by the Actigraph accelerometer could predict each of the

measured cardiometabolic risk factors. This same analysis was repeated using total time (mins/d) spent in sitting/lying down postures measured by the activPal™. For both analyses age, gender, accelerometer time worn, and total time spent in moderate to vigorous physical activity measured by the accelerometers were adjusted as potential confounders. There are four assumptions associated with this statistic and each were examined: linearity between the independent and dependent variables, independence of error terms, homoscedasticity, and normality of error terms.

The last analysis conducted was logistic regressions. The first regressions were used to determine if moderate or high volumes of sedentary behavior could predict certain health variables found to be significantly related in the Pearson correlation analysis. In this analysis age, gender, and accelerometer wear time additionally medication usage were controlled in necessary. Then the independent predictors of moderate and high volumes of both accelerometry assessed sedentary behavior and moderate to vigorous participation in physical activity with the Actigraph accelerometer were added. Low volumes of both behaviors were used as referent groups.

The second logistic regressions were used to determine whether sedentary behavior measured by both accelerometers could predict participant classification of having Metabolic Syndrome. The predictors entered into the model were the control variables age and gender, the independent predictors of moderate and high volumes of both accelerometry and the independent predictors of moderate and high volumes of sedentary behavior. Low volumes of both moderate to vigorous physical activity and sedentary behavior were used as referent groups.

Assumptions for logistic regressions are dichotomy and independence of the outcome variable scores (multicollinearity), all relevant predictors were entered into the model, and the outcome variable was mutually exclusive meaning the study participants fell into only one category of the outcome variables. Violations for these assumptions were tested prior to analysis.

CHAPTER IV: RESULTS

Introduction

The intention of this study was to examine whether a relationship exists between objectively determined total time spent in sedentary behavior and cardiometabolic risk factors in community dwelling older adults, as well as, to explore the descriptive characteristics of sedentary behavior. The beginning of this chapter presents an overview of the demographic information, the cardiometabolic risk factor profiles of the participants, and the measured time spent in sedentary behavior and physical activity. Following these results, the statistical analyses are discussed in the following order: the partial correlations and Pearson correlations between total time spent in sedentary behavior from both the Actigraph accelerometer and then the activPal™ accelerometer and each health outcome, logistic regressions to examine whether sedentary behavior predicts specific anthropometric and metabolic variables, one-way analysis of variance to determine differences in health across physical activity levels, hierarchical regression analysis to determine if total time spent in sedentary behavior can predict each health outcome, and lastly the logistic regressions to predict participant classification of having the Metabolic Syndrome. Then the description of commonly reported sedentary behaviors are presented as well as the factors associated with engaging in these behaviors.

Participant Characteristics

There were seventy-three adults 65-90 years of age who completed the study protocol. However, not all participants had complete data in the following areas: three women participants did not have blood pressure values due to a history of breast cancer,

one participant did not have blood lipid analysis because of the technician's inability to draw the blood, one male participant did not have Actigraph accelerometer data and one male participant did not have activPal™ accelerometer data due to device malfunction, and two female participants recorded only two days of sedentary behavior diaries because they chose to not complete the third day. The available data for these participants was used in other analyses.

Participant Demographics

A majority of this sample is married (52.1±1.08%), does not live alone (60.3±0.5%), and completed college and/or graduate school (68.5±0.78%). Participants in this study have been retired for approximately 11.5±9.4 years and 58.9±0.5% of this sample volunteers for 3.1±5 hours per week. Many individuals in this study are taking over the counter and/or prescription medications (91.8±0.28%) and doctor prescribed medication specifically to control hypertension (45.2±0.5%), hyperlipidemia (52.1±0.5%), and diabetes (2.7±0.16%).

Participant Characteristics of Cardiometabolic Variables

The participant cardiometabolic characteristics (anthropometric, metabolic, and cardiovascular) are discussed and the results are presented in Table 2. To determine if gender differences occurred independent *t*-tests were performed. Gender differences were apparent at the .05 level, men were significantly taller, weighed more, and had larger waist circumferences, higher body fat percentages, and higher total cholesterol values but lower high-density lipoprotein cholesterol than the women.

Table 2

Participant Characteristics

Cardiometabolic Characteristics	Women ($n = 47$)	Men ($n = 26$)	All ($N = 73$)
Anthropometrics			
Age (yrs)	73.5±5.8	73.6±6.4	73.5±5.9
Height (cm)	161.8±5.5	173.1±7.9*	165.8±8.4
Weight (kg)	69.8±13.9	81±13*	73.8±14.5
BMI (kg/m^2)	26.7±5.2	27±3.9	26.8±4.8
WC (cm)	82.9±11.5	92.4±10.6*	86.3±12
Body Fat (%)	36.2±8.8	24.9±7.7*	32.2±10
Metabolic			
LDL-C (mg/dL)	104.6±26.7	96.8±29.8	101.8±27.9
HDL-C (mg/dL)	65.3±17.2	56.5±15.3*	62.1±17
Triglyceride (mg/dL)	123.1±60.5	101.2±49.3	115.2±57.4
FBG (mg/dL)	91.1±8.2	96.5±15.1	93.1±11.4
Total Cholesterol (mg/dL)	194.5±31	165.9±43.2*	184.1±38.2
Cardiovascular			
V1 Left Arm SBP‡†	125.1±16.9	123.4±10.2	124.5±14.7
V1 Left Arm DBP‡†	76.4±9.4	79.6±9.7	77.6±9.6
V1 Right Arm SBP‡	125.5±14.7	123.4±10.7	124.8±13.4
V1 Right Arm DBP‡	77.1±8.9	79±10	77.8±9.3
V2 Left Arm SBP†	121.1±13.3	119.8±14.8	120.6±13.8
V2 Left Arm DBP†	72.9±8.2	78±9.6*	74.8±9
V2 Right Arm SBP	120.9±13.3	119.8±14.6	120.5±13.7
V2 Right Arm DBP	73.8±8.2	75.3±11.7	74.3±9.6

Note. Values represent mean ± standard deviation. BMI = Body Mass Index; WC = waist circumference; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; FBG = Fasting Blood Glucose; V = visit 1 or 2; SBP = systolic blood pressure; DBP = diastolic blood pressure. Men significantly different from women at *$p < .05$. Differences in blood pressure between visit 1 and 2. ‡ $p < .05$. Differences between left and right arm blood pressure values† $p < .05$.

Participant Risk Factor Profile for Chronic Disease

Many of the participants in this study also have risk factors for chronic disease development. Table 3 displays the percent of individuals with or without risk factors for Cardiovascular Disease. In accordance with the American College of Sports Medicine Risk Factors for Atherosclerotic Cardiovascular Disease (2006), 11.1% of participants were classified as low risk, 59.7% as moderate risk, and 29.2% as high risk for Cardiovascular Disease development (low risk is $\leq$1 risk factor, moderate risk is $\geq$2 risk factors, and high risk is someone with a known cardiovascular, pulmonary or metabolic disease or one or more signs and symptoms of disease). Additionally, 23.3% of the participants also meet the criteria for having the Metabolic Syndrome as discussed previously in Table 1 (page 74). The percentage of participants with the risk factors for the Metabolic Syndrome is presented in Table 4. When independent *t*-tests were conducted to determine whether gender differences occurred between frequencies of having a risk factor for either Cardiovascular Disease or the Metabolic Syndrome there were no statistically different frequencies between men and women.

Table 3

Percentage of Individuals with Risk Factors for Cardiovascular Disease

	Women (n=47)		Men (n=26)		All (N=73)	
Risk Factors for CHD	Yes	No	Yes	No	Yes	No
Positive Risk Factor						
Age	100	0	100	0	100	0
Family History	17	83	30.8	69.2	21.9	78.1
Smoking	4.3	95.7	0	100	2.7	97.3
Sedentary	53.2	46.8	34.6	65.4	46.6	53.4
Obesity	31.9	68.1	26.9	73.1	30.1	69.9
Hypertension	42.6	57.4	53.8	46.2	46.6	53.4
Dyslipidemia	68.9	31.1	76.9	23.1	71.8	28.2
Prediabetes	15.6	84.4	30.8	69.2	21.1	78.9
Negative Risk Factor						
HDL-C	53.3	46.7	30.8	69.2	45.1	54.9

Note. CHD = Coronary Heart Disease; HDL-C = high-density lipoprotein cholesterol. A negative risk factor decreases the risk for cardiovascular disease risk. A person was considered to have a risk factor (yes or no) in the following way: Age for men ≥45 years of age; women ≥55 years of age; Family history of myocardial infarction, coronary revascularization, or sudden death before 55 years of age in father or other male first-degree relative, or before 65 years of age in mother or other female first-degree relative; Cigarette smoking if current cigarette smoker or those who quit within the previous six months; Sedentary lifestyle of not participating in at least 30 minutes of moderate intensity (40-60% VO_2R) physical activity on at least three days of the week for at least three months; Obesity if they have a body mass index of ≥30 kg/m^2 or waist girth >102 cm for men and > 88 cm for women; Hypertension if they have systolic blood pressure ≥140 mmHg and/or diastolic ≥90 mmHg, confirmed by measurements on at least two separate occasions or on antihypertensive medication; Dyslipidemia if they have low-density lipoprotein cholesterol of ≥130 mg/dL or high density lipoprotein cholesterol <40 mg/dL or on a lipid-lowering medication or if total serum cholesterol is available use ≥200 mg/dL; Prediabetes if they have impaired fasting glucose of ≥100 mg/dL but <126 mg/dL; High-density lipoproteins can be a negative risk factor if they have ≥60 mg/dL. (ACSM, 2006).

Table 4

Percentage of Individuals with Risk Factors for the Metabolic Syndrome

	Women (n=47)		Men (n=26)		All (N=73)	
Risk Factors for MS	Yes	No	Yes	No	Yes	No
Obesity	34	66	19.2	80.8	28.8	71.2
Triglycerides	27.7	72.3	11.5	88.5	21.9	78.1
HDL-C	12.8	87.2	3.8	96.2	9.6	90.4
Blood Pressure	51.1	48.9	53.8	46.2	52.1	47.9
Fasting Blood Glucose	2.1	97.9	11.5	88.5	5.5	94.5

Note. Presence of Metabolic Syndrome for the entire group = 23.3%, women = 25.5%, and men = 19.2%. MS = Metabolic Syndrome; HDL-C = High-density lipoprotein cholesterol. A person was considered to have a risk factor (yes or no) in the following way: Obesity >102 cm for men and >88 cm for women; Triglycerides ≥150 mg/dL or medication treatment of this abnormality; High-density Lipoprotein <40 mg/dL for men and <50 mg/dl for women or specific medication treatment of this abnormality; Blood pressure ≥130 mmHg and/or ≥85 mmHg (systolic/diastolic) or medication treatment of previously diagnosed hypertension, right and left blood pressures were averaged for visit one and visit 2 and if both blood pressures met this criteria they had the risk factor for blood pressure; Fasting glucose >100 mg/dL. (ACSM, 2006).

Participant Sedentary Behavior and Physical Activity Profiles

The information recorded by the Actigraph and activPal™ accelerometers are presented in Tables 5 and 6, respectively. Each table displays information about the sedentary behavior and physical activity profiles of the sample. In general the participants were compliant and wore both monitors for 6.8 days out of a possible 7 days. They wore the devices for approximately 15.7 hours per day and of those hours approximately 8-10 hours per day were spent in sedentary behaviors.

When health promoting moderate and vigorous physical activity was examined only 19.3 minutes of the day was spent in this behavior. Based on the accelerometer assessment of physical activity participation in moderate to vigorous physical activity, 39.7% engaged in no leisure time moderate to vigorous physical activity (0-9 minutes per day), 32.9% engaged in an insufficient amount of moderate to vigorous physical activity (10-29 minutes per day), and 26% engaged in ≥30 minutes per day of moderate to vigorous physical activity.

When independent *t*-tests were conducted to determine if there were gender differences for time spent in either sedentary behavior or physical activity, significant differences were evident at the .05 level. The men engaged in significantly more sedentary behavior (M=652.9 minutes per day, SD=91.7 minutes per day, $t(70) = 2.949$, p=.004) than the women (M=595.8 minutes per day, SD=70 minutes per day), and stood less (M=3.2 hours per day, SD=1 hours per day, $t(70) = -3.093$, p=.003) than the women (M=4.2 hours per day, SD=1.4 hours per day). However the men participated in significantly more health promoting moderate (M=25.8 minutes per day, SD=16.9 minutes per day, $t(70) = 2.918$, p=.005) and combined moderate to vigorous physical

activity (M=26.2 minutes per day, SD=17.1 minutes per day, $t(70) = 2.665$, p=.010) than the women (moderate physical activity, M=14.5 minutes per day, SD=14.9 minutes per day; moderate to vigorous physical activity, M=15.6 minutes per day, SD=15.7 minutes per day).

Unfortunately, there was a lack of variation in the time spent engaging in sedentary behaviors. There was a wide range of time spent in sedentary behaviors assessed with the Actigraph, 449.7 minutes per day or 7.4 hours per day. However when the group was divided into low (≤549.4 minutes per day or 9.2 hours per day), moderate (549.4-645.3 minutes per day or 9.23-10.8 hours per day), and high (≥645.3 minutes per day or ≥10.81 hours per day) volumes of time engaged in sedentary behaviors the majority of the sample (76.7%) engaged in moderate to high amounts of sedentary behavior whereas 21.9% engage in low amounts of sedentary behavior. Even less variability occurred between genders, there was only 57.1 minutes per day difference between men and women in the average time spent in sedentary behavior or 4.6%. There was slightly more variation when time spent in sedentary behavior was examined with the activPal™ for low (≤452.5 minutes per day or ≤7.5 hours per day, 35.6%), moderate (452.51-518.8 minutes per day or 7.56-8.64 hours per day, 34.2%), and high (≥518.89 minutes per day or ≥8.65 hours per day, 28.8%) volumes. The majority of the sample (63%) engaged in moderate to high volumes of sedentary behavior. However no variation in time spent in sedentary behavior was observed between genders for time spent in sedentary behavior.

Table 5

Actigraph Accelerometer Sedentary Behavior and Physical Activity Profiles

Variables	Women (*n*=47)	Men (*n*=25)	All (*N*=72)
Wear Time (mins/d)	935.1±68.3	955.3±72.2	942.1 ± 69.8
Days worn	6.8±0.5	6.9±0.4	6.8 ± 0.5
SB Variables			
SB (mins/d)	595.8±70	652.9±91.7*	615.6 ± 82.3
% Day in SB	63.8%	68.4%*	65.4%
PA Variables			
LPA (mins/d)	55.8±28.5	57.2±24.8	56.3 ± 27.1
MPA (mins/d)	14.5±14.9	25.8±16.9*	18.4 ± 16.4
VPA (mins/d)	1.1±2.6	0.5±1	0.9 ± 2.2
LMVPA (mins/d)	71.4±38.7	83.4±37	75.6 ± 38.3
MVPA (mins/d)	15.6±15.7	26.2±17.1*	19.3 ± 16.87
Counts/day	189625±85516	216055±90434	198802 ± 87539

Note. Values represent mean ± standard deviation. SB = sedentary behavior (≤50 cts/min); LPA = lifestyle and moderate physical activity (760-5724); MPA = moderate physical activity (1952-5724 cts/min); VPA = vigorous physical activity (≥5725 cts/min); LMVPA = lifestyle physical activity (≥760 cts/min); MVPA = moderate and vigorous physical activity (≥1952 cts/min); Mins/d = average minutes per day. Men significantly different from women, $*p < .05$.

Table 6

ActivPal™ Accelerometer Sedentary Behavior and Physical Activity Profiles

Variables	Women (n=46)	Men (n=26)	All (N=72)
Days worn	6.7±0.8	6.9±0.4	6.8±0.7
SB Variables			
Sit/Lie Time (mins/d)	485.8±51.3	469.5±59.3	479.9±54.8
PA Variables			
Sit to Stand Transitions	46.9±13.1	46.7±12.5	46.8±12.8
Standing Time (hrs/d)	4.2±1.4	3.2±1*	3.8±1.3
Stepping Time (hrs/d)	1.7±0.6	1.8±0.6	1.7±0.6
Steps/day	7755.1±3253.1	8411.6±3085.8	7992.2±3187.6

Note. Values represent mean ± standard deviation. SB = Sedentary Behavior; PA = Physical Activity; Hrs/d = average hours per day; Mins/d = avaerage minutes per day. Sit to Stand transitions = average number per day. Men significantly different than women, *$p < .05$.

Differences in Sedentary Behavior Across Age and Gender

A two-way between groups analysis of variance was conducted to explore whether gender and age had an impact on older adult sedentary behavior. When examining the differences the effect sizes are interpreted as .01 = small, .06 = medium, .14 = large (Cohen, 1988). If the initial results were significant post hoc analysis was conducted with the Tukey HSD test. If interaction effects occurred further one-way analysis of variance was conducted to determine the simple effects. The older adults were divided into three age categories, (n=27,65-69 years; n=31, 70-79 years; n=27, 80-90 years of age) and gender. The results in Table 7 are presented according to measurement device, the Actigraph and the activPal™.

Actigraph - Daily Time Spent in Sedentary Behavior

The Actigraph accelerometer was used to determine daily time spent in sedentary behavior. When differences in daily sedentary behavior were examined there were significant main effects for gender, $F(1,66)=10.673$, $p=.002$, eta squared, .14 and age, $F(2,66)=3.330$, $p=.042$, eta squared, .09. Post hoc analysis approached significance, $p=.056$, between the 65-69 year olds (M=590 minutes per day, SD=60.88 minutes per day) and the 80-90 year olds (M=650.52 minutes per day, SD=93.12 minutes per day). The men engaged in significantly more sedentary behavior across all age groups. The interaction effect was not significant, $F(2,66)=.468$, $p=.628$, eta squared, .014.

Table 7

Differences in Sedentary Behavior Between Gender and Age

	Actigraph – Daily Time in SB (mins/d)			Actigraph – Portion of Day in SB (%)			activPal™ – Daily Time in SB (mins/d)		
	All (*N*=27)	Women (*n*=16)	Men (*n*=11)	All (*N*=27)	Women (*n*=32)	Men (*n*=13)	All (*N*=27)	Women (*n*=16)	Men (*n*=11)
65-69 yrs	590±60.9	571±54.1	617.6±61.9*	64.1±7	61.2±5.6	68.3±6.9*	498.5±57.3+	491.5±53.1	508.7±64.1
	All (*N*=31)	Women (*n*=24)	Men (*n*=8)	All (*N*=27)	Women (*n*=32)	Men (*n*=13)	All (*N*=31)	Women (*n*=23)	Men (*n*=8)
70-79 yrs	623.1±88.8	609.3±81.1	664.5±103.7*	66.6±8.4	65.9±7.7	68.9±10.6*	478.7±48	487.5±49.2	453.4±35.8
	All (*N*=27)	Women (*n*=7)	Men (*n*=7)	All (*N*=27)	Women (*n*=32)	Men (*n*=13)	All (*N*=14)	Women (*n*=7)	Men (*n*=7)
80-90 yrs	650.5±93.1	606.3±50.5	702.1±108.7*	65.1±6.6	62.7±4.1	67.9±8.2*	446.7±49.3	467.3±57.9	426.1±30.4

Note. Values represent means ± standard deviations. SB = Sedentary Behavior. * Gender difference for daily time spent sedentary and the percent of day spent sedentary measured by the Actigraph, $p<.05$. + Age differences for activPal determined sedentary behavior between the 65-69 year olds and the 80+ year olds in men only, $p<.05$.

Actigraph - Percent of Day in Sedentary Behavior

The Actigraph accelerometer was also used to determine percent of day engaged in sedentary behavior. The total time spent in sedentary behavior was divided by how long the accelerometer was worn to get a percent value. There was a significant main effect for gender, $F(1,66)=6.932$, $p=.011$, eta squared, .095 but not age, $F(2,66)=.844$, $p=.435$, eta squared, .025. The men spent a larger portion of their day being sedentary than the women. There was no significant interaction effect, $F(2,66)=.484$, $p=.619$, eta squared, .014.

activPal™ - Daily Time Spent in Sedentary Behavior

When daily time spent in sedentary behavior was assessed with the activPal™ there was a significant main effect for age, $F(2,66)=5.355$, $p=.007$, eta squared, .14 but not gender, $F(1,66)=2.140$, $p=.148$, eta squared, .031. There were significant differences in sedentary behavior between the 65-69 year olds (M=498.51 minutes per day, SD=57.59 minutes per day) and the 80-90 year olds (M=446.7 minutes per day, SD=49.29 minutes per day). The 70-79 year old group (M=4478.73 minutes per day, SD=47.98 minutes per day) did not engage in a significantly different amount of sedentary behavior from their younger and older peers. The main effect for gender, $F(1,66)=2.140$, $p=.148$, eta squared, .03 and the interaction effect were not significant, $F(2,66)=2.188$, $p=.120$, eta squared, .062.

Differences in Sedentary Behavior Across Levels of Physical Activity

There are national recommendations for the amount of physical activity necessary to promote health for the general population as well as for older adults. The amount needed to promote and maintain health for this age group is a minimum of 30 minutes of

moderate intensity aerobic activity on five or more days of the week and/or a minimum of 20 minutes of vigorous intensity aerobic activity on three or more days of the week (Nelson et al., 2007). This amount of regular physical activity is positively associated with a reduction in cardiovascular disease, stroke, hypertension, stroke and helps maintain physical function and is therapeutic for many chronic disease conditions prevalent in older adults (Haskell et al., 2007; Nelson et al., 2007; Fielding et al., 2007). Next, further examination of sedentary behavior was done across levels of health promoting physical activity.

To examine whether differences in sedentary behavior occurred across physical activity levels a one-way analysis of variance was conducted with effect sizes interpreted as .01 = small, .06 = medium, .14 = large (Cohen, 1988). If the initial results were significant post hoc analysis was conducted with the Tukey HSD test. The participant's time spent in health promoting moderate and vigorous physical activity was divided into three levels. Participants were split into three groups, (1) participating in no leisure time physical activity (0-9 minutes per day of moderate and/or vigorous physical activity), (2) insufficient leisure time physical activity (10-29 minutes per day of moderate and/or vigorous physical activity) and (3) meeting the physical activity recommendations ($\geq$30 minutes of moderate and/or vigorous physical activity). The distribution of participants in each physical activity level is as follows: 39.7% in the no leisure time physical activity group, 32.9% in the insufficient group, and 26% in the met physical activity recommendation group. There were differences in sedentary behavior for the entire group, men and women across physical activity categories and these results are presented in Table 8.

Table 8

Sedentary Behavior Across Physical Activity Categories by Gender

	Women			Men			All		
	1 (*n*=23)	2 (*n*=17)	3 (*n*=7)	1 (*n*=6)	2 (*n*=7)	3 (*n*=12)	1 (*n*=29)	2 (*n*=24)	3 (*n*=19)
SB‡	617.4±68.6[a]	586.8±66.3	547.1±61.6	699.6±54.5	669.5±89.7	619.8±100.3	634.4±73.3	610.9±81.5	593.3±21.4
% SB‡	66.5± 5.7[a]	63.4± 7[b]	56±3.4	74.8± 4[a]	70± 9	64.2±7	68.2±6.3[a]	65.4±8	61.2±7.3
SB+	488.7±49.9	497.2±51.4	449.2±45.4	471.9±32.8	504.6± 62.1	452.7±63.1	485.1±46.7	499.3±53.4[b]	451.4±54.2

Note. Values represent mean ± standard deviation. 1= No Leisure Time Physical Activity (0-9 minutes per day of moderate and/or vigorous physical activity); 2 = Insufficient Leisure Time Physical Activity = 10-29 minutes per day of moderate and/or vigorous physical activity; 3 = Met Physical Activity Recommendations = 30 or more minutes per day of moderate and/or vigorous physical activity. ‡ Actigraph accelerometer was used (mins/d). +activPal™ accelerometer was used (mins/d). $P < .05$. [a] = different between 1and 3; [b] = different between 2 and 3.

Because sedentary behavior was assessed with two different accelerometers, the Actigraph and the activPal™, the results are presented by monitor and discussed in order of overall group findings and then gender specific results if necessary.

Actigraph - Daily Time Spent in Sedentary Behavior

When sedentary behavior was examined as average daily minutes of sedentary behavior the only significant differences in sedentary behavior across physical activity levels was in women, $F(2,44) = 3.21$, $p=.050$, eta squared, 13. The results suggested the no leisure time physical activity group participated in significantly more sedentary behavior ($n=23$, $M=617.4$ minutes per day, $SD=68.6$ minutes per day, $p=.049$) than the met physical activity recommendations group ($n=7$, $M=547.1$ minutes per day, $SD=62$ minutes per day) but there were no differences with the insufficient physical activity group ($n=17$, $M=586.8$ minutes per day, $SD=66.3$ minutes per day, $p=.390$).

Actigraph - Percent of Day in Sedentary Behavior

In this analysis the total time spent in sedentary behavior was examined as a percent of the day. There were significant findings for the group, women and men. In the group analysis, there were significant differences in the percent of day spent in sedentary behavior across physical activity levels, $F(2,69)=5.454$, $p=.006$, eta squared=.13. The no leisure time physical activity group ($n=29$, M=68.2%, $SD=6.3\%$, $p=.004$) spent a significantly higher percent of their day being sedentary compared to the met physical activity recommendations group ($n=19$, M=61.2%, $SD=7.3\%$) and there were no differences between these groups and the insufficient leisure time physical activity group ($n=24$, M=65.4%, $SD=8\%$, $p=.149$-.332).

There were also differences in the percent of day spent in sedentary behavior across physical activity levels for both women, $F(2,44) = 8.345$, $p=.001$ and men, $F(2,22)=4.548$, $p=.022$, eta squared, .28 and .29, respectively. The insufficient physical activity group of women ($n=17$, $M=63.4\%$, $SD=7\%$, $p=.021$) engaged in a higher percent of the day in sedentary behavior than the met physical activity recommendations group ($n=7$, $M=56\%$, $SD=3.4\%$) but there were no differences with the no leisure time physical activity group ($n=23$, $M=66.5\%$, $SD=5.7\%$, $p=.260$). When men were examined separately significant differences were observed between the no leisure time physical activity group and the met recommendations physical activity group. The no leisure time physical activity group ($n=6$, $M=74.8\%$, $SD=4\%$, $p=.020$) spent a significantly larger portion of their day in sedentary behaviors than the met physical activity recommendations group ($n=12$, $M=64.2\%$, $SD=7\%$) and no differences occurred with the insufficient physical activity group ($n=7$, $M=70\%$, $SD=9\%$, $p=.473$).

activPal™ - Daily Time Spent in Sedentary Behavior

In addition to the Actigraph accelerometer, the activPal™ accelerometer was also used as a measurement device of sedentary behavior. When average daily sedentary behavior was examined with this device there were also differences in sedentary behavior across physical activity levels, $F(2,68)=4.741$, $p=.012$, eta squared, .14. The insufficient physical activity group ($n=24$, $M=499.3$ minutes per day, $SD=53.4$ minutes per day, $p=.010$) spent significantly more time of their day engaging in sedentary behavior than the met physical activity recommendations group ($n=19$, 451.4 minutes per day, $SD=54.2$ minutes per day) but there were no difference between these groups and the no leisure

time physical activity group (n=19, M=485.1 minutes per day, SD=55.9 minutes per day, p=.078-.585).

Summary

This study examined a number of cardiometabolic health variables related to chronic disease development and the sedentary behavior and physical activity profiles of retired older adults. Almost 60% of the sample was at a moderate risk for developing Cardiovascular Disease and over 20% were classified as having the Metabolic Syndrome. When their sedentary behavior and physical activity was monitored objectively via accelerometry they spent approximately 8-10 hours per day engaging in sedentary behavior and only 26% of them engaged in the recommended amount of moderate and/or vigorous physical activity to promote health. The men engaged in significantly more sedentary behavior, approximately one hour more than women. The men also engaged in more sedentary behavior than women across the age span. There were additional differences in sedentary behavior across age groups when assessed with the activPal™, the oldest participants engaged in the least amount of sedentary behaviors. Furthermore when sedentary behavior was investigated across physical activity categories there were significant differences in sedentary behavior for the group, women and men especially between those who met the physical activity recommendations and those who did not.

The relationship between sedentary behavior and cardiometabolic health

Partial Correlations

Partial correlations were calculated to explore the relationship between total time spent in sedentary behavior from both the Actigraph accelerometer and the activPal™ accelerometer and each cardiometabolic health outcome while controlling for total time

spent in health enhancing moderate and vigorous physical activity. Interpretations of these results are as follows: r=.10 to .29 and r=-.10 to -.29 is small, r=.30 to .49 and r=.30 to -.49 is medium and r=.50 to 1.0 and r=-.50 to r=-1.0 is large (Cohen, 1988).

The results for the partial correlations between cardiometabolic health and sedentary behavior assessed with the Actigraph accelerometer are displayed in Table 9 and the activPal™ accelerometer data are in Table 10. Partial correlation results for each monitor are presented because the time spent in sedentary behavior was significantly different at the .05 level. The activPal™ accelerometer (M=479.92, SD=54.50) reported older adults spending less time in sedentary behavior than the Actigraph accelerometer [M=615.65, SD=82.26 $t(70) = 10.492$, p <.001]. The following results will be further presented by group, women and men if necessary, and in order of anthropometrics, metabolic and cardiovascular results when present.

Actigraph- Daily Time Spent in Sedentary Behavior

The following results are reported for women only because there were no significant relationships between sedentary behaviors assessed with the Actigraph accelerometer and health outcomes for the entire group or men. There were negative, small, partial correlations between sedentary behavior assessed by the Actigraph accelerometer and body mass index (r=-.27, p < .05) as well as waist circumference (r=.27, p < .05), with higher time spent in sedentary behaviors associated with lower body mass indexes and waist circumferences. There were no other health variables related to sedentary behavior in this analysis.

Table 9

Partial Correlation Results Between Cardiometabolic Health Variables and Sedentary Behavior (Actigraph) Controlling for Moderate and Vigorous Physical Activity

	Women (n=42)	Men (n=25)	All (N=67)
Measure	*SB*	*SB*	*SB*
SB	-	-	-
Anthropometric			
BMI	-.27*	-.06	-.11
WC	-.27*	.06	.13
% Fat	.12	.09	-.14
Metabolic			
LDL	.23	-.17	-.02
HDL	-.13	-.02	-.19
TG	.06	-.05	-.01
FBG	-.23	.32	.20
TC	.16	.04	-.06
Cardiovascular			
V1 LT SBP	-.03	.2	.04
V1 LT DBP	-.03	-.14	.03
V1 RT SBP	.02	.21	.06
V1 RT DBP	-.15	-.22	-.08
V2 LT SBP	.12	.07	.10
V2 LT DBP	-.07	.05	.15
V2 RT SBP	.09	.05	.07
V2 RT DBP	-.16	.08	.04

Note. SB = Sedentary Behavior; BMI = Body Mass Index; WC = waist circumference; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TG = triglycerides; FBG = Fasting Blood Glucose; LT = left arm; RT = right arm; SBP = systolic blood pressure; DBP = diastolic blood pressure. Differences between gender *$p < .05$.

Table 10

Partial Correlation Results Between Cardiometabolic Health Variables and Sedentary Behavior (activPal™) Controlling for Moderate and Vigorous Physical Activity

	Women (n=41)	Men (n=25)	All (N=66)
Measure	*SB*	*SB*	*SB*
SB	-	-	-
Anthropometric			
BMI	.18	.09	.13
WC	.24	-.13	.03
% Fat	.09	-.01	.21
Metabolic			
LDL	.03	-.13	-.03
HDL	.01	-.00	.03
TG	.15	.14	.15
FBG	.12	-.04	.01
TC	.09	-.03	.06
Cardiovascular			
V1 LT SBP	.07	.05	.06
V1 LT DBP	.21	.22	.19
V1 RT SBP	.11	-.03	.06
V1 RT DBP	.16	.26	.18
V2 LT SBP	-.02	-.19	-.10
V2 LT DBP	.22	-.14	.03
V2 RT SBP	.02	-.20	-.08
V2 RT DBP	.20	-.50*	-.16

Note. SB = Sedentary Behavior; BMI = Body Mass Index; WC = waist circumference; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TG = triglycerides; FBG = Fasting Blood Glucose; LT = left arm; RT = right arm; SBP = systolic blood pressure; DBP = diastolic blood pressure.

*$p < .05$.

activPal™ - Daily Time Spent in Sedentary Behavior

When examining the relationship between the activPal™ accelerometer recorded sedentary behavior and health there were negative, large partial correlations with the right arm diastolic blood pressure taken on the second visit in men only (r=-.50, $p < .05$), with higher time spent in sedentary behaviors associated with lower diastolic blood pressures. There were no significant relationships between sedentary behavior assessed with the activPal™ and any other health variables for the entire group or women.

Pearson Correlations

Further analysis was done using Pearson correlations to examine the relationship between the different measures of sedentary behavior and physical activity with health outcomes. Interpretations of these results are as follows: r=.10 to .29 and r=-.10 to -.29 is small, r=.30 to .49 and r=-.30 to -.49 is medium and r=.50 to 1.0 and r=-.50 to r=-1.0 is large (Cohen, 1988). The assumption of normality was violated for triglycerides and a Log_10 transformation was performed. The results of these Pearson Product-Moment Correlations are discussed by accelerometer and then by group and gender if necessary and further by anthropometric, metabolic and cardiovascular results if present. These results are presented for the entire group, women and men in Table 11-13, respectively.

Actigraph- Daily Time Spent in Sedentary Behavior

There were no significant relationships for the group, women and men between daily sedentary behavior measured by the Actigraph and health.

Table 11

Pearson Correlations Between Sedentary Behavior and Physical Activity, with Health Variables for the Entire Group

	SB (Actigraph)		SB (activPal™)	PA (Actigraph)						PA (activPal™)	
Measure	*SB*	*% day in SB*	*SB*	*Avg. Counts*	*LMPA*	*MPA*	*VPA*	*LMVPA*	*MVPA*	*Steps/day*	*Sit to Stand Transitions*
BMI	-.04	.11	.18	-.27*	-.09	-.24*	-.28*	-.18	-.27*	-.12	-.13
WC	.15	.25*	.07	-.26*	-.10	-.15	-.34*	-.16	-.19	-.17	-.08
% Fat	-.02	.13	.20	-.47*	-.27*	-.50*	-.12	-.42**	-.51**	-.39**	-.26*
LDL	-.03	-.04	.00	-.02	.11	-.09	.05	.05	-.08	-.00	.13
HDL	-.14	-.19	-.02	.14	.08	.04	.24*	.09	.07	.10	.11
TG	.09	.17	.26*	-.38**	-.14	-.37*	-.17	-.27*	-.38**	-.27*	-.09
FBG	-.05	-.12	-.00	.15	.22	-.09	.02	.19	.09	.03	.12
TC	-.01	.01	.10	-.15	.02	-.24*	.09	-.09	-.22	-.09	.10
V1 LT SBP	.06	-.05	.06	-.13	-.19	-.12	-.17	-.20	-.13	-.02	.03
V1 LT DBP	.03	.03	.21	-.09	-.09	-.03	-.18	-.08	-.01	.02	.16
V1 RT SBP	.09	-.03	.06	-.16	-.23	-.14	-.13	-.23	-.15	-.02	-.02
V1 RT DBP	-.08	-.07	.19	-.03	-.05	-.02	-.08	-.05	-.03	.10	-.07
V2 LT SBP	.10	.01	-.06	-.07	-.11	-.06	-.09	-.11	-.07	.05	-.09
V2 LT DBP	.14	.14	.05	-.05	-.02	-.05	.02	-.03	-.04	.03	-.08
V2 RT SBP	.08	-.01	-.04	-.06	-.09	-.04	-.10	-.08	-.05	.04	-.11
V2 RT DBP	.03	.00	-.12	-.00	.01	-.04	.03	-.01	-.03	.05	-.01

Note. SB = Sedentary Behavior; BMI = Body Mass Index; WC = waist circumference; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TG = triglycerides; FBG = Fasting Blood Glucose; V = visit 1 or 2; LT = left arm; RT = right arm; SBP = systolic blood pressure; DBP = diastolic blood pressure. SB = sedentary behavior (≤50 cts/min); LMPA = lifestyle physical activity (760-5724); MPA = moderate physical activity (1952-5724 cts/min); VPA = vigorous physical activity (≥5725 cts/min); LMVPA = lifestyle, moderate, and vigorous physical activity (≥760 cts/min); MVPA = moderate and vigorous physical activity (≥5725 cts/min). Significant relationships between health variables and measure of sedentary behavior, $^{**}p < .01$ and $^{*}p < .05$.

Table 12

Pearson Correlations Between Sedentary Behavior and Physical Activity, with Health Variables for Women

	SB (Actigraph)		SB (activPal™)	PA (Actigraph)						PA (activPal™)	
Measure	*SB*	*% day in SB*	*SB*	*Avg. Counts*	*LMPA*	*MPA*	*VPA*	*LMVPA*	*MVPA*	*Steps/day*	*Sit to Stand Transitions*
BMI	-.14	.04	.19	-.27	-.13	-.27	-.27	-.22	-.30*	-.19	-.11
WC	-.10	.10	.24	-.35*	-.18	-.31*	-.31*	-.27	-.35*	-.28	-.13
% Fat	.13	.32*	.15	-.43*	-.39**	-.32*	-.23	-.43**	-.34*	-.47*	-.41**
LDL	.13	.11	.03	-.05	.07	-.08	.05	.02	.06	-.00	.18
HDL	-.11	-.17	-.11	.27	.16	.22	.24	.22	.25	.14	.17
TG	.16	.23	.22	-.32*	-.11	-.28	-.17	.20	-.29*	-.28	-.14
FBG	-.27	-.30*	.14	.25	.23	.20	.03	.25	.19	.18	.05
TC	.11	.08	.05	-.01	.10	-.05	.12	.06	-.03	-.05	.18
V1 LT SBP	.04	-.06	.05	-.14	-.23	-.15	-.20	-.25	-.17	-.05	.00
V1 LT DBP	.00	-.06	.20	-.15	-.15	-.13	-.19	-.17	-.15	-.07	-.12
V1 RT SBP	.07	-.05	.07	-.16	-.29	-.13	-.17	-.27	-.16	-.04	.00
V1 RT DBP	-.08	-.13	.14	-.11	-.19	-.12	-.10	-.19	-.13	.05	-.02
V2 LT SBP	.19	.10	-.05	-.21	-.31*	-.18	-.14	-.30*	-.19	-.11	-.07
V2 LT DBP	-.03	-.04	.19	-.07	-.09	-.13	.06	-.11	-.12	-.05	-.05
V2 RT SBP	.17	.08	-.01	-.20	-.25	-.17	-.15	-.26	-.19	-.16	-.10
V2 RT DBP	-.06	-.08	.18	-.11	-.12	-.19	.01	-.16	-.18	-.11	-.02

Note. SB = Sedentary Behavior; BMI = Body Mass Index; WC = waist circumference; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TG = triglycerides; FBG = Fasting Blood Glucose; V = visit 1 or 2; LT = left arm; RT = right arm; SBP = systolic blood pressure; DBP = diastolic blood pressure. SB = sedentary behavior (≤50 cts/min); LMPA = lifestyle and moderate physical activity (760-5724); MPA = moderate physical activity (1952-5724 cts/min); VPA = vigorous physical activity (≥5725 cts/min); LMVPA = lifestyle, moderate, and vigorous physical activity (≥760 cts/min); MVPA = moderate and vigorous physical activity (≥5725 cts/min). Significant relationships between health variables and measure of sedentary behavior, $^{**}p < .01$ and $^{*}p < .05$.

Table 13

Pearson Correlations Between Sedentary Behavior and Physical Activity, with Health Variables for Men

	SB (Actigraph)		SB (activPal™)	PA (Actigraph)						PA (activPal™)	
Measure	SB	% day in SB	SB	Avg. Counts	LMPA	MPA	VPA	LMVPA	MVPA	Steps/day	Sit to Stand Transitions
BMI	.09	.24	.18	-.31	.04	-.30	-.33	-.12	-.32	-.10	-.19
WC	.21	.24	-.03	-.35	.02	-.35	-.41*	-.16	-.37	-.14	-.00
% Fat	.33	.43*	.15	-.56*	-.09	-.60**	-.27	-.34	-.61**	-.25	-.10
LDL	-.14	-.16	-.09	.08	.22	-.02	.00	.14	-.01	.04	.05
HDL	-.00	-.07	.00	.01	-.08	-.04	.15	-.07	-.03	.10	-.01
TG	.16	.28	.25	-.45*	-.20	-.41*	-.42*	-.33	-.43*	-.21	-.02
FBG	.14	.05	-.14	-.10	.19	-.22	.11	.02	-.21	-.32	.26
TC	.14	.18	.04	-.23	-.09	-.25	-.16	-.18	-.25	-.06	-.01
V1 LT SBP	.19	.01	.09	-.07	-.04	-.02	.00	-.03	-.02	.10	.10
V1 LT DBP	-.10	.02	.27	-.06	.04	-.06	-.05	-.01	-.06	.14	-.22
V1 RT SBP	.23	.07	.01	-.15	-.05	-.11	.05	-.08	-.10	.07	-.08
V1 RT DBP	-.20	-.09	.20	.04	.29	.00	.07	.13	.01	.16	-.16
V2 LT SBP	.01	-.12	-.10	.16	.07	.13	.11	.26	.14	.33	-.12
V2 LT DBP	.12	.19	-.04	-.16	.27	-.20	.10	-.04	-.19	.10	-.12
V2 RT SBP	-.03	-.16	-.12	.18	.20	.17	.11	.26	.17	.39*	-.12
V2 RT DBP	.05	.03	-.41*	.09	.26	.04	.16	.16	.05	.24	.04

Note. SB = Sedentary Behavior; BMI = Body Mass Index; WC = waist circumference; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TG = triglycerides; FBG = Fasting Blood Glucose; V = visit 1 or 2; LT = left arm; RT = right arm; SBP = systolic blood pressure; DBP = diastolic blood pressure. SB = sedentary behavior (≤50 cts/min); LMPA = lifestyle and moderate physical activity (760-5724); MPA = moderate physical activity (1952-5724 cts/min); VPA = vigorous physical activity (≥5725 cts/min); LMVPA = lifestyle, moderate, and vigorous physical activity (≥760 cts/min); MVPA = moderate and vigorous physical activity (≥5725 cts/min). Significant relationships between health variables and measure of sedentary behavior, $^{**}p < .01$ and $^{*}p < .05$.

Actigraph- Physical Activity

In all three tables, there were significant relationships between health variables and physical activity intensities. In the group analysis there were significant inverse relationships between percent body fat and all measures of physical activity intensity, except for vigorous physical activity. Similar results were noted with triglycerides and waist circumference in all measures of physical activity except for low to moderate physical activity and vigorous physical activity. However few relationships existed with blood pressure. The same trends were observed in the gender analysis.

Actigraph - Percent of Day in Sedentary Behavior

When the group analysis was conducted there was a positive, small, correlation between the percent of day spent in sedentary behavior and waist circumference (r=.26, p < .05), with higher daily percentages being related to larger waist circumferences. There were no other significant findings in the group analysis.

Next this relationship was examined by gender and there were significant correlations for women and men with the percent of day spent in sedentary behavior and percent body fat. Two positive, medium, correlations existed with percent body fat in women (r=.32, p < .05) and men (r=.43, p < .05), suggesting those with higher percentages of their day spent being sedentary is related to higher body fat percentages. Also for women, a negative, medium, correlation existed between the percent of day in sedentary behavior with fasting blood glucose (r=-.30, p < .05), with higher daily percentages of the day being sedentary related to lower fasting blood glucose. There were no significant findings with other anthropometrics, metabolic or cardiovascular health variables.

activPal™- Daily Time Spent in Sedentary Behavior

When sedentary behavior was examined with the activPal™ there were correlations for the entire group and men only. Results for the group analysis demonstrated a positive, small, correlation between triglycerides and daily time spent in sedentary behavior (r=.26, p<.05), with more time being sedentary related to higher triglyceride values. In men only, there was an additional negative, medium, correlation between sedentary behavior measured with the activPal™ and right arm diastolic blood pressure taken on the second visit (r=-.41, p<.05), with increased time being sedentary related to lower diastolic blood pressure. No other significant relationships existed between daily time in sedentary behavior assessed with the activPal™.

One-way Analysis of Variance

To further explore sedentary behavior and health additional one-way analysis of variance was conducted to examine if differences in health variables occurred in low, moderate, and high time spent in sedentary behavior with the Actigraph and activPal™. The groups were divided into equal percentages of low, moderate, and high time spent in sedentary behavior. The effect sizes of this analysis is interpreted as .01 = small, .06 = medium, .14 = large (Cohen, 1988). If the initial results were significant post hoc analysis was conducted with the Tukey HSD test. The results of this section are displayed by accelerometer, group and gender analysis, and further by anthropometric, metabolic and cardiovascular results.

Actigraph – Daily Time Spent in Sedentary Behavior

Participants were divided into three groups according to the average time spent being sedentary (n=16, low: ≤549.3 minutes per day; n=33, moderate: 549.4-645.2

minutes per day; n=23, high: ≥645.3 minutes per day). The only health variable that differed significantly at the .05 level across the sedentary groups was waist circumference for the entire group, $F(2,69)$=4.398, p=.016, eta squared, .11. The mean waist circumference for the moderate sedentary group (M=82.6 cm, SD=11.3 cm) was significantly lower than the high sedentary group (M=91.9 cm, SD=11.8 cm). However, there were no differences between either the moderate or high groups for waist circumference with the low group (M=86 cm, SD=11.6 cm). There were no significant differences between different times spent in sedentary behavior and health when gender was examined.

Actigraph – Percent of Day in Sedentary Behavior

The percent of day spent in sedentary behavior was divided into three groups (n=23, low: ≤62.1%; n=25, moderate: 62.2-68.2%; n=24, high: ≥68.3%) and compared to each health variable. In the group analysis the only significant difference occurred in waist circumference measurements, $F(2,69)$ = 4.545, p =.014, eta squared, .11. There were differences in mean waist circumference between the moderate (M=82.5 cm, SD=12.5 cm) and high sedentary groups (M=92 cm, SD=10.5 cm) but not with the low sedentary group (M=84.6 cm, SD=11.3 cm). When this analysis was examined by gender the only significant finding was in men with percent body fat. There was a significant difference in percent body fat at the .05 level across the sedentary groups, $F(2,22)$ = 4.456, p=.024, eta squared, .24. The difference in percent body fat was between the moderate (M=19.7%, SD=8.8%) and high sedentary groups (M=29.1%, SD=5.4%) but not with the low sedentary group (M=24.4%, SD=6.2%). There were no significant findings for women.

activPal™ - Daily Time Spent in Sedentary Behavior

When the same analysis was conducted using the activPal™ participants were clustered into three groups of time spent in sedentary behavior (n=25, low: ≤ 452.5 minutes per day; n=25, moderate: 452.5-518.8 minutes per day; n=21, high: ≥518.8 minutes per day). The only significant finding was observed in the group analysis. The triglyceride values that differed at the .05 for the entire group, $F(2,68) = 3.395$, p=.039, eta squared, .09. The low sedentary group had significantly lower mean triglyceride values (M=93.2 mg/dL, SD=37.91 mg/dL) compared to the high sedentary group (M=135.1 mg/dL, SD=72.7 mg/dL) and the moderate sedentary group (M=116.5 mg/dL, SD=51.4 mg/dL) had significantly lower triglycerides than the high sedentary group. There were no differences in health variables across different amounts of sedentary behavior for either men or women.

Logistic Regressions – Sedentary Behavior Predicting Obesity and Triglycerides

Based on the results of the Pearson correlation, Actigraph determined percent time spent in sedentary behavior was positively related to waist circumference and percent body fat and daily time spent in sedentary behavior with the activPal™ was positively related to triglycerides, additional examination was done with logistic regressions to further explore these relationships. The control variables were age, gender, and accelerometer wear time with the addition of medications for cholesterol in the triglyceride analysis. The health variables were dichotomized into low and high values and percent of day in sedentary behavior and daily time spent in sedentary behavior were dichotomized into moderate and high levels with low levels serving as the referent group. Low volumes of sedentary behavior and moderate to vigorous physical activity were used

as a referent category. The sedentary behavior variables were used to predict obesity based on waist circumference in Table 14, percent body fat in Table 15, and triglycerides in Table 16.

Table 14

Logistic Regression Analysis using the Percent of Day in Sedentary Behavior (Actigraph) to Predict the Likelihood of Obesity when Waist Circumference is used as a Measure of Obesity

Predictors	*b*	SE	Wald	df	*P*	OR (95% CI)
Age	-.175*	.067	6.735	1	.009	.840 (.736, .958)
Gender	-.077	.690	.012	1	.912	.926 (.239, 3.583)
Wear Time	.007	.005	1.829	1	.176	1.007 (.997, 1.017)
MVPA (1)	-1.864*	.809	5.305	1	.021	.155 (.032, .757)
MVPA (2)	-3.116*	1.118	7.770	1	.005	.044 (.005, .396)
SB (1)	-.859	.755	1.294	1	.255	.423 (.096, 1.861)
SB (2)	-.302	.793	.145	1	.703	.739 (.156, 3.498)

Note. 22 out of 73 participants were obese (≥102 cm in men and ≥ 88 cm in women). Control variables (Model 1) were age, gender, and accelerometer wear time. Independent predictors (Model 2) = MVPA (0) = low ≤6.3 minutes per day used as a referent category; MVPA (1)= Moderate to Vigorous Physical Activity, moderate volume, 6.3-28.44 minutes per day; MVPA (2)= Moderate to Vigorous Physical Activity, high volume, ≥28.45 minutes per day. Independent predictors (Model 3) SB (1) = moderate volume of percent of day spent in sedentary behavior, 62.07-68.22%. SB (2) = high volume of percent of day spent in sedentary behavior, ≥68.23%; SB (0) = low ≤62.06% used as a referent category. Independent predictors of obesity, *p<.05.

Table 15

Logistic Regression Analysis using the Percent of Day in Sedentary Behavior (Actigraph) to Predict the Likelihood of Obesity when Percent Body Fat is used as a Measure of Obesity

Predictors	*b*	SE	Wald	df	*P*	OR (95% CI)
Age	-.092	.057	2.574	1	.109	.912 (.815, 1.021)
Gender	-.708	.813	.759	1	.384	.492 (.100, 2.423)
Wear Time	.003	.005	.330	1	.565	1.003 (.993, 1.012)
MVPA (1)	-.936	.832	1.267	1	.260	.392 (.077, 2.001)
MVPA (2)	-2.793*	1.089	6.578	1	.010	.061 (.007, .518)
SB (1)	-.367	.653	.315	1	.574	.693 (.193, 2.494)
SB (2)	1.427	.877	2.647	1	.104	4.165 (.747, 23.223)

Note. 46 out of 73 participants were obese (≥23% body fat for men and ≥33% body fat for women measured by the Dual Energy X-Ray Absorptiometer). Control variables (Model 1) were age, gender, and MVPA. Independent predictors (Model 2) were MVPA (0) = low ≤6.3 minutes per day used as a referent categoryMVPA (1)= Moderate to Vigorous Physical Activity, moderate volume, 6.3-28.44 minutes per day. MVPA (2)= Moderate to Vigorous Physical Activity, high volume, ≥28.45 minutes per day. Independent predictors (Model 3) were SB (0) = low ≤62.06% used as a referent category; SB (1) = moderate volume of percent of day spent in sedentary behavior, 62.07-68.22%. SB (2) = high volume of percent of day spent in sedentary behavior, ≥68.23%. Independent predictors of obesity, *p<.05.

Table 16

Logistic Regression Analysis using the Percent of Day in Sedentary Behavior (activPal™) to Predict the Likelihood of Having High Triglycerides

Predictors	*b*	SE	Wald	df	*P*	OR (95% CI)
Age	-.093	.072	1.633	1	.201	.912 (.791, 1.051)
Gender	.481	.863	.311	1	.577	1.618 (.298, 8.778)
Wear Time	-.004	.006	.367	1	544	.996 (.984, 1.009)
Meds	-.757	.691	1.200	1	.273	.469 (.121, 1.818)
MVPA (1)	-.923	.774	1.422	1	.233	.397 (.087, 1.811)
MVPA (2)	-20.663	8507.365	.000	1	.998	.000 (.000, 000)
SB (1)	.545	.906	.363	1	.547	1.725 (.292, 10.180)
SB (2)	.146	.930	.025	1	.875	1.158 (.187, 7.160)

Note. 15 participants out of 73 had high triglycerides (≥150 mg/dL). Control variables (Model 1) were age, gender, and MVPA. Independent predictors (Model 2) were MVPA (0) = low ≤6.3 minutes per day used as a referent category; MVPA (1)= Moderate to Vigorous Physical Activity, moderate volume = 6.3-28.44, minutes per day. MVPA (2)= Moderate to Vigorous Physical Activity, high volume, ≥28.45 minutes per day. Independent predictors (Model 3) were SB (0) = low ≤517.75 minutes per day used as a referent category SB (1) = moderate volume of sedentary behavior, 452.51-518.75 minutes per day. SB (2) = high volume of sedentary behavior, ≥518.76 minutes per day. Meds = Medications for cholesterol.

The results of all three tables suggest moderate and high percentages of the day spent in sedentary behavior (Actigraph) or moderate and high daily time spent in sedentary behavior (activPal™) were not significant independent predictors of being obese or having elevated triglycerides. However, moderate and high volumes of participation in moderate and vigorous physical activity were significant independent predictors of obesity determined by waist circumference when compared to low volumes of moderate to vigorous physical activity. Additionally, participation in a high volume of moderate to vigorous physical activity was a significant independent predictor of obesity determined by total body fat percentage when compared to low and moderate volumes of moderate to vigorous physical activity. For example when obesity was assessed with waist circumference every time a person engages in a moderate volume or high volume of moderate to vigorous physical activity the odds of him/her being obese decreases by approximately 84.5% and 95.6% respectively. Interestingly there were no statistically significant predictors for elevated triglycerides.

Hierarchical Multiple Regression Analysis

Hierarchical Multiple Regression Analyses were used to determine whether sedentary behavior assessed with either accelerometer (Actigraph or activPal™) could predict each anthropometric, metabolic and cardiovascular variable (i.e., body mass index, waist circumference, percent body fat, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, fasting plasma glucose, total cholesterol, and blood pressure). These results are presented in Tables 17a-17d (Actigraph – daily time spent in sedentary behavior), Tables 18a-18d (Actigraph – percent of day spent in

sedentary behavior), and Tables 19a-19d (activPal™ - daily time spent in sedentary behavior).

Table 17a

Summary of Predictors for Anthropometric & Metabolic Variables §

	Body Mass Index				Waist Circumference				% Body Fat				Low-Density Lipoproteins			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	54.26		54.47		138.93		139.59		63.49		611.36		93.90		97.26	
Age	-.30*	-.37	-.29*	-.37	-.46*	-.23	-.46*	-.23	-.44*	-.26	-.45*	-.27	-.36	-.08	-.34	-.07
Gender	-1.58	-.16	-1.97	-.20	-12.65*	-.51	-13.14*	-.53	8.49*	.41	10.07*	.49	7.51	.13	4.87	7.36
Wear Time	-.00	-.04	.00	.012	-.01	-.03	-.00	-.01	.00	.01	-.01	-.10	.05	.12	.00	.012
MVPA	-.11*	-.40	-.13*	-.45	-.28*	-.39	-.30*	-.42	-.26*	-.45	-.21*	-.36	-.04	-.02	-.12	-.08
Meds													-27.56*	-.50	-28.15*	-.51
SB			-.01	-.10			-.01	-.05			.02	.19			-.04	-.12
R^2	.18*		.18		.27*		.26		.46*		.47		.21*		.21	
F	4.99*		4.05		7.44*		5.90		16.07*		13.66		4.73*		4.02	
ΔR^2			.01				.00				.02				.01	
ΔF			.426				.121				2.548				.59	

Note. § Daily Time spent in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for cholesterol. SB = Sedentary Behavior. *p <.05.

Table 17b

Summary of Predictors of Metabolic Variables §

	High-Density Lipoproteins (n=72)				Triglycerides (n=72)				Fasting Blood Glucose (n=72)				Total Cholesterol (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	.42		2.059		217.02		210.59		93.90		97.26		131.36		129.68	
Age	.80*	.28	.81*	.36	-1.02	-.11	-1.06	-.11	-.36	-.08	-.34	-.07	.24	.04	.23	.04
Gender	11.20*	.31	9.91*	.28	8.80	.07	13.85	.12	7.51	.13	4.87	7.36	26.71*	.34	28.04*	.35
Wear Time	-.01	-.04	.00	.01	-.01	-.01	-.06	-.07	.05	.12	.00	.012	.04	.07	.03	.05
MVPA	.24	.01	.20	.20	-1.22*	-.36	-1.06*	-.31	-.04	-.02	-.12	-.08	-.19	-.08	-.15	-.06
Meds	.23	.01	-.06	-.00	-.27	-.00	.86	.06	-27.56*	-.50	-28.15*	-.51	-26.41*	-.35	-26.11*	-.34
SB			-.02	-.93			.08	.11			-.04	-.12			.02	.04
R^2	.09*		.08		.08		.07		.21*		.21		.21*		.20	
F	2.35*		1.20		2.22		1.91		4.73*		4.02		4.68*		3.85	
ΔR^2			.00				.01				.01				.00	
ΔF			.33				1.91				.59				.08	

Note. § Daily Time spent in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for cholesterol. SB = Sedentary Behavior. *p <.05.

Table 17c

Summary of Predictors for Cardiovascular Variables §

	V1 Left SBP (n=70)				V1 Left DBP (n=70)				V1 Right SBP (n=72)				V1 Right DBP (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	76.82		79.14		109.37		110.54		81.34		82.97		110.83		112.94	
Age	-.07	-.03	-.06	-.02	-.65*	-.40	-.64*	.21	-.14	-.06	-.14	-.06	-.58*	-.38	-.58*	-.37
Gender	.87	.03	-.90	-.03	-.35	-.22	13.85	.12	1.30	.05	.06	.00	-2.74	-.14	-4.35	-.23
Wear Time	.05*	.26	.07*	.33	.02	.16	.03	.22	.06*	.30	.07	.36	.01	.11	.03	.22
MVPA	-.14	-.16	-.20	-.23	-.14	-.25	-.17*	-.30	-.16	-.20	-.20	-.25	-.10	-.18	-.15	-.28
Meds	8.60*	.29	8.64*	.30	1.09	.06	1.11	.06	6.27*	.24	6.30*	.24	.99	.05	1.02	.06
SB			-.03	-.15			-.01	.02			-.04	-.12			-.02	-.21
R^2	.08		.08		.11*		.11		.08		.07		.07		.16	
F	2.25		2.00		2.73*		2.34		2.20		1.90		2.10		2.06	
ΔR^2			.01				.01				.01				.02	
ΔF			.812				.50				.49				1.74	

Note. § Daily Time spent in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for blood pressure. SB = Sedentary Behavior. *p <.05.

Table 17d

Summary of Predictors for Cardiovascular Variables §

	V2 Left SBP (n=70)				V2 Left DBP (n=70)				V2 Right SBP (n=72)				V2 Right SBP (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	84.48		84.49		105.26		105.22		84.14		84.60		92.59		93.34	
Age	-.15	-.07	-.15	-.07	-.60*	-.40	-.60*	-.40	-.12	-.05	-.12	-.05	-.53*	-.33	-.52*	-.33
Gender	1.15	.04	1.14	.04	-6.42*	-.34	-6.39*	-.34	1.06	.04	.70	.03	-2.11	-.11	-2.69	-.14
Wear Time	.05	.25	.05	.25	.02	.17	.02	.17	.05	.23	.05	.25	.03	.18	.03	.22
MVPA	-.09	-.10	-.09	-.10	-.15*	-.27	-.15	-.27	-.06	-.08	-.08	-.09	-.11	-.19	-.12	-.22
Meds	5.54	.20	5.54	.20	.92	.05	.91	.05	6.20	.23	6.21	.23	.00	.00	.02	.00
SB			.00	-.00			.00	.02			-.01	-.03			-.01	-.07
R^2	.02		.00		.17*		.16		.03		.01		.03		.02	
F	1.26		1.03		3.83*		3.14		1.35		1.12		1.45		1.22	
ΔR^2			.00				.00				.00				.00	
ΔF			.00				.00				.04				.20	

Note. § Daily Time spent in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for blood pressure. SB = Sedentary Behavior. *p <.05.

Table 18a

Summary of Predictors for Anthropometric & Metabolic Variables †

	Body Mass Index (n=73)				Waist Circumference (n=73)				% Body Fat (n=73)				Low-Density Lipoproteins (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	54.26		57.95		138.93		143.34		63.49		46.30		93.90		123.10	
Age	-.30*	-.37	-.29*	-.37	-.46*	-.23	-.46*	-.23	-.44*	-.26	-.45*	-.27	-.36	-.08	-.34	-.07
Gender	-1.58	-.16	-1.92	-.19	-12.65*	-.51	-13.05*	-.53	8.49*	.41	10.06*	.49	7.51	.13	4.83	.08
Wear Time	-.00	-.04	-.00	-.04	-.01	-.03	-.01	-.03	.00	.01	.00	.01	.05	.12	.05	.11
MVPA	-.11*	-.40	-.12*	-.44	-.28*	-.39	-.29*	-.41	-.26*	-.45	-.21*	-.36	-.04	-.02	-.13	-.08
Meds													-27.56*	-.50	-28.21*	-.10
SB			-.05	-.08			-.06	-.04			.22	.17			-.40	-.10
R^2	.18*		.18		.27*		.23		.46*		.47		.21*		.21	
F	4.99*		4.02		7.44*		5.88		16.07*		13.66		4.73*		4.02	
ΔR^2			.00				.00				.02				.01	
ΔF			.33				.08				2.54				.61	

Note. † Percent of day in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for cholesterol. SB = Sedentary Behavior. *p <.05.

Table 18b

Summary of Predictors for Metabolic Variables†

	High-Density Lipoproteins (n=72)				Triglycerides (n=72)				Fasting Blood Glucose (n=72)				Total Cholesterol (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	.42		13.22		217.02		161.40		101.57		116.46		131.36		118.23	
Age	.80*	.28	.81*	.28	-1.02	-.11	-1.05	-.11	-.27	-.19	-.26	-.20	.24	.04	.23	.04
Gender	11.20*	.32	10.03*	.29	8.80	.07	13.91	.12	-3.31	-.19	-4.61	-.26	26.71*	.34	27.91*	.35
Wear Time	-.01	-.04	-.01	-.04	-.01	-.01	-.01	-.01	.01	.11	.01	.11	.04	.07	.04	.07
MVPA	.24	.24	.20	.15	-1.22*	-.36	-1.06*	-.31	-.01	-.02	.01	.11	-.19	-.08	-.15	-.07
Meds	.23	.01	-.06	-.00	-.27	-.00	.97	.01	-7.16	-.14	-5.54	-.18	-26.41*	-.35	-26.11*	-.34
SB			-.17	-.08			.73	.10			-.20	-.18			.17	.03
R^2	.09*		.08		.08		.07		.01		.02		.21*		.20	
F	2.35*		1.98		2.22		1.91		1.11		1.17		4.680*		3.86	
ΔR^2			.00				.01				.02				.00	
ΔF			.28				.45				1.45				.07	

Note. † Percent of day in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for cholesterol. SB = Sedentary behavior. *p <.05.

Table 18c

Summary of Predictors for Cardiovascular Variables†

	V1 Left SBP (n=70)				V1 Left DBP (n=70)				V1 Right SBP (n=72)				V1 Right DBP (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	76.82		97.02		109.37		119.05		81.34		94.55		110.83		128.02	
Age	-.07	-.03	-.06	-.02	-.65*	-.40	-.64*	.21	-.14	-.06	-.14	-.06	-.59*	-.38	-.58*	-.37
Gender	.87	.03	-.99	-.03	-4.35	-.22	-5.25	-.26	1.30	.05	.09	.00	-2.74	-.14	-4.32	-.23
Wear Time	.05*	.26	.05*	.25	.02	.16	.02	.15	.06*	.30	.06*	.36	.01	.11	.01	.10
MVPA	-.14	-.16	-.20	-.23	-.14	-.25	-.17*	-.30	-.16	-.20	-.19	-.24	-.10	-.18	-.15	-.27
Meds	8.60*	.29	8.65*	.30	1.09	.06	1.12	.06	6.27*	.24	6.30*	.24	.99	.05	1.03	.06
SB			-.03	-.14			-.13	-.10			-.17	-.10			-.22	-.18
R^2	.08		.08		.11*		.11		.08		.07		.07		.08	
F	2.25		2.02		2.73*		2.34		2.20		1.90		2.10		2.05	
ΔR^2			.01				.01				.01				.02	
ΔF			.90				.50				.47				1.1.69	

Note. † Percent of day in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for blood pressure. SB = Sedentary Behavior. *p <.05.

Table 18d

Summary of Predictors for Cardiovascular Variables†

	V2 Left SBP (*n*=70)				V2 Left DBP (*n*=70)				V2 Right SBP (*n*=72)				V2 Right DBP (*n*=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	84.48		83.39		105.26		104.77		84.14		86.77		92.59		98.46	
Age	-.15	-.07	-.15	-.07	-.60*	-.40	-.60*	-.40	-.12	-.05	-.12	-.05	-.53*	-.33	-.52*	-.33
Gender	1.15	.04	1.25	.04	-6.42*	-.34	-6.39*	-.34	1.06	.04	.81	.03	-2.11	-.11	-2.65	-.13
Wear Time	.05	.25	.05	.25	.02	.17	.02	.17	.05	.23	.05	.23	.03	.18	.03	.18
MVPA	-.09	-.10	-.08	-.10	-.15*	-.27	-.14	-.27	-.06	-.08	-.07	-.09	-.11	-.19	-.12	-.22
Meds	5.54	.20	5.54	.20	.92	.05	.91	.05	6.20	.23	6.21	.23	.00	.00	.02	.00
SB			.01	.01			.01	.01			-.03	-.02			-.08	-.06
R^2	.02		.00		.17*		.16		.03		.01		.03		.02	
F	1.26		1.03		3.83*		3.14		1.35		1.11		1.45		1.22	
ΔR^2			.00				.00				.00				.00	
ΔF			.00				.00				.02				.17	

Note. † Percent of day in sedentary behavior measured by the Actigraph. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for blood pressure. *p <.05.

Table 19a

Summary of Predictors for Anthropometric & Metabolic Variables+

	Body Mass Index (*n*=73)				Waist Circumference (*n*=73)				% Body Fat (*n*=73)				Low-Density Lipoproteins (*n*=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	54.26		54.42		138.93		144.07		63.49		67.19		93.90		35.40	
Age	-.30*	-.37	-.30*	-.37	-.46*	-.23	-.47*	-.23	-.44*	-.26	-.45*	-.27	-.36	-.08	-.30	-.06
Gender	-1.58	-.16	-1.58	-.16	-12.65*	-.51	-12.62*	-.51	8.49*	.41	8.51*	.41	7.51	.13	7.24	.13
Wear Time	-.00	-.40	-.00	-.04	-.01	-.03	-.01	-.04	.00	.01	-.00	-.01	.05	.12	.07	.18
MVPA	-.11*	-.40	-.11*	-.40	-.28*	-.39	-.28*	-.40	-.26*	-.45	-.27*	-.45	-.04	-.02	-.01	-.01
Meds													-27.56*	-.50	-28.82*	-.52
SB			.00	-.00			-.01	-.03			-.00	-.02			.06	.12
R^2	.18*		.17		.27*		.26		.46*		.45		.21*		.21	
F	4.92*		3.88		7.33*		5.78		15.83*		12.49		4.73*		4.10	
ΔR^2			.00				.00				.00				.01	
ΔF			.00				.04				.04				.81	

Note. +Daily Time spent in sedentary behavior measured by the activPal™. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for cholesterol. SB = Sedentary Behavior *p <.05.

Table 19b

Summary of Predictors for Metabolic Variables+

	High-Density Lipoproteins (n=72)				Triglycerides (n=72)				Fasting Blood Glucose (n=72)				Total Cholesterol (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	.42		-14.74		217.02		32.88		99.02		90.73		131.36		6.85	
Age	.80*	.28	.82*	.29	-1.02	-.11	-.75	-.08	-.26	-.20	-.25	-.18	.24	.04	.42	.07
Gender	11.20*	.32	11.13*	.32	8.80	.07	7.93	.07	-2.81	-.16	-2.85	-.16	26.71*	.34	26.12*	.33
Wear Time	-.01	-.04	-.00	-.02	-.01	-.01	.07	.08	.02	.13	.02	.16	.04	.07	.09	.16
MVPA	.24	.24	.25	.25	-1.22*	-.36	-1.13*	-.33	-.02	-.04	-.01	-.03	-.19	-.08	-.13	-.06
Meds	.23	.01	-.10	-.00	-.27	-.00	-4.24	-.04	.23	.01	.05	.00	-26.41*	-.35	-29.09*	-.38
SB			.02	.05			.20	.19			.01	.06			.13	.19
R^2	.09*		.08		.08		.09		-.01		-.03		.21*		.22	
F	2.35*		2.0		2.22		2.14		.839		.712		4.68*		4.29	
ΔR^2			.00				.02				.00				.02	
ΔF			.13				165				.14				1.99	

Note. +Daily Time spent in sedentary behavior measured by the activPal™. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for cholesterol. SB = Sedentary Behavior. *p <.05.

Table 19c

Summary of Predictors for Cardiovascular Variables+

	V1 Left SBP (n=70)				V1 Left DBP (n=70)				V1 Right SBP (n=72)				V1 Right DBP (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	76.82		22.64		109.37		67.90		81.34		30.14		110.83		80.24	
Age	-.07	-.03	.01	.00	-.65*	-.40	-.58*	-.36	-.14	-.06	-.07	-.03	-.59*	-.38	-.54*	-.35
Gender	.87	.03	.59	.02	-4.35	-.22	-4.57	-.23	1.30	.05	1.04	.04	-2.74	-.14	-2.90	-.15
Wear Time	.05	.26	.08	.36	.02	.16	.04	.28	.06*	.30	.08*	.40	.01	.11	.03	.20
MVPA	-.14	-.16	-.12	-.14	-.14	-.25	-.12	-.30	-.16	-.20	-.20	-.25	-.10	-.18	-.09	-.16
Meds	8.60*	.29	8.72*	.30	1.09	.06	1.18	.06	6.27*	.24	6.38*	.24	.99	.05	1.06	.06
SB			.06	.21			.04	.25			.05	.22			.03	.19
R^2	.08		.10		.11*		.14		.08		.10		.07		.09	
F	2.25		2.29		2.73*		2.91		2.20		2.30		2.10		2.08	
ΔR^2			.03				.04				.03				.02	
ΔF			2.29				3.3				2.53				1.85	

Note. +Daily Time spent in sedentary behavior measured by the activPal™. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for blood pressure. SB = Sedentary Behavior. *p <.05.

Table 19d

Summary of Predictors for Cardiovascular Variables+

	V2 Left SBP (n=70)				V2 Left DBP (n=70)				V2 Right SBP (n=72)				V2 Right SBP (n=72)			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta	b	Beta
Constant	84.48		78.60		105.26		98.84		84.14		71.55		92.59		123.60	
Age	-.15	-.07	-.14	-.06	-.60*	-.34	-.60*	-.39	-.12	-.05	-.10	-.04	-.53*	-.33	-.57*	-.36
Gender	1.15	.04	1.12	.04	-6.42*	-.34	-6.45*	-.35	1.06	.04	.99	.04	-2.11	-.11	-1.95	-.10
Wear Time	.05	.25	.05	.26	.02	.17	.02	.19	.05	.23	.05	.26	.03	.18	.01	.09
MVPA	-.09	-.10	-.08	-.10	-.15*	-.27	-.14*	-.27	-.06	-.08	-.06	-.07	-.11	-.19	-.12	-.21
Meds	5.54	.20	5.56	.20	.92	.05	.93	.05	6.20	.23	6.23	.23	.00	.00	-.07	-.00
SB			.01	.03			.01	.04			.01	.05			-.03	-.19
R^2	.02		.00		.17*		.16		.03		.01		.03		.04	
F	1.26		1.04		3.83*		3.16		1.35		1.14		1.45		1.50	
ΔR^2			.00				.00				.00				.02	
ΔF			.03				.09				.13				1.70	

Note. +Daily Time spent in sedentary behavior measured by the activPal™. Controlling variables were age, gender, accelerometer wear time, MVPA = Moderate and vigorous physical activity, and medications. Meds = medications for blood pressure. SB = Sedentary Behavior. *p <.05.

Regardless of how sedentary behavior was measured, it was a non-significant predictor of the health outcomes after controlling for age, gender, accelerometer wear time, moderate to vigorous physical activity and medications for either cholesterol or blood pressure.

Logistic regression to predict participant classification of having Metabolic Syndrome

A logistic regression was conducted to determine whether the additional factor of sedentary behavior predicted the likelihood of being classified as having the Metabolic Syndrome. There were a total of 72 individuals in this analysis and 17 of them were classified as having the Metabolic Syndrome. Classification was based on whether or not the participant had each risk factor for the Metabolic Syndrome in the risk factor profile in Table 1 (page 74). The control variables were age, gender, and accelerometer wear time. Then the independent predictor variables of moderate (6.3-28.44 minutes per day) and high (≥28.45 minutes per day) volumes of moderate to vigorous physical activity were added into the model. Lastly, moderate and high volumes of sedentary behavior were added into the model. The Actigraph accelerometer daily time in sedentary behavior was divided into moderate (549.4-645.2 minutes per day) and high (≥ 645.3 minutes per day) volumes of sedentary behavior, then the percent of day engaged in moderate (62.07-68.22% of day) and high (≥ 68.23% of day) volumes of sedentary behavior and the activPal™ time in sedentary behavior was done in the same manner (moderate: 452.51-518.75 minutes per day; high: ≥518.76 minutes per day). Low volumes of sedentary behavior and moderate to vigorous physical activity were used as a referent category.

The results presented in Table 21-22 suggest there were no significant predictors for classifying older adults with having the Metabolic Syndrome.

Table 20

Logistic Regression Analysis to Predict Classification of The Metabolic Syndrome Based on Risk Factors and Daily Time in Sedentary Behavior (Actigraph)

Predictors	*b*	SE	Wald	df	*P*	OR (95% CI)
Age	-.106	.099	1.134	1	.287	.900 (.741, 1.093)
Gender	1.470	1.440	1.042	1	.307	4.348 (.259, 73.112)
Wear time	.001	.008	.011	1	.916	1.001 (.984, 1.018)
MVPA (1)	-1.766	1.165	2.298	1	.130	.171 (.017, 1.678)
MVPA (2)	-2.053	1.794	1.310	1	.252	.128 (.004, 4.318)
SB (1)	-.784	1.180	.441	1	.506	.457 (.045, 4.612)
SB (2)	-.176	1.651	.011	1	.915	.838 (.033, 21.306)

Note. 17 out of 72 participants were classified as having the Metabolic Syndrome. Control variables were age and gender. Independent predictors (Model 2) were MVPA (0) = low ≤6.3 minutes per day used as a referent category;MVPA (1)= Moderate to Vigorous Physical Activity, moderate volume = 6.3-28.44, minutes per day. MVPA (2)= Moderate to Vigorous Physical Activity, high volume, ≥28.45 minutes per day. Independent predictors (Model 3) were SB (0) = low ≤549.39 minutes per day used as a referent category; SB (1) = moderate volume of sedentary behavior, 549.4-645.2 minutes per day. SB (2) = high volume of sedentary behavior, ≥645.3 minutes per day.

Table 21

Logistic Regression Analysis to Predict Classification of The Metabolic Syndrome Based on Risk Factors and Percentage of Time in Sedentary Behavior (Actigraph)

Predictors	*b*	SE	Wald	df	*P*	OR (95% CI)
Age	-.100	.086	1.345	1	.246	.905 (.764, 1.071)
Gender	1.065	1.258	.716	1	.397	2.900 (.246, 34.138)
MVPA (1)	-1.787	1.072	2.776	1	.096	.167 (.020, 1.370)
MVPA (2)	-1.849	1.512	1.496	1	.221	.157 (.008, 3.046)
SB (1)	.133	1.069	.016	1	.901	1.143 (.141, 9.282)
SB (2)	-.442	1.304	.115	1	.734	.643 (.050, 8.269)

Note. 17 out of 72 participants were classified as having the Metabolic Syndrome. Control variables were age and gender. Independent predictors (Model 2) were MVPA (0) = low ≤6.3 minutes per day used as a referent category;MVPA (1)= Moderate to Vigorous Physical Activity, moderate volume = 6.3-28.44, minutes per day. MVPA (2)= Moderate to Vigorous Physical Activity, high volume, ≥28.45 minutes per day. Independent predictors (Model 3) were SB (0) = low ≤62.06% used as a referent category; SB (1) = moderate volume of percent of day spent in sedentary behavior, 62.07-68.22%. SB (2) = high volume of percent of day spent in sedentary behavior, ≥68.23%.

Table 22

Logistic Regression Analysis to Predict Classification of The Metabolic Syndrome Based on Risk Factors and Daily Time in Sedentary Behavior (activPal™)

Predictors	*b*	SE	Wald	df	*P*	OR (95% CI)
Age	-.114	.088	1.685	1	.194	.892 (.751, 1.060)
Gender	1.236	1.249	.979	1	.322	3.443 (.298, 39.837)
Wear time	.002	.007	.065	1	.799	1.002 (.988, 1.015)
MVPA (1)	-2.036	1.219	2.788	1	.095	.131 (.012, 1.424)
MVPA (2)	-2.432	2.493	2.652	1	.103	.088 (.005, 1.640)
SB (1)	-2.036	1.241	2.691	1	.101	.131 (.011, 1.486)
SB (2)	-1.337	1.091	1.501	1	.221	.263 (.031, 2.230)

Note. 17 participants out of 72 participants were classified as having the Metabolic Syndrome. Control variables were age and gender. Independent predictors (Model 2) were MVPA (0) = low ≤6.3 minutes per day used as a referent category; MVPA (1)= Moderate to Vigorous Physical Activity, moderate volume = 6.3-28.44, minutes per day. MVPA (2)= Moderate to Vigorous Physical Activity, high volume, ≥28.45 minutes per day. Independent predictors (Model 3) were SB (0) = low ≤452.5 minutes per day used as a referent category; SB (1) = moderate volume of sedentary behavior, 452.51-518.75 minutes per day. SB (2) = high volume of sedentary behavior, ≥518.76 minutes per day.

Sedentary behavior, regardless of how it was measured, was not a significant predictor of classifying the Metabolic Syndrome in this sample of older adults.

Summary

Upon examination of the relationship between cardiometabolic health and sedentary behavior there were inconsistencies across the results. There were no common findings between the assessments when different monitors were used to assess sedentary behavior as well as there were no similar results across group and gender analysis.

Specifically, the results of the partial correlations suggest inverse relationships between sedentary behavior and waist circumference and body mass index in women and diastolic blood pressure in men. Similarly to the partial correlation results, Pearson correlations also resulted in inconsistent findings across assessment methods, group and gender analysis. However there was a trend with positive relationships between the percent of day being sedentary and measures of body size, either by waist circumference or body fat percentage, in men and women.

There were more significant findings when changes in health variables were examined across different amounts of sedentary behavior. However there were similar inconsistencies in these findings similar to those in previous analyses. When significant differences occurred in health across sedentary behavior groups, regardless of assessment tool, they occurred between the moderately sedentary and highly sedentary groups with the most sedentary group having the worse health outcome. For example there were strong relationships between higher daily percentages of sedentary behavior and body size measures; waist circumference and percent body fat, supportive to what was observed in the Pearson correlation analysis.

When further analysis was done to examine the significant findings from the Pearson Correlations, moderate and high volumes of sedentary behavior were not significant predictors of obesity measured as waist circumference or percent body fat and high triglycerides. The significant predictors of obesity measured with waist circumference were the participation in moderate and high volumes of moderate to vigorous physical activity. Only the participation in high volumes of moderate to vigorous physical activity was predictive of obesity measured as percent body fat. Lastly there were no significant predictors of high triglycerides. These results could be due to the lack of variation in the time spent engaging in sedentary behavior.

Sedentary behavior was further examined as a predictor of anthropometric, metabolic, and cardiovascular health variables. The current study did not find sedentary behavior to be predictive of any of these health variables, regardless of how sedentary behavior was assessed. The common variables that were predictive of anthropometric, metabolic, and cardiovascular variables were age, gender, and participation in moderate to vigorous physical activity. Medication usage also predicted some of the metabolic and cardiovascular variables.

The last analysis of sedentary behavior and health was an examination of whether moderate or high volumes of sedentary behavior could predict the likelihood of older adults being correctly classified as having the Metabolic Syndrome. There were no statistically significant predictors of the Metabolic Syndrome. Sedentary behavior again was not predictive of classifying the Metabolic Syndrome.

In general sedentary behavior was mostly related to measures of body size (i.e., waist circumference or percent body fat). Also individuals who were more active

(meeting the physical activity recommendations) engaged in significantly less sedentary behavior (30-70 minutes per day assessed with the Actigraph and activPal™ accelerometers, respectively) than those who were least active engaging in less than 10 minutes per day of moderate to vigorous physical activity. Interestingly sedentary behavior was not predictive of any anthropometric, metabolic, or cardiovascular health variable. Lastly, sedentary behavior was unable to predict the classification of older adults having the Metabolic Syndrome.

The next section will examine the results of sedentary behavior recorded in self-report sedentary behavior diaries.

Objective 2: Factors of Sedentary Behavior

Sedentary Behavior Diary Overview

To better understand the contextual factors of sedentary behavior the participants were asked to report their daily activities in self-report diaries. These diaries where completed on two weekdays and one weekend day. Each diary timeframe was 24-hours. All participants completed one weekend diary however two women did not complete a weekday diary. The diary days were randomized so the data would be representative of an entire week. Table 23 presents the frequency of days the diaries were completed. In the diaries the participants were asked if this was a typical day for them. A majority of this sample did make comments of their diary days not always being typical, "Because once you are retired there are no time schedules or routines, therefore no real typical days." However 49.3% of the group said the days they were required to complete the diary were typical and this was consistent between weekend and weekdays, 47.2% and 50.3%, respectively.

Table 23

Days of the Week Frequencies for Entire Group Completing the Self-Report Diary

Days of the Week	Diary Day 1	Diary Day 2	Diary Day 3
Sunday ($n = 34$)	11	15	8
Monday ($n = 32$)	2	13	17
Tuesday ($n = 24$)	7	7	10
Wednesday ($n = 31$)	14	2	15
Thursday ($n = 26$)	11	7	8
Friday ($n = 31$)	18	10	3
Saturday ($n = 41$)	10	19	12

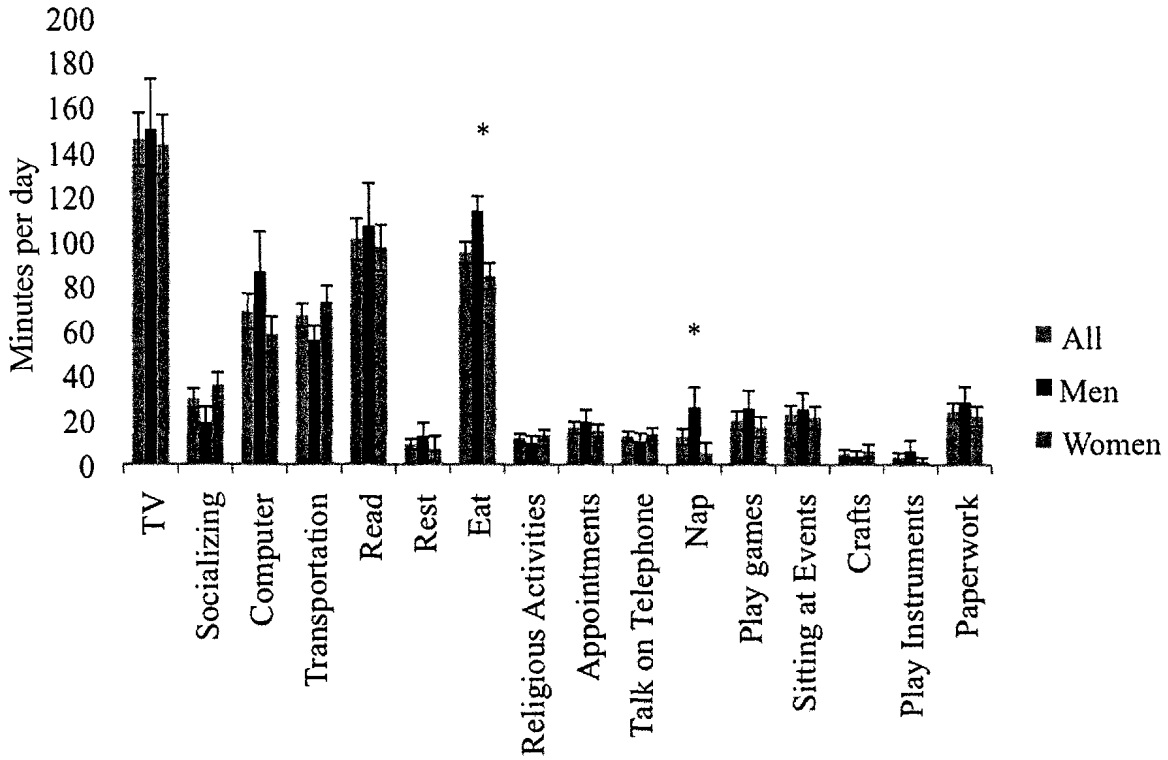
Characteristics of Sedentary Behavior Reported in the Diary

Descriptive information is presented next and will be described by group and gender first and then according to weekday or weekend day. The diary entries were for every half hour of the day and participants were asked to report only one primary behavior that took place during that timeframe. Because of the diary design all of the results are an estimate of the time spent in each reported behavior.

Group and Gender Descriptives of Sedentary Behavior

The participants reported sleeping for approximately 498.2±54.3 minutes per day (8.3 hours per day), therefore the majority of sedentary behaviors occurred during the time they were awake (941.8±54.3 minutes per day or 16 hours per day). During the reporting time, older adults recorded approximately 32 general behaviors and of those 16 were considered sedentary activities. The average time the participants reported in these sedentary behaviors is presented in Figure 1.

Figure 1. Gender Differences in Reported Time Spent in Sedentary Behaviors.



Note. The time spent in sedentary behavior is the mean with standard errors. The means are reported over a three-day period, two weekdays and one weekend day. $p < .05$.

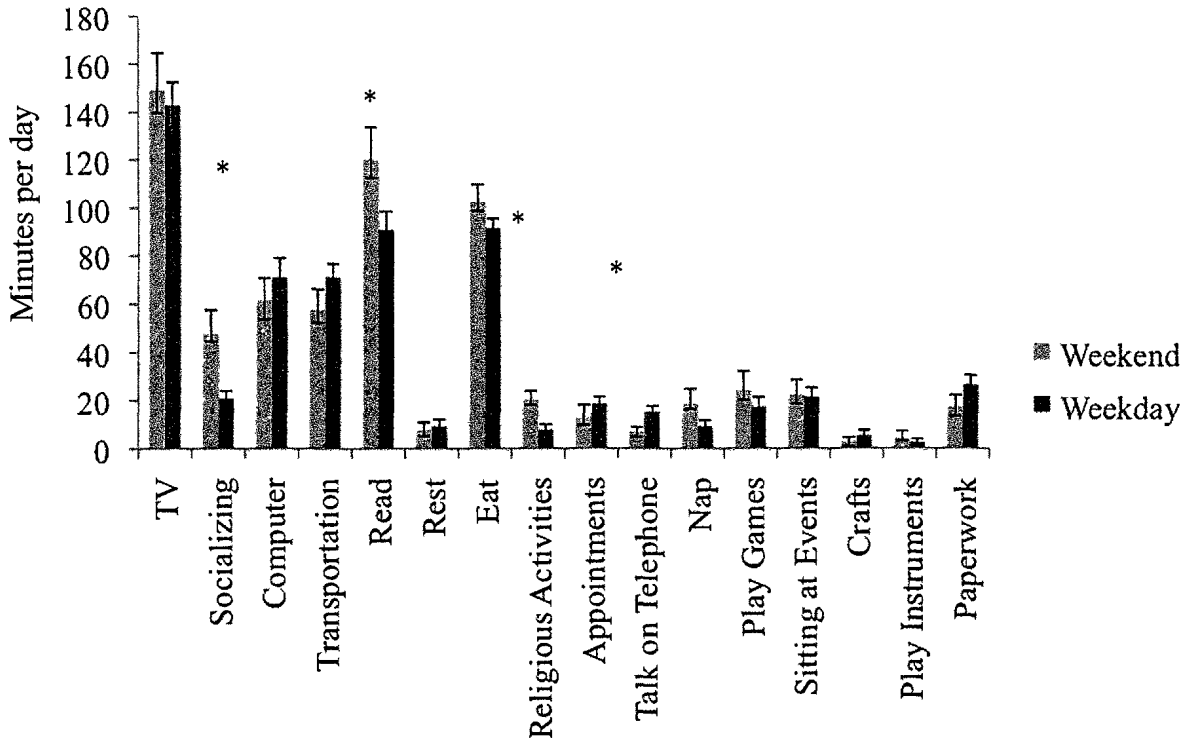
This sample of older adults engaged in 10 or more sedentary behaviors during the hours of 7 a.m. to 10 p.m. The most frequently reported sedentary behaviors for the entire group were watching television (145.3±99.1 minutes per day), reading (100.8±79.7 minutes per day), eating (94.9±40.2 minutes per day), using the computer (68.4±69.8 minutes per day), and sitting in their vehicle for transportation (66.6±45.7 minutes per day). The least reported were resting (9±20.7 minutes per day), doing crafts (4.7±16.6 minutes per day) and playing instruments (3.3±16.8 minutes per day). There were significant gender differences at the .05 level. The men reported eating [*M*=113.46 minutes per day, *SD*=33.93 minutes per day; $t(71)=3.112$, $p=.003$] significantly more than women (*M*=84.57 minutes per day, *SD*=40.01 minutes per day). Men also napped [*M*=25.7, *SD*=46.49; $t(71)=2.220$, $p=.035$] significantly more than women (*M*=5.10, *SD*=12.83) . There were no other gender differences in the recorded sedentary behaviors.

Weekday and Weekend Descriptive of Sedentary Behavior

Because there were limited gender differences in sedentary behaviors gender was not examined when comparing sedentary behaviors between weekdays and weekends. The analysis demonstrated significantly more differences depending on whether it was a weekend versus weekday. There were significant differences in time spent socializing with greater time spent socializing on the weekends [*M*=47.92 minutes per day, *SD*=83.45 minutes per day, $t(215)$, 2.611, $p = .011$] versus the weekdays (*M*=20.9 minutes per day, *SD*=38.78). Also this group read significantly more on the weekends [*M*=120.42 minutes per day, *SD*=114.1 minute per day; $t(215) = 2.036$, $p = .043$] versus during the week (*M*=91.03 minutes per day, *SD*=92.43 minutes per day). Intuitively, more time was spent engaged in religious activities on the weekend [*M* = 20.42 minutes

per day, *SD*=32.17 minutes per day; $t(122.58) = 2.846$, $p = .005$] versus weekday (*M*=7.86 minutes per day, *SD* = 27.16 minutes per day). And lastly, this group talked on the telephone significantly more during the week [*M*=15.52 minutes per day, *SD*=29.39 minutes per day; $t(212.35) = -2.715$, $p = .007$] than on the weekends (*M*=7.1 minutes per day, *SD*=16.3 minutes per day).

Figure 2. Weekday and Weekend Differences in Sedentary Behaviors.



Note. The time spent in sedentary behavior on weekends and weekdays are the mean with standard errors. The means are reported over a three-day period, two weekdays and one weekend day.

$p < .05$.

Weekday and Weekend Commonly Recorded Sedentary Behaviors

The last area examined with the sedentary behavior diary was the factors relating to these behaviors. Based on previous pilot work to design and test a sedentary behavior diary, the following factors were informed by that project. For each diary entry the participants were asked to answer whether they were alone during the activity (yes or no), if they were eating during the activity (yes or no), and how enjoyable that activity was (1 very enjoyable to 7 least enjoyable). There were five commonly reported sedentary behaviors; watching television, reading, sitting in a vehicle (transportation), using the computer and eating. The frequencies of the aforementioned factors relating to the engagement in these five commonly recorded sedentary behaviors are presented in Table 23.

The weekday results suggest this group of older adults ate more times during the week while engaging in these behaviors than on the weekends. However eating was not as prevalent while using the computer. Individuals also reported eating while alone more times during the week rather than on the weekends. Moving onto the weekend analysis there was only one stand out difference. The participants reported being alone less while engaging in these sedentary behaviors than they would be during the week. In general for the week the average enjoyment values for these behaviors were a rating of three or less.

Table 23

Frequencies of the Factors Relating to the Commonly Reported Sedentary Behaviors for the Entire Group

Activity	Eating	Alone	Average Enjoyment	Alone and Eating
Weekend (n = 73)				
TV	12.3%	53.4%	2.6	8.2%
Computer	9.6%	50.7%	3	6.8%
Transportation	13.7%	52.1%	2.7	9.6%
Reading	12.3%	50.7%	2.3	9.6%
Eating	100%	56.2%	2.3	--
Weekday (n = 71)				
TV	22.5%	76.1%	2.8	22.5%
Computer	8.4%	70.4%	2.7	7%
Transportation	16.9%	78.9%	2.9	9.9%
Reading	39.4%	84.5%	2.4	26.8%
Eating	100%	88.7%	2.3	--

Note. TV = watching Television. The enjoyment scale ranged from a ranking of 1 = very enjoyable to 7 = the least enjoyable.

Summary

Participants of this study were required to complete a diary describing their daily activities on two weekdays and one weekend day. During this time they recorded activities for approximately 16 hours each day. There were 32 behaviors recorded and half of them were sedentary behaviors. During the hours of 7 a.m. to 10 p.m. these older adults engaged in 10 or more sedentary behaviors out of the 16 recorded in their diaries. The most commonly reported sedentary behaviors were watching television, using the computer, sitting in a vehicle (transportation), reading, and eating. Upon examination there were very few gender differences between these behaviors, however more differences occurred depending on whether it was a weekday versus a weekend day. These older adults napped, attended religious services, read, and socialized more on the weekends than during the week. Lastly, participants recorded when they were alone, ate, and how much they enjoyed doing the activities they recorded. From this information it was gleaned that this sample of older adults ate more and are alone engaging in sedentary behaviors more so during the week than on the weekends.

Chapter Summary

This project explored the relationship between sedentary behavior measured with accelerometers and cardiometabolic health variables related to chronic disease development in a group of retired older adults, aged 65-90. The study also explored the actual types of sedentary behaviors this group of participants engaged in by having them self-report their activities in a diary on three days of the week. Additional information was reported in the diaries about whether they were alone, ate during the activity, and how much they enjoyed the activity. Because this study was comprehensive in the

assessment of sedentary behavior and health the information gleaned portrays an interesting picture of the relationship between sedentary behavior and health in older adults.

The participants in this study were primarily sedentary when examined with objective monitors. They engaged in sedentary behaviors for approximately 8-10 hours per day and engaged in less than 30 minutes per day of health promoting moderate and vigorous physical activity. However these older adults walked an average of 8000 steps per day. The men were more sedentary but engaged in more moderate and/or vigorous physical activity and stood for a longer period of time each day than the women. Additionally when this group was divided into three groups of physical activity levels based upon compliance with national physical activity recommendations, there were differences between the amounts of sedentary behavior. The individuals who engaged in the recommended amount of physical activity to promote health were less sedentary than the individuals engaging in no leisure time physical activity or an insufficient amount to meet the physical activity recommendations. The following paragraphs summarize the findings from the statistical analysis exploring the relationship between sedentary behavior and health in older adults.

When examining the relationships between sedentary behavior and health with while controlling for health promoting physical activity the partial correlations revealed no relationship between this behavior and any health outcome when the entire sample was examined. However when men and women were investigated separately negative relationships existed. For women the relationships were small and suggested with increased sedentary behavior (assessed with the Actigraph accelerometer) they would

have lower body mass index values and smaller waist circumferences. In men there was a strong negative relationship suggesting increased sedentary behavior (assessed with the activPal™) was related to lower right arm diastolic blood pressure.

Furthermore when Pearson correlations were conducted significant relationships also varied by gender and the assessment of sedentary behavior. For the entire group sedentary behavior was positively related to waist circumference and triglyceride values when measured as a percent of the day in sedentary behavior with the Actigraph accelerometer and sedentary behavior measured with the activPal™, respectively. This suggests increased time being sedentary behavior is related to higher triglyceride values and larger waist circumferences. Again when sedentary behavior was measured as a percent of the day, similar relationship existed in both men and women. In both genders there were positive relationships with percent body fat, again suggesting increased sedentary time is related to increased body fat. However these were the only health variables relating to sedentary behavior.

Additional support was observed when the one-way analysis of variance was conducted. There was evidence that individuals engaging in the most sedentary behavior had larger waist circumferences and body fat percentages (sedentary behavior assessed with the Actigraph accelerometer) as well as higher triglyceride values (sedentary behavior assessed with the activPal™). These results suggest sedentary behavior is related to some health variables, like triglycerides and those related to measures of body size and/or obesity like body mass index, waist circumference and percent body fat.

However when sedentary behavior was examined in hierarchical regression analysis as an independent predictor of various health measures, there were no significant

findings. This was also observed when sedentary behavior was examined to be a predictor of classifying individuals with the Metabolic Syndrome. However participation in moderate to vigorous physical activity was a significant predictor for most variables.

When examining self-report sedentary behavior through diaries it was observed that older adults engage in about 32 different activities throughout the day and half of those were activities they reported as being sedentary. Ten or more of the 16 sedentary behaviors were done between the hours of 7 a.m. and 10 p.m. The most commonly reported activities were watching television, using the computer, sitting in a vehicle for transportation, eating, and reading. There were gender differences with men engaging in more eating and napping than women. Also people engaged in more socializing, readings, religious activities, and talking on the telephone on the weekends than weekdays. More people also reported being alone and eating more during these behaviors on the weekdays than on the weekends. The participants in this sample rated these activities at an enjoyment of 3 using a 1 out of 7 scale, with 1 being highly enjoyable and 7 being the least enjoyable.

The combined approach to examining sedentary behavior and health objectively with accelerometers and the additional use of self-reported sedentary behavior diaries provides an interesting look at this prevalent behavior. The following chapter discusses these results in relation to the current literature relating to this topic.

CHAPTER V: DISCUSSION

Introduction

Over the next twenty years individuals over 65 years of age will make up approximately 20% of the United States population (Wan et al., 2005; CDC, 2007). Because a majority of older adults have preventable health conditions (i.e., heart disease, cancer, type 2 diabetes, obesity, and stroke) that can develop from lifestyle factors, especially physical inactivity, interest has arisen in examining the relationship between health and physical inactivity behavior (Mokdad et al., 2000). A primary contributor to a person's high physical inactivity level is the participation in sedentary behavior.

Sedentary behaviors include activities like reading, lying down, sitting, watching television and/or other forms of screen based entertainment. Older adults have been observed to engage in nine or more hours of sedentary behavior and not enough moderate and/or vigorous physical activity to meet the national recommendations for health promotion (Troiano et al., 2007; Matthews et al., 2008). Physical activity reduces the risk for cardiovascular disease development, helps maintain physical function, reduces fall risk and injury and is therapeutic for many of the chronic disease conditions seen in older populations (Hageberg et al., 1989; Fielding et al., 2007, Smulders, et al., 2010). Because older adults do not engage in enough physical activity their level of sedentary behavior could be problematic for their health.

Interest in the topic of sedentary behavior and health in adults arose when epidemiological study findings suggested positive relationships between increased time watching television and the increased likelihood of those individuals having a chronic condition like obesity, impaired fasting glucose, cardiovascular disease, and the

metabolic syndrome (Hu et al., 2003; Healy et al., 2007; Katzmarzyk et al., 2009; Dunstan et al., 2010). Similar results were apparent when sedentary behavior was assessed with objective assessments (i.e., accelerometry) suggesting increased total time spent in sedentary behaviors were negatively related to individuals having certain heath conditions (i.e., abnormal cholesterol, high blood pressure, larger waist circumference) in younger and middle-aged adults (Healy et al., 2007; Healy et al., 2008). These findings are important when we think about an older persons health and how prevalent these conditions are in this population, especially if they engage in high amounts of a behavior that could contribute to their disease development.

Unfortunately not a lot of information exists about sedentary behavior and how it impacts the health of older adults specifically. In younger populations researchers have monitored sedentary behavior with objective monitors and explored this behavior through self-report survey analysis of specific behaviors like television viewing or using the computer as well as time spent sitting at work (McCormack et al., 2003; Evenson & McGinn, 2005; Matthews et al., 2008). In older adults specifically their physical activity and sedentary behavior has been monitored objectively and there are some reports about what types of general activities older adults do but no studies have examined sedentary behaviors and the factors that relate to them (Davis & Fox, 2007; BLS, 2008). Therefore very little comprehensive information exists about the quantity and quality of sedentary behavior in an older adult population.

Because the previous research has examined sedentary behavior and health outcomes in primarily younger age groups with limited methodologies very few conclusions can be drawn about this behavior as it relates to the health of older adults.

Little is known about the types of sedentary behaviors older adults engage in on a regular basis. Therefore research examining the relationship between sedentary behavior and health and the exploration of sedentary behavior with more complete methodologies (i.e., objective monitoring of sedentary behavior and subjective self-report of sedentary behavior) is necessary. Results of a comprehensive study like the current one will help researchers identify if this behavior is related to health, which could lead to national recommendations for the reduction of sedentary behavior for older adults.

The purpose of this study was two-fold; first, to examine the relationship between objectively defined total time spent in sedentary behavior and the cardiometabolic risk factors associated with chronic disease development in older adults; and second to define the common sedentary behaviors in which older adults regularly participate and the characteristics and context in which the behaviors are performed. To examine the primary purpose or study objective the following examinations were done: (1) explored the profiles of older adult physical activity and sedentary behavior with objective assessment, (2) determined the strength of the relationship between total time (minutes per day and as a percent of day) in sedentary behavior with cardiometabolic risk factors for chronic disease development; investigated the differences in health outcomes across levels of sedentary behavior, (3) established whether total time (minutes per day) spent in sedentary behavior could predict each of the cardiometabolic risk factors with age, gender, accelerometer time worn, and total time spent in moderate to vigorous physical activity measured by the accelerometers adjusted as potential confounders, (4) examined whether low and high amounts of sedentary behavior predicted participant classification of having the Metabolic Syndrome. To address the second purpose the current study (5)

explored sedentary behavior with self-report diaries and the factors relating to the participation in sedentary behaviors.

The study results demonstrated (1) older adults engage in sedentary behavior for approximately 8-10 hours per day with men being more sedentary than women; men also spent significantly more time engaged in moderate to vigorous physical activity than women and the individuals who met the physical activity recommendations engaged in significantly less sedentary behavior than those who were less active, (2) positive, medium to strong relationships were present between increasing sedentary behavior time and triglycerides, although moderate and high volumes of sedentary behavior were unable to predict whether older adults would be likely to be obese or have high triglycerides, (3) the low and moderately sedentary groups had significantly lower triglycerides and waist circumferences, respectively, than the highly sedentary group, (4) sedentary behavior was not a predictor of any health variable related to chronic disease development in older adults; low and high levels of sedentary behavior were unable to classify participants as having the Metabolic Syndrome. There is one primary limitation to this study, which impacted some of the findings previously reported and that is the lack of variation in sample for time spent in sedentary behavior and the limited number of people whose health was not medically controlled. (5) Older adults engaged in approximately 16 different sedentary behaviors with the most time spent watching television, using the computer, sitting in a vehicle for transportation, reading, and eating; adult men engaged in more napping and eating more than women; and the weekends were spent engaging in longer periods of specific sedentary behaviors than during the week.

The following sections of this discussion will address the results as they relate to the current literature relationships between sedentary behavior and health (anthropometrics, metabolic, and cardiovascular). Then a discussion relating to the findings from the self-report sedentary behavior diaries and lastly the chapter will end with limitations of the current study and future research directions.

Actigraph - Sedentary Behavior Profiles of Older Adults

The participants in the current study engaged in approximately 10.3 hours per day of sedentary behavior, which consisted of approximately 65.4% of their day. The group of older adults in the current study engaged in approximately one hour of sedentary behavior more than those observed in the NHANES 2003-04 study but the percent of day they were sedentary was similar, 65.4% (the current study) versus 66.3-67.8% (60-69 year olds and >70 years of age, NHANES 2003-04 study) (Matthews, et al., 2008).

Also both the current study and that conducted by Matthews and colleagues (2008) observed gender differences in sedentary behavior. The men in both the current study (10.9 hours per day) and the men in the study conducted by Matthews et al. (2008) (9.5 hours per day) engaged in more sedentary behavior than women (9.9 hours per day, 9.1 hours per day, respectively). Similar gender differences in sedentary behavior time were also observed in older adults, 70 years of age and older, participating in the Better Ageing Project (Davis & Fox, 2007). In the study by Fox and Davis (2007) sedentary behavior was measured as bouts (a bout was 60 minutes) and the men engaged in 1.42 bouts, which was significantly more than the women 1.05 bouts, p=.009.

Previous literature also suggests there are differences in time being sedentary with increased age. In the current project there were no differences in sedentary behavior time

across age groups (65-69 year olds: 9.83 hour per day, 70-79 year olds: 10.4 hours per day, 80-90 year olds: 10.8 hours per day) but differences between the 65-69 year olds and the 80-90 year olds did approach significance, p=.056. The oldest age group spent approximately one hour per day more engaged in sedentary behaviors, which is similar to what the literature has described. Matthews and colleagues (2008) observed adults 70 years of age and older to be more sedentary, spending 9.1-9.5 hours per day engaging in sedentary behaviors compared to those 60-69 years of age engaging in 8.1-8.8 hours of sedentary behavior (Matthews, et al., 2008).

In general the older adults in the current study engaged in a significant amount of sedentary behavior, greater than 65% of their day was spent being sedentary. Their sedentary behavior profile is similar to what other studies have observed and evidence suggests that sedentary behavior may increase with age. In the current study there were two monitors used to capture sedentary behavior and in the next section the sedentary behavior profile of older adults will be discussed with the second monitor, the activPal™.

activPal™ - Sedentary Behavior Profiles of Older Adults

When the activPal™ monitor was used in this study to capture sedentary behavior it reported that the group was sedentary for approximately eight hours per day, which is about 2.3 hours less than what the Actigraph accelerometer measured. These findings are approximately .4-1.3 hours less than that reported when Actigraph accelerometers were used to assess sedentary behavior in adults 60-69 years of age and 70-85 years of age in the NHANES 2003-04 study (Matthews et al., 2008). The activPal™ data also suggested differences in sedentary behavior across age groups like the previous literature has suggested (Matthews et al., 2008). However in the current study these differences were

opposite, the 80-90 year olds engaged in significantly less sedentary behavior (7.4 hours per day) than the 65-69 year olds (8.3 hours per day), a difference of approximately 82 minutes. These results differ from those in the previously mentioned study by Matthew et al. (2008) that found the oldest age groups to engage in more sedentary behavior than their younger peers. However in that study the Actigraph accelerometer was the device used to assess sedentary behavior (Matthews et al., 2008).

Currently there are no published studies reporting on the sedentary behavior profiles captured with this monitor. The current study adds to the literature by describing the sedentary behavior profiles of older adults with a novel monitor. Evidence from the current study finding suggests the activPal™ monitor to report significantly lower amounts of sedentary behavior than the Actigraph monitor [activPal™: M=480.89 minutes per day, SD=54.424 minutes per day; Actigraph: M=617.82 minutes per day, SD=80.74 minutes per day, $t(70) = 10.492$, p=.000]. However very few published studies have examined the differences in sedentary behavior between these accelerometers and none have been published with an older adult population.

When researchers have examined the convergent validity in a general aged population between the Actigraph and activPal™ the results are conflicting. Hart and colleagues (2011) observed the Actigraph to measure significantly more sedentary behavior than the activPal™. However the results of another convergent validity study by Kozey-Keadle and researchers (2011) resulted in no statistically significant differences between devices for measuring total sedentary behavior. However they used more stringent data processing procedures than the Hart et al. (2011) study. When conflicting results like this occur it becomes apparent that more research examining the

convergent validity of both monitors is necessary not just in older adult populations but across age groups.

Besides sedentary behavior both types of accelerometers also record measures of physical activity. The next sections compare the physical activity profiles of older adults in the current study with that reported in the literature. The sections are in order by monitor and will be described further by group then gender results if necessary.

Actigraph – Physical Activity Profiles

The older adults in the current study engaged in an average of 19 minutes of health promoting moderate to vigorous physical activity with less than one minute spent in vigorous physical activity. The time engaged in moderate to vigorous physical activity from this sample is similar to previous assessments of this physical activity intensity with accelerometers. Studies reporting on data from NHANES 2003-04 and the Better Ageing Project observed older adults participating in moderate to vigorous physical activity for 5-17 minutes per day and almost 20 minutes per day, respectively (Davis & Fox, 2007; Troiano et al., 2007).

In general the physical activity profile of the older adults in the current study are similar to the previous reports on older adult engagement in moderate to vigorous physical activity intensity. However more of the older adults in the current study met the national physical activity recommendations. The next section will describe the physical activity profile of older adults with the activPal™ monitor.

activPal™ - Physical Activity Profiles

The activPal™ monitor also records physical activity variables in addition to sedentary behavior. The older adults in the current study engaged in approximately 47 sit

to stand transitions throughout the day, stood for about 3.8 hours per day, and walked for approximately 2 hours per day. The men stood for approximately one hour less than the women and this was the only gender difference observed. This was a somewhat active group that took on average 7992 steps per day (Tudor-Locke and Bassett, 2004).

The activPal™ was primarily developed to assess sedentary behavior so no published studies have reported the physical activity information gleaned from this monitor. Therefore this information will be an addition to the physical activity literature by presenting some new descriptions of physical activity in older adults, sit to stand transitions, standing and walking time.

Sedentary Behavior Across Physical Activity Levels

In the current study there was a proportionate amount of older adults engaging in no leisure time physical activity (Group1: n=29, 0-9 minutes per day of moderate to vigorous physical activity), insufficient amounts of physical activity (Group 2: n=24, 10-29 minutes per day of moderate to vigorous physical activity), and meeting the national physical activity recommendations (Group 3: n=19, >30 minutes per day of moderate to vigorous physical activity). Therefore we examined if there were differences in sedentary behavior across these groups. When sedentary behavior was assessed as daily time with the Actigraph there were no differences across physical activity levels for groups 1-3 (10.6-9.9 hours per day).

However there were significant differences in sedentary behavior when it was examined as a percent of the day (measured by the Actigraph). The no leisure time physical activity group (group 1) was sedentary for about 10% more of their day than the met physical activity recommendations group (group 3) when the entire sample was

examined. A similar relationship was observed in both women and men. When gender was examined the women participating in the least amount of physical activity (group 1) was also significantly more sedentary, by 70 minutes per day, than those who met the physical activity recommendations (group 3). Also when the activPal™ monitor was used the insufficient physical activity group (group 2) spent significantly more time in sedentary behaviors than the met physical activity recommendations group (group 3), approximately 48 minutes.

This information has not been presented in the literature before and sheds new light on whether engaging in physical activity impacts the amount of time older adults are sedentary. The results in the current study make sense with the least active individuals being the most sedentary. The time these individuals should be engaging in physical activity is most likely being substituted with sedentary behaviors (Owen et al., 2000). In general, the differences were most apparent when sedentary behavior was examined as a percentage rather than in minutes per day, with those individuals meeting the physical activity recommendations spending the smallest percent of their day engaging in sedentary behaviors.

The current study used information on sedentary behavior and physical activity profiles of older adults to explore whether this combined behavior or sedentary behavior alone impacts the health profile of older adults. The next section will discuss the current study results on this relationship and how our results compare to what is commonly discussed within the literature.

The Relationship Between Sedentary Behavior and Health

In the current study the primary objective was to understand the relationship between objectively defined sedentary behavior and various anthropometric, metabolic, and cardiovascular measures that are related to chronic disease development in older adults. Currently a majority of studies have used surrogate measures of sedentary behavior like time spent watching television or overall sitting time that are self-report surveys or questionnaires and compared the time reported to various cardiometabolic health variables. Recently a few studies have reported examining this relationship with accelerometry to assess sedentary behavior in older adults. In general both types of studies have observed inverse relationships between self-report television watching and sitting time, and accelerometer determined sedentary behavior and cardiometabolic health. In other words the literature with younger and middle aged adults suggests that as people watch more television, sit more, or engage in longer amounts of sedentary behavior they have worse cardiometabolic health.

Sedentary Behavior and the Relationship to Anthropometric Variables

Body Mass Index

The research examining the relationship between sedentary behavior and obesity assesses sedentary behavior with primarily self-reports of television watching and engagement in sedentary leisure activities (Ching et al., 1996; Fung et al., 2000; Hu et al., 2003). Obesity has been assessed primarily with indirect measures of body mass index and with direct measures of percent body fat using bioelectrical impedance (BIA) or skin-fold assessment. All of these assessments of obesity besides body mass index differ from what has been done in the current study. Because of this the current study adds to the literature by incorporating new and more accurate assessments of total time in sedentary

behavior and more precise measures of obesity. The current study used accelerometers to objectively assess sedentary behavior, adds the indirect assessment of waist circumference and the direct assessment and current gold standard for body composition, the dual energy x-ray absorptiometer to assess obesity.

In the current study there were no significant relationships between sedentary behavior measured objectively with accelerometry and body mass index for the group, women and men (r= -.14-.09, p >.05). These results differ slightly from what has been reported when television watching was used as a measure of sedentary behavior. Fung et al. (2000) reported a positive relationship between television watching and body mass index (r=.13, p <.05).

Further differences between the current study and others occur during examinations of differences in body mass index across low, moderate, and high volumes of sedentary behavior. The current study suggests that body mass index is not affected by the time older adults spend being sedentary (26.8-27.2 kg/m^2, F(2,69)=.125, p=.882). This was also reported when Hu and colleagues (2003) examined the relative risks for being obese across increasing quintiles of sedentary behavior time spent sitting at home (reading, eating or at a desk) (0-40+ hours per week). They reported no significant differences in being obese (RR=.99-1.11, p=.52) (Hu et al., 2003). However when Hu and colleagues (2003) examined this same relationship with television watching there were significant increases in the risk for being obese (RR=1.22-1.94, p=.02). Similarly to Hu et al. (2003) other studies reported a dose response relationship between increased television watching and body mass index. For women and men watching two or more hours of television their likelihood of being obese increased 24% and 42%, respectively

(Ching et al., 1996; Hu, Li, Colditz, Willet, & Manson, 2003). The odds of being obese also increased 2-4 times the original percentage when television was watched for more than five hours per day (Ching et al., 1996). Other studies examining different types of sedentary behaviors observed similar results to the television and obesity research. Vandelanotte and colleagues (2009) observed high computer and Internet users (>3 hours per day) to be more likely overweight or obese compared to those who do not use the computer (RR=1.46 and 2.52, respectively). The majority of these results suggest increasing time engaged in sedentary behaviors, specifically television watching and computer usage are related to obesity when measured as body mass index.

The differences in results between the current study and the self-report literature with television watching can be attributed to differences in study methodology. The current study used objective assessments of sedentary behavior and did not rely upon self-report of specific sedentary behaviors like television viewing. When objective measures are used they capture all sedentary behaviors and cannot decipher between specific behaviors and these specific behaviors or attributes of those behaviors could make them more related to health or in this case body mass index. For example Vandelanotte and colleagues (2009) observed those who engage in specific sedentary behaviors like computer usage are also 2.5 times more likely to engage in more than five hours of other sedentary behaviors per day (Vandelanotte et al., 2009). Also researchers report differences across results between differing sedentary behaviors are because of differences in the energy costs of these activities. For example television watching has one of the lowest energy expenditures when compared to other activities like writing, playing games, etc. and these low energy activities could lead to weight gain and

ultimately increase body mass index (Hu et al., 2003; Ainsworth et al., 2003). Also during television viewing people tend to eat more or eat higher caloric foods that could lead to increased body weight and body mass index (Hu et al., 2003).

Another difference between these studies and the current one is the difference in the age of the participants, on average the participants in the literature ranged in age from 35-75 years old whereas the current study participants were 65-90 years old. With increasing age there are physiological differences that occur, there are decreases in both fat free mass and fat mass in individuals over 70 years of age (Villareal, Apovian, Kushner, & Klein, 2005). Additionally there is a natural reduction in height due the compression of the vertebrae and when combining these two changes body mass index values are altered (Villareal et al., 2005). All of these differences may impact the relationship between sedentary behavior and body mass index in the current study and how they compare to previously published results.

Waist Circumference

The current study also adds to the topic of obesity and sedentary behavior by incorporating the use of waist circumference to assess obesity. In the group analysis there was a significant positive relationship between waist circumference and the percent of day spent in sedentary behaviors assessed with the Actigraph accelerometer (r=.25). There were also significant differences in waist circumference across volumes of sedentary behavior measured with the Actigraph as a percent of the day. There was a significant increase in waist circumference from the moderately sedentary (62.2-68.8% of the day or 9.3-10.8 hours per day) to the highly sedentary groups (≥68.3% of the day or ≥10.9 hours per day or) of approximately 9.3 and 9.5 cm, respectively. This is a

significant finding and the difference is large enough to move someone from a normal body size classification into an obese classification, which could become a positive risk factor for the development of cardiovascular disease or a risk factor for having the Metabolic Syndrome (NCEP, 2004).

However when the current study examined whether sedentary behavior measured, as a percent of the day, was a predictor of obesity measured as waist circumference, it was not. These results differ from when Healy and colleagues (2008) conducted a similar analysis and observed a positive relationship between the percent of day being sedentary to the anthropometric assessment of waist circumference [β = .22 (95% CI = 0.09-0.36)]. Differences between these results could be due to differences in sample size, the Healy (2008) study had 100 more participants, who were younger, less sedentary and engaged in more light and moderate to vigorous physical activity but had larger waist circumferences than the participants in the current study. However both studies used the same accelerometer and assessment method of waist circumference. The differences in results could also be related to the differences in physical activity participation. Healy and colleagues (2008) did not control for participation in physical activity in their analysis where as the current study did and moderate to vigorous physical activity was a significant contributor to waist circumference in older adults [β= -.41 (95% CI= -.484 – -.107)].

The current study findings add to the literature with older adults suggesting a positive relationship between increasing sedentary behavior and waist circumference, therefore the more sedentary older adults are more likely to have significantly larger waist circumference values compared to less sedentary older adults. Interestingly these

results differed from what the current study found when body mass index was used as a measure of obesity. Intuitively obesity is obesity and there should be no differences in the results if they are estimating the same outcome. However in older adults there are limitations to using the body mass index because it becomes altered with the changes in body composition and height with age, the relationship to percent body fat is either over or underestimated depending on what changes (Villareal et al., 2005). The differences in results between obesity measures could also be due to changes in body fat distribution, the aging process is also associated with increases in intraabdominal body fat (Villareal et al., 2005). Therefore if waist circumference is used it may be a better estimate of obesity in this population over the measurement of body mass index whereas in younger populations that have not been effected by these changes, body mass index could be a better surrogate measure of obesity and therefore have a stronger relationship to sedentary behavior. Because of these interesting comparisons between measures of obesity and sedentary behavior future studies may want to explore these relationships further across different age groups or between normal, overweight and obese individuals to see if differences occur between measures of obesity and sedentary behavior.

Percent Body Fat

Obesity as a percent body fat was compared to sedentary behavior. The current study observed that a relationship exists between sedentary behavior and percent body fat. When sedentary behavior was assessed as a percent of day there were significant positive relationships in women and men with percent body fat, (r=.32 and r=.43, p <.05, respectively). There were also relationships between increasing percent of day in sedentary behavior and percent body fat in men. The percent body fat was significantly

lower for men in the moderately sedentary group (62.2-68.8% of the day or 9.3-10.8 hours per day = 35.5% body fat) compared to the highly sedentary group (≥68.3% of the day or ≥10.9 hours per day = 40.2% body fat), by approximately 4.7%.

The current study findings were supported within the literature, Jakes et al., (2003) reported that when women and men watched four or more hours of television they had higher percent body fat (37.1-41.6%) than those watching two hours of television (22.5-25.3%). Similarly Tucker and Friedman (1989) and Tucker and Bagwell (1991) observed obesity risk increasing in women and men 1.89 and 1.9 times, respectively, in those watching 3-4 hours of television compared to 2.15 and 2.05 times, respectively, for those watching four or more hours of television.

In general these studies as well as the current one suggest engaging in more than two hours of television watching or spending more than 60% of the day being sedentary can increase the likelihood of having a higher percent body fat than engaging in less sedentary behaviors. These results mimic those observed when obesity was assessed by waist circumference, further suggesting that waist circumference may be a better measure to use when examining the relationship between sedentary behavior and obesity in an older adult population if there is no access to a direct measure of body fat.

The current study examined the relationship between sedentary behavior and health variables relating to chronic disease development in older adults. The next health variables that were examined were metabolic health outcomes. The following discussion will focus on the findings from the current study and those in the published literature.

Sedentary Behavior and the Relationship to Metabolic Variables

The next area discussed under the umbrella of sedentary behavior and health is the relationship with metabolic variables. The most commonly examined metabolic

variables are high-density lipoprotein cholesterol, triglycerides, and fasting blood glucose. In the literature time spent watching television and overall time sitting were the variables used as measures of sedentary behavior. As in the obesity literature these variables are self-reported by the participants.

Triglycerides

In the current study there was a positive association between time spent in sedentary behavior measured with the activPal™ and triglycerides (r=.26, p <.05) in the group analysis but sedentary behavior was not predictive of triglycerides.

When the literature was reviewed, sedentary behavior was observed to be a significant predictor of triglycerides. Healy and colleagues (2008) observed in their sample when the percent of day was used as a measure of sedentary behavior, with the Actigraph accelerometer, it was positively predictive of triglycerides [β = .19 (95% CI=.03-.34)]. Similarly, television watching (women only) and sitting time (women and men) were also significant predictors of triglycerides [television, b = .04 (95% CI=.02-.05)], [sitting time, women, b =.02 (95% CI=.01-.02)], [sitting time, men, b =.02 (95% CI=.01-.03)] (Thorp et al., 2009). These are interesting results when compared to the current study findings. There seems to be a stronger relationship with the self-report measures of sedentary behavior and predicting triglycerides. However as with the obesity literature when similar methodologies are used, like accelerometry the results are also different. As mentioned within the obesity review there may be stronger relationships between health variables and specific types of sedentary behaviors.

Even though the current study did not find sedentary behavior to be predictive of triglycerides, it was observed that a relationship existed across increasing volumes of

sedentary behavior. Triglycerides were significantly lower in the least sedentary group (measured with the activPal) (≤452.5 minutes per day or 7.5 hours per day) compared to the high sedentary group (≥518.8 minutes per day or 8.6 hours per day) by 41.9 mg/dL. Also triglyceride values were significantly lower between the moderately sedentary group (452.6-518.7 minutes per day or 7.6-8.5 hours per day) and the high sedentary group, a difference of 16.5 mg/dL. These changes are significant enough like in the obesity literature to cause people to move triglyceride classifications from normal to high and again these changes could become a risk factor for the development of cardiovascular disease or the Metabolic Syndrome, (NCEP, 2004).

Thorp and colleagues (2009) examined this relationship with quartiles of television viewing and sitting time in women and men. The results suggested women watching the most television (≥2.49 hours per day) each day had higher triglycerides than the lowest quartile of women watching television (≤.85 hours per day). Chang et al. (2008) observed similar results as Thorp and colleagues (2009). In their study they observed increasing triglyceride values across tertiles of television watching (<14 hours per week, 14-20 hours per week and >20 hours per week) in women (92.63-118.68 mg/dL) and men (125.64-148.04 mg/dL). When a similar analysis was conducted with quartiles of sitting time, triglycerides were still significantly higher for women sitting across all quartiles (3.35-4.84 hours per day, 4.85-6.77 hours per day and ≥6.78 hours per day) compared to the lowest quartile of sitting time (≤3.34 hours per day). In men those sitting the most (≥7.49 hours per day) had higher triglycerides compared to the lowest quartile of sitting (≤3.78 hours per day). Unfortunately Thorp and colleagues (2009) did not present the triglyceride values so we do not know exactly how much they changed

across levels of television watching or sitting time to compare with the current study findings.

Across all studies there appears to be a strong relationship between increasing volumes of sedentary behavior and triglycerides, suggesting that more sedentary behavior is associated with higher triglyceride values. The present study adds to the current literature supporting a significant relationship between increased sedentary behavior and triglyceride values specific to an older adult population. These results also align with the current findings of obesity relating to increased sedentary behavior because elevated triglycerides are associated with abdominal obesity in older adults (Villareal et al., 2005). Therefore a relationship may exist among these two health variables and sedentary behavior, which could be problematic because they are both risk factors for chronic conditions such as cardiovascular disease and the Metabolic Syndrome. Therefore these results are an important contribution to the literature examining chronic disease development in older adults.

High-Density Lipoprotein Cholesterol

Another important metabolic variable examined in the literature is high-density lipoprotein cholesterol and how it relates to sedentary behavior. In the current study sedentary behavior was not related to, or predictive of, high-density lipoprotein cholesterol. Similarly, when Healy and colleagues (2007) examined sedentary behavior as a percentage of the day, they also did not find sedentary behavior to be predictive of high-density lipoprotein cholesterol (Healy et al., 2007). These results differ from those presented within the self-report of sedentary behavior literature. In women only, television watching was positively predictive of lower values of high-density lipoprotein

cholesterol [b = .02 (95% CI=-.001-.04)] (Thorp et al., 2009). Also sitting time predicted lower values of high-density lipoprotein cholesterol in both women and men [women, b =-.01 (95% CI=-.01- -.003)], [men, b =-.01 (95% CI=-.01- -.005)] (Thorp et al., 2009). As with the triglycerides there seems to be stronger relationships with self-reported sedentary behaviors for predicting metabolic health variables. Again similar insignificant results were observed in the current study and the Healy et al. (2007) study when examining sedentary behavior with objective assessment. Therefore this suggests again that there could be relationships between specific domains of sedentary behavior rather than the total amount of sedentary behavior.

The current study also did not find any difference in high-density lipoproteins across low, moderate, or high amount of sedentary behavior. This was supported when Chang and colleagues (2008) examined the differences in high-density lipoprotein cholesterol across tertiles of television viewing (<14 hours per week, 14-20 hours per week and >20 hours per week) in men (41.65-41.47 mg/dL, p=.95) and women (51.22-49.81 mg/dL, p=.23). This differed from the findings of Fung and colleagues (2000) when they examined the relationship between tertiles of television viewing and physical activity MET hours per week with high-density lipoprotein cholesterol in men only. They observed the most active men (37.1 MET/hours/week) watching the least amount of television per week (3.4 hours per week) had higher high-density lipoprotein cholesterol (12.8 mg/dL, 95% CI = -2.2-27.8) values compared to the least active men (1.43 MET/hours/week) watching the most television per week (18.1 hours per week) (Fung et al., 2000). Similarly to the studies of Fung et al. (2000) when Thorp and colleagues (2009) examined tertiles of sitting time, those sitting longer had lower high-density

lipoprotein cholesterol. In women those sitting in the third and fourth quartile (4.85-6.77 hours per day and ≥6.78 hours per day) had significantly lower high-density lipoprotein cholesterol values compared to the lowest sitting quartile or first quartile. In men those sitting in the third quartile (5.5-6.48 hours per day) had significantly lower high-density lipoprotein cholesterol compared to the lowest quartile of sitting (≤3.77 hours per day). Again Thorp and colleagues (2009) did not provide values besides the log transformations of the high-density lipoprotein cholesterols so it is difficult to determine the significance of their findings.

The similar findings between the current study and Chang et al (2008) could be related to physical activity participation because both assessments did not control for physical activity when they examined the relationships between high-density lipoprotein cholesterol across differing volumes of sedentary behavior. Therefore the effects of physical activity on high-density lipoprotein could outweigh the effect of sedentary behavior. Both Fung et al (2000) and Thorp et al. (2009) did control for exercise and leisure time physical activity. Therefore these findings could suggest that participation in physical activity, regardless of how it was assessed across studies may mediate the relationship between sedentary behavior and high-density lipoprotein cholesterol.

Fasting Blood Glucose

The current study did not find sedentary behavior to be related to fasting blood glucose. Healy and colleagues (2007) also did not find sedentary behavior relating to fasting blood glucose when they assessed sedentary behavior as a percent of the day with accelerometry [β = .13 (95% CI= -.02-.28)]. These findings differed again from the self-report literature. Thorp and colleagues (2009) observed television watching to predict

increasing fasting blood glucose in women and men [women, b = .004 (95% CI=.0001-.01), [men, b = .01 (95% CI= .001-.01)]. Chang and colleagues (2008) reported significant increases in fasting blood glucose for both women and men (103.07-110.16 mg/dL and 97.08-104.94, respectively) across tertiles of television watching (<14 hours per week, 14-20 hours per week, and >20 hours per week).

There were no significant relationships between sedentary behavior measured objectively with accelerometry most likely because the current study along with that by Healy and colleagues (2007) did not have a sample with a significant range of fasting blood glucose values. Healy et al. (2007) participants had fasting blood glucose ranges between 92.7-96.4 mg/dL and the current study was 73-113 mg/dL. The current study range was larger however in both studies there were not a lot of values outside the normal range, >100 mg/dL (American Diabetes Association, 2004). Interestingly in the Chang and colleagues (2008) study they did not report descriptive ranges of fasting blood glucose however when examining the means across their analysis (women = 97.08-104.94 mg/dL; men = 103.07-110.16 mg/dL, these were across low, moderate, and high volumes of television watching ≤14-20+ hours per week) their participants had values similar to the Healy et al. (2007) study. As with the other results future research needs to examine this relationship with more specific sedentary behaviors to see if associations exist with health variables that may be more related to actual sedentary behavior type.

The last health variable that is important when examining the relationship between sedentary behavior and chronic disease development in older adults is the cardiovascular variable, blood pressure. The next section will discuss the current study findings and what has been found within the literature on this topic.

Sedentary Behavior and Cardiovascular Variables

The relationship between the cardiovascular variables of blood pressure and sedentary behavior is not reported in very many studies, therefore the findings from this study add to what is known about the relationship between sedentary behavior and blood pressure. The current study did not find a significant relationship between sedentary behavior and blood pressure or sedentary behavior being a predictor of systolic or diastolic blood pressure. Similarly Healy and colleagues (2008) also did not find sedentary behavior measured as a percentage related to either, systolic and diastolic blood pressures. However Thorp et al (2009) did observe in women television watching and sitting time to be predictors of systolic blood pressure, [television, b = .39 (95% CI=.13-.64) and [sitting, b = .92 (95% CI=.36-1.448) and diastolic blood pressure [television, b = .25 (95% CI=.11-.39) and [sitting, b = .59 (95% CI=.28-.29)].

The current study did not find differences in blood pressure across low, moderate, and high volumes of sedentary behavior. This differed from the results of a study by Chang et al. (2008) whom observed dose response relationships across increasing tertiles of television viewing. These researchers observed significant increases in blood pressure in both women (systolic blood pressure, 127-136 mmHg; diastolic blood pressure, 73-77 mmHg) and men (systolic blood pressure, 137-141 mmHg) Chang et al., 2008).

The current study and one by Healy et al. (2008) did not find sedentary behavior, when assessed with accelerometry, to be related to the cardiovascular variables namely blood pressure. However when television was examined as a sedentary behavior there were more significant relationships. In the current study there was about a 20 mmHg range in systolic and diastolic blood pressures and in Chang et al. (2008) study there were

<10 mmHg difference across systolic blood pressures and <5 mmHg difference across diastolic blood pressures, therefore the large difference in sample size could be a significant contributor to why they saw relationships in elevated blood pressures across increasing time watching television and no differences were observed in the current study. Healy et al. (2008) study did not report blood pressure values in their paper so differences again could be related to a type of sedentary behavior like television being more related to sedentary behavior than total volume of sedentary behavior. Future studies could examine blood pressure changes during different sedentary behaviors to see if differences exist.

The previous discussion has focused on individual anthropometric, metabolic, and cardiovascular health outcomes. However when these variables are outside the normal range they become risk factors for certain chronic conditions like the Metabolic Syndrome. Therefore the following discussion examines the relationship between sedentary behavior and the classification of the Metabolic Syndrome in this sample of older adults.

Sedentary Behavior and the Relationship to the Metabolic Syndrome

The current study findings did not suggest moderate or high volumes of time engaged in sedentary behavior compared to low volumes of sedentary behavior, regardless of how it was assessed, to be a significant predictor of classifying an older adult with having the Metabolic Syndrome. In the current study, 23.3% were classified as having the Metabolic Syndrome. The individual risk factors for the Metabolic Syndrome; obesity, high triglycerides, and high blood pressure were the significant predictors of classifying this group of older adults with the Metabolic Syndrome. The older adults in the current study were 168-293 times, 34-42 times, and 43 times more

likely to be classified with having the Metabolic Syndrome if they were obese or had elevated triglycerides, or had high blood pressure, respectively. The participation in moderate to vigorous physical activity however did not change the odds of someone having the Metabolic Syndrome.

There are few studies that have examined whether sedentary behavior can predict the classification of the Metabolic Syndrome. Different from what the current study findings were Chang et al. (2008) observed women and men (aged 40-90) watching television for greater than 20 hours per week more likely to have the Metabolic Syndrome, 93% and 50%, respectively. Another study by Bertrais et al. (2005) reported similar findings and suggested the more television watched (<1 hour to 3 hours per day) increased the likelihood of having the Metabolic Syndrome from 41-70%.

Similar to the previous study Dunstan et al. (2005) observed when men and women watched greater than 14 hours of television per week compared to those watching less than 7 hours per week the odds for having the Metabolic Syndrome was 1.64 and 2.16, respectively. All of these findings controlled for physical activity.

There were differences from the current study to those in the published literature and the primary reason is the difference in sample sizes. The current study only had 73 participants and the other studies had 2500-6500+ participants and the percent of women and men with the Metabolic Syndrome were similar between the current study and others in this review. For example the current study had 25.5% of women and 19.2% of men classified with the Metabolic Syndrome while Dunstan et al. (2005) had 14% of women and 25% of men.

Examining the relationship between sedentary behavior and conditions like the Metabolic Syndrome are significant areas of research in older adults. Especially when many older adults already have a number of the risk factors for this condition and the prevalence of the Metabolic Syndrome increases with age, with odds ratio for developing the Metabolic Syndrome increasing from 5.8 in men and 4.9 in women when individuals greater than 65 years of age are compared to those 20-34 years of age (Villareal et al., 2005).

As a general theme throughout this discussion, there were more consistent results with sedentary behavior measured as television viewing being related to the individual anthropometric, metabolic, and cardiovascular variables that when clustered together cause the Metabolic Syndrome, therefore we see the same relationship with sedentary behavior and the Metabolic Syndrome. And to make things more interesting the volume of sedentary behavior measured with accelerometry was related to some of the individual risk factors but not all. Because the Metabolic Syndrome is related to other and potentially more serious conditions like type 2 diabetes and cardiovascular disease it is important to determine the predictors of the Metabolic Syndrome and if sedentary behavior an easy and simple behavior to manipulate it becomes important to discover which types of sedentary behaviors significantly impact health. Is it television? General sitting? Or the total volume or percent of day that someone is sedentary?

Sedentary Behavior Recorded in Self-Report Diaries

The current study used self-report diaries to learn more about the different sedentary behaviors older adults engage in on a regular basis. This is new information and therefore is a significant contribution to the field as researchers begin developing

interventions to reduce daily sedentary behavior. One interesting finding from the current study is that older adults engaged in 16 different sedentary behaviors and the most frequently recorded sedentary behaviors were watching television, using the computer, eating, reading, and sitting in a vehicle for transportation. These activities took up 44% or about 7 hours of their waking hours with television watching accounting for 15% of these waking hours or approximately 2.4 hours. These findings are significant especially after discussing the impact television viewing has on the anthropometric, metabolic, and cardiovascular health variables that relate to chronic disease development of older adults.

Interestingly this study suggested older adults to only watch slightly over two hours of television per day. This is a similar value to what was used as a referent category in some of the literature recently discussed (Dunstan et al., 2005; Chang et al., 2008). If this little amount of television is used as the referent group in many of the large epidemiological studies it could explain why the current study did not find sedentary behavior to be predictive of some of the health variables examined. Therefore it would be interesting to examine if there are differences in specific types of sedentary behaviors or different durations of them across age groups and if there are different effects on health.

These findings are also important because the current questionnaires inquiring about sedentary behaviors assess primarily television viewing and if older adults engage in only two hours these surveys may not be representative of their sedentary behavior. One of the original reasons for using television as the primary assessment of sedentary behavior was because it was thought to be a common activity and best representative of sedentary behaviors (Ainsworth et al., 2000). Other sedentary behaviors may need to be

added to future surveys to assess this behavior in order to have a better portrayal of older adult sedentary behaviors.

The current study adds to the literature a sedentary behavior diary that can capture these activities in older adults. The participants in this study were provided with diaries to complete and the sedentary behaviors were determined by the activities recorded. Other assessments of sedentary behavior exist but they only ask an open-ended question about one or two sedentary activities and heavily rely on the individuals recall ability (Matton et al., 2007; Sugiyama et al., 2008; Otten et al., 2009). The diary in the current study overcomes this limitation by providing a half hour-by-half hour daily account of an older adult's sedentary behaviors.

Marshall et al. (2010) created a survey that is supposed to capture a variety of sedentary behaviors but it only inquires about computer, transportation, television watching, work activities, and leisure time activities. Unfortunately this may not be a good assessment of sedentary behavior in older adults because a majority of older adults no longer work and results from the current study suggest that other sedentary behaviors could be added to the survey, such as reading. Therefore if surveys like this are used in an older adult population we may not be capturing an accurate portrayal of their sedentary behavior. Diaries like the one used in the current study could guide the development of future surveys or questionnaires specifically to capture the sedentary behaviors of older adults.

Another finding in this study not previously found in other literature were gender differences in sedentary behaviors. The current study found men to engage in more eating (men = 113.5 minutes per day; women = 84.6 minutes per day) and napping (men

= 25.7 minutes per day) than the women (5.1 minutes per day). The findings about eating could contribute negatively to the relationship between sedentary behavior and the health outcome obesity. As the previously discussed literature observed significant relationships between being obese and sedentary behavior this could be problematic for older adults, especially the men. Hu et al. (2003) found that men and women ate less healthy foods when they engaged in sedentary behaviors and the combination of reduced energy expenditure with sitting and the increased caloric intake could increase the likelihood of these being obese.

The current study also observed differences in time between certain sedentary behaviors done during the week versus the weekend. Older adults engaged in more socializing (weekday=47.9 minutes per day; weekend=83.5 minutes per day), reading (weekday=91 minutes per day; weekend=120.4 minutes per day), religious activities (weekday=20.4 minutes per day; weekday=7.9 minutes per day), and talking on the telephone (weekday=15.5 minutes per day; weekend=7.1 minutes per day) on the weekends. These results could be useful when developing interventions to reduce this behavior. For example if we know older adults are more social on the weekends we can substitute sedentary social events like playing cards with more active social events like walking the mall.

The findings from these diaries also resulted in unique information about what factors contribute to an older adult's participation in sedentary behavior. The factors most prevalent with sedentary behavior were eating while reading, watching television, and during transportation. This is a commonly thought reason for why there is a relationship between health variables like obesity and elevated triglycerides with

sedentary behaviors like television watching and this study supports those assumptions (Hu et al., 2003). Also a majority of older adults were alone while they engaged in sedentary behaviors. This is an interesting finding from these diaries especially when over 60% of this sample does not live alone. This variable has not been discussed in the published literature so only assumptions can be made for why this relationship exists. One assumption is that many sedentary behaviors may be easier to do when alone, like reading or using the computer. Also sedentary behaviors maybe done to get away from others or for relaxation, like driving to have a coffee and read the newspaper or doing a puzzle. Or sedentary behaviors could be done alone because some older adults are less social and prefer to be alone. Further qualitative analysis would be an interesting addition to these findings to better understand why older adults engage in sedentary behaviors alone instead of with others.

Lastly enjoyment was examined as a factor relating to sedentary behavior based off previous study findings by Salmon et al. (2003). However in the current study enjoyment was not as variable as in the study by Salmon and colleagues (2003). Frequently comments were made, "when you are retired you only do what you enjoy or you would not do the activity." In the diaries from the current study, participants were asked to rate their level of enjoyment for each activity they wrote down, from 1=highly enjoyable to 7=least enjoyable. In the current study the average enjoyment ranking was three. Therefore the older adults in this study enjoyed many of the sedentary activities they did. This could be due to the fact that they are retired and have more of a choice to what activities they engage in and more time to engage in these behaviors than younger potentially working populations like in Salmon and colleagues (2003) study.

Factors of sedentary behaviors in the current study differed slightly from a study by Salmon et al. (2003). In their study they used a one-week recall of sedentary behaviors commonly reported in time use surveys. Then participants were asked about their preferences for certain sedentary behaviors and their enjoyment and inquired about any environmental aspects that could impact their decision for engaging in sedentary behaviors. Salmon and colleagues (2003) reported that high levels of enjoyment were related to engaging in more than two hours per day of television, reading for more than five hours per day and sitting during socialization for more than eight hours per week. Lastly poor weather and feeling tired were associated with a 50% increased likelihood of participating in sedentary behaviors (Salmon et al., 2003). Obviously differences in study finding were primarily due to differences in study methodology. The study by Salmon and colleagues (2003) inquired about other factors than those in the current study, however enjoyment was a similar factor and the results varied significantly. One contributor to the different results about enjoyment could be the sample of participants. The study by Salmon et al. (2003) used a sample of individuals who were not necessarily retired like in the current study. Because of this their participants are more likely forced to engage in some sedentary behaviors that may not be as enjoyable like sitting at work for eight hours. In this instance the retired older adults in the current study do not have to do that anymore and therefore have the luxury of sitting when they want.

The current study findings suggest that sedentary behaviors are multifaceted and people choose to engage in them for different reasons. This study presents new descriptive findings about the different sedentary behaviors older adults engage in, the duration and timing of these events. Also this study discusses some new and old factors

related to engaging in sedentary behaviors. Because so few studies like this exist much if not all of the information presented from this study are new findings.

Scientific Implications

The multi-method approach to examining the relationship between sedentary behavior and health in older adults is a novel approach. This study was one of the first in this field to examine sedentary behavior in multiple ways with a strictly retired older adult population. Most of the literature has examined sedentary behavior through self-report recall questions and looking for an estimation of only one activity such as time spent watching television or time spent sitting. There were also very few reports on the factors relating to why people engage in sedentary behaviors. Therefore many of the findings in the current study have not been previously reported.

Because the methods were multifaceted the current study was able to describe the sedentary behavior of older adults both as a quantity of sedentary behavior like in previous reports but also this study provides a description of sedentary behaviors that has not been frequently reported, especially in an older adult population. Information in this study that was not found in the present literature includes information about the amount of time older adults engage in sedentary behavior. These older adults engaged in 8-10 hours of sedentary behavior or approximately 65% of their day. There were also gender and age differences in sedentary behavior. Also information about sedentary behavior across physical activity levels was observed and sedentary behavior was significantly different between those who meet the national physical activity recommendations and those who do not. In this sample of older adults sedentary behavior was positively related to obesity and triglycerides but no other anthropometric, metabolic, or

cardiovascular variables. Also these results were the only ones to suggest that sedentary behavior in moderate and high amounts is not always predictive of anthropometric, metabolic, or cardiovascular health outcomes and these results could be dependent on how sedentary behavior is measured.

Further significant and novel findings from the current study include the usefulness of a sedentary behavior diary for older adults. To our knowledge a self-report diary has not been designed and tested in an older adult population previous to the current study. From this diary we are able to get descriptive information about the sedentary behaviors older adults engage in. This information will be useful to researchers and health professionals who want to develop interventions to manipulate or reduce this behavior in older adults.

The specific information that can be gleaned from this diary includes knowledge about what sedentary behaviors are the most prevalent, how long people engage in these behaviors, when they are done, do they do these activities alone or with others and if they enjoy these activities. This is all new information about sedentary behavior that has not been previously reported in the published literature. For example the current study observed older adults to engage in ten or more sedentary behaviors throughout their waking hours. They reported 16 distinct sedentary behaviors with the most prevalent being watching television, reading, eating, using the computer, and sitting in a vehicle during transportation. Also there were differences how much time was spent in certain sedentary behaviors during the week versus the weekend. Another application of this novel sedentary behavior diary, beyond the scope of this project is how these reported

behaviors relate to health and does the results of this methodology differ from the more commonly utilized objective assessments (i.e., accelerometry) of sedentary behavior.

The last important contribution of this study was the observation that there were differences between the results for the quantity of sedentary behavior between the objective and self-report assessments of sedentary behavior. The objective monitors did not equally assess sedentary behavior, for example the activPal™ under reported sedentary behavior when compared to the Actigraph accelerometer. Because of these observed differences it made interpreting the results and comparing the current study findings to previous literature very challenging. This is a significant finding because currently both monitors are being used to assess the same sedentary behavior and more research may be needed to better understand these differences in sedentary behavior findings.

Limitations

There were limitations in this study. The cross-sectional design of the study was a limiting factor because no causality can be gleaned from this study. Also the current study sample consisted of freely ambulating retired Caucasian adults 65-90 years of age. Therefore the results of this study cannot be generalized to other older adults of differing race or those who are not retired or unable to ambulate on their own. Also the age and gender composition of the sample was a limitation of the study. Almost twice as many women as men participated in this study and a majority of the women were between 70-79 years of age. There were also significantly fewer men and women 80-90 years of age in this study. Thus comparisons between gender and across age were difficult to make.

Using the Actigraph accelerometer to assess sedentary behavior was a limitation to assessing sedentary behavior. Even though the Actigraph has been reported to be an accurate and reliable assessment of sedentary behavior it was originally created to assess body movement and not necessarily sedentary behavior (Crouter et al., 2006; Hart et al., 2011). Also recent research suggests that both monitors used in this study measure the same behavior but the activPal™ is more precise at detecting changes in sedentary behavior than the Actigraph, therefore discrepancies may exist between recorded sedentary behaviors, which were apparent in this study (Kozey-Keadle et al., 2011). The disparities in measuring sedentary behavior could also be from the difference in technology for measuring sedentary behavior. For example the Actigraph records activities as body movements therefore sedentary behavior is recorded as infrequent movements whereas the activPal™ assesses whether someone was either in a sitting or lying posture or not. The Actigraph allows more activities to be captured and assumed to be sedentary because it has a range of sedentary behavior from 0-50 cts/min where as the activPal™ counts a posture as either yes it happened or no it did not happen. Future examination of these monitors in assessing sedentary behavior is warranted.

Wearing multiple monitors was also a limiting factor in the study. Despite both monitors being small and lightweight, the participants had to wear two monitors everyday for seven days. One monitor was worn around the waist and the other was held in place with tape on the thigh and therefore became cumbersome for some or the tape became irritating. Because of this some participants removed the monitors prematurely or chose to not wear them for particular events. Therefore some people's information may not be representative of their entire day. The last limiting factor relating to the monitors was the

fact that they were not waterproof. Therefore every time a person engaged in water-based activities they had to remove the monitors and that time was not recorded.

The sedentary behavior diary format was also a limitation to the study. The participants were asked to complete the diaries in half hour increments continuously throughout the day. They were also asked to report only one primary behavior. This was difficult for people to report when they were multi-tasking and therefore if someone wrote down a sedentary behavior as their primary activity they could have been engaging in other activities and this information was not easily captured in the diary. For example someone could have recorded reading however they were actually waiting for their laundry and in the mean time the television was on and their spouse was talking to them. Therefore the diary information is only an estimate of their behaviors. Participant compliance with the sedentary behavior diaries was another limitation in the study. If participants did not complete the diary continuously throughout the day their information may not be as accurate as others who did complete the diaries as requested. This could be problematic as recall ability becomes more difficult for older adults (Masse et al., 1998).

The last primary limiting factor was the range of data for sedentary behavior and health variable values. Not enough of the study sample engaged in extremely high or low amounts of sedentary behavior when looking across the entire sample or between gender and across age, or physical activity levels. Also when examining some of the health variables because almost the entire sample was medically controlling their health most had values within the normal range and because of this we were unable to detect differences in health outcomes across volumes of sedentary behavior.

Future Directions

Sedentary behavior assessed in the current study was significantly related to waist circumference and percent body fat as measures of obesity and triglycerides. These are significant findings in the scope of older adults. Being obese and having high triglycerides are two risk factors for having the Metabolic Syndrome and to be classified as having the Metabolic Syndrome only three risk factors are needed. Also these health variables are related to developing type 2 diabetes and cardiovascular disease. Therefore future research could benefit from these findings and use this information and that gleaned from the diaries to create interventions to reduce this behavior in older adults who are overweight and have borderline high triglycerides or who are at risk for having type 2 diabetes, the Metabolic Syndrome or cardiovascular disease. Information from the diaries could be used to determine what activities to reduce, is it television for someone or playing the computer? When should people be more active? On the weekends or during the week? Also should we reduce activities that people really enjoy or reduce the sedentary behaviors that people do not care about?

Throughout this discussion it was more apparent in younger populations that sedentary behaviors assessed as television watching and overall sitting time were related to more health variables and these sedentary behaviors were also more likely to predict these health outcomes. However in the current study findings these relationships were not as strong or did not exist. The primary difference was the choice of methodology to assess sedentary behavior. The current study used objective measures to assess sedentary behavior as a total volume or quantity of a behavior whereas the majority of the literature used self-report assessment of television watching. These results suggest that a specific sedentary behavior or factors related to that behavior relates to health and not necessarily

the total volume of sedentary behavior. As discussed previously, television is a low energy expenditure activity and people engage in other behaviors like eating and this combination can lead to excess body fat or eventually obesity (Hu et al., 2003). Also researchers observed participating in some sedentary behaviors, like using the computer to increase the participation in other sedentary behaviors (Vandelanotte et al., 2009). Also information from the diaries suggested that television watching was the more recorded sedentary behavior but the actual amount is the same the published epidemiological reports use as the referent category when they look at health across increasing amounts of television watching. Therefore the act of watching television may or may not be as detrimental to the health of older adults and further examination of this behavior in various amounts would be important.

Lastly, because this study utilized diaries to assess sedentary behavior the information gleaned from them could be used to design and refine surveys or questionnaires specifically for this population to assess sedentary behavior. Also more qualitative assessments of sedentary behavior are needed so we can further our knowledge about the factors we know less about like being alone while engaging in sedentary behaviors so we can better understand how to further manipulate this behavior. All of this information would be important for developing interventions to disrupt or reduce sedentary behavior.

Chapter Summary

This study was novel in the methodology used to quantify and describe the sedentary behaviors of older adults. When sedentary behavior and health were examined the study observed significant relationships between sedentary behavior and measures of

obesity and elevated triglycerides. This is an important finding when we think about the development of chronic disease in older adults. Both obesity and high triglycerides are risk factors for having cardiovascular disease, type 2 diabetes, and the Metabolic Syndrome. Yet sedentary behavior is a behavior that can be easily manipulated through increases in physical activity.

In the current study it was also found that sedentary behavior differed across older adult physical activity levels and with increasing time spent being sedentary some health outcomes worsened (obesity and triglyceride values). This is also an important finding and again supports the importance of engaging in the recommended amount of health enhancing physical activity. Because we know less active individuals are the most sedentary, we can now target these individuals in interventions to reduce their sedentary behavior.

Interestingly, the current study did not find sedentary behavior to be predictive of any anthropometric, metabolic, or cardiovascular health variables or the Metabolic Syndrome, which differed significantly from what was reported in the epidemiological literature. This was most likely due to the actual behaviors examined or the act of engaging in the behaviors surveyed, like television watching. The findings of the current study and those by Healy et al. (2007 and 2008) suggest that the volume of sedentary behavior may not predict health variables however the actual sedentary behavior itself may have more of an impact on health.

When sedentary behavior diaries were used to assess sedentary behavior this study observed older adults to engage in 16 distinct sedentary behaviors. Television watching, using the computer, eating, transportation, and reading were the most prevalent

behaviors. Also eating and being alone were frequently reported while engaging in sedentary behaviors. Lastly it was observed that older adults engaged in more socializing, reading, religious activities, and talking on the telephone on the weekend versus weekdays. This information can be used to develop interventions to reduce sedentary behavior and the other contributing factors to the health outcomes most related to sedentary behavior, obesity and elevated triglycerides. Therefore we can reduce the time spent in the specific prevalent sedentary behaviors, like television watching and time on the computer or encourage people to not eat while engaging in those behaviors or to be more active during social events and less sedentary.

These results are significant contributions to the topic of sedentary behavior and health. This was one of the first studies to report on this relationship in an older adult population with both objective and self-report assessments of sedentary behaviors. These results provide a starting point for a number of future studies to better understand and identify if total sedentary behavior is a health concern for older adults or if we should focus on specific sedentary behaviors. Or should the focus still be on increasing the participation in moderate to vigorous physical activity. This was not the focus of the current study but upon observation there were significantly more relationships across the physical activity variables and health that were not apparent with sedentary behavior. Lastly the sedentary behavior diary reported numerous findings that have not been mentioned in the literature and again this information is a good platform for the development of surveys or questionnaires about sedentary behavior because to date very few exist for younger populations and none for older adults.

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APPENDICES

Appendix A

Informed Consent Document

UNIVERSITY OF WISCONSIN – MILWAUKEE
CONSENT TO PARTICIPATE IN RESEARCH

1. General Information

Study title: Sedentary Behavior and the Relationship to Health in Older Adults

Person in Charge of Study (Principal Investigator):

Scott J. Strath, Ph.D.
Associate Professor
Department of Human Movement Sciences
University of Wisconsin – Milwaukee

And

Elizabeth Grimm, MS
Student Principal Investigator
Department of Human Movement Sciences
University of Wisconsin - Milwaukee

2. Study Description

Study description:
The purpose of this study is twofold; first to examine the relationship between sedentary behavior and risk factors such as having low good cholesterol (high density cholesterol) and having high bad cholesterol (low density cholesterols), triglycerides, blood sugar (glucose), distance around your waist (waist circumference), blood pressure, and body fat percentage (i.e., cardiometabolic risk factors) associated with chronic disease development in Caucasian older adults. A second purpose is to explore the various sedentary behaviors Caucasian older adults participate in regularly. You will be one of 120 retired Caucasian older adults between the ages of 65-90 participating in this research project. This study will take place at the Physical Activity and Health Research Laboratory at the University of Wisconsin – Milwaukee. This study will be conducted over two visits and will consist of having measures of height, weight, waist circumference, blood pressure, and a blood sample collected. You will also be provided directions for wearing two physical activity devices that you will wear for one week, behavior diaries and sitting recall questionnaires that you will be required to complete three times over the one-week period. There will be approximately one to two weeks between the first and second visits. On the second visit you will have your blood pressure re-assessed and complete a body composition/bone mineral density test. Then you

will receive the results of all health measures taken. Both visits will last approximately 30-60 minutes. Participation in this research project is completely voluntary and you do not have to participate if you do not want to.

3. Study Procedures

What will I be asked to do if I participate in the study?
This research study will consist of two visits to the Physical Activity and Health Research Laboratory at the University of Wisconsin-Milwaukee. Each visit will be 1-2 weeks apart and each visit will last approximately 30-60 minutes.

Lab Visit #1
On the first visit, you will report to the Physical Activity and Health Research Laboratory. Metered parking is available near the laboratory, and directions will be provided during the initial telephone screening. During this visit you will receive another introduction to the study. This visit will last approximately 30-60 minutes.

Demographics, Health History, and Anthropometrics:
You will be asked to complete a demographics and health history questionnaire. This questionnaire will inquire about demographics, current health status, risk factors for chronic disease, and the use of medication. Following the questionnaire your blood pressure will be measured. Blood pressure will be measured twice on both arms. The researcher will place a cuff around your upper arm, inflating it with air, and releasing it slowly. The researcher will listen to the changes pulse sound as the cuff is released with a stethoscope and this sound is used to determine a blood pressure value. Next anthropometric assessments will be taken. These include measures of height and body weight and the distance around your waist with a tape measure.

Blood Collection:
You will be asked to sit in a chair and a blood sample will be taken from a vein on the inside of your elbow. A trained technician will conduct this procedure. They will insert a new sterile needle which is similar to those used when donating blood or having it drawn at the doctor's office (21 or 22 gauge) into your arm for the blood collection. There will be 2 tubes of blood drawn, which is approximately 2 teaspoons. From this blood draw we will be measuring your good cholesterol (High Density Cholesterol), bad cholesterol (Low Density Cholesterol), triglycerides, and fasting blood sugar (glucose).

Accelerometer Instructions:
You will be asked to wear two small match-boxed sized devices for a one-week period and assess your current physical activity and sedentary behavior. These devices are called an accelerometer and activPal. The accelerometer will be worn on the waistband of your pants on a provided elastic belt. The activPal will be worn on the front of the left or right thigh and held in place by hypoallergenic tape. You

will receive verbal and written instructions as well as an example on the correct use and wear of both devices.

Sedentary Behavior Diary Instructions:
You will be asked to complete a total of three sedentary behavior diaries over a one-week period while wearing the physical activity devices. Each participant will be asked to complete two of these diaries during the week and one on a weekend day. The researcher will choose these days. For example, someone may be asked to complete the diary on a Monday, Tuesday, and Sunday and another participant will be asked to complete them on a Wednesday, Friday, and Saturday. This format will allow the researcher to have various diary days of sedentary behavior. Next, you will receive instructions on how to complete each diary and an example of a completed diary.

Sitting Recall Questionnaire Instructions:
You will be asked to complete a total of three questionnaires inquiring about daily sitting behavior over a one-week period. Each participant will be asked to complete these surveys on the days they complete the sedentary behavior diaries. These surveys inquire about a person's daily sitting habits during leisure time, while traveling, volunteering, watching television, and socializing.

Lab Visit #2
Approximately two weeks later you will be asked to return to the Physical Activity and Health Research Laboratory for approximately 30-45 minutes.

We will ask you to return both of the physical activity devices and the three sedentary behavior diaries. Then the researcher will measure your resting blood pressure again as done in the first visit. Measuring blood pressure will be done twice one both arms. The researcher will place a cuff around your upper arm, inflating it with air, and releasing it slowly. The researcher will listen to the changes pulse sound as the cuff is released with a stethoscope and this sound is used to determine a blood pressure value.

Body Composition Testing/Bone Mineral Density Testing:
To measure total body composition or body fat percentage we will use the dual energy x-ray absorptiometer or DXA scan. This is a common and painless procedure and involves lying on your back (supine) on a padded table for approximately 10 minutes while a low-energy x-ray scan is completed. You will be instructed to lay still while the scan is performed. Because the test involves taking an x-ray picture of the body, you will be exposed to a very low dose of radiation. You will be exposed to a similar exposure to flying from New York to Los Angeles, and much less radiation than a standard chest X-ray. This test is included solely for research purposes and is not considered part of your standard clinical care. There is no need to stop taking any medicines, follow a special diet, or limit activity in any way before the test. Please do not wear clothing with any metal (buttons, snaps, or zippers) on the day of the test. If you do wear metal, we will ask you to remove it for the test. If you have

recently had x-ray tests using barium or any nuclear medicine tests, you should have your bone density test at least a week after those tests. It is very important to tell the researcher if you are or might be pregnant or breast feeding at the time of the test.

After the blood pressure reassessment and body composition/bone mineral density testing the researcher will provide you with the health information collected on the first visit. The results will include height, weight, waist circumference, blood pressure, the measured cholesterol values, and results from the body composition/bone mineral testing.

4. Risks and Minimizing Risks

What risks will I face by participating in this study?
There may be minor localized bruising and/or tenderness of the arm where the blood draw is taken. There is also a small risk of infection and to reduce this a sterile needle will be used. A trained technician will perform the blood sampling.

Some individuals may experience minor irritation from wearing the hypoallergenic tape on the thigh over the one week study period. To reduce this irritation we will ask you to wear the activPal on either leg throughout the week (for example wearing the device on your left leg Monday, Wednesday, Friday, and Sunday while wearing it on your right leg during the other days of the week).

Another minimal risk you face by participating in this research study includes the risks associated with the body composition/bone mineral test (DXA scan). While taking part in this study as a participant, as a part of the research, you will be exposed to a small amount of radiation during the body fat test. The overall effect of radiation on the human body is measured in terms of Roentgen equivalents in man, or "rem", which is a unit of uniform whole body exposure. The radiation you will be exposed to in this study will amount to 0.00004 rems. The effects on your body of this radiation exposure will be added to your overall lifetime radiation risk. Your lifetime radiation risk includes the background radiation you are exposed to naturally like everyone else living on this planet, which is on the average 0.3 rems per year. In terms of radiation a person may get exposed to during medical care, the amount you will receive in this study will be tiny compared to the amount of radiation received during a routine chest x-ray, which is 0.01 rems. The risk of harm from radiation exposure of this amount is too small to estimate.

All of the information collected throughout the study (i.e. data sheets, questionnaires, body composition/bone mineral density analysis, and diaries) will be kept strictly confidential. Only those researchers directly involved in this study will have access to the information. Your name will not be associated with your participation in this research study. You will be assigned an identification number

to ensure that your name, health information, and diary responses cannot be traced back to this research study. If the researcher decides to publish any of the results from this study in a scientific conference or journal your name will never be associated with any of the data collected. All study information collected will be stored electronically on a password safe computer and a hard copy will be stored in a secure cabinet.

As with all reseach studies there may be additional risks of participating that are unforeseeable or hard to predict.

5. Benefits

Will I receive any benefit from my participation in the study?
Yes, we will provide you with the health information collected in this study. You will learn about your height, weight, waist circumference, blood pressure, your good and bad cholesterol, triglycerides, blood glucose, and total cholesterol. You will also receive the results of your body fat percentage and bone mineral density. The researchers will not provide any medical diagnosis as a result from this study.

6. Study Costs and Compensation

Will I be charged anything for participating in the study?
You will not be responsible for any of the cost from taking part in this research study, You will be reimbursed for parking, $1 for each visit, a total of $2. .
Are subjects paid or given anything for being in the study?
Every participant will be eligible at the completion of the study for a lottery prize of $50. Every participant who completes both visits will be entered into a random drawing, with the winner receiving the cash prize. A total of four lottery prizes will be awarded..

7. Confidentiality

What happens to the information collected?
All information collected about you during the course of this study will be kept confidential to the extent permitted by law. We may decide to present what we find to others, or publish our results in scientific journals or at scientific conferences. Only the researchers directly involved in this research project will have access to the information. However, the Institutional Review Board at UW-Milwaukee or appropriate federal agencies like the Office for Human Research Protections may review this study's records.

8. Alternatives

Are there alternatives to participating in the study?
There are no known alternatives available to you other than not taking part in this study.

9. Voluntary Participation and Withdrawal

What happens if I decide not to be in this study?
Your participation in this study is entirely voluntary. You may choose not to take part in this study. If you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will not change any present or future relationships with the University of Wisconsin Milwaukee. If you decide to end your participation in this study your information collected up to that point would be used. The investigator may stop your participation in this study if he/she feels it is necessary to do so.

10. Questions

Who do I contact for questions about this study?
For more information about the study or the study procedures or treatments, or to withdraw from the study, contact:

Scott J. Strath, Ph.D.
Associate Professor
Department of Human Movement Sciences
University of Wisconsin – Milwaukee
P.O. Box 413, Milwaukee, WI 53201
Telephone Number: (414) 229-3666

Or

Elizabeth Grimm, MS
Student Principal Investigator
Department of Human Movement Sciences
University of Wisconsin – Milwaukee
P.O. Box 413, Milwaukee, WI 53201
Telephone Number: (414) 229-4392

Who do I contact for questions about my rights or complaints towards my treatment as a research subject?

The Institutional Review Board may ask your name, but all complaints are kept in confidence.

Institutional Review Board
Human Research Protection Program
Department of University Safety and Assurances
University of Wisconsin – Milwaukee
P.O. Box 413
Milwaukee, WI 53201
(414) 229-3173

11. Signatures

Research Subject's Consent to Participate in Research:
To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study, you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read or had read to you this entire consent form, including the risks and benefits, and have had all of your questions answered, and that you are 18 years of age or older.

_____
Printed Name of Subject/ Legally Authorized Representative

_____ _____
Signature of Subject/Legally Authorized Representative Date

Principal Investigator (or Designee)
I have given this research subject information on the study that is accurate and sufficient for the subject to fully understand the nature, risks and benefits of the study.

_____ _____
Printed Name of Person Obtaining Consent Study Role

_____ _____
Signature of Person Obtaining Consent Date

Appendix B

Participant Screening Form

Physical Activity & Health Research Lab

Department of Human Movement Sciences

Screening Form for Sedentary Behavior and the Relationship to Health in Older Adults

Call log: Date/ Time Comment

Hello, my name is _____ and I am a_____ working with the Physical Activity & Health Research Laboratory at the University of Wisconsin- Milwaukee. You have indicated that you are interested in participating in research with our Lab. If you have a moment, please let me tell you about a study that we are currently working on. It is a study designed to learn more about the relationship between sedentary behaviors and health in Caucasian older adults. Before I tell you about the study, do you mind if I ask you a few questions about yourself to determine if you qualify for the study.

1. What is your ethnicity? ☐ Yes ☐ **No**

If Caucasian/white then continue, if not explain that this is a dissertation protocol examining a smaller sample size hoping for growth of diversity in future projects.

2. What is your current age?_____ Date of birth: _____

3. Are you currently retired (no longer working 40 hours per week at profession)?

☐ Yes ☐ **No**

If yes, how long have you been retired?_____

4. Do you regularly volunteer? ☐ Yes ☐ No

If yes, approximately how many hours/wk do you volunteer?_____

5. Are you regularly using a wheel chair, walker, or cane? ☐ Yes ☐ **No**

6. Have you been diagnosed with a terminal illness? ☐ Yes ☐ **No**

7. Do you have any orthopedic limitations that affect your walking gait?

☐ Yes ☐ **No**

8. Do you have a lower limb amputation? ☐ Yes ☐ **No**

9. Can you please describe your usual daily physical activity?

The participant qualifies if they are between the ages of 65-90 years, are not using a wheelchair, have no terminal illness, or anything that impairs their walking gait.

IF THEY QUALIFY...

You are one of 120 individuals who are being asked to participate in this study at the Physical Activity and Health Research Laboratory of the University of Wisconsin-Milwaukee. The study involves two visits, both lasting approximately 30-60 minutes.

On the day of your testing session, you will report to the Physical Activity and Health Research Laboratory in Enderis Hall, Room 434, after fasting for 8-12 hours where we will ask you to provide us with your demographic information, health history and the health history of your family. Then we will measure your blood pressure, heart rate, height, weight and the distance around your waist. After we take those measurements we will then conduct a blood draw to assess various blood cholesterols. Before the visit is complete we will then provide you with two physical activity monitors to wear over a one-week period and three sedentary behavior diaries and three sitting recall questionnaires to complete during that same period. Approximately two weeks later we will ask you to return for a second visit consisting of a body composition assessment and bone mineral density test using our Dual Energy X-ray Absorptiometer (DXA), reassessing your blood pressure, and reviewing with you the outcomes of all the health measures we took during the first visit.

Do you have any questions, comments, or concerns about this study? ☐ Yes ☐ **No**

If yes, _____

Is there any reason why you cannot complete the study? ☐ Yes ☐ **No**

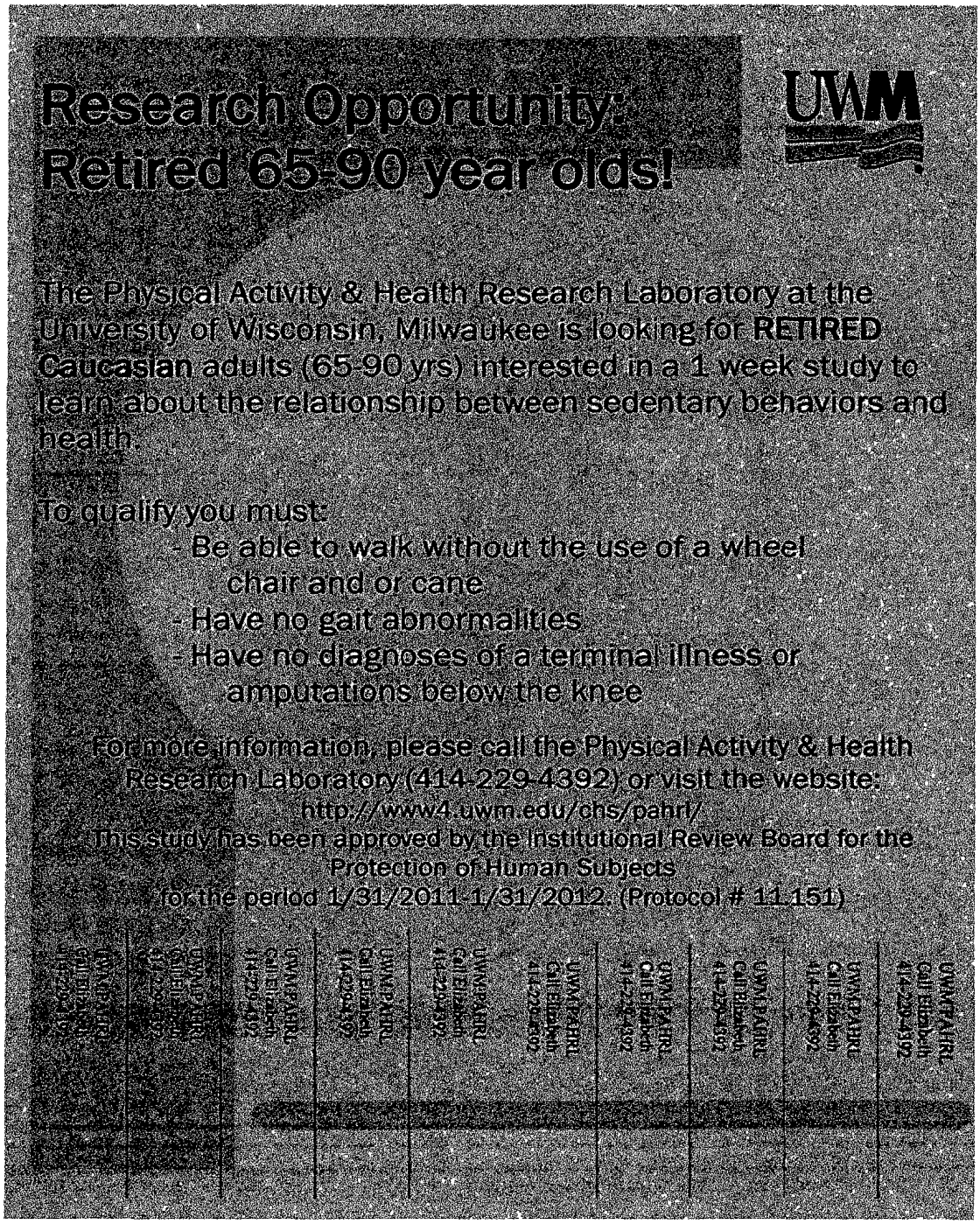
IF NO, SCHEDULE THEM FOR THE STUDY

Telephone: _____

Initials and date of person who filled out this form_____

Appendix C

Research Flyer


Research Opportunity:
Retired 65-90 year olds!
UWM
The Physical Activity & Health Research Laboratory at the University of Wisconsin, Milwaukee is looking for RETIRED Caucasian adults (65-90 yrs) interested in a 1 week study to learn about the relationship between sedentary behaviors and health
To qualify you must:
- Be able to walk without the use of a wheel chair and or cane
- Have no gait abnormalities
- Have no diagnoses of a terminal illness or amputations below the knee
For more information, please call the Physical Activity & Health Research Laboratory (414-229-4392) or visit the website:
http://www4.uwm.edu/chs/pahrl/
This study has been approved by the Institutional Review Board for the Protection of Human Subjects
for the period 1/31/2011-1/31/2012. (Protocol # 11.151)

Appendix D

Research Advertisement

Retired Volunteers Needed for Study Examining Sedentary Behavior & Health

A research study currently being conducted at the University of Wisconsin-Milwaukee is examining the relationships between sedentary behaviors and health in retired Caucasian adults over 65 years of age. All eligible study participants will wear two small devices to measure their physical activity and sedentary behavior, complete three diaries, and answer three questionnaires over a

one week period, as well as receive a cholesterol screening: high density lipoproteins, low density lipoproteins, total cholesterol, triglycerides, and blood glucose. Additionally participants will receive one bone

Appendix E

Sedentary Behavior Diary

UNIVERSITY OF WISCONSIN-MILWAUKEE

Sedentary Behavior Diary

Physical Activity and Health Research Laboratory

Participant ID#_____

- Please complete a total of 2-weekday and 1-weekend day diaries of your sitting/lying or moving behaviors. Weekday 1:_____Weekday 2:_____Weekend:_____
- Please complete each 24-hour diary on the days provided.
- Please write down **one** main behavior that took up the majority of each half hour period and any additional activities you may have done. If you did this activity for more than a half hour please draw an arrow indicating that you were still doing the activity until it stopped.
- Please **check** the appropriate box of whether you were sitting/lying or moving during the behavior, if you are alone during the behavior (yes/no), if you were eating during the behavior (yes/no), and **circle** how much you enjoyed the behavior from 1 (most enjoyable) to 7 (not very enjoyable).

There is an example below and if you have any further questions please contact Elizabeth Grimm at 414-229-4392.

Time of day	What is the MAIN activity you are or were doing?	Are you or were you sitting/lying or moving during the main activity?	Are you or were you alone during the main activity?	Are you are or were you eating during the behavior?	Circle how enjoyable the main activity was 1 2 3 4 5 6 7 ☺ 😐 ☹
12:00- 12:30AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
12:30- 1:00AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
1:00- 1:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

1:30- 2:00AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
2:00- 2:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
2:30- 3:00AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	_____				
3:00- 3:30AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
3:30- 4:00AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
4:00- 4:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	_____				
4:30- 5:00AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
5:00- 5:30AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
5:30- 6:00AM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

6:00- 6:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
6:30- 7:00AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
7:00- 7:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
7:30- 8:00AM	**Main Activity:**	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	Record Any other activity:				
8:00- 8:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
8:30- 9:00AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
9:00- 9:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

9:30- 10:00AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
10:00- 10:30AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
10:30- 11:00AM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
11:00- 11:30AM	**Main Activity:**	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	Record Any other activity:				
11:30- 12:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
12:00- 12:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
12:30- 1:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

1:00-1:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
1:30-2:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
2:00-2:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
2:30-3:00PM	**Main Activity:**	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	Record Any other activity:				
3:00-3:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
3:30-4:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
4:00-4:30PM	**Main Activity:**	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	Record Any other activity:				
4:30-5:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
5:00-5:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
5:30-6:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	_____				
6:00-6:30PM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
6:30-7:00PM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
7:00-7:30PM	**Main Activity:** Record Any other activity: _____	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

7:30-8:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
8:00-8:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
8:30-9:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
9:00-9:30PM	**Main Activity:**	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

	Record Any other activity:				
9:30- 10:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
10:00- 10:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
10:30- 11:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

11:00- 11:30PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**
11:30- 12:00PM	**Main Activity:** Record Any other activity:	Sitting/Lying Moving	Yes No	Yes No	**1 2 3 4 5 6 7**

Is this a typical day for you?

☐ **Yes**

☐ **No Please explain how today was different from a typical weekday or weekend day for you.**

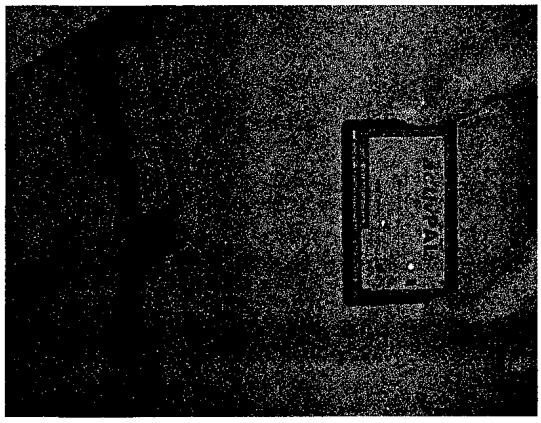
Appendix F

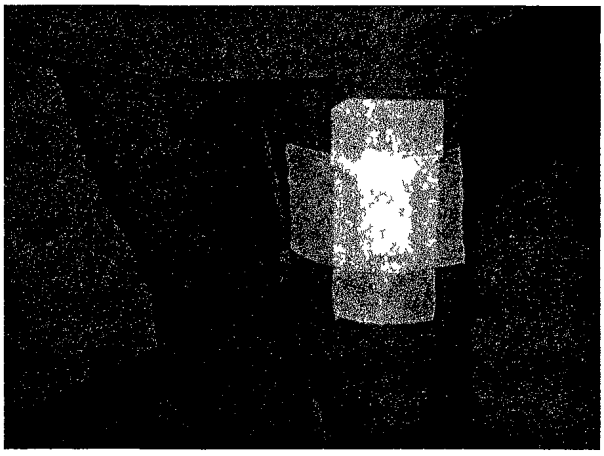
Accelerometer Directions

ActivPal Directions

Wearing the ActivPal

- Please wear the device from the time you get up in the morning until the time you lie down for bed
- The ActivPal is not waterproof and should be removed before bathing or participating in water activities
- Clean and dry the skin, on the front of the thigh, before wearing the ActivPal
    - Please do not wear lotion where the device will be touching your skin
- Place the ActivPal on the front of the right thigh, 1/2 of the way between the hip and the knee
    - Make sure the device is placed vertically with the picture of the person, on the front of the device, standing straight up, facing away from you
- Place 2 strips of the tape provided by the laboratory, over the ActivPal on the thigh
    - Please make sure the tape is securely fastened to the skin (2 pieces to make a +)
    - The ActivPal should not be able to move while on your thigh, it should remain in the same position throughout the day
- There will be a GREEN light that flashes as it records your activity and that is how we know it is working



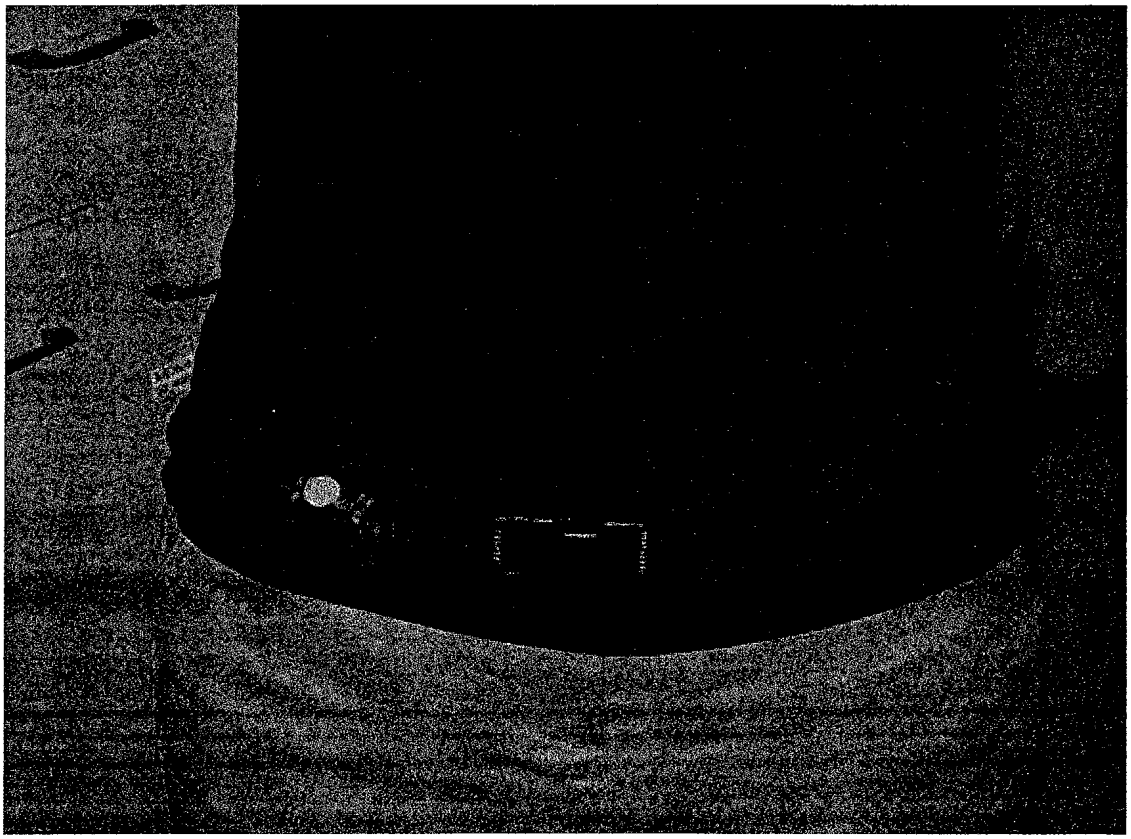


Removing the ActivPal

- Remove the tape from your leg and the device
- After removing the ActivPal, please place the device on a flat surface with the picture side facing up until you are ready to wear

INSTRUCTIONS FOR WEARING THE ACCELEROMETER

- The accelerometer is the red unit
- Wear the accelerometer on your right hip, in line with your right knee cap. **Please make sure that the accelerometer is as vertical as possible (not slanting away from or toward your body).
- Wear the accelerometer for all hours you are awake. Only remove the accelerometer for showering/bathing or swimming and while sleeping. It is essential that the accelerometer stays in a specific orientation with the **orange dot facing up**.
- You are not required to record any information, press any buttons, etc. for the accelerometer. Simply wear it as instructed for the intervention and return on your next visit.



CURRICULA VITAE

Elizabeth K. Grimm

Education

Formal Education:

Doctoral Candidate	**University of Wisconsin-Milwaukee,** Milwaukee WI, College of Health Sciences, Department of Human Movement Sciences - Exercise Physiology, 2007-Expected Graduation Summer 2011
M.S.	**Ball State University,** Muncie IN, College of Applied Science and Technology, The School of Sport, Physical Education and Science – Adult Fitness and Cardiac Rehabilitation Program, 2005-2007
B.S.	**University of Missouri,** Columbia MO, College of Human Environmental Sciences, Department of Nutrition and Fitness, 2001-2005

Significant Continuing Education (in service training)

- Dual Energy X-Ray Absorptiometry 2005-Present
- Air Displacement Plethsmography (Bod Pod) 2005-Present
- Phlebotomy 2005-Present
- Cardiopulmonary Resuscitation through the American Red Cross 2005-Present
- Advanced Cardiac Life Support 2006-2008

Experience

- Exercise Testing Technician, The School of Sport and Physical Education, Ball State University, Muncie IN 2005-2007
- Exercise Program Leader of the Adult Physical Fitness Program, The School of Sport and Physical Education, Ball State University, Muncie IN 2005-2007
- Graduate Assistant, The School of Sport and Physical Education, Ball State University, Muncie IN 2005-2007
- Student Exercise Technician in Cardiac, Pulmonary, and Cancer Rehabilitation, Ball Memorial Hospital, Muncie IN 2005-2007
- Graduate Research Assistant, Department of Human Movement Sciences, University of Wisconsin – Milwaukee, Milwaukee WI 2007-Present

Teaching

- Observing undergraduate Exercise Physiology and teaching Pulmonary Physiology, Department of Human Movement Sciences, University of Wisconsin-Milwaukee, Wisconsin — 2010
- Observing undergraduate Exercise Testing and Prescription and teaching Exercise Testing and Prescription for Special Populations, University of Milwaukee, Wisconsin — 2011

Service

- Student Representative on the Search and Screen Committee for Nutrition faculty position in the Department of Human Movement Sciences, University of Wisconsin-Milwaukee — 2008
- Officer of the Human Movement Sciences Graduate Association, University of Wisconsin-Milwaukee — 2008-Present

Honors

- The Center on Aging and Community Scholarship, University of Wisconsin-Milwaukee, Milwaukee WI — 2007-2009
- Golden Key Scholar — 2010
- University of Wisconsin-Milwaukee Outstanding Graduate Student Award — 2010

Grants

- College of Health Sciences Student Research Grant, University of Wisconsin-Milwaukee WI (funded) — 2010
- Institute of Race and Ethnicity Graduate Scholars Associates Program, University of Wisconsin-Milwaukee WI (not funded) — 2010

Publications

Published Abstract Proceedings

- Ewalt, L.A., Swartz, A.M., Strath, S.J., Miller, N.E., Gennuso, K.P., **Grimm, E.K.** & Loy, M.S. (2008). Validity of physical activity monitors in assessing energy expenditure in normal, overweight, and obese adults. *Medicine and Science in Sports and Exercise*, 40:S198.
- **Grimm, E.K.**, Strath, S.J., Swartz, A.M., Miller, N.E., Loy, M.S., Ewalt, L.A. &

Gennuso, K.P. (2008). Comparison of the IPAQ- Short Form and accelerometry predictions of physical activity in older adults. *Medicine and Science in Sports and Exercise*, 40(5):S197.

- Loy, M.S., Swartz, A.M., Strath, S.J., Miller, N.E., Ewalt, L.A., Gennuso, K.P. & **Grimm, E.K.** (2008). Objectively measured physical activity and Framingham Risk Score in healthy older adults. *Medicine and Science in Sports and Exercise,* 40(5):S222.
- Rote, A.E., Swartz, A.M., Cashin, S.E., Strath, S.J., Miller, N.E., **Grimm, E.K.**, Dondzila, C.J. & Sweere, K.M. (2009). Psychosocial factors influencing physical activity in older adults. *Medicine and Science in Sports and Exercise,* 41(5):S126-127.
- Strath, S.J., Swartz, A.M, Tarima, M.M., Gennuso, K.P., Miller, N.E., **Grimm, E.K.**, & Cieslik, L.J. (2009). Dose-response walking activity and physical function in older adults. *Medicine and Science in Sports and Exercise.* 41(5):S377.
- **Grimm, E.K.,** Strath, S.J, Swartz, A.M., Miller, N.E., Gennuso, K.P., Rote, A.R., Dondzila, C.J., & Sweere, K.M. Objective measurement of sedentary and active behavior in older adults.(2009). *Medicine and Science in Sports and Exercise,* 41(5):S379.
- **Grimm, E.K.,** Swartz, A.M., Harley A., & Strath, S.J. (2011). The exploration of sedentary behavior in older adults. *Medicine and Science in Sports and Exercise,43*(5), S539.

Published Journal Articles

- Swartz, A.M., Strath, S.J., Miller, N.E, **Grimm, E.K.,** Ewalt, L.A., Loy, M.S. & Gennuso, K.P. (2009). Validity of physical activity monitors in assessing energy expenditure in normal, overweight, and obese adults. *The Open Sports Science Journal* 2: 58-64.
- Strath, S.J. Swartz, A.M., Parker, S.J., Miller, N.E., **Grimm, E.K.,** & Cashin S.E. A Randomized pilot trial evaluating motivationally matched pedometer feedback to increase physical activity behavior in older adults. *Journal of Physical Activity and Health* (In press, 2011**).**
- **Grimm, E.K.,** Strath, S.J., Swartz, A.M., Hart, T.L. & Miller, N.E. (2010). Comparison of the IPAQ-Short Form and Accelerometer-Determined Physical Activity Level in Older Adults. *Journal of Aging and Physical Activity* (Accepted).
- Swartz, A.M, Miller, N.E., Hart, T.L., **Grimm, E.K.,** Rote, A.E., & Strath, S.J. Time spent in moderate intensity physical activity, but not sedentary behavior is related to body fat in older adults. *Journal of Physical Activity and Health* (Accepted).

Journal Articles

- Strath, S.J. Swartz, A.M., Tarima, S.S., Gennuso, K.P., Miller, N.E., **Grimm, E.K.,** & Cieslik, L.J. Dose response walking and physical function in older

adults. *Journal of the American Geriatrics Society* (in preparation).
- **Grimm, E.K.**, Strath, S.J., Swartz, A.M., & Cashin, S.E. Objective examination of sedentary behavior across step indices. *Journal of Physical Activity and Health* (in preparation).

Published Book Chapters

- Strath, S.J. & **Grimm, E.K.** (2011). Active Living - Options and Benefits for Seniors *ACSM Guide to Exercise and Physical Activity for Older Adults.* Baltimore, MD: Lippincott, Williams & Wilkens. (in press).

Presentations

Local

- "Physical Activity Behavior Change and Older Adults", University of Wisconsin-Milwaukee, Department of Social Work, Research and Processes of Individual Change Across the Lifespan, April 2008.
- "The Rise of Chronic Disease and the Fall of Physical Activity-Problem Conceptualization", University of Wisconsin-Milwaukee, College of Health Sciences Research Seminar, April 2008.
- "Walk Your Way to Health" Chai Point Senior Living Community, Milwaukee Wisconsin, August 2008.
- "Comparison of the IPAQ-Short Form to Accelerometry Predictions in Older Adults", University of Wisconsin-Milwaukee, College of Health Sciences Research Seminar, May 2008.
- "Translating Research from an Exercise Physiology Perspective", Medical College of Wisconsin CTSI Translational Research Group, Wauwatosa Wisconsin, October 2010.

National/International

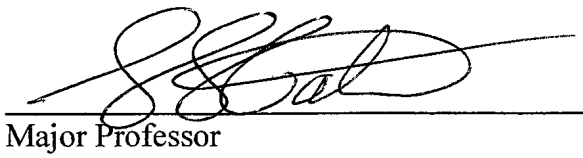
- Ewalt, L.A., Swartz, A.M., Strath, S.J., Miller, N.E., Gennuso, K.P., **Grimm, E.K.** & Loy, M.S. (2008). Validity of physical activity monitors in assessing energy expenditure in normal, overweight, and obese adults. *American College of Sports Medicine*, Indianapolis Indiana.
- **Grimm, E.K.**, Strath, S.J., Swartz, A.M., Miller, N.E., Loy, M.S., Ewalt, L.A. & Gennuso, K.P. (2008). Comparison of the IPAQ- Short Form and accelerometry predictions of physical activity in older adults. *American College of Sports Medicine*, Indianapolis IN.
- Loy, M.S., Swartz, A.M., Strath, S.J., Miller, N.E., Ewalt, L.A., Gennuso, K.P. & **Grimm, E.K.** (2008). Objectively measured physical activity and Framingham Risk Score in healthy older adults. *American College of Sports Medicine*, Indianapolis Indiana.
- Rote, A.E., Swartz, A.M., Cashin, S.E., Strath, S.J., Miller, N.E., **Grimm, E.K.**, Dondzila, C.J. & Sweere, K.M. (2009). Psychosocial factors influencing physical activity in older adults. *American College of Sports Medicine*, Indianapolis Indiana.

- Strath, S.J., Swartz, A.M, Tarima, M.M., Gennuso, K.P., Miller, N.E., **Grimm, E.K.**, & Cieslik, L.J. (2009). Dose-response walking activity and physical function in older adults. *American College of Sports Medicine*, Seattle Washington.
- **Grimm, E.K.,** Strath, S.J, Swartz, A.M., Miller, N.E., Gennuso, K.P., Rote, A.R., Dondzila, C.J., & Sweere, K.M. (2009). Objective measurement of sedentary and active behavior in older adults. *American College of Sports Medicine*, Seattle Washington.
- Swartz, A.M., Strath, S.J., Miller, N.E., Hart, T.L., **Grimm, E.K.,** & Rote, A.R. (2010). Time spent in moderate intensity physical activity, but not sedentary behavior is related to body fat in older adults. 3rd *International Congress on Physical Activity and Public Health*, Toronto, Ontario Canada.
- **Grimm, E.K.,** Strath, S.J., Swartz, A.M., Cashin, S.E., & Miller, N.E. (2010). Objective examination of sedentary behavior across step indices. *International Society for Behavioral Nutrition and Physical Activity,* Minneapolis Minnesota.
- Rote, A.R., Swartz, A.M., Strath, S.J., Cashin, S.E., & **Grimm, E.K.** (2010). Obesity assessment method does not alter relationship with health-related quality of life in older women. *International Society for Behavioral Nutrition & Physical Activity,* Minneapolis Minnesota.
- Squires, L.L., Swartz, A.M., Strath, S.J., Hart, T.L., **Grimm, E.K.,** & Rote, A.R. (2010). Acute physiological response to disruption of sedentary behavior: preliminary results. *College of Health Sciences Research Symposium, University of Wisconsin-Milwaukee,* Milwaukee Wisconsin.
- **Grimm, E.K.,** Swartz, A.M., Harley A.,& Strath, S.J. (2011). The exploration of sedentary behavior in older adults. *Medicine and Science in Sports and Exercise,* Denver Colorado.
- **Grimm, E.K.,** Swartz, A.M., Miller, N.E., & Strath, S.J. (2011). Changes in total physical activity, at three and six months, following the completion of a 12-week walking intervention in older adults. 2nd *International Conference on Ambulatory Monitoring of Physical Activity and Movement,* Glasgow, Scotland.
- Dondzila, C.J., Swartz, A.M., Keenan, K.G., **Grimm, E.K.,** Gennuso, K.P., & Strath, S.J. (2011). Lower Physical Functions is Related to Sedentary Behavior in Older Adults. 2nd *International Conference on Ambulatory Monitoring of Physical Activity and Movement,* Glasgow, Scotland.
- Swartz, A. M., **Grimm, E.K.,** Hart, T.L., Miller, N.E., & Strath, S.J. Energy Cost of Step Frequencies Across Age. (2011). 2nd *International Conference on Ambulatory Monitoring of Physical Activity and Movement,* Glasgow, Scotland.
- Strath, S.J., Keenan, K.G., Hart, T.L., **Grimm, E.K.,** Miller, N.E., & Swartz, A.M. (2011). 2nd *International Conference on Ambulatory Monitoring of Physical Activity and Movement,* Glasgow, Scotland.

Affiliations/Memberships

- American College of Sports Medicine 2004-Present

- International Society for Behavior, Nutrition, and Physical Activity — 2009-Present



Major Professor

August 11th, 2011

Date