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THE EFFECTS OF A TWELVE WEEK SEDENTARY BREAK INTERVENTION VERSUS A STANDARD WALKING PROGRAM IN ADULTS WITH TYPE II DIABETES

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THE EFFECTS OF A TWELVE WEEK SEDENTARY BREAK INTERVENTION VERSUS A STANDARD WALKING PROGRAM IN ADULTS WITH TYPE II DIABETES

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF HEALTH AND EXERCISE SCIENCE

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This project is dedicated to my grandmother who struggled with Type II Diabetes and to my current and future family.

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Abstract

PURPOSE: To determine if a 12-week program designed to increase breaks in sedentary time will improve blood glucose control compared to a standard 12-week walking program for patients with Type II Diabetes. **METHODS**: 19 participants (ages 40-64) were randomized into a Breaks Group (BG) or a Walking Group (WG) for the 12 week intervention. The BG was asked to take 2-minute breaks every hour of sedentary time and the WG was asked to increase their walking to 10,000 steps per day, including at least 30 minutes of moderate-vigorous physical activity (PA) in chunks of at least 10 minutes. Physical activity, sedentary time, and breaks were measured pre- and post-intervention using minutes of moderate-vigorous PA (Actigraph GT1M accelerometers) and steps were also measured (Yamax SW200 pedometers). Blood glucose and Hemoglobin A_{1C} levels were measured pre- and post-intervention. Researchers maintained minimal contact with participants during the intervention through weekly emails and bi-weekly phone calls. Analysis of Variance with repeated measures was used to make comparisons ($p < 0.05$). **RESULTS**: 12 participants completed all measurements. Moderate-vigorous PA increased over time (16.7 minutes per day, $p = 0.043$), along with a decrease in Hemoglobin A_{1C} (1.6%, $p = 0.033$). Pedometer steps increased while sedentary time and fasting blood glucose decreased, but not significantly. There were no differences between groups. **CONCLUSION**: Both interventions resulted in improvement in moderate-vigorous PA and Hemoglobin A_{1C} levels in adults with Type II Diabetes, however, no differences were observed between groups. The small sample size likely contributed to the inability to obtain significant

results and future studies should include a larger sample size and incentives to promote compliance.

Chapter I: Introduction

Type II diabetes mellitus (T2DM) is a major concern in the United States and represents 90-95% of all cases of diabetes.[1] Due to a lack of initial symptoms, T2DM often goes unnoticed by those at high risk or in early stages of the disease. In 2010, almost two million adults over age 20 were diagnosed with diabetes and millions more were identified as pre-diabetic or exhibited multiple risk factors for the disease.[2] Hundreds of billions of dollars are spent each year in the U.S. on indirect and direct costs related to diabetes.[2] If diabetes is left untreated, the vascular system and multiple organ systems are damaged and eventually lose their functions. Subsequently, people diagnosed with diabetes have twice the risk of stroke or heart attack compared to those who do not have diabetes.[1] Finding an effective prevention and treatment method for T2DM will result in significant health and financial benefits for individuals and our society.

Many factors contribute to T2DM risk. These risk factors can and should be the targets of intervention. The American Diabetes Association (ADA) has listed several risk factors for T2DM: impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG), 45+ years of age, a family history of diabetes, overweight and obesity status, physical inactivity, low HDL cholesterol and/or high triglycerides, high blood pressure, certain racial and ethnic group membership, and women who had gestational diabetes or a baby weighing over nine pounds at birth.[1] Of those risk factors, physical inactivity is one that is modifiable and has been the target of much previous research.[3-8] Physical activity (PA) has been shown to have beneficial effects on both treatment and prevention of T2DM.[9-12]

Walking is a common form of PA performed by those with T2DM because this activity is low impact and can be done anywhere and anytime with relative ease. Walking also can be used to satisfy the suggested PA recommendations for people with T2DM. Albright et al.[13] compiled PA recommendations for those with T2DM and concluded that on most if not all days of the week an individual should perform low to moderate-intensity cardiorespiratory PA (40 – 70% VO_2max). This PA should reach at least 30 minutes in duration and increase intensity and duration where possible to 70–90% of VO_2max and for up to one hour. In addition, Hordern et al.[14] recommended that persons with T2DM should accumulate a minimum of 210 minutes of moderate intensity aerobic PA (55-69% HRmax) or 125 minutes of vigorous intensity aerobic PA (70-89% HRmax) per week,while going no more than two consecutive days without exercising. Because of the importance of regular PA, walking programs have been implemented to test what methods are most effective in increasing PA in order to meet the recommendations and improve health among those with T2DM.

Pedometer-based walking programs have been widely used as an effective and cost-efficient means of helping T2DM patients become more active.[15] Lengths of these programs have ranged from six weeks to 24 weeks, and include study samples that average about 25 T2DM patients in each group. Participants in these studies ranged in age from 18-89 with an average age of 57. All of these interventions used some type of logbook to record daily steps along with the use of theoretically based strategies such as goal setting and self-regulation techniques. Group counseling was also used in some studies[16-20] while other programs used one-on-one counseling techniques with a health professional.[20-23] With the exception of one,[23] all of these programs produced significant increases (from 837 to 8,948 more steps per day) in PA in T2DM patients. Use of pedometers as a motivational tool is therefore thought to be effective at increasing PA in clinical T2DM populations. This increase in PA was subsequently associated with an improvement in short-term health outcomes such as blood glucose and Hemoglobin A1c.

Sedentary time has also been linked to several risk factors for T2DM such as obesity, cardiovascular disease (CVD), insulin resistance, and metabolic diseases.[24] Sedentary time refers to any time spent in activities involving very little or no movement and can include sitting during travel time, sitting at work, sitting at a computer or TV, or just sitting during leisure time. These activities generally use little energy (1-1.5 METs) at or above resting metabolic rate.[25] One recommendation suggests that sitting time should be limited to no more than two hours of discretionary time per day and breaks should be taken for every 30 minute block of sedentary time (standing up and moving around).[26] Decreasing sedentary time has been successful as part of a walking program designed to increase steps and a program designed to increase breaks in sedentary time.[27,28] Targeting decreased sedentary time in walking programs for adults with T2DM is a relatively new research area where more study is needed.

Purposes

The primary purposes of the proposed study include examining differences in the effect of a 12-week minimal contact walking program (walking group) as compared to a 12-week program that targeted increasing the number of breaks in sedentary time (breaks only group) on:

1. increasing PA levels of inactive T2DM patients;
2. decreasing sedentary time of inactive T2DM patients;
3. better understanding the association of self-efficacy with PA and sedentary time in inactive T2DM patients; and
4. improving blood glucose control and blood lipids (Total/HDL) in inactive T2DM patients.

Research Questions

The research questions for this study include:

RQ1: Will there be differences in self-efficacy (exercise, walking, and sedentary break) pre- to post-intervention based on participation in a 12-week minimal contact walking program as compared to a 12-week breaks only intervention in inactive T2DM patients?

RQ2: Will there be differences in steps/day, minutes in moderate and vigorous intensity PA, MET minutes associated with PA, and sedentary time measured pre- and post-intervention based on participation in a 12-week minimal contact walking program as compared to a 12-week breaks only intervention in inactive T2DM patients?

RQ3: Will there be differences in fasting blood glucose, HbA1c, and fasting blood lipid levels (Total/HDL) pre- to post-intervention based on participation in a 12-week minimal contact walking program as compared to a 12-week breaks only intervention in inactive T2DM patients?

RQ4: If there are significant changes over time in PA and self-efficacy, is self-efficacy a predictor of changes in PA and sedentary time?

Research Hypotheses

The research hypotheses for this study include the following:

H_R1: Participation in a 12-week minimal contact walking program for 12 weeks will result in a significantly greater increase in measures of self-efficacy (exercise and walking) pre- to post-intervention as compared to a 12-week breaks only intervention in inactive T2DM patients, while participation in a breaks only intervention will significantly increase measures of sedentary break self-efficacy pre- to post-intervention compared to a 12-week minimal contact walking program in inactive T2DM patients.

H_R2: Participation in a 12-week minimal contact walking program will result in a significantly greater increase in the number of steps/day, minutes in moderate and vigorous intensity PA, and MET minutes associated with PA compared to a 12-week breaks only intervention in inactive T2DM patients, while participation in a breaks only intervention will significantly decrease sedentary time pre- to post-intervention compared to a 12-week minimal contact walking program in inactive T2DM patients.

H_R3: Participation in a 12-week minimal contact walking program will result in a significantly greater decrease in fasting blood glucose, HbA1c, and fasting blood lipid levels (Total/HDL) pre- to post-intervention as compared to a 12-week breaks only intervention in inactive T2DM patients.

H_R4: If there is a significant change in PA and sedentary time from pre-to post-intervention, exercise and walking self-efficacy will predict changes in PA level and sedentary self-efficacy will predict changes in sedentary time.

Null Hypotheses

The null hypotheses for this study include the following:

$H_0 1$: There will be no differences in self-efficacy (exercise, walking, and sedentary break) pre- to post-intervention based on participation in a 12-week minimal contact walking program as compared to a 12-week breaks only intervention in inactive T2DM patients.

$H_0 2$: There will be no differences in steps/day, minutes in moderate and vigorous intensity PA, MET minutes associated with PA, or sedentary time measured pre- and post-intervention based on participation in a 12-week minimal contact walking program as compared to a 12-week breaks only intervention in inactive T2DM patients.

$H_0 3$: There will be no differences in fasting blood glucose, HbA1c, and fasting blood lipid levels (Total/HDL) pre- to post-intervention based on participation in a 12-week minimal contact walking program as compared to a 12-week breaks only intervention in inactive T2DM patients.

$H_0 4$: If there are significant changes over time in PA and self-efficacy, self-efficacy will not be a predictor of changes in PA and sedentary time?

Significance of Study

This study was meaningful because it was the first to test the possible effect of an intervention that was designed to break up sedentary time in patients with T2DM compared to a "standard care" intervention (i.e. walking). A one-week feasibility study has been conducted to increase breaks in sedentary time, but this study assessed feasibility and impact of a three-month intervention with breaks assigned throughout the entire day for all sedentary time. Implications from this study could help guide future interventions focused on decreasing sedentary time in a manner more suitable to participants and/or allowing for additional options to intervene beyond a standard walking program.

Delimitations

Delimitations for this study include:

1. Participants were adults 40 to 64 years of age who were diagnosed with T2DM.
2. Participants were currently living in or around the Norman/Oklahoma City, Oklahoma area.
3. Adults unable to walk regularly per physician determination were excluded from the study. Each participant was required to provide a Medical Clearance Form that was signed by a physician in order to participate.
4. Adults with bone or joint problems that potentially could be exacerbated by increased physical activity were excluded from the study.
5. Adults who have experienced dizziness or chest pain while participating in physical activity were excluded from the study.
6. Adults taking insulin were excluded from the study, but the use of other hypoglycemic medications was permitted.
7. Adults with diabetic complications (e.g., cardiovascular disease, stroke, heart attack) that would make walking unsafe were excluded.
8. Females who were pregnant or planning to become pregnant were excluded from the study.
9. Adults with a pacemaker were excluded from the study.

10. Adults that were already part of an exercise group or who were exercising more than 30 minutes/day on at least five days/week were excluded from the study.
11. The intervention (walking and breaks only groups) was administered during winter and spring months.

Limitations

Limitations for this study include:

1. The pedometer is not accurate at measuring cycling or water activities; therefore, those activities were not included in daily step counts.
2. Participants were volunteers and, therefore, may not be representative of the general T2DM adult population.
3. A "no-intervention" comparison group was not included in this study. Instead, as is common in clinical research, the group of the intervention that reflects standard practice (walking) was used as the comparison condition. Because of this, treatment effects cannot be exclusively attributed to the intervention.
4. Most participants were affiliated with the University of Oklahoma and, therefore, likely had a higher than average education status as compared to the general population.

Assumptions

Assumptions of the current study include:

1. All participants answered the surveys honestly and accurately.
2. All participants measured and recorded their pedometer steps on a log sheet honestly and according to the study protocol.

3. All participants were in a fasted state for all study-related blood tests.
4. All participants consistently followed the protocols for the walking and breaks only groups.
5. All participants took their medications according to the prescription reported at baseline and/or reported any usage changes that occurred during the study.

Operational Definitions

Operational definitions for this study include:

1. Accelerometer – Device used to measure body movements in terms of acceleration. They can be used to estimate intensity of physical activity over time. Accelerometers use piezoelectric sensors to detect accelerations in one or more directions (only the vertical direction in this study).[29]
2. Exercise – Planned, structured, repetitive bodily movement designed specifically to maintain or improve bodily fitness.[30]
3. Pedometer – A device worn on the hip with a spring-loaded lever arm that moves vertically with accelerations of the hip when a step is taken. With each step, the lever arm contacts a sensor that records the action as one step.[31]
4. Physical Activity – Any bodily movement using the skeletal muscles that results in energy expenditure.[30] This is operationalized using daily step counts using a pedometer and activity counts from an accelerometer summed into 15-second intervals and accumulated throughout the day. Water activities and other activities that do not cause the hips to move significantly are not captured using the pedometer.

5. Sedentary Behavior – Any activity involving little or no physical activity, such as riding in a car, working at a desk, eating a meal at a table, playing video games, using a computer, and watching television.[32] This will be operationalized by collecting hours of very low movement using the accelerometer.
6. Self-efficacy – The conviction that one can successfully execute the behavior required to produce [an] outcome.[33] An example would be having confidence that one can successfully increase physical activity to improve their diabetes status.

Chapter II: Review of the Literature

Diabetes

Types of Diabetes

Diabetes is a global epidemic that is growing and expected to affect over 366 million people, 4.4% of world population, by the year 2030.[34] Diabetes is a metabolic disease involving the body's inability to adequately process glucose due either to a dysfunction in the insulin receptors or to destruction of the cells that produce insulin in the pancreas. Type I Diabetes requires supplemental insulin and occurs when the beta cells of the pancreas are targeted and destroyed by the immune system while Type II Diabetes (T2DM) is non-insulin dependent and occurs as the cell receptors for insulin become desensitized and nonresponsive to insulin. Gestational Diabetes is glucose intolerance that occurs during pregnancy and increases a woman's likelihood of developing T2DM in the next 10-20 years by 35-60%.[2] Of the three main types of diabetes, Type II is by far the most prevalent in the United States, accounting for 90-95 percent of diagnosed diabetes cases.[2]

Demographics of Type II Diabetes

The increased prevalence of T2DM has created a health and financial strain; 1.9 million new cases were identified in 2010 for adults age 20 and older in the United States.[2] Diabetes is expected to be increasingly concentrated in urban areas and spread to developing countries.[35] Slightly more men (13 million) are diagnosed with diabetes in the United States compared to women (12.6 million); the prevalence of T2DM increases in older populations.[2] The economic cost of diabetes in 2012 for the United States was $176 billion in direct medical expenditures and $69 billion in reduced national productivity.[36] As T2DM advances, serious medical conditions begin to develop and if left untreated can lead to disability and death.

Effects of Type II Diabetes

All of the systems of the body that receive blood can be negatively affected by the high glucose levels which occur under diabetic conditions. Some of these complications include nephropathy, neuropathy, blindness, amputations, and cardiovascular disease (CVD). Diabetes is the leading cause of kidney failure (nephropathy) which is one effect of the high blood sugar levels which damage the small blood vessels in the kidneys. As the kidney damage advances, filtration of the blood becomes ineffective causing proteins and blood cells leaking into the urine. Kidney failure results in a need for dialysis or kidney transplantation. Nerve damage (neuropathy) is caused as the nerves are unable to get sufficient blood flow due to damage to the blood vessels that supply blood to them. Just like kidney damage, the blood vessel damage is caused at least in part by the high blood sugar levels. As nerve damage progresses the organs activated by those nerves eventually lose sensation and function. Nerve damage along with damage to blood vessels causes an inability for the tissues to heal and function properly. This is the major factor in leading to amputation of limbs. Diabetes is also a major cause of CVD due to the blood vessel damage caused by high blood sugar levels. Those with diabetes are at twice the risk of a stroke or heart attack compared to those without diabetes.[1]

Determinants of Type II Diabetes

Understanding the determinants of T2DM and how to affect them is important to decrease risk for and complications of T2DM. The more risk factors a person has, the more likely they are to be diagnosed with T2DM. The American Diabetes Association lists eight factors that have been associated with T2DM: people with impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG), people over age 45, people with a family history of diabetes, people who are considered overweight or obese, people who do not exercise regularly, people with low HDL cholesterol and/or high triglycerides, people with high blood pressure, people of certain racial/ethnic groups (e.g., Non-Hispanic Blacks, Hispanic/Latino Americans, Asian Americans and Pacific Islanders, and American Indians and Alaska Natives), and women who have had Gestational Diabetes, or who have had a baby weighing nine pounds or more at birth. With each additional risk factor, the likelihood for developing T2DM is increased.

Type II Diabetes Interventions

Several methods are currently used to prevent and treat T2DM including: education, medical nutrition therapy, physical activity, oral hypoglycemic agents, and insulin.[37] Education, nutrition, and physical activity (PA) are fundamental treatments that should be the focus of early treatment and should be individualized to each patient.[38] Standards for diabetes education suggest that certain topics be covered in a diabetes education program: (1) disease process; (2) treatment options; (3) nutritional plans; (4) exercise plans; (5) knowledge of the diabetes medicines prescribed; (6) blood glucose monitoring techniques; (7) knowledge of acute and chronic diabetic complications; (8) psychosocial issues; and (9) individual strategies to promote health.[39] Nutritional interventions usually involve a level of calorie restriction to promote weight loss, along with lower consumption of total and saturated fats and processed foods, as well as a higher consumption of fiber, whole grains, fruits, and vegetables, which can lead to improvement in glycemic control in diabetic patients.[37] When combining PA with a low glycemic diet, one study found no added benefit with the addition of the diet component beyond just increasing PA.[40] However, several other studies have shown that the combination of diet and PA can improve glycemic control.[41-43] Further research is needed to better understand what combination of diet and PA can produce efficacious results in T2DM patients.

Physical activity alone, usually in the form of walking, is also widely and effectively used as a lifestyle modification for those diagnosed or at risk for T2DM.[9,16,19] As glucose control decreases and the disease progresses, medication (e.g., MetFormin) and eventually insulin may be used to control blood sugar levels. Current pharmacological methods for treating T2DM are discussed in detail elsewhere,[37] but their purpose is to improve glycemic control by stimulating the beta cells to increase insulin secretion, decrease hepatic glucose output, decrease insulin resistance, delay glucose absorption, or some combination of those effects. As T2DM advances, it may become necessary to administer exogenous insulin to compensate for the inability of the pancreas to meet the demand of the body for normal function. Lifestyle interventions are, however, the most reasonable solutions for most people in increasing quality of life and decreasing risk for and development of T2DM.

Physical Activity

Demographics of Physical Activity

Physical activity is an important target for intervention because a lack of PA is among the leading causes of death in the United States.[44] Inadequate PA, which is distinct from sedentary behavior, has long been a serious concern in the U.S. and other developed countries as lifestyles become more sedentary and energy dense foods become more prevalent. The 1996 Surgeon General's report found that at least one fourth of U.S. adults acquired no leisure time PA and as people aged their activity level decreased.[45] In 2009, only about half (51%) of adults in the U.S. reported getting more than 30 minutes of moderate intensity PA on five or more days of the week, or 20 minutes or more of vigorous PA on at least three days per week.[46] Additionally, 23.8% of Americans reported not participating in any PA in the last month.[46]

These low PA levels have an effect on the health of the nation which increases cost of living and decreases quality of life.[47] In a study with transport and post office employees, men who were more physically active had lower mortality rates from heart disease than their less active counterparts.[48] The Harvard Alumni Study showed that increased PA is associated with a decrease in all-cause mortality which can in part be attributed to the effects of chronic diseases.[49]

Recommendations for Physical Activity

Several organizations have observed the trends of physical inactivity and have provided guidelines to increase awareness of the amount and type of PA that will produce significant health benefits.[45,50,51] The Surgeon General's Report on Physical Activity and Health summarized the PA recommendations up to the year 1996 by recommending "All people over the age of two should accumulate at least 30 minutes of endurance-type physical activity, of at least moderate intensity, on most – preferably all – days of the week".[45] In 2002, the Department of Health and Human Services outlined the costs and benefits of PA with a call to action that people of all ages should acquire 30 minutes of moderate intensity PA on five or more days of the week, which can be performed in 15- or 10-minute segments.[50] The report went on to recommend simple ways to change, such as promoting a walking program in schools, worksites, or communities to meet the recommendations. In a combined report, the American College of Sports Medicine and the American Heart Association published PA recommendations in 2007 to promote adults between 18 and 65 to get a minimum of 30 minutes of moderate intensity aerobic PA on five days per week or 20 minutes of vigorous aerobic PA on three days per week in bouts of at least 10 minutes.[51] They also recommended that when these minimum recommendations are exceeded there is a greater likelihood for preventing chronic disease and disability.

Physical Activity Effects on People with Type II Diabetes

Physical activity is important for individuals at all levels of health, but can be especially helpful at improving glucose metabolism in those who have been diagnosed or are at risk for T2DM. Males with T2DM with low self-reported PA and low cardiorespiratory fitness have been shown to be at higher risk for all-cause mortality than those who were active or had higher fitness.[52] Physical activity has also been shown to prevent and treat metabolic syndrome which is a group of diseases associated with high risk for T2DM and heart disease.[53] Physical activity recommendations for those with T2DM have been established,[13,14] yet PA is highly neglected among those with T2DM.[54-57] Short and longer-term exercise has been shown to improve insulin sensitivity and blood glucose control in patients with T2DM.[3-8]

Physical activity guidelines have been established and walking is a common form of PA for T2DM patients. In a two year counseling intervention, 179 T2DM patients were randomized into groups and were tracked over the intervention to assess the overall MET's per week they achieved through walking. Those who acquired more PA had better control of their blood glucose, better physiological and anthropometric outcomes, and spent less money on disease-related expenses.[58] Albright et al. compiled PA recommendations for those with T2DM and concluded that on most, if not all, days of the week they should perform low to moderate-intensity cardiorespiratory PA (40 – 70% VO_2max) reaching at least 30 minutes in duration and increasing intensity and duration where possible to 70–90% of VO_2max and for up to one hour.[13] Hordern et al. recommended a minimum of 210 minutes of moderate intensity aerobic PA (55-69% HR_{max}) or 125 minutes of vigorous intensity aerobic PA (70-89% HR_{max}), and going no more than two consecutive days without exercising.[14] In summary, PA levels are relatively low in the U.S. and increased PA levels have been associated with decreased risk for and development of many chronic diseases.

Sedentary Behavior

Demographics of Sedentary Behavior

Sedentary time can be considered an independent risk factor for development of chronic diseases.[59] Sedentary behavior has been defined as any waking behavior characterized by an energy expenditure ≤ 1.5 METs while in a sitting or reclining posture.[60] Due to the use of postural muscles, standing may not be considered a sedentary behavior even though no movement is involved.[61] The increase in "sitting time" may be a cause for chronic disease regardless of the amount of PA obtained. The Nurses' Health Study showed an association between TV viewing and obesity and diabetes.[62] Relative risk for developing obesity was almost double while risk of developing T2DM was 70% higher in those who watched 40+ hours of TV/week compared to those who watched one or less hour/week.[62] Sedentary behavior has also been linked to many other conditions related to T2DM and other chronic diseases.[24]

Recommendations for Sedentary Behavior

The recommendations for limiting sedentary behaviors do not have the same strength as the PA recommendations due to the relative novelty of this area of research and the difficulty with measurement. Research studies have examined various interventions including a reduction in TV time,[63,64] increasing breaks in sedentary time,[65] limiting leisure time sedentary behavior,[66] and discouraging sitting for extended periods of time.[32] Sitting time, TV time, and travel time are often used to estimate sedentary time, however, those are only surrogate measures for sedentary and do not fully capture all sedentary time. Measurement of PA and sedentary time both require some degree of estimation due to the complexity and diversity of activities that cannot all accurately be measured with current methods. One recent study suggested that, "the next iteration of the Physical Activity and Public Health recommendations of ACSM/AHA will include a statement on the health benefits of reducing and breaking up prolonged sitting time."[67] Formal recommendations for reducing sedentary time do not yet exist. However, one review of determinants and interventions to reduce sedentary behavior concluded that based on previous evidence, sitting time should be limited to no more than two hours per day and breaks should be taken for every 30 minute block of sedentary time (e.g., standing up and moving around).[26]

Sedentary Behavior and Type II Diabetes

The mechanisms by which sedentary behavior contributes to T2DM risk have been studied and are beginning to be understood. One area being studied is the effect of sedentary time on lipoprotein lipase (LPL), which is a protein important in controlling plasma triglyceride catabolism, HDL cholesterol, and other metabolic risk factors that are closely associated with T2DM.[59,68] LPL is the first protein that interacts with and regulates lipoproteins at the cellular level and could possibly regulate other metabolic activities.[68] It appears that LPL activity is acutely sensitive to muscle contraction and therefore long periods of sedentary time cause a prolonged decrease in LPL activity, especially in the red oxidative muscles.[69] It also appears that there is a local process involved with LPL activity in inactive muscles which can be reversed through engagement in standing or light PA.[69] Altered triglyceride metabolism has strong evidence showing its relationship to disease.[70,71] Overexpression of LPL has been shown in animal studies to potentially decrease diet-induced adiposity, hyperlipidemia, and insulin resistance.[72,73]

Interventions to Reduce Sedentary Behavior

Longitudinal and intervention studies have been reviewed to describe effective techniques to decrease sedentary time in adults.[26,74] Using accelerometers to measure sedentary time, Gardiner et al.[27] used constructs from the Social Cognitive Theory to interrupt sedentary time in older adults. They used goal setting techniques, benefits and barriers, rewards, and identified enjoyable non-sedentary activities to increase self-efficacy, outcome expectancies, reinforcement, and enjoyment. The goal of the intervention was to understand how to effectively interrupt long periods of sedentary time. The two-week intervention was successful at decreasing sedentary time by 3.2% ($p < 0.001$) and increasing the number of breaks in sedentary time throughout the day by four ($p = 0.003$). Another study by De Greef et al.[28] used a face-to-face interview session, pedometers, and telephone follow-ups to encourage T2DM patients to take 10,000 steps/day and decrease sedentary time. Follow-up measures were taken at 24 weeks and one year. The intervention group had increased steps/day by 2744 at 24 weeks and maintained an increase of 1872 steps at one year. Additionally, the intervention group decreased sedentary behavior (measured by accelerometer) by 23 min/day after 24 weeks ($p < 0.05$) and maintained a decrease of 12 min/day at one year ($p < 0.001$).

Measurement Tools

Appropriately measuring PA allows for an accurate understanding of which intervention techniques are effective and can therefore potentially affect health. Physical activity can be measured directly through direct observation, accelerometers, pedometers, doubly-labeled water, indirect or direct calorimetry, heart rate monitors, global positioning systems, or indirectly through diaries or logs, questionnaires, surveys, and recall interviews.[75] Physical activity in walking programs has been measured using various tools such as accelerometers,[21,76] pedometers,[16,20,21,23] exercise logs,[23] and self-report surveys.[19,20] Direct observation is an accurate method of measuring PA because a trained observer can record every movement that another person makes and describe exactly the type, duration, and intensity of all activities performed by another person. It is, however, impractical to directly observe people in their daily lives for any extended period of time, so other direct methods have been created to measure PA.

Accelerometers have previously been cited in a systematic review as the most often used direct measure of PA for studies that compared direct and indirect measures.[75] They accurately measure all accelerations of the center of mass of the body and unlike other measurement tools, accelerometer data produces information on acceleration which can also be processed to obtain speed and distance information.[77] Accelerometers produce high quality PA data, but they are expensive and the data analysis is a more complicated process when compared to other simpler forms of PA measurement.[78]

Pedometers are an inexpensive, easy to manage way to directly measure PA by obtaining the number of steps a person takes over a certain time period.[79] Pedometers have been highly correlated with accelerometers (r = .86)[80] and have also been correlated with increased PA and improved health.[81] They have been used as motivational tools to increase PA as a tracking device, a feedback tool, and an environmental cue with minimal contact from supervisors.[82] The Yamax SW200 pedometer has been frequently used in walking studies,[16,18,19,21] and has been used as a criterion with which to compare other pedometers.[83] The Yamax SW model gave mean step counts that were within 1% of actual steps at different walking speeds and was the only one out of 10 models that did not differ significantly from actual steps at five different walking speeds.[84] It has also been shown to be reliable in normal weight, overweight, and moderately obese populations.[85]

Self-report measures have been evaluated[86] as the most widely used and convenient form of PA measurement, yet have many limitations due to indirect measurement.[87] Self-report measures may produce bias by influencing respondents to provide answers that are socially desirable.[88] Recalling information is a complex cognitive task[89] and respondents and researchers must have the same understanding of the terminology of concepts being measured.[86] Activity logs and diaries are limited by participant response rates and how they follow the directions.[86] Surveys, however, are easy to use and can be administered on a large scale. The International Physical Activity Questionnaire (IPAQ) is a widely used self-report measure that has been validated across many countries and is able to be used to compare population health across countries.[90] It assesses PA over the previous seven days and comes in a short and long form which breaks PA down into components of different intensities. A combination of indirect and direct measures will provide the most complete assessment of PA.

Valid and reliable measurement of sedentary behavior utilizes similar methods to PA. The definition of sedentary behavior includes components of body position and metabolic rate and both components are not usually measured in each research study reporting sedentary behavior.[91] Understanding the mechanism by which sedentary behavior contributes to disease risk will help determine which measurement technique to use.[91] Currently, direct observation has been established as a criterion for PA and sedentary behavior measurement.[92]

Since direct observation is not practical, other measures will be used to determine the amount of sedentary behavior. As described above, accelerometers have been used to classify PA. Sedentary behavior is defined as any activity contributing less than 100 counts per minute and therefore if body position is not taken into account accelerometers may provide a fairly accurate measure of sedentary time.[93] Self-report measures may also be used for larger populations to get an estimate of sedentary time by using surrogates such as TV time or time to travel.[26] A combination of these measures will allow for a more complete understanding of sedentary behavior.

Walking Programs

Several significant studies are described below which include characteristics of effective walking programs similar to the current study, but not necessarily with T2DM patients.

General Walking Programs

The first study reviewed on this topic was conducted by Moreau et al.[94] in 2001 with 24 postmenopausal women (54 ± 1 yr.) who were diagnosed with borderline or stage one hypertension. Fifteen women were randomized to the intervention group and nine to the non-exercise control group. All subjects were given a Yamax SW200 pedometer to wear for one to two weeks before the study in order to measure pre-intervention activity levels. During the 24 week walking program, women in the exercise group were told to increase their total steps enough to add 1.4 km/day to their total daily walking. One half a km was added each week until they were walking three km/day above their baseline value. They used daily log sheets to track their step values and were allowed to accumulate steps in whatever pattern best fit their lifestyles. The control group was asked to maintain their current lifestyle habits and they measured their steps one week each month to document activity levels. Outcome measurements were taken at baseline, 12 weeks, and 24 weeks and included resting blood pressure, fasting glucose and insulin, body composition (using a BOD POD), and three-day dietary food records. At baseline, the exercise group walked significantly less than the control group (5400 ± 500 steps/day, 7200 ± 700 steps/day, respectively, $p < 0.05$). However, women in the walking group increased their walking by 4300 steps to 9700 ± 400 which was different from baseline and the control ($p < 0.05$). Women in the control group did not change their walking over the 24 weeks. The exercise group reduced body mass by 0.9 ± 0.3 kg after 12 weeks ($p < 0.05$) and an additional 0.3 kg after 24 weeks of walking ($p < 0.005$). After 12 weeks, fasting insulin increased in the control group by 23% and remained elevated at 24 weeks ($p < 0.05$), but did not change in the exercise group. Body composition, dietary intake, resting heart rate, fasting glucose, and HOMA did not change in either group. Resting systolic BP was reduced in the exercise group at 12 weeks by six mm Hg ($p < 0.005$) and was further reduced by five mm Hg after 24 weeks ($p < 0.005$). Diastolic BP did not change and neither systolic nor diastolic changed in the control group. Detailed intervention methods were not described nor were discussions included that hypothesized what made the program successful at increasing PA.

Another study was performed by Miyatake et al.[10] in 2002 with 31 Japanese male subjects with a BMI ≥ 25 and between the ages of 32 and 59. The subjects were instructed to record their daily steps using a pedometer (Seiko WZ100A). They increased their steps by 1000 above their baseline level and maintained their current dietary behaviors. Body composition, submaximal aerobic capacity, muscle strength, gait speed, flexibility, BP, and fasting cholesterol, HDL, triglycerides, insulin, and glucose were measured before and after the one year intervention. Although little information was given on what was done to increase PA, average daily steps were increased during the study from 7012.5 ± 3076.7 to 8839.7 ± 4342.2 ($p < 0.05$). HOMA index (a calculation of insulin resistance), fasting glucose, and insulin were significantly decreased following the study ($p < 0.01$). Body composition measures improved along with aerobic exercise level, leg strength, and weight bearing index ($p < 0.01$). In addition, SBP and DBP improved ($p < 0.05$) along with triglycerides and HDL cholesterol ($p < 0.05$). This study protocol appeared to be very effective at improving many health characteristics by increasing steps by less than 2000 per day over the course of one year. However, it is not clear what intervention techniques facilitated the high compliance rate and/or what influenced the participants to maintain increased activity for the entire one year study.

The next study was performed by Swartz et al.[9] in 2003 with 18 sedentary women between 40 and 65 who had a family history of T2DM and an average BMI of 35 (± 5.1 kg/m^2). The intervention included a four-week control period where participants did not change PA levels followed by an eight-week walking period where participants increased walking to meet the recommended 10,000 steps/day. Pedometers (Yamax SW200) were used to track steps on a step log and diet was kept constant throughout the study. Measurements were taken at the same time during the day at baseline, four weeks, and 12 weeks and included resting HR, body composition (BOD POD), waist and hip girth, oral glucose tolerance, and fasting plasma glucose and insulin. Participants increased their daily steps from 4972 ± 419 to 9213 ± 362 during the intervention. Two-hour post-load glucose decreased by 11% ($p < 0.001$), area under the curve of glucose decreased ($p = 0.025$), and systolic BP and diastolic BP decreased ($p < 0.001$, $p = 0.002$, respectively). All other variables did not change significantly. Little information was given on how the program was administered and what methods were used to increase and maintain increased walking in the participants.

Chan et al.[95] performed a walking program for 92 women and 14 men at five worksites in Canada in 2004. All of their jobs were sedentary in nature and 55% of the employees engaged in strenuous PA (producing sweat and elevated heart rate) less than three days/week. The average age of the participants was 43 ± 9 years with a BMI of 29.5 ± 6.2 kg/m^2 and average daily steps of 6981 ± 3140 for women and 7661 ± 2474 for men. The walking program was based off of the First Steps Program and was organized into a four-week adoption phase followed by an 8-week adherence phase. Facilitators were hired to administer the program at each workplace and held 30-60 minute learning sessions for the adoption phase to teach strategies for goal setting, benefits to PA, and strategies for overcoming relapse. Steps were recorded using a pedometer (Yamax SW200). During the adherence phase, subjects received minimal contact with the researchers and monitored their own progress and goals. Anthropometric measures, resting HR, BP, and steps/day were measured before and after the program. Steps/day increased from 7029 ± 3100 at baseline to 10480 ± 3224 where they hit a plateau about four weeks into the intervention. Body weight, BMI, waist girth, and resting HR significantly decreased following the intervention ($p < 0.001$), however, there were no significant interactions between each of the predictors. This study demonstrated that it takes some time for sedentary people to adapt to a new program and that after 12 weeks there can be significant anthropometric and cardiovascular changes. Instructional sessions at the start of a walking program appear to be effective at helping people maintain higher activity levels.

Hultquist et al.[96] recruited 73 sedentary women between 33 and 55 to participate in a walking study comparing a recommendation to walk 10,000 steps versus a recommendation to walk for 30 minutes. Participants' PA was measured using the New Lifestyles NL-2000 pedometer over the course of 14 consecutive days. These participants walked an average of 5760 ± 1143 steps/day at baseline and had an average BMI of 29.6 ± 6.1. The 4-week intervention included a group that wore a sealed pedometer; they were told to take a brisk 30 minute walk on most or all days of the week. They kept activity logs to track PA, but were not aware of the number of steps/day. The second intervention group was instructed to walk 10,000 steps/day which was recorded using a sealed pedometer and a second pedometer that could be reset each day as they tried to obtain the 10,000 steps/day. All of the subjects returned to the lab to have their sealed pedometer data and activity logs collected. Over the four weeks the group assigned to walk for 30 minutes accumulated an average of 8270 ± 354 steps/day while the group assigned to walk 10,000 steps/day averaged 10159 ± 292 steps/day. There was no significant difference in average daily steps in the 30 minute walking group while the group assigned to take 10,000 steps/day significantly increased steps even if the goal of 10,000 steps was not achieved ($p < 0.05$). Blood pressure significantly changed over time for both groups ($p < 0.05$). It appears that a recommendation of “30 minutes” will result in reaching the recommended amount of daily steps when followed, but this recommendation is not followed as often as is with the recommendation of “10,000 steps”. A specific recommendation of 10,000 steps appears to effectively increase PA on more days/week in the short term compared to the 30 minutes/day recommendation. No other motivational techniques were mentioned as a means to increase activity except for goals setting and tracking behavior.

In 2005 Wilson et al.[97] implemented an eight-week walking program with 22 breast cancer survivors who had completed treatment for at least three months prior to starting the study. The participants were African American and under 70 years old. The intervention was based on the Health Belief Model and included eight 75-minute weekly sessions designed to educate participants on the perceived seriousness and susceptibility of disease risk related to physical inactivity. They tracked walking using a scheduler/tracker and a pedometer. Measurements were taken before the intervention, following the eight-week intervention, and three months after the conclusion of the intervention. Physical activity was measured with the pedometer, and BMI, other anthropometric measures, blood pressure, and attitudes were also measured. Seventy percent of the participants attended at least seven of the weekly meetings and about 25% reported lost or broken pedometers which were replaced. Average steps increased from 4791 to 8297 steps/day from pre- to post-test which was a significant increase ($p < 0.001$). Hip circumference ($p < 0.009$), forearm circumference ($p < .001$), systolic BP ($p < 0.002$), diastolic BP ($p < 0.001$), and attitude toward exercise also significantly changed following the intervention. Attitude toward exercise improved by the end of the intervention, but at the three month follow-up that attitude had declined again despite no change in steps/day. This study shows the effectiveness of an eight-week walking program at increasing activity which potentially affects health outcomes, which may not persist long-term after the study because attitudes became more negative as soon as three months after the intervention.

An internet-mediated walking intervention was administered by Richardson et al. [98] where 324 individuals were randomized into two intervention groups to increase PA. The average age was 52 ± 11.4; two-thirds of the individuals were female. All participants were required to have at least one of the following criteria: BMI ≥ 25, T2DM, or coronary artery disease and all were required to be getting less than 150 minutes of moderate PA each week. Subjects were randomized into two groups where all received individually tailored, web-based motivational messages, weekly goals, and graphs to track their progress. While one group was allowed to read and post online messages, the other group was not. The main outcomes measured were participant attrition and daily step counts measured by Omron HJ-720-ITC pedometers. Social cognitive theory and social influence theory were used as theoretical underpinnings for the interventions. Both intervention groups increased steps by 1888 ± 2400 steps (about 1 mile) with no difference in increase between groups. The online community group uploaded valid pedometer data on more days than the no online group (79% vs. 66%, respectively, $p = 0.001$). Online community participants remained engaged in the program longer than those not engaged in the online community ($p = 0.02$) and those with lower baseline social support posted more messages to the online community ($p < 0.001$) and viewed more posts ($p < 0.001$) than participants with higher social support at baseline. This study shows that adding an online feature to an internet-mediated walking program may not increase steps/day, but can help retain more participants and support especially those who do not currently have adequate social support.

Walking/Diet Programs in Type II Diabetes and Impaired Glucose Tolerance in Adults

Yamanouchi et al.[43] performed a walking and diet intervention on obese patients who had been diagnosed with T2DM within one year of the start of the study. Participants were sedentary and had not participated in regular exercise. Ten were assigned to the diet only group and fourteen were assigned to a diet plus exercise group with both groups matched for age, sex and BMI. All participants were hospitalized and received a supervised diet for six to eight weeks including: 1,000-1,600 kcal/day (54-

58% carbohydrate, 17-20% protein, and 25-26% fat). The diet plus exercise group was instructed to walk 10,000 steps/day (OMRON HJ-7 pedometer). Both groups significantly decreased in body weight ($p < 0.01$) but the decrease was greater in the diet plus exercise group. Blood glucose concentrations in both groups were similar at pre-test and both groups slightly improved ($p < 0.05$) at post-test along with decreased insulin levels in the diet plus exercise group only ($p < 0.05$). Insulin sensitivity also improved in the diet plus exercise group ($p = 0.0005$) with a significant correlation with steps/day ($r = 0.7257$, $p < 0.005$) in the diet plus exercise group. The addition of walking to a strict medical diet improved insulin sensitivity and reduced weight in six to eight weeks. The recommendation of 10,000 steps appeared to be more effective because the diet plus walking group reached 19,200 ± 2,100 steps/day while the diet only group walked 4,500 ± 290 steps/day.

In a study by Walker et al.,[99] 11 postmenopausal women with T2DM and 20 normoglycemic women participated in a 12 week walking program. The women followed their normal diet and were instructed to walk for at least one hour on at least five days/week. Participants were told to write start and stop times for their walk sessions and to walk at their own paces. Fitness was measured using heart rate and time to complete a 1.6 kilometer walk to estimate maximal aerobic capacity. Following the 12 week intervention, both groups exhibited an improvement in maximal oxygen consumption ($p < 0.005$). The diabetic women decreased in BMI and fat content in the upper body and waist region decreased ($p < 0.05$) along with fasting blood glucose levels ($p < 0.05$), HbA1c ($p < 0.05$), total cholesterol ($p < 0.005$), and LDL cholesterol ($p < 0.05$). HDL cholesterol and sex hormones did not change. The normoclycemic women failed to lose body fat following the intervention, but they did decrease HbA1c, total cholesterol, LDL cholesterol, and sex hormones ($p < 0.05$). However, the normoglycemic women walked more than the women with T2DM (4.8 ± 2.3 hr/week and 4.1 ± 1.6 hr/week, respectively) despite greater measured improvements in the T2DM women. Both groups reported similar energy intakes, but women with T2DM may have had to expend more energy for the same workload as the normoglycemic women and therefore were able to change their respective body composition. Walking for an hour a day appears to be beneficial in many ways to women with and without T2DM.

An internet based PA program was performed by McKay et al.[100] with T2DM patients. All participants were at least 40 years old and did not meet the ACSM PA guidelines of 30 minutes of moderate intensity PA on five days/week. Seventy eight participants (53% female) were randomized into the study with 40 in an information-only group and 38 in an internet intervention group. Those in the information only group had access to a website with diabetes articles and could track their blood glucose for the eight week study. Participants in the intervention group received a personalized eight week PA program. Intervention participants identified benefits and barriers to PA, preferred activities, and goals, then received tips and information on how to achieve their goals. Participants had online access to personal coaches who provided individualized support and access to health professionals to give advice on how to answer questions. A social support conference area was also provided on the intervention website for members of the intervention group to post comments and interact with other members of the intervention. There was a moderate improvement in

PA in both groups and a wide variety in the usage profile of all participants. Intervention participants found that the personal coach was helpful (88%) while only a few found the peer support aspect to be helpful (23%). Participants who used the website the most derived the most benefit in increasing PA.

The Diabetes Prevention Program Research Group performed a large scale (3234 participants) intervention for people with risk factors for T2DM.[101] Participants had a BMI of 24 or higher, high fasting blood glucose levels (95-125 mg/dl) and blood glucose levels of 140-199mg/dl following an oral glucose tolerance test. They could not have been diagnosed with diabetes prior to entry into the study. A four-step screening process was used to recruit with an emphasis on racial/ethnic minorities. Participants were randomly assigned to one of three interventions: standard lifestyle recommendations plus metformin, standard lifestyle recommendations plus a placebo, and an intensive lifestyle intervention. Physical activity and dietary recommendations for the metformin and placebo groups followed the Food Guide Pyramid guidelines to reduce their weight and increase PA. Members in the intensive lifestyle intervention were instructed to reach and maintain a seven percent body weight reduction through a low-calorie, low-fat diet and at least 150 minutes of brisk walking every week. A curriculum was taught on a one-on-one basis for 24 weeks to each lifestyle intervention participant with individualized counseling on how to achieve their goals and reinforce behavior changes. The average follow-up was 2.8 years and incidence of T2DM was 11.0, 7.8, and 4.8 cases per 100 person-years in the placebo, metformin, and lifestyle groups, respectively. The weight loss goal of 7% of body weight was reached by 50% of the lifestyle intervention group and 74% of the intervention participants met the goal of 150 minutes of PA each week. The lifestyle intervention decreased T2DM incidence by 58% and metformin use by 31% and was significantly more effective than metformin.

Goldhaber-Fiebert et al.[41] recruited 75 patients with T2DM to participate in a nutrition and exercise program for a 12-week randomized controlled trial. Those in the intervention group received 11 weekly nutrition classes (90 minutes each) and were encouraged to bring family members. They also participated in 60 minute group walking sessions three times per week for 12 weeks. Sixty-one of the initial 75 subjects completed the study. Thirty-three subjects were assigned to the intervention group and 20 of them attended more than 70% of the nutrition classes and nine subjects attended the walking groups at least 60 minutes per week. At the end of the 12 week period, the intervention group had lost 1.0 ± 2.2 kg of weight, decreased fasting blood glucose levels by 19 ± 55 mg/dl, and lowered HbA1c by 1.8 ± 2.3%. The control group gained 0.4 ± 2.3 kg, increased fasting blood sugar by 16 ± 78 mg/dl, and decreased HbA1c by 0.4 ± 2.3%. Weight, fasting glucose levels, and HbA1c levels were all significantly different between groups ($p < 0.05$).

In 2004, Mshunqane et al.[11] randomly assigned 30 T2DM patients to a medical exercise intervention group or an at-home exercise intervention group. Exercise time was used to determine program progression. Participants in the at- home exercise group were told to record walk time in an exercise diary and to start off with at least 10 minutes per day and increase to 30 minutes per day on alternate days. Those in the medical exercise group were supervised by medical staff at a hospital and performed either the same protocol as the at-home walking group or cycled at an intensity of at least 70% maximal heart rate for six minutes initially and worked up to 30 minutes. Twenty-four participants completed the study and mean fasting glucose levels, exercise capacity, body weight, body fat percentage (skinfolds) were all improved following the intervention (with no significant differences between groups, $p < 0.05$). This study suggests that there may be no additional advantage to a medically supervised exercise program compared to a home-based program.

Van Rooijen et al.[102] implemented a home-based walking program and compared the effects to a relaxation program in South Africa. One hundred fifty-eight women were randomized into the exercise or relaxation group. The exercise group was encouraged to walk in groups with other women and to increase walking session length from 10-45 minutes over the 12 week training period. Participants were instructed to walk twice per day, starting with five minutes per session and increasing by 10 minutes per session every two weeks until 45 minutes per session was reached. Duration of PA was recorded on an activity log. A 45 minute exercise session was held at the hospital once every two weeks to educate subjects about how to exercise and provide an environment to exercise with trained instructors. The relaxation group was required to attend an education session at the hospital once every two weeks and was told to perform progressive relaxation exercises in their homes. Both the exercise group and relaxation group significantly decreased HbA1c levels (-.39% and -.97%, respectively), but the group differences were not significant ($p = 0.052$). The exercise group did walk significantly farther than the relaxation group (46.76 m and 22.7 m, respectively, $p < 0.01$). The increase in PA did not improve blood glucose control with this intervention when compared to relaxation training.

Praet et al.[103] randomized 92 T2DM patients into a 12-month brisk walking program or a medical fitness program. Those in the brisk walking group were supervised by a certified trainer and a physical therapist for three, 60-minute sessions per week for the first three months. Exercise sessions consisted of an aerobic component which included interval type walking at 5-6 km/hr with the intensity gradually increasing to about 75 ± 5% of maximal heart rate. The resistance exercises consisted of floor exercises with body weight and resistance exercises using elastic bands. The medical fitness program consisted of three sessions per week using a home trainer, elliptical trainer, or a rowing ergometer at an average intensity of 73 ± 2% of maximal heart rate and was tailored to individual exercise capacity. The resistance training included eight exercises targeting upper and lower body muscle groups and was progressively increased in intensity over a six month period from three times, 30 minutes per week toward a goal of 180-225 minutes per week. At six months, 22 (45%) brisk walking participants and 13 (30%) of the medical fitness program participants had dropped out of the study. At 12 months 18 (37%) brisk walking and 19 (44%) medical fitness participants still actively participated in the program. Motivational issues accounted for 25% of the dropout with a variety of injuries and co-morbidities accounting for the remaining drop outs. No significant changes occurred over time or between groups for fasting blood glucose, HbA1c, HOMA, or BMI. Neither program appeared to be very successful with small changes and a high attrition rate.

Furber et al.[104] conducted a two-week walking intervention with 226 T2DM patients or people with imparied glucose tolerance who participated in education courses which were designated as intervention and conrol without participants knowing beforehand. Both groups attended the educational sessions which covered diabetes physiology, diabetes care, and PA. The intervention group also received instruction on how to use a pedometer and participants were asked to record their daily steps for two weeks following the education sessions. They were also encouraged to set their own PA goals such as reaching a certain step number or amount of time spent in PA. Two hundred and ten participants completed the two-week follow up and 184 completed the 20-week follow up. Self-reported minutes walked were higher in the intervention group compared to the control (223 min. and 164 min., respectively, $p = 0.01$). Participants in the intervention group also got more moderate intensity PA (63.5%) compared to the control (41.8%, $p = 0.02$). This intervention was effective in improving PA using education and a pedometer in the short term, but did not produce changes that could significantly affect disease status.

A one year hospital-based intervention was conducted by Hordern et al.[105] with diagnosed T2DM patients to assess the effectiveness of a supervised exercise program compared to standard care. The exercise intervention consisted of general dietary guidelines and a two-stage exercise program. The exercise program began with a four-week supervised gym-based program, followed by a home-based training program aimed at attaining at least 150 minutes of PA per week. The program consisted of aerobic and resistance training and supervisors provided telephone counseling once a week for the first three months of home-based exercise, once every other week for the second three months, and once a month for the rest of the program. The intervention group participated in more vigorous PA compared to the controls throughout the intervention ($p < 0.01$), but with no difference between groups in time spent walking.

The intervention group improved in waist circumference, fat mass, fasting glucose levels, HbA1c levels, and aerobic capacity ($p < 0.05$).

Cheong et al.[40] designed a 16 week walking versus walking plus diet intervention for T2DM patients based on Social Cognitive Theory constructs. Twenty-two participants were randomized to each group and all participants attended four 60-90 minute group meetings for the first four weeks and received two motivational postcards at weeks six and ten to encourage adherence. All participants recorded daily steps and set goals to gradually increase step values. Participants in the walking plus diet intervention received counseling on how to eat a low glycemic diet. Both groups increased their total daily steps at week 16 by about 3,000 steps compared to baseline ($p < 0.01$). Differences between groups did not exist for any variables, indicating that the addition of a low glycemic index component to a walking program did not add any additional benefit to a T2DM intervention program. However the program did induce a decrease in waist girth, hip girth, but no difference in HbA1c over time.

Shenoy et al.[12] recruited 40 T2DM patients in India to participate in an eight-week walking intervention using a pedometer and heart rate monitor. Participants were randomly assigned to the walking group or a standard care control group. Those in the walking group were instructed to use a pedometer and heart rate monitor to implement a 30 minute exercise session five days per week at a heart rate 50-70% of maximum. The goal was to go from approximately 3,000 to 4,000 steps per half hour exercise session and reach 70% maximum heart rate by the end of the study. Intervention participants kept a daily diary of PA and were told not to change their current diet. Following the eight-week intervention, the intervention group exhibited a significant decrease in

HbA1c from 7.25 ± 1% to 6.5 ± 0.87% ($p = 0.0001$) which was significantly different than the control ($p < 0.01$) which did not change. Fasting blood glucose values were different between groups at initial testing, and both groups significantly decreased blood glucose at the end of the intervention period ($p < 0.01$). Body Mass Index decreased in the intervention group ($p < 0.01$) and significantly increased in the control group ($p < 0.01$). This intervention appeared to be effective at improving health parameters in patients with T2DM.

Morton et al.[106] performed a similar study to the previous intervention conducted by Shenoy et al. and used heart rate to prescribe a seven-week walking program to improve health parameters in T2DM patients. Morton et al. randomly assigned 27 patients with T2DM to a seven-week supervised walking program which met four times per week and was monitored by heart rate monitors. There were no changes in HbA1c levels due to training, but there were improvements in sub-maximal cardiorespiratory responses which are beneficial to patients with T2DM.

Van Rooijen et al.[42] randomized 51 participants with T2DM into intervention and control groups to implement a walking and nutrition intervention in South Africa. Both groups received usual care while the intervention group also attended four weekly group sessions where they were given knowledge and skills to eat healthier and control blood sugar levels. They also received a pedometer to wear and walk at least 10,000 steps per day on at least five days per week. At 16 weeks the pedometers were returned and the intervention participants were told to continue their walking and diet program. Follow-up occurred at 16 weeks and one year. Hemoglobin A1c levels of the intervention group were significantly lower after 16 weeks ($p < 0.05$) compared to the control, but were not different at one year. Diabetes knowledge was higher in the intervention group at 16 weeks and at one year ($p < 0.01$).

A final study by Negri et al.[107] randomized 59 T2DM patients in a one to two ratio to a control group or walking intervention. The walking intervention consisted of supervised walking sessions held by a personal trainer three times per week. The walking was at a low intensity and progressed to a moderate intensity through the four-month walking program. Intervention participants also participated in one individual and one group counseling session. After four months, the intervention group had higher exercise capacity, but there were no differences in glycemic or metabolic variables. When the intervention group was separated into only those who attended at least 50% of the exercise sessions, those that complied with the exercise program did significantly differ compared to the control group in HbA1c ($p = 0.01$) and fasting glucose levels ($p = 0.05$). The researchers concluded that participants must be compliant with the exercise program in order to obtain physiological benefits.

Pedometer-Based Walking Programs in Free-Living Adults with Type II Diabetes

In this section, several studies are described from a systematic literature review performed using MEDLINE, CINAHL, SPORTDiscus, ERIC, and Academic Search Premier.[15] Combinations of the following keywords were used: walk, walking, intervention, and type 2 diabetes. The primary focus was on interventions designed to increase PA in the form of walking using a pedometer to motivate, measure, track, and improve health outcome variables. Articles from 1995 to 2011 were included in the search.

The first study was conducted by Tudor-Locke et al.[16] in Ontario, Canada with 60 people with previously diagnosed T2DM (minimum 3 months post-diagnosis). Participants were required to be inactive (< 8800 steps/day) and not taking insulin. Eligible participants were randomized into intervention and control groups with 47 completing the 16-week intervention. The intervention group attended a weekly group meeting for the first four weeks where they were taught principles of self-monitoring and problem-solving. They were also given a pedometer and a program manual which contained additional information and activities on goal-setting and problem-solving. Intervention participants were asked to use their pedometers and calendars for goal-setting and self-monitoring during the remaining 12 weeks of the program. Participants in the control group received no intervention. At 16 weeks, the pedometers and calendars were collected from the intervention group to find that they had significantly increased steps/day compared to the pretest and control group. However, at the 24 week follow up the steps/day in the intervention group were no longer significantly different than the control group. Waist girth decreased over time ($p = 0.025$), but not between groups ($p = 0.128$). Correlations of the baseline data for those taking oral hypoglycemic medications revealed an inverse relationship between steps/day and fasting blood glucose ($p = 0.0001$), glucose at 120 min. postglucose load ($p = 0.02$), and HbA1c ($p = 0.003$) indicating that those who were more active at baseline were at lower risk of disease progression. This study showed that through group meetings, a walking intervention can significantly increase PA over the short-term in an inactive T2DM population.[15]

The second study by Engel et al.[22] focused on using health coaching and pedometers to increase PA in T2DM patients (mean = 8 years post-diagnosis) in Australia. Fifty-four inactive (< 150 min. PA/week) people were randomized to participate in the study and all received health coaching focused on education, goal setting, and supportive/motivational strategies aimed at increasing walking time. The average BMI was 32kg/m^2 with an average participant age of 62 years. Each group received six visits: 1- baseline measures (BP, HbA1c, anthropometric and fitness measures), 2- physical activity strategies explained and health logs given, 3 and 4- emotional/social support, 5 and 6- baseline assessments taken again. The coaching-only group received an activity log and was counseled how to set goals and record activity time each week. The coaching + pedometer group received the same materials as the coaching-only group with the addition of a pedometer which they used to record steps/day. Assessments were taken at baseline, three months, and six months. The coaching-only group spent significantly more time walking than the coaching + pedometer group at both three and six month follow ups ($p = 0.02$). When analysis of covariance was used to control for all other variables, the between group differences disappeared ($p = 0.207$). With all the subjects combined, there was a significant reduction in waist circumference and weight at both three and six months ($p < 0.05$). Changes in BMI occurred only at six months ($p < 0.05$) while cardiovascular fitness increased at three months and was maintained at 6 months ($p < 0.001$). Overall, the addition of a pedometer added no extra beneficial effect beyond a coaching intervention for these T2DM patients.[15]

The third study by Araiza et al.[108] in New Mexico focused on improving various physical parameters of T2DM patients through walking 10,000 steps/day on five or more days/week. Participants had been diagnosed with T2DM for at least a year and all were taking oral hypoglycemic medications. Fifteen subjects were randomized into the active group and 15 into the control with an average age of 50 years. The active group received a pedometer and was instructed to walk 10,000 steps/day on five or more days/week and maintain their current diet for six weeks while the control group received no pedometer or intervention. The active group increased their steps 69% to 10410 ± 4162 steps/day ($p = 0.002$) while the control group did not change. Resting energy expenditure increased in the active group ($p = 0.014$) along with HDL-C ($p = 0.022$) while plasminogen activating inhibitor-1 decreased in the active group compared to the control ($p = 0.03$). Little information was given on how the program was actually implemented to understand what might have contributed to the participant's success in reaching the desired number of steps/day or why there was no attrition in this study.[15]

The fourth study was performed by Richardson et al.[109] in Michigan to determine if a target goal of steps/day or a focus on walking intensity of PA bouts would be more effective at increasing PA among sedentary (< 150 min. PA/week) adults with T2DM. Thirty participants completed this randomized pilot trial in which all subjects used an enhanced pedometer for six weeks and received individual goals and motivational messages (using Health Belief Model constructs) from the study website. Participants in the lifestyle group focused on increasing total daily steps while those in the structured group focused on bout steps (bouts of walking that last for at least 10 minutes each at an intensity of 60 steps/min). Pedometer information was uploaded onto a computer and goals were automatically calculated based on performance over the previous seven days with a maximum goal of 10,000 steps/day. Both groups significantly increased average daily bout steps by 1921 ± 2729 ($p = 0.0006$) and total average daily steps 1938 ± 3298 ($p = 0.0032$) with no differences between groups. The lifestyle group had higher satisfaction with the program compared to the structured group (100%, 62%, respectively), reporting that they would definitely recommend the walking program to a friend. Structured goal participants felt like they did not get credit for their shorter walks if they were not able to walk for at least 10 minutes. The structured goal group wore the pedometers for less time each day compared to the lifestyle group (14.5hrs, 16.5hrs, respectively, $p = 0.038$). According to this study, it appears that a total steps/day count is more satisfying, and just as effective at increasing PA, as including a recommendation to get bouts of a certain time and intensity.[15]

The fifth study was done by Bjorgaas et al.[23] in 2008 to investigate whether the addition of a pedometer would increase walking and influence clinical outcomes in people with T2DM in Trondheim, Norway. Seventy people (mean age = 58) started the study and 22 dropped out due to illness, work commitments, and personal circumstances. All of the participants were instructed to keep a log of all their major physical activities and to increase their PA between each visit. Participants in the pedometer group were told to monitor and increase their step count each day while those without a pedometer were told to increase their time spent doing PA. All the participants were given strategies to increase walking in addition to setting reasonable PA targets to reach between each visit. Aerobic capacity was lower in those who dropped out, indicating that those who needed the intervention most were not able to complete the intervention. Participants in the pedometer group did not increase steps from month one to month six ($p = 0.65$) which therefore could indicate that the pedometers may not have been effective at increasing PA in this population. The clinical variables were not significantly different between groups (all p values greater than .38), but combined there were decreases over time in body weight ($p = 0.005$), HbA1c ($p = 0.034$), fasting glucose ($p = 0.033$), triglycerides ($p = 0.002$), diastolic BP ($p = 0.048$), and increased HDL cholesterol ($p < 0.001$). These results indicate that a pedometer may not be necessary or helpful at increasing PA levels in people diagnosed with T2DM who receive PA counseling under the conditions of this intervention.[15]

The sixth intervention by Johnson et al.[18] included 41 participants in Alberta, Canada with a baseline walking program for 12 weeks, followed by two different variations to the program plus a dietary component for an additional 12 weeks. Changes in cardiovascular and glycemic health due to the increased PA were primary outcomes. Participants were T2DM patients that were not using insulin, able to walk, and were between 40 and 70 years old (mean age = 56.5). The participants used a pedometer and walk log to increase their daily steps for the first 12 weeks. Mandatory group meetings were held for the first four weeks which included a supervised group walk session. For the following eight weeks optional walk sessions were held and all subjects were asked to record and increase their daily steps based on their baseline measures. At 12 weeks, participants were randomized into either the Basic Lifestyle Program (BLP) or the Enhanced Lifestyle Program (ELP). During weeks 13-16 all participants were asked to attend a weekly meeting with their assigned program including a supervised walk session. During weeks 17-20 participants attended two weekly booster sessions and during weeks 21-24 they attended only one booster session per week. The BLP continued with the same walking program as the first 12 weeks and continued to increase daily steps while adding a nutrition component to decrease high glycemic index (GI) foods. The ELP group continued the same number of steps that they walked during weeks 10-12, but were told to increase their walking speed by 10% during a 30 min walk session performed on at least three days of the week in at least 10 minute intervals. The ELP group also received the same dietary instructions to decrease intake of high GI foods and exchange them for low GI foods. The change score for steps/day was significant in all subjects over the first 12 weeks with an increase of 1562 steps ($p = 0.02$). Body weight, BMI, and systolic and diastolic blood pressures also decreased significantly over the 12 weeks of walking ($p < 0.01$). Following the 24th week, no group differences existed on all measures except for resting pulse rate which was lower in the ELP compared to the BLP ($p = 0.03$). These programs show that walking seems to be beneficial to cardiovascular health but goals to increase walking intensity do not seem to be more effective than simply increasing number of steps/day.[15]

The seventh study was described by Deborah Vincent using Mexican Americans diagnosed with T2DM (mean = 7.9 years post-diagnosis).[17] Following randomization, the intervention group attended weekly group meetings for the eight week duration of the study. The meetings included education, demonstrations, and group support. The intervention group received pedometers and was instructed on how to use them and that they should record their daily steps. They were also encouraged to bring family members to the meetings to provide social support. Average steps/day increased from baseline to eight weeks in the intervention group ($p = 0.03$) along with a decrease in weight ($p = 0.03$) and BMI ($p = 0.03$) over time. There was a slight increase in weight and BMI in the control group, though not significant. This study shows that including a pedometer in a culturally tailored walking program for Mexican Americans could be beneficial at increasing activity levels in the short term.[15]

The next study by Diedrich et al.[19] included 53 T2DM patients (mean age = 54.2 years) in the U.S. who were enrolled in a Diabetes Self-Management Education Program (DSMEP). Individuals were randomly assigned to the intervention or control group and each group participated in the DSMEP program which included a two-hour assessment and eight hours of educational group meetings. In addition to the DSMEP program, the intervention subjects received a pedometer, a copy of the book "Manpo-ki" ("Manpo-ki" is the Japanese term for pedometer), and a concise summary handout with important points from the book. They were instructed to read the book and record their steps using the pedometer and logbook which they were given. Those who completed the 12 week study received a $50 gift card. The two groups were equal at pretesting and 62% of the participants completed the study. The number of those who reported regular PA increased in both groups and steps increased in the pedometer group ($p = 0.01$). The intervention group decreased HbA1c levels ($p = 0.002$), weight ($p = 0.011$), and body fat ($p = 0.037$) following the intervention, however these variables were not different between groups. The control group also showed a significant decrease in HbA1c ($p = 0.005$) and weight ($p < 0.001$). Diastolic BP was the only variable that was different between groups at post-test with a favorable decrease in the intervention group compared to the control ($p = 0.024$). This intervention seems to show that this DSMEP program was just as effective with or without a pedometer on the variables measured in this study.[15]

De Greef et al.[21] performed a 24-week pedometer-based walking intervention in Belgium with 92 T2DM patients who had been diagnosed for at least six months and were being pharmaceutically treated, but had no physical limitations. The participants were 69% male with a mean age of 62 and a mean BMI of 30 kg/m^2. The intervention was based off of cognitive-behavioral therapy, the Diabetes Prevention Program, the First Step Program, and Motivational Interviewing. It began with a face-to-face session with a psychologist which lasted for about 30 minutes and consisted of a motivational interviewing component followed by the creation of an individualized lifestyle plan describing when, where, and how the intervention would take place. Participants received a phone call every two weeks for the first four weeks and then every four weeks for the remaining 20 weeks. The calls lasted about 20 minutes and provided counseling on goal-setting, self-monitoring, self-efficacy, benefits, decision balance, problem-solving strategies, social support, and relapse prevention. Patients were given a pedometer with the goal of reaching 10,000 steps/day by monitoring and recording their steps. The control group received usual care. Following the 24-week intervention, the intervention group increased their steps/day by 2744 while the control group decreased by 1256 ($p < 0.001$). Changes remained after one year in both groups with an increase of 1872 in the intervention group and a decrease of 1275 in the control ($p < 0.001$). The effects were confirmed by accelerometer with the intervention group increasing total activity in the short and intermediate term and the control group decreasing total activity. The IPAQ also confirmed a decrease in sedentary time in the intervention group with an increase in the control group. This intervention appeared to be effective in the short and long term at increasing PA and decreasing sedentary time in T2DM patients.[15]

The final intervention also took place in Belgium by De Greef et al.[20] with 67 patients (mean age = 67.4 years) diagnosed with T2DM. The 12-week pedometer-based program compared delivery of the materials through group counseling and general practitioner counseling, in addition to a control group. Both intervention groups received a pedometer and a diary as motivational tools and to use in setting goals. Participants were asked to record their number of steps/day and the type and duration of their PA. Those assigned to group counseling participated in three 90 minute sessions led by a behavioral expert who used techniques based on cognitive-behavioral therapy. The other intervention group received three 15 minute sessions with a general practitioner who received training from the behavioral expert to deliver some of the components that were discussed in the group sessions. An overall time by group effect was observed ($p \leq 0.05$) for daily step counts with the group counseling participants increasing their steps by 1706 ± 698 steps/day which was more that the individual consultation and control groups (+ 837 ± 688, + 313 ± 493 steps/day respectively, $p \leq 0.05$). The group counseling participants also self-reported more total PA compared to the control group which showed a decrease ($p \leq 0.05$). Waist circumference, BMI, and HbA1c changed significantly in the time-by-group analysis between the individual consultation group compared to the control ($p \leq 0.05$). The group consultation appears to be effective at increasing steps/day while the individual consultation appears to have improved several health outcomes in the short-term.[15]

Summary

All of the studies included in this review were published between 2004 and 2011 and were randomized controlled trials, except for one quasi-experimental[21] design.[15] Five studies[16,17,19,22,108] used a “usual care” control group compared to a pedometer-based walking intervention, one study[20] used a “usual care” control and two intervention groups, while the remaining studies compared two intervention groups. The study durations went from 6 weeks to 24 weeks with only two studies including post intervention measurements at six months[16] and one year.[21] All the studies in this review included two groups with 10 to 60 people in a group with an average of about 25 in each group. Ages of the participants ranged from 18-89 with an average age of 57. Intervention locations included Canada,[16,18] Australia,[22] the United States,[17,19,108,109] Norway,[23] and Belgium.[20,21]

Important insights can be gained from the various intervention methods that were used to increase PA and affect health. All intervention groups received a pedometer and some type of logbook to record steps/day or major PA performed throughout each day. Additionally, all of the interventions included some form of personal or assisted goal setting and self-regulation techniques. These skills seem to be a crucial part in establishing consistent personal habits that will allow a behavior to be maintained over time. Group counseling was used in some of the studies[16-20] as an effective means of increasing PA and creating an environment where participants would have opportunities for social interaction. Other studies included counseling sessions with a health coach,[22] nurse,[23] psychologist,[21] general practitioner,[20] or only the use of pedometer logs[108] or computer aided motivational messages.[109] Each intervention type was able to produce increases in PA with or without a pedometer with the exception of one study.[23] It may therefore be assumed that most types of interventions beyond the usual care for patients with T2DM will increase PA at least in the short-term. This could potentially be due to the novelty of the intervention or the specific attention the patients get during the intervention which might fade over time unless some continued contact is made. A pedometer might be one type of intervention to help T2DM patients track and increase their PA levels, but pedometers don't seem to produce added benefits in greater amounts of PA or increased physiological benefits beyond other intervention techniques.[15]

The duration of the studies included in this review is relatively short and that could contribute to the significant increases in PA while making it difficult to detect differences in physiological measures. The shortest studies were six weeks[108,109] and the longest was 6 months with a one year follow-up.[21] Five studies[16-18,22,108] failed to find a significant change in HbA1c in the intervention group, two studies[21,109] did not measure HbA1c, two studies[19,23] recorded decreases in HbA1c in both intervention groups, and one study[20] observed decreases in HbA1c in physician led counseling compared to a group led counseling intervention. Of the studies that saw significant differences, the interventions lasted for three or six months which indicates that shorter term studies may not be able to impact HbA1c in less than three months. Four interventions[16,17,20,108] measured, but did not cause significant decreases in fasting blood glucose levels, while five[18,19,21,22,109] did not measure fasting glucose and one found a significant decrease in fasting glucose levels in both groups included in the study.[23] These six-week to six-month studies therefore do not produce evidence that pedometer-based walking programs can effectively change blood HbA1c levels or fasting glucose levels to a significant degree. A longer duration, larger sample size, higher intensity, or addition of a dietary component may be necessary to produce and detect changes in glycemic measures though there are other additional benefits to increasing PA through walking.[15]

Pedometers seem to help increase PA among T2DM patients, but not necessarily any more than other interventions. The most common type of pedometer used in these studies was the Yamax Digi-walker SW-200,[16,18-20] with other types of Yamax pedometers[22,23,108] and one type of Omron[109] pedometer also used. Only three studies[21,108,109] recommended 10,000 steps/day while the remaining studies encouraged a general increase in PA and setting individual goals to increase PA. When two intervention methods were compared[22,23] with a pedometer group and a non-pedometer intervention, the addition of the pedometer did not add any additional benefit. Therefore, pedometers were effective intervention tools at increasing PA among these T2DM patients, but may not be needed if other intervention methods are available.[15]

At least for the pedometer based walking studies in T2DM adults, there is only one[23] that found changes in fasting blood glucose which was after only a month and they also found significant changes in HbA1c also only after a month and at three months compared to baseline. Another study[19] found significant changes after three months while the remainder of the studies that measured HbA1c and glucose failed to find significant differences following a walking program. Several of the studies mentioned that they were underpowered and therefore could not detect significant changes in HbA1c if differences did occur.[16-18,22] Based on the results from Tudor-Locke, et al.,[16] at least 84 participants would be needed to see a significant 0.5-1%

difference in HbA1c between groups while Araiza, et al.[108] confirmed that 15 subjects was sufficient to find a significant reduction in HbA1c of 0.7% within the treatment group with 80% power and $\alpha = .05$ by a paired t test.

Motivation/Theory

Theories Used in Health Psychology

The use of theory can guide research and practice in social psychology, leading to more effective interventions and outcomes. Using complementary aspects of several theories can lead to a greater impact than pitting theories against each other, which can lead to fragmented knowledge about a certain behavior.[110] The Theory of Reasoned Action, Theory of Planned Behavior, Health Belief Model, and the Transtheoretical Model have been cited as some of the most popular theories used in health psychology research.[111] In a systematic review of health behavior research, 37.5% of the articles mentioned theory and the three most common theories used were Transtheoretical Model, Social Cognitive Theory, and Health Belief Model.[112]

Social Cognitive Theory

Social Cognitive Theory was developed by Albert Bandura and was made official in 1986 with his book, “Social Foundations of Thought and Action: A Social Cognitive Theory.” The core determinants set forth by Social Cognitive Theory include knowledge, perceived self-efficacy, outcome expectations, perceived facilitators, and impediments.[113] It deals with the interaction of the person trying to change their behavior, the behavior they are trying to change, and the environment (reciprocal determinism). The self-efficacy and self-regulation constructs have been adopted by several other theories such as Protection Motivation Theory and Health Belief Model, and have been powerful predictors and intervention techniques for behavior change.[114]

Social Cognitive Theory and Walking Programs for Type II Diabetes

Constructs from Social Cognitive Theory are used in many of the walking programs for T2DM patients. Self-control was targeted with goal setting and self-management techniques such as using a behavior log and setting reasonable goals to work toward.[16-18,22,23,108] As reasonable goals are made and progress is observed, a person's self-efficacy increases due to success with a certain task.[115] Behavioral capabilities are increased by increasing knowledge about a certain behavior and the determinants that affect it. This has been used in T2DM walking interventions through increased knowledge with instruction on the effects of exercise and nutrition on T2DM.[17,19] The environment has also been affected by providing motivational messages and social support to individuals trying to change their behavior.[18,20-22] As these social psychological targets are affected, activity levels and the disease symptoms have been improved.[19,23]

Summary

Social Cognitive Theory provided guidance for a theory-based approach to the current intervention. Building on constructs outlined in Social Cognitive Theory, intervention strategies were created that could help influence adoption of PA behaviors. Self-control, behavioral capabilities, self-efficacy, and environment were used in the current study, though only self-efficacy was measured because that is the main antecedent that was measured in similar interventions. The constructs were used in this study through various intervention methods described in the next section.

Chapter III: Methods

The primary purpose of this study was to evaluate the effectiveness of a 12-week walking program in increasing moderate/vigorous intensity walking and decreasing sedentary time in inactive adults with Type II Diabetes mellitus (T2DM). Secondary purposes were a) to determine whether a 12-week walking program increases self-efficacy related to exercise, walking, and taking breaks in sedentary time, and b) to determine whether a 12-week minimal contact walking program can improve blood glucose, hemoglobin A1c (HbA1c), and Total Cholesterol:HDL ratio in inactive adults diagnosed with T2DM.

Participants

After obtaining approval from the University of Oklahoma Institutional Review Board, participants were recruited from the Norman and Oklahoma City, Oklahoma areas. Men and women between 40 and 64 years of age with no physical limitations to walking were recruited. All participants had been diagnosed with T2DM for at least three months and were insufficiently active (<150 minutes of moderate intensity physical activity per week). Pregnant women and those with a pacemaker or who were on insulin treatment were excluded from the study, though they were allowed to be on other hypoglycemic medications. All participants completed the informed consent document and obtained permission from their primary care physicians or diabetes specialists before participating in the study.

Recruitment

Participants were primarily recruited from the University of Oklahoma Healthy Sooners organization via mass email to identify eligible university faculty and staff.

Participants also were encouraged to refer friends or family members that fit the inclusion criteria. All potential participants were subsequently screened through a telephone interview to ensure eligibility.

Experimental Design

This was a 12-week pre-test, post-test experimental design with participants randomly assigned to a "Breaks Only" group (BG) or a standard of care ("Walking") group (WG). Walking was used as the standard of care intervention (control group) because of the regularity with which walking is recommended to diabetic patients as a means of improving glucose control. The BG participated in an intervention that was designed to interrupt sedentary time by taking a break (at least two minutes of moderate/vigorous intensity activity) for every hour of sedentary time. The WG received a walking recommendation to reach 10,000 steps per day by walking for at least 30 minutes/day in intervals of at least 10 minutes. All measurements were taken prior to the intervention, during the final week of the 12-week program, and at three months follow-up. Physical activity also was measured at week seven to assess progress. The independent variables for this study were time and intervention group assignment. Dependent variables were clustered into three groups: (1) behavioral antecedents; (2) behavioral targets; and (3) clinical outcomes. Behavioral antecedents included: (1) exercise self-efficacy; (2) walking self-efficacy; and (3) sedentary self-efficacy. Behavioral targets included: (1) steps walked per day as measured by a sealed pedometer and MET minutes expended per week in physical activity; (2) minutes per day of moderate and vigorous physical activity (PA); and (3) minutes of sedentary time measured by accelerometer and survey. Clinical outcomes included: (1) fasting blood glucose; (2) hemoglobin A1c (HbA1c); and (3) HDL-Cholesterol/Total Cholesterol ratio.

Instruments/Measures

Demographics Questionnaire

A demographic survey (Appendix A) was administered online during the first PA measurement week in order to obtain contact information and descriptive data about each participant. The demographic information collected included age, gender, race/ethnicity, annual household income, level of education, marital status, and smoking status.

Health History Questionnaires

An online health history and eligibility survey was used to confirm that participants met the inclusion/exclusion criteria (Appendix B and Appendix C). Information included: (1) physical activity level, presence of any health issues that may cause inability to participate in a walking program (e.g., chest pain, dizziness, joint problems, or heart problems), (2) diagnosis of hypertension or hyperlipidemia, diagnosis of diabetes or heart disease; pregnant or planning to become pregnant, (3) presence of a pacemaker, and (4) family history of diabetes and/or cardiovascular disease. Each participant was also asked how long they had been diagnosed with diabetes and if they currently used insulin. They also listed all current medications (diabetic and other) at each visit to account for potential effects related to changes in type or dose of medications.

Food Frequency Questionnaire

To ensure that diet remained constant throughout the intervention, a Food Frequency Questionnaire (FFQ) was administered online before and after each program. The FFQ (Appendix D) addresses food intake over the previous seven days and includes 14 items that ask how often certain foods are consumed. The specific areas of diet that were analyzed were cheese (portions per day or week), red meat (portions per week), canned fish (portions per week), deli meats (times per week), pizzas and pies (times per week), French fries (times per week), fruit juices (portions per week), nuts (yes or no), vegetables (portions per week), butter and cream (portions per day), oil (for cooking or as spread meals per day), and salad dressings (tablespoons per day). The FFQ has been tested against a seven-day Diet History and produced a moderate correlation with fruits and vegetables ($r = 0.47$) and a stronger, but still moderate correlation with polyunsaturated and saturated fatty acids ($r = 0.63$, $p < 0.05$).[116] The average Spearman correlation coefficient for the FFQ compared to dietary recall was moderate ($r = 0.54$). The FFQ was also analyzed for test-retest reliability and produced a strong correlation between the two attempts ($r = 0.81$).[116]

Twelve participants completed the FFQ at pre-testing and three of those participants failed to complete the FFQ at post-testing. A qualitative comparison was made from pre- to post-intervention for the specific dietary components that had a high fat content or a high glycemic index since these foods were most likely to affect the clinical outcomes that were monitored for this study. These included consumption of cheese, red meat, deli meats, pizza and pies, pastries and cakes, French fries, fruit/fruit juices, butter/creams/margarines, and oils. Two participants slightly increased cheese consumption, two slightly decreased, and the rest of the participants did not report changes in cheese consumption after the intervention. One participant increased red meat consumption and one participant decreased red meat consumption. One participant slightly decreased deli meat consumption while the other participants did not report changes in deli meat consumption. Three participants increased and three participants decreased in their consumption of pizza and commercial sandwiches, while the other participants did not report changes. Most participants reported eating restaurant or fast food French fries both before and after the intervention. Two participants slightly decreased cake and pastry consumption while one increased. The remainder of the participants did not report changes in cake and pastry consumption. Several changes in fruit/fruit juice consumption were reported; four participants reported decreases in fruit/fruit juice consumption while three reported increases. Three participants slightly increased their consumption of butter and cream while one decreased, and the remaining participants did not report any changes in butter and cream consumption. Apart from butter and cream, two participants increased consumption of other fat spreads (e.g. margarine) on cooked meals while two decreased consumption. Three participants increased use of margarine or other oils in cooking. Results from the FFQ did not appear to indicate any systematic changes in dietary behaviors that might have made a significant impact on the clinical outcomes measured in this study.

Self-Efficacy Questionnaires

Self-efficacy is the perceived ability of a person to exercise control over a particular behavior and was described by Albert Bandura and implemented into his Social Cognitive Theory.[113] Bandura argued that self-efficacy should be measured for a specific behavior and that self-efficacy will be different for different behaviors.[33] Sallis et al.[117] created a survey measuring exercise self-efficacy using 40 subjects who were interviewed about a behavior they were in the process of changing. Self-efficacy scales were developed and a factor analysis was used to extract overall concepts from the scales. Subsequently, a 12-question survey was developed to measure exercise self-efficacy (Appendix E). This survey asks how confident a person would be to motivate himself/herself to perform certain exercise related behaviors consistently for the next six months and measures confidence for each behavior on a five-point Likert. The scale ranges from one to five with a score of one indicating low confidence to perform exercise in a variety of situations and five indicating high confidence at performing exercise in a variety of situations. Criterion validity was tested by comparing survey data with reported participation in vigorous PA ($r = 0.32$, 0.40 for exercise self-efficacy factors, $p < 0.001$). Higher scores indicated that higher participation in vigorous activity correlated with higher self-efficacy for that activity. Test-retest reliability for the survey was moderate for both of the exercise factors ($r = 0.68$, $p < 0.001$). Internal consistency was strong (Cronbach's $\alpha = 0.83$ and 0.85 for both factors). The Sallis instrument was used to measure exercise self-efficacy in this study.

Self-efficacy is conceptualized as specific to a certain behavior and generalizable to similar behaviors.[118] If a specific behavior is targeted, a questionnaire should address self-efficacy related to that specific behavior. Therefore, additional self-efficacy questionnaires were developed to measure self-efficacy related to vigorous walking (Appendix F) and interruption of sedentary behavior (Appendix G). These instruments were based on the Sallis Exercise Self-efficacy instrument, with the changes made that were appropriate for each targeted behavior. All self-efficacy surveys were completed online. The internal consistency was acceptable for the exercise, walking, and “breaks in sedentary time” self-efficacy (Chronbach’s $\alpha = 0.924$, 0.868, 0.866, respectively for all pre-values). The exercise self-efficacy survey was used as the criterion with which to compare the other two surveys and the walking self-efficacy survey was strongly correlated with the exercise self-efficacy survey ($r = 0.809$). The breaks in sedentary time survey was moderately correlated with the exercise self-efficacy survey ($r = 0.475$).

International Physical Activity Questionnaire – Long Form

The International Physical Activity Questionnaire (IPAQ) is a widely used self-report measure that assesses PA related to occupation, transportation, yard and garden, household, leisure time, and sitting time over the previous seven days. The IPAQ-long form (Appendix H) has been validated across 12 countries using 1880 participants and is able to be used to compare population health across countries.[90] Test-retest reliability was very strong in most countries (Spearman coefficient = about 0.8).[90] Criterion validity was measured against total activity as measured by an Actigraph accelerometer (N = 744 adults, pooled $\rho = 0.33$, 95% CI 0.26–0.39).[90] A high correlation with accelerometry activity data would indicate that participants report similar amounts of PA compared to how much they actually get as measured by the accelerometer. This form was completed online before, after, and three-months following the program as a survey measure. This instrument has been used previously in a pedometer-based walking program for patients with T2DM.[21] This measurement was used in addition to accelerometer measured PA as dependent variables in this study.

Blood Pressure

Blood pressure was assessed for descriptive purposes using an electronic sphygmomanometer (Omron HEM-780, Kyoto, Japan). The participant was seated for a minimum of five minutes to allow blood pressure to stabilize at resting level. During measurement, the dominant arm (self-reported) was placed on a table at chest level. The lower edge of the cuff was applied about one inch above the antecubital space with the air bladder covering the brachial artery.[119] Several participants were measured at the forearm due to inability to fit the cuff correctly around the upper arm. The cuff pressure was raised rapidly and slowly released until systolic and diastolic values were obtained. Two or more measurements were taken 30-60 seconds apart until two consecutive measurement within 5 mmHg for each value were obtained.[119] The average of the values was recorded. A higher value indicated that there was a higher pressure built up in the blood vessels that may represent higher likelihood of vascular damage and disease development.

Heart Rate

Heart rate was measured for descriptive purposes at the same time as the blood pressure with the same machine as described above. Participants were required to be seated for at least five minutes prior to the measurement and they were instructed to relax while sitting upright in a padded chair. High resting heart rates indicate increased workload on the heart that over time may increase the risk for disease development.

Height

Height was assessed for descriptive data using a measuring tape attached to the wall. Participants were asked to remove their shoes, and then stand as tall as possible while looking straight ahead with their heels together and their arms to their sides. They were then asked to take a deep breath and hold it until the horizontal bar was brought down to compress their hair and touch the highest point of their head.[119] Measurements were taken to the nearest 0.5 inch.

Weight

Weight was measured as a component part of the BIA body composition assessment (as described in the next section) and as another descriptive measure. Participants were asked to remove their shoes and excess clothing, then step onto the BIA platform with both feet. They were asked to rest their arms at their sides and to look forward and remain still until a stable reading was obtained. Weight was recorded to the nearest 0.1 pound.

Anthropometric Measures

A tension loaded plastic tape measure was used to assess waist and hip circumferences for descriptive purposes. Waist circumference was taken at the smallest part of the waist below the rib cage and above the umbilicus while standing and relaxing the abdominal muscles. If no “smallest part” area around the waist existed above the umbilicus, then the measurement was taken at the level of the umbilicus.[119] Hip measurements were taken at the largest part of the hip-buttocks area while the participant was standing.[119] All circumferences were taken at the right side of the participant. Waist to hip ratio was calculated by dividing the waist circumference by the hip circumference.

Body fat percentage was measured using bioelectrical impedance analysis, BIA (Tanita, BC-418, Tokyo, Japan). Participants placed both bare hands and feet on the conduction points of the BIA device, then stood still with their hands relaxed, but not touching their sides. Body fat was measured to the nearest 0.1 percent with this machine and has been shown to measure 2-6% lower values for fat mass (in most people) compared to DXA.[120] However, compared to DXA, this BIA method has also been shown to overestimate fat mass in men and underestimate fat mass in women.[121]

Blood Draw

A finger prick method was used by a qualified phlebotomist to obtain one drop of blood from each participant at pre-test, post-test, and three-month follow-up to measure fasting blood glucose, HbA1c, and total cholesterol/HDL ratios. All blood draws were performed using universal precautions provided by Blue Cross and Blue Shield. Blood cholesterol and glucose measures were analyzed using the Cholestech LDX System® (Alere Inc., Waltham, MA). This device has been validated for HDL and total cholesterol measurement, but information on glucose and HbA1c is not available.

Step Count Measurement – Pedometer

The pedometer used in this intervention (Yamax SW200, Tokyo, Japan) was relatively inexpensive (≈ $20 each) and has been frequently used in walking studies,[16,18,19,21] as well as a criterion reference by which to compare other pedometers.[83] In a previous study, the Yamax SW model gave mean step counts that were within 1% of actual steps at different walking speeds and was the only one out of 10 models that did not differ significantly from actual steps at five different walking speeds.[84] It has also been shown to be reliable in normal weight, overweight, and moderately obese populations.[85] The pedometer was used to measure daily steps for members of the WG during the entire intervention (Appendix I). In addition to the accelerometer, pedometers were used to collect daily step counts in both groups during pre-, mid-, post-, and follow-up measures.

Activity Monitor – Accelerometer

The accelerometer used in this intervention (Actigraph GT1M, Pensacola, Florida) has been frequently used to measure step counts, energy expenditure, and minutes spent in various levels of PA. Accelerometers have previously been cited as the most often used direct measure of PA for studies that compared direct and indirect measures.[75] They accurately measure all accelerations of the center of mass of the body and, unlike other measurement tools, produce information on acceleration that also can be processed to obtain speed and distance information.[77] Although accelerometers produce high quality PA data, they are expensive and the data analysis is a more complicated process when compared to other simpler forms of PA measurement.[78]

The GT1M accelerometer has been shown to be valid and reliable for adults during walking. Using the GT1M, counts and energy expenditure were highly correlated during graded walking at different speeds.[122] The GT1M has also demonstrated reliability in measuring both counts (intra-instrument reliability coefficient of variation = 2.9%; inter-instrument reliability coefficient of variation = 3.5%) and steps (intra-instrument reliability coefficient of variation = 1.1%; inter-instrument reliability coefficient of variation = 1.2%).[123] The data obtained from the accelerometers provides objectively measured minutes in moderate and vigorous PA and minutes of sedentary time (dependent variables). Accelerometer data were processed using ActiLife 6.0 software. The data were considered if the participant wore the accelerometer for a minimum of four days of the total seven and for ten hours each day. They were told to wear the device during all waking hours and to remove it for water activities or sleeping. Non-wear time was excluded from the analysis. Sedentary time was classified as all minutes with 0-99 counts per minute and moderate to vigorous PA was classified as ≥ 1952 counts per minute.[124] That number of minutes in PA and sedentary time was summed to obtain a total number of hours spent in sedentary time each week and averaged out for each valid measurement day.

Participants tracked breaks in sedentary time on a break log (Appendix J). Breaks also were calculated from accelerometry data. These breaks were only calculated for valid wear time with the accelerometer (at least four days of at least 10 hours per day). In each case, a break was defined as values greater than 99 accelerometer counts per minute once participants had been sedentary for at least 30 minutes.

Procedures

Pre-test Visit

Participants who met initial inclusion criteria were scheduled for a pre-test visit where the study details were explained. They completed the informed consent and HIPAA documents and were allowed to ask any questions concerning the study. They were given a medical clearance form to give to their physicians for clearance to participate in the study. Following the initial visit, participants completed several surveys prior to the second visit, including: the demographics survey, health history questionnaire, diabetes questionnaire, and eligibility form to ensure that they qualified for participation in the study. If participants qualified, they also completed the exercise self-efficacy, walking self-efficacy, sedentary time self-efficacy, food frequency, and IPAQ questionnaires online (Qualtrics Survey Software, Provo, UT).

Upon completion of the surveys and receipt of the medical clearance, participants were visited by one of the study researchers. Participants received a Yamax SW200 pedometer and Actigraph GT1M accelerometer and were instructed to wear them on the right side of the body in line with the center of the right leg, or they could move the devices around toward the rear of the right side depending on where an accurate pedometer reading could be taken. They practiced calibrating the pedometer by first setting it to zero, then walking 20 normal steps. They then checked to see how many steps were recorded on the pedometer. If the number of recorded steps deviated from the actual number taken, they were instructed to move the pedometer around the right side of the waistline until 20 steps were recorded on the pedometer after resetting it to zero and taking another 20 calibration steps.

Once the participants felt comfortable calibrating the pedometer, they were instructed to wear it along with the accelerometer for the next seven days. They were instructed to calibrate the pedometer on the morning of the first day, take note of the appropriate pedometer position, and then place a sticker over the step count numbers on the pedometer so that they would not be able to read the number of daily steps taken during the measurement period. They wore the pedometers during all waking hours for the seven days, removing it only for water activities and sleep. They also were instructed to maintain their normal lifestyle during the seven days of PA measurement and that the walking program would begin following these initial PA measurement days.

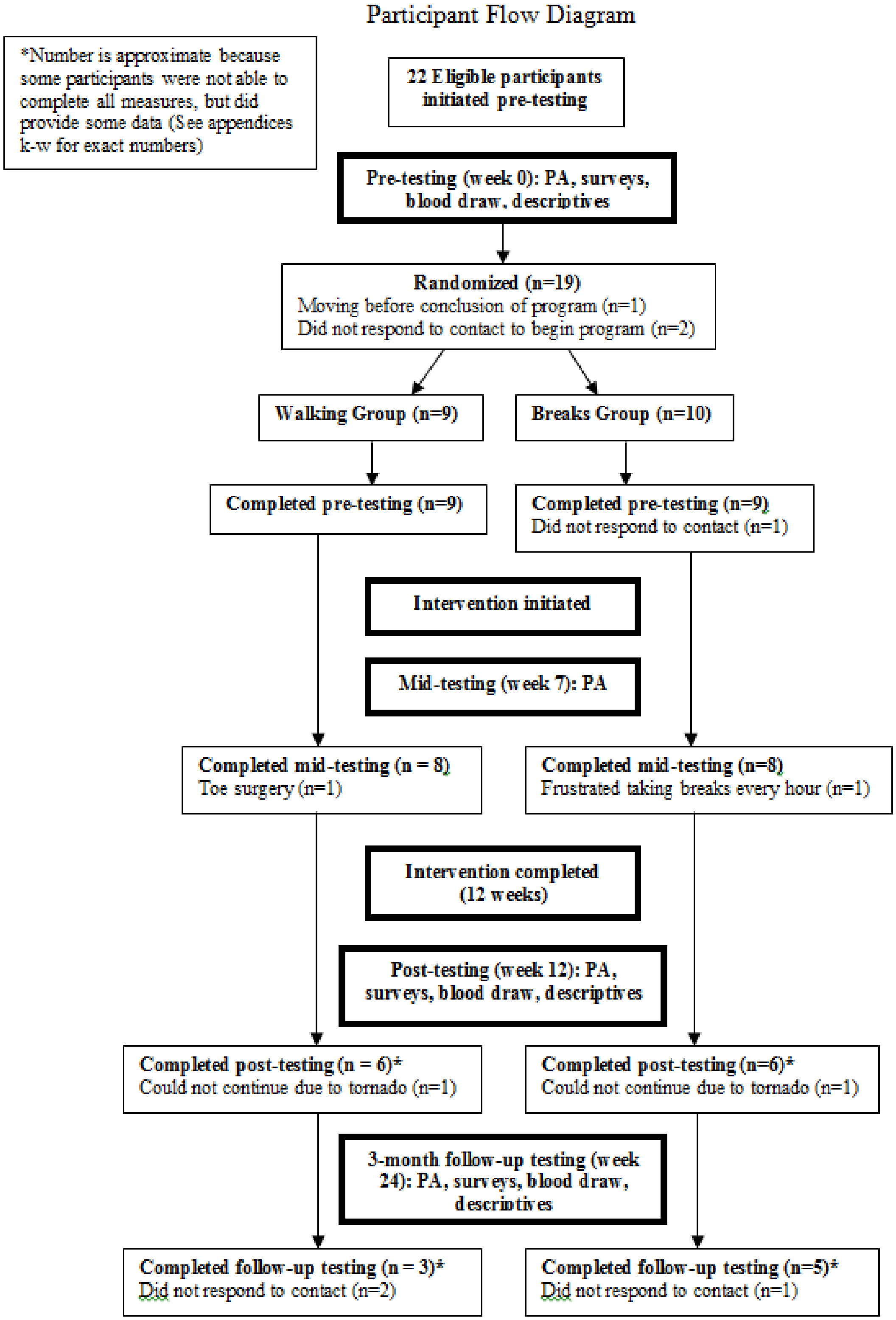
Following the surveys and baseline PA measurement, participants met at a pre-determined location for more measurements and to return their pedometers and accelerometers. Resting heart rate, blood pressure, height, weight, body composition, and waist and hip circumferences were measured by a member of the research team. Following a 12-hour fast, they received a finger prick from a qualified phlebotomist to obtain one drop of blood. Blood glucose, hemoglobin A1c, and a lipid panel were obtained from this blood sample.

One final visit was made to each participant to explain the walking program. Participants were then randomly assigned to either the BG group or the WG by using a random number generator that created equal groups. The walking program was then explained to each participant assigned to the WG. The members of the WG received a pedometer so they could use it during the intervention. Both groups received behavior logs to track their progress in taking steps and breaks. The intervention began on the same day for everyone. For complete participant flow chart see Figure 1.

Walking Group

All participants began their assigned intervention following the pre-testing visits. The WG was instructed to calibrate the pedometer each day and to record the number of steps they took each day along with any unusual activities that may have created an abnormal step count (e.g., injuring an ankle or taking an unusually long walk or hike). They were emailed an electronic step log that was to be turned in at the end of each week. Each participant was asked to accumulate at least 10,000 steps/day through increasing PA. They were also asked to include a 30 minute block of moderate intensity walking (causing slight shortness of breath or mild onset of sweating) in bouts of at

Figure 1. Participant Flow Chart



least 10 minutes, but that would add up to at least 30 minutes/day. Participants were allowed to take their baseline number of steps as measured during pre-testing, then work up to 10,000 steps/day by adding 1,000 steps/day to that baseline number, building each week.

Using Social Cognitive Theory constructs, intervention methods were developed. Self-control was developed by providing daily logs for participants to set goals and monitor their own behavior to progress in their number of steps each day. Instruction was given on how to make progress and strategies to increase activity in order to increase behavioral capability. Self-efficacy was targeted by making small changes each week to the number of steps so participants could see their progress. Participants recorded daily blood glucose levels in their behavior logs as they regularly should be doing for diabetes treatment and so they could see improvement. During the intervention, participants received a weekly email message (Appendix K) designed to increase exercise self-efficacy through social support and encouragement (vicarious experience and verbal persuasion). A follow-up email was sent each week to reinforce the motivational message that was introduced earlier in the week and to remind them to submit their weekly step logs. A Facebook page also was available for participants to log onto and interact with other participants in order to share successes and strategies that helped them succeed. Biweekly phone calls were made to all participants to assess program adherence and resolve any concerns. The phone call dialogues were typed as they were given in order to obtain qualitative data to help explain program results. Lastly, participants were encouraged to change their environment to promote activity, such as setting reminders around themselves or setting their walk log near them to remind them to be more active.

Breaks Group

Before the first day of the program each member of the BG was emailed an electronic break log. They were instructed to stand up and perform at least two minutes of moderate intensity walking to break up every one-hour block of sedentary time (computer time, watching television, sitting at a desk, etc.). They were also sent weekly emails that included the additional information about sedentary behavior (Appendix L) and received a biweekly phone call similar to the one received by the WG. A separate Facebook group was also created for the BG so that they could interact with each other and provide social support. The same theory-based methods for behavior change used in the WG were used in the BG except focused on increasing breaks in sedentary time.

Mid-test Visit

During week seven of the intervention, all participants performed a mid-test PA measurement. Prior to week seven, both intervention groups received the same pedometer (blinded for BG) as well as the accelerometer that they used during the pre-test measurements. During week seven, all participants wore the measuring devices during all waking hours of the day except during any water activities. The devices for the BG were returned at the end of the week The WG retained their pedometers for continued use.

Post-test Visit

Prior to week 12, participants returned and repeated the same procedures as during the initial visit with the exception of completing the informed consent and

HIPAA. After explaining the pedometer calibration process again, the participants repeated the PA measurement during the final seven days of the intervention using their assigned pedometers and accelerometers. They were then instructed to return the pedometers and accelerometers following the third measurement period during the health screening. The health screening followed immediately after week 12 was completed. All participants were allowed to keep their pedometers at the completion of the study as a "thank you" for their participation.

Follow-up Visit

Three months following the post-test visit, participants were contacted and all measurements that were performed during the post-test visit were repeated using the devices and equipment used during the previous testing sessions.

Sample Size Estimation

Sample size was estimated using results from previously conducted walking interventions in similar contexts to the current study. The variable least sensitive to change within the 12 week walking intervention was hemoglobin A1c (HbA1c) and was therefore the variable that was used to estimate sample size. Hemoglobin A1c results from eight-week[12] and 12-week[19] walking studies in T2DM patients were used to calculate intervention treatment effects (Cohen's *d*) of .82 and 1.16, respectively. This was done by calculating mean HbA1c differences and dividing that by the standard deviation of the initial measurement for the control group. Following procedures outlined for estimating effect sizes using GPower, the Cohen's *d* values were divided in half to estimate the *f* value which was then inserted into GPower to estimate sample size using a within-between-factors, repeated measures ANOVA test with a power of 0.8, α

= 0.05, two groups, and two measurements.[125] Using the more conservative sample size estimate for HbA1c, at least 14 total subjects were needed to produce an effect that could be statistically significant. This was confirmed in the post hoc analysis of a six-week walking study that determined that 15 subjects in the intervention group was enough to observe a 0.7% decrease in HbA1c with a power of 80% and $\alpha = 0.05$ using a paired *t* test.[108]

The primary target variable in this intervention was PA as measured by steps/day and was also used to calculate sample size in order to ensure adequate power. Using a walking intervention with sedentary women and a similar design to the current study,[9] a sample size estimation was determined using a within-between group factors, repeated measures ANOVA test with a power of 0.8, $\alpha = 0.05$, two groups, and two measurements. After following the procedure outlined above, a total sample size of four was calculated as the minimum number of participants needed to observe significant differences in steps/day. With the combined information provided from the calculations above, it was determined that a final sample size of 16-20 in each group was adequate to produce statistically significant effects in all variables included in the study.

Statistical Analyses

All statistics were calculated using IBM SPSS Statistics software, version 19.0 (SPSS Inc., Chicago, IL). Descriptive statistics were obtained using data from demographic and dependent variables for the 16 participants who were randomized into the intervention. Two-way, repeated measures ANOVA's were used to examine the effect of increasing PA (steps and minutes in moderate/vigorous PA) and decreasing sedentary time on self-efficacy (walking, exercise, sedentary), fasting blood lipid levels

(Total/HDL), as well as glucose and HbA1c levels. Effect sizes were described using the partial eta squared statistic (small: partial $\eta^2 \geq 0.01$, moderate: partial $\eta^2 \geq 0.06$, large: partial $\eta^2 \geq 0.13$).[126]

Process Evaluation

Process evaluation was performed at each point of measurement or intervention. At testing periods, a checklist was used to ensure important points were described to each participant and each measurement taken. In addition to checklists, emails were tracked and confirmation was received as to whether the email was successfully delivered to each participant. Further information was collected as participants were able to click on a link to declare that they had read the email. During phone calls the length of the call and a detailed description of the conversation were recorded simultaneously as the conversation took place.

Questions to Consider

1. Was everything accomplished at the pretest visit? Were participants given all materials?
2. Was the intervention explained with essential steps described in detail?
3. Did participants come back seven days after measuring PA levels?
4. Did participants turn in walking logs every week for 12 weeks?
5. Were motivational and reminder emails sent and read?
6. Were participants satisfied with the program?
7. How many participants volunteered but were not eligible?
8. How many participants dropped out? Is there a significant difference in any study variable for those who dropped out versus those who stayed in?

9. Were there any aspects of the environment that may have influenced intervention implementation or study outcomes?

Chapter IV: Results and Discussion

Descriptive Statistics

Initial data were collected for 16 participants who met inclusion criteria and were randomized into one of the two intervention groups (eight participants in each group), a walking group (WG) and a sedentary breaks group (BG). Physical characteristics did not differ between groups at baseline using independent t-tests to compare groups for each variable using $p > 0.05$ (see Table 1). Most participants were female (81.3%) with the exception of two males in the BG and one male in the WG. All participants lived or worked on or around the University of Oklahoma (Norman or Health Science Center campus). The ethnic distribution of the participants was 50% White, 25% Black, 18.8% American Indian/Native Alaskan, and 6.2% Hispanic.

Table 1. Physical Characteristics by Group at Baseline

Variable	Group[1]	n	Mean ± SD	t (df)*	p-value (2-tailed)*
Resting Heart Rate	WG	8	79.1 ± 8.8	0.088	0.931
	BG	8	78.6 ± 13.5	(12.1)	
Systolic Blood Pressure	WG	8	130.3 ± 22.2	0.476	0.608
	BG	8	124.6 ± 20.7	(13.9)	
Diastolic Blood Pressure	WG	8	82.3 ± 9.2	0.688	0.848
	BG	8	81.3 ± 11.2	(13.5)	
Height (inches)	WG	8	66.4 ± 3.1	0.686	0.591
	BG	8	65.5 ± 3.3	(14.0)	
Waist Circumference (cm)	WG	8	42.9 ± 8.3	0.439	0.565
	BG	8	40.8 ± 6.0	(12.8)	
Hip Circumference (cm)	WG	8	47.0 ± 6.8	0.030	0.306
	BG	8	44.0 ± 4.2	(11.6)	
Waist/Hip Ratio	WG	8	0.91 ± 0.12	0.930	0.883
	BG	8	0.92 ± 0.11	(13.8)	
Body Fat Percentage	WG	8	43.4 ± 7.2	0.443	0.533
	BG	8	41.4 ± 5.8	(13.4)	
Body Mass Index (BMI)	WG	8	33.9 ± 7.8	0.174	0.620
	BG	8	32.2 ± 4.8	(11.6)	
Weight (pounds)	WG	8	214.9 ± 63.0	0.198	0.515
	BG	8	197.1 ± 40.9	(12.0)	

[1]WG – Walking Group; BG – Breaks Group; *Equal variance not assumed

A majority of the participants (62.6%) earned $50,000 or more per year for their combined annual household income. The participants also had a relatively high educational status; 87.5% had some college or obtained a college degree. Additionally, 10 of the participants were married. Demographic information is listed in Table 2 below. Based on interaction with the participants, many of them worked in professions that required large amounts of sitting time each day (i.e. secretary). There were no differences at baseline between groups for any socio-demographic variables ($p > 0.05$ for all variables).

Table 2. Socio-Demographic Characteristics

Variable		**Total Sample n = 16**	**Walking Group n = 8**	**Breaks Group n = 8**
Gender	Male	3 (18.8%)	1 (12.5%)	2 (25%)
	Female	13 (81.3%)	7 (87.5%)	6 (75%)
Race/Ethnicity				
	White	8 (50%)	5 (62.5%)	3 (37.5%)
	Black	4 (25%)	2 (25%)	2 (25%)
	Native American/Alaskan	3 (18.8%)	1 (12.5%)	2 (25%)
	Hispanic	1 (6.2%)		1 (12.5%)
Household Annual Income				
	Less than $10,000	1 (6.3%)	1 (12.5%)	
	$15,000-20,000	1 (6.3%)		1 (12.5%)
	$25,000-35,000	4 (25%)	1 (12.5%)	3 (37.5%)
	$50,000-75,000	5 (31.3%)	2 (25%)	3 (37.5%)
	More than $75,000	5 (31.3%)	4 (50%)	1 (12.5%)
Education				
	High School Graduate	2 (12.5%)	1 (12.5%)	1 (12.5%)
	Some College	8 (50%)	6 (75%)	2 (25%)
	College Graduate	6 (37.5%)	1 (12.5%)	5 (62.5%)
Marital Status				
	Married	10 (62.5%)	6 (75%)	4 (50%)
	Divorced	3 (18.8%)	1 (12.5%)	2 (25%)
	Separated	1 (6.2%)		1 (12.5%)
	Never Married	2 (12.5%)	1 (12.5%)	1 (12.5%)

During pretesting, baseline values for all research variables were obtained (see Table 3). Data were compared between groups using independent t-tests to ensure equality. All baseline variables were equal between groups at baseline except for sedentary self-efficacy ($p = 0.020$). Equality at baseline was controlled for through random group assignment and is essential for comparison between groups using analysis of variance (ANOVA).

Table 3. Baseline Values for Study Dependent Variables

Variable	Group[1]	n	Mean ± SD	t (df)*	p-value (2-tailed)*
Physical Activity	WG	7	16.7 ± 7.8	-0.29	0.776
(accel. MVPA minutes)	BG	7	18.4 ± 13.4	(9.67)	
Physical Activity	WG	8	4388 ± 1821	-0.64	0.532
(pedometer steps)	BG	8	4873 ± 1825	(14.0)	
Sedentary Hours	WG	7	11.1 ± 1.3	-0.84	0.417
(accelerometer)	BG	7	11.6 ± 1.3	(12.0)	
Sedentary Time Breaks	WG	7	5 ± 1.9	-1.13	0.280
(accelerometer)	BG	7	6 ± 1.9	(12.0)	
Exercise Self-Efficacy	WG	8	4.3 ± 0.40	-1.13	0.280
	BG	8	4.6 ± 0.52	(13.3)	
Walking Self-Efficacy	WG	8	4.3 ± 0.43	-1.03	0.320
	BG	7	4.5 ± 0.42	(12.8)	
Sedentary Self-Efficacy	WG	8	4.3 ± 0.50	-2.87	0.020
	BG	8	4.8 ± 0.16	(8.4)	
Fasting blood Glucose	WG	8	134.3 ± 34.0	-0.76	0.462
	BG	8	152.6 ± 59.2	(11.2)	
Hemoglobin A1c	WG	8	7.4 ± 1.7	-1.22	0.245
	BG	8	8.7 ± 2.6	(12.3)	
Total/HDL Cholesterol	WG	8	4.0 ± 0.81	0.67	0.517
	BG	8	3.8 ± 0.92	(13.8)	

[1]WG – Walking Group; BG – Breaks Group
*Equal variance not assumed

Physical Activity

Accelerometry Measures

The combined minutes (moderate and vigorous) of physical activity (PA) per day were assessed between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Six participants in the WG and six in the BG recorded measurements for the two time points and were included in the analysis (See Appendix M). There was a significant time effect [F (1) = 5.396, p = 0.043], but no time-by-group interaction [F (1) = 1.403, p = 0.264] or group effect [F (1) = 0.598, p = 0.457] (see Table 4).

Moderate to vigorous PA increased more in the WG compared to the BG. Mean values for the WG increased from 16 minutes of moderate/vigorous PA (MVPA) to 41.8 minutes at week seven and stayed at 41.2 minutes during week 12 indicating that there was some impact of the program on activity levels despite a fall to 21.3 minutes of MVPA at the three-months follow-up. The BG slightly increased from 16.2 minutes of

Table 4. Summary of Final ANOVA Model for Accelerometer Average Moderate/Vigorous Minutes of PA per Day by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
MVPA (accel.)	<u>Between Subjects</u>							
	Group	1	416.667	416.667	0.598	0.457	0.108	0.056
	Error	10	6968.167	696.817	-	-	-	-
	<u>Within Subjects</u>							
	Time	1	1666.67	1666.67	5.396	0.043	0.555	0.350
	Time*Group	1	433.50	433.50	1.403	0.264	0.189	0.123
	Error	10	3088.833	308.883	-	-	-	-

MVPA to 16.8 minutes from baseline to week seven, then increased to 24.3 and 28.8 minutes at week 12 and the three-months follow-up, respectively.

When individual scores are considered, the overall results can be better understood. As the intervention was initiated, all participants in the WG increased their time spent in MVPA dramatically, ranging from an increase of seven minutes to an increase of 52 minutes per day from baseline to week seven. About half of the members of the BG increased slightly and the other half decreased slightly in MVPA. At week 12, all members of the WG slightly decreased minutes of MVPA from week seven, except for participant 22 who dramatically increased again. With the exception of one participant, all members of the BG increased MVPA or stayed the same from week 7 to 12. These results fit the purpose of the study in increasing MVPA in the WG and only slightly in the BG. The results suggest that there might be a concurrent improvement in clinical variables in the WG, but potentially not as much in the BG.

Results for both groups have been observed in previous research with sedentary adults. De Greef et al.[127] found that the total PA (light, moderate, and vigorous) increased in both a “usual care” control and walking intervention groups following a 12 week intervention with five counseling sessions. This intervention was similar to the one received by the WG. At one-year follow-up total PA decreased toward baseline values in the De Greef et al. study. However, this study did not include a component designed to increase breaks in sedentary time. A feasibility study with sedentary older adults (≥ 60yrs.) measured PA and breaks with accelerometers for an intervention designed to break up sedentary time, which was similar to the intervention delivered to the BG.[27] Neither study used participants with Type II Diabetes (T2DM), but both found decreases in sedentary time and Gardiner et al. found increases in daily breaks.

Pedometry Measures

The average steps per day were assessed between and within groups using a repeated measures ANOVA that included baseline and post-intervention measures. The post-measurement was missing for participant 21 so the mid-measurement value was inserted to assume that he/she maintained his/her same activity level through the intervention. Seven participants in the BG and four participants in the WG were included in the analysis (See Appendix N). There was no significant time-by-group interaction [F (1) = 1.100, p = 0.322], time effect [F (1) = 2.952, p = 0.120], or group effect [F (1) = 0.003, p = 0.959] (see Table 5).

Table 5. Summary of Final ANOVA Model for Pedometer Average Steps per Day by Group (Walking vs. Breaks) and Time (pre and post)

Variable	**Source**	**df**	**SS**	**MS**	**F**	**p-value**	**Power (1-β)**	**Effect Size partial η^2**
Steps (ped.)	Between Subjects							
	Group	1	56989.651	56989.651	0.003	0.959	0.050	<0.001
	Error	9	1.801E8	20007819.3	-	-	-	-
	Within Subjects							
	Time	1	27601192.3	27601192.3	2.952	0.120	0.336	0.247
	Time*Group	1	10284165.0	10284165.0	1.100	0.322	0.156	0.109
	Error	9	84142566.8	9349174.09	-	-	-	-

Significant differences were likely not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect sizes for the interaction and time effects were moderate (partial $\eta^2 > 0.10$). Mean values for the WG increased dramatically from 3182 steps per day to 6931 steps per day at post-testing indicating that there was some immediate impact of the program on activity levels in this group despite a fall to 2430 steps per day at three-months follow-up. The BG slightly increased from 4497 steps per day to 5404 steps per day from baseline to week 12, then decreased to 4895 steps per day at three-month follow-up. These results are confirmed by MVPA data obtained with the accelerometer.

One individual's scores may have had a significant influence on results obtained for the pedometer data. This participant recorded 5,236 steps per day at week zero and increased to 17,931 steps per day at post-test. This unusually high value was not technically classified as an outlier, but the value was more than three times any other individual value for the WG at post-test. Only three members of the WG recorded valid pedometer data for the post-testing, which also makes the data less meaningful because of the small sample size.

Members of the BG generally exhibited an increase in daily steps from pre- to post-test. Most participants recorded decreased steps at the three-month follow-up when compared to post-intervention data. This suggests that some type of continued intervention is necessary to keep participants motivated and aware of their activity levels in order to be maintained after the organized activities of the program/ intervention are complete. Maintenance of improved activity levels is important since health benefits take time to develop.

These data are consistent with results from other pedometer-based walking programs. Multiple studies have illustrated a dramatic increase in daily steps as a walking program begins, perhaps due to the novelty of the program.[9,15,95] Many walking programs for patients with T2DM last from six weeks to six months; many include reminders and external prompts from program administrators. When this supervision is removed, many participants seem to fall back into former habits and return to their baseline levels of steps per day.[16] However, one study did observe maintenance of step counts for one year after participation in a four-month minimal contact intervention based on motivational phone calls.[21]

Daily steps were recorded by members of the WG every day as they attempted to achieve the recommended 10,000 steps per day. The average number of steps per day increased overall throughout the program for the WG as tracked by group members (Appendix O and Figure 2). However, the number of participants in the WG that consistently turned their logs decreased as the program progressed (Figure 3). The participants who turned in their logs were the participants who were more engaged in the program or who were more successful, as a result, the weekly averages for steps may have been artificially inflated. Participant 22, for example, was very enthusiastic and consistently had an average daily step count far higher than any other participant, which increased the average daily step for the group (Appendix O).

Figure 2. Average Steps per Day on Walk Logs (Walking Group Only)

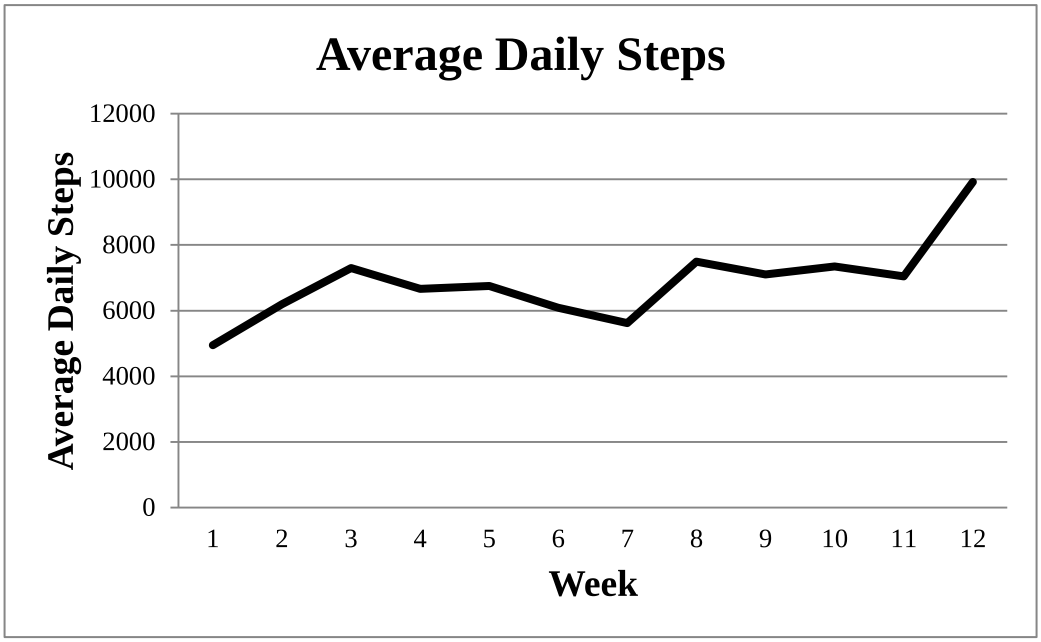
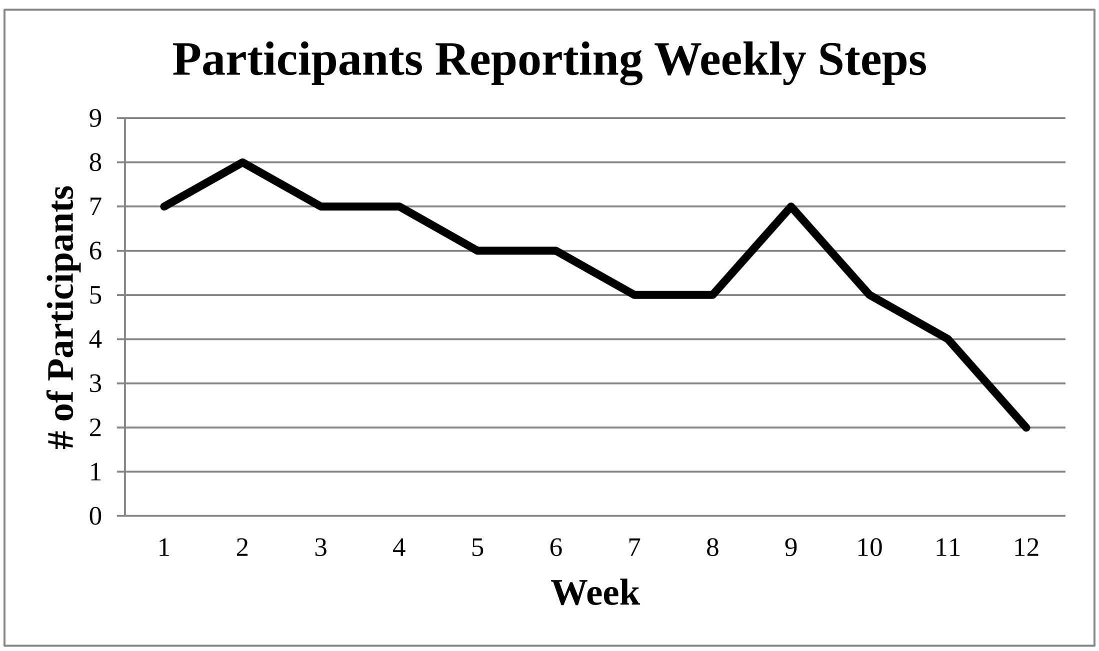


Figure 3. Number of Participants Reporting Daily Steps (Walking Group Only)



International Physical Activity Questionnaire

The combined minutes of MVPA per week were assessed between and within groups using a repeated measures ANOVA that included baseline and post-test (week 12) measures. Six participants in each group recorded measurements for the two time points and were included in the analysis (See Appendix P). There was no significant time-by-group interaction [F (1) = 2.957, p = 0.116], time effect [F (1) = 3.701, p = 0.083], or group effect [F (1) = 0.356, p = 0.564] (see Table 6).

Table 6. Summary of Final ANOVA Model for Moderate/Vigorous MET-Minutes per Week by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Total MET-minutes (IPAQ)	Between Subjects							
	Group	1	50723663.5	50723663.5	0.356	0.564	0.084	0.034
	Error	10	1.424E9	1.424E8	-	-	-	-
	Within Subjects							
	Time	1	2.593E8	2.593E8	3.701	0.083	0.413	0.270
	Time*Group	1	2.071E8	2.071E8	2.957	0.116	0.343	0.228
	Error	10	7.005E8	70054604.4	-	-	-	-

Significant differences were likely not observed because of the small sample size that resulted in the study being underpowered (Power < 0.8). The effect sizes for the interaction and time effects were relatively large for the time*group interaction and time effects (partial η^2 = 0.228 and 0.270, respectively). Mean values for the walking group (WG) increased from 1,337.7 MET-minutes of MVPA per week to 13,786.8 MET-minutes of MVPA per week during week 12, indicating that there was some impact of the program on the participant's self-reported activity levels. The BG increased slightly from 4,305.8 MET-minutes of MVPA to 5,003.5 MET-minutes per week from baseline to week 12.

Due to the small sample size, individual results contributed much of the change in self-reported activity. In the WG, several of the participants initially reported only a few thousand MET-minutes per week and then following the program reported over 10, 20, or 30 thousand MET-minutes per week following the program. Several of these values are far out of proportion compared to pedometer and accelerometer data, indicating that there may have been a perceived increase in activity when actual activity did not increase as much. Most of the participants reported less than 1,000 MET-minutes per week before and after the program. About 500 MET-minutes per week is equal to 30 minutes of moderate intensity activity on five days per week. Half of the participants reported more than 500 MET-minutes at baseline, and all participants reported more than 500 MET-minutes at the end of the program.

Two similar studies used the IPAQ to measure activity during a walking program for patients with T2DM. Both studies used the interview form of the IPAQ because of reports that the written form tends to produce over-reporting.[128] Both studies found significant time*group interaction effects for MVPA for the intervention group compared to the control in 12-week[20] and 6-month[21] interventions. Using the interview version of the IPAQ rather than the self-report version that was utilized may have improved the accuracy of reported MVPA levels in the current study.

Sedentary Time

Accelerometer

Total hours of daily sedentary time was compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention measures. Six participants in each group recorded measurements for the two time points and were included in the analysis (See Appendix Q). There was no significant time-by-group interaction [F (1) = 0.279, p = 0.609], time effect [F (1) = 1.798, p = 0.210], or group effect [F (1) = 2.162, p = 0.172] (see Table 7).

Table 7. Summary of Final ANOVA Model for Sedentary Hours per Day by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Sedentary hours (accel.)	Between Subjects							
	Group	1	4.002	4.002	2.162	0.172	0.265	0.178
	Error	10	18.507	1.851	-	-	-	-
	Within Subjects							
	Time	1	1.815	1.815	1.798	0.210	0.229	0.152
	Time*Group	1	0.282	0.282	0.279	0.609	0.077	0.027
	Error	10	10.093	1.009	-	-	-	-

Significant differences were not likely observed because of a small sample size that resulted in the study being underpowered (Power < 0.8). The effect sizes for the interaction and time effects were relatively large (partial $\eta^2 > .13$). Mean values for WG decreased slightly from 11.3 hours of sedentary time per day to 10.6 hours during week 12, indicating that there was a potential impact of the program on hours of sedentary time despite the fact that the intervention received by this group did not specifically target reducing sedentary behavior. There was an increase back to baseline values at three-months follow-up in the walking group. The BG slightly decreased from 11.9 hours to 11.6 hours from baseline to week 12. Three months following the intervention, hours of sedentary time decreased again slightly to 10.5 hours per day for the BG.

Similar results have been previously reported for inactive adults with T2DM. A study by De Greef et al.[127] used a 12-week pedometer-based walking intervention to increase PA and decrease sedentary time. The program included five counseling sessions using educational and motivational strategies along with tracking of activity levels. Steps increased in the intervention group and not in the control following the intervention, while sedentary time decreased in the intervention group and not in the control. There were about 20 participants in each group, and the intervention was conducted in a hospital with the control group receiving usual care for treatment of diabetes. The additional resources included by De Greef et al. may have improved the effectiveness of this program. Also, larger sample size and better power increased the likelihood of documenting significant findings.

International Physical Activity Questionnaire

Self-reported daily sitting time (hours) was compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Six participants in the BG and seven participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix R). There was no significant time-by-group interaction [F (1) = 0.794, p = 0.392], time effect [F (1) = 1.845, p = 0.202], or group effect [F (1) = 0.345, p = 0.569] (see Table 8).

Table 8. Summary of Final ANOVA Model for Sitting Hours per Day by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Sitting hours (IPAQ)	Between Subjects							
	Group	1	6.868	6.868	0.345	0.595	0.084	0.030
	Error	11	219.074	19.916	-	-	-	-
	Within Subjects							
	Time	1	11.405	11.405	1.845	0.202	0.237	0.144
	Time*Group	1	4.907	4.907	0.794	0.392	0.129	0.067
	Error	11	67.989	6.181	-	-	-	-

Significant differences likely were not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the interaction time effect was relatively large (partial $\eta^2 > 0.13$), while the interaction and group effects had smaller effect sizes (partial $\eta^2 < 0.07$). Mean values for WG decreased slightly from 8.6 hours of sitting time per day to 8.2 hours from baseline to week 12. The BG decreased slightly more than the WG, changing from 10.5 hours per day to 8.3 hours from baseline to week 12. This suggests that the breaks only intervention may have had more impact on participants' self-report of sitting time than the walking intervention. De Greef et al. also did not observe significant differences in sitting time using the interview IPAQ before and after a 24 week pedometer-based intervention for adults with T2DM. There was poor compliance in completing the online survey in the current study even though they could do it at a convenient time for them.

Breaks in Sedentary Time

Total breaks in sedentary time were compared between and within groups using a repeated measures ANOVA that included baseline and post- measures. Six participants in each group recorded measurements for the two time points and were included in the analysis (See Appendix S). There was no significant time-by-group interaction [F (1) = 0.044, p = 0.838], time effect [F (1) = 2.168, p = 0.172], or group effect [F (1) = 3.816, p = 0.079] (see Table 9).

Table 9. Summary of Final ANOVA Model for Accelerometer Average Breaks in Sedentary Time per Day by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Breaks (accel.)	Between Subjects							
	Group	1	15.042	15.042	3.816	0.079	0.423	0.276
	Error	10	39.417	3.942	-	-	-	-
	Within Subjects							
	Time	1	2.042	2.042	2.168	0.172	0.266	0.178
	Time*Group	1	0.042	0.042	0.044	0.838	0.054	0.004
	Error	10	9.417	0.942	-	-	-	-

Significant differences likely were not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the interaction, time, and group effects were relatively large (partial $\eta^2 > .13$). Mean values for WG decreased by about one break through week 12, but increased back to baseline values at the three-month follow-up. The BG slightly decreased by about one break from baseline to week 12 and continued to decrease until the three-month follow-up measure.

This study did not produce evidence of the efficacy of a program designed to increase the number of breaks in sedentary time each day. Gardiner et al.[27] found conflicting results in a study designed to assess the feasibility of a program designed to interrupt sedentary time in older adults. They found high satisfaction, high compliance, an increase in the number of breaks in sedentary time, and a significant decrease in sedentary time. However, the intervention was very involved and only lasted for one week. Additionally, most of the increases in breaks occurred after 7pm during sedentary time at home after work. This time is likely more under the control of the participant compared to taking breaks during the day at work. In the current study, participants were encouraged to take breaks throughout the day, especially during their long working hours when most of them were sitting at a desk most of the time. Participants also kept "break logs" where they marked each time they took a two-minute break in their sedentary time throughout the day. In response to participant feedback, it appeared to be a tedious task to mark every time a participant took a break every day for the duration of a 12 week intervention.

Self-Efficacy

Exercise Self-Efficacy

Average exercise self-efficacy values were compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Four participants in the BG and five participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix T). There was no significant time-by-group interaction [$F(1) = 0.915$, $p = 0.371$], time effect [$F(1) = 2.100$, $p = 0.191$], or group effect [$F(1) = 0.207$, $p = 0.663$] (see Table 10).

Table 10. Summary of Final ANOVA Model for Exercise Self-Efficacy by Group Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Exercise self-efficacy	Between Subjects							
	Group	1	0.067	0.067	0.207	0.663	0.068	0.029
	Error	7	2.275	0.325	-	-	-	-
	Within Subjects							
	Time	1	1.157	1.157	2.100	0.191	0.241	0.231
	Time*Group	1	0.504	0.504	0.915	0.371	0.132	0.116
	Error	7	3.856	0.551	-	-	-	-

Significant differences likely were not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the time effect was relatively large (partial $\eta^2 > 0.13$), while the time*group interaction and group effects were moderate to small (partial $\eta^2 = 0.116$ and 0.029, respectively). Mean values of exercise self-efficacy for WG stayed almost the same from baseline to post-test, while the exercise self-efficacy of the BG decreased (week 0 = 4.9, week 12 = 4.1). Due to the small sample size it is difficult to draw conclusions for self-efficacy. However, based on phone calls with the participants and the follow-up interviews, the beginning of the program was new and exciting for the participants. They initially were motivated to do something challenging. As the program progressed, they found it more difficult to keep up with the logs and reported feeling unsuccessful in their efforts to comply with the recommendations for their respective interventions. In comparison, one eight-week counseling intervention in Mexican Americans showed small increases in self-efficacy in both an intervention group and a usual-care control group, but these increases were not significant.[17]

Walking Self-Efficacy

Average walking self-efficacy values were compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Four participants in the BG and six participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix U). There was no time-by-group interaction [F (1) = 0.086, p = 0.777], time effect [F (1) = 5.143, p = 0.053], or group effect [F (1) = 0.814, p = 0.393] (see Table 11).

Table 11. Summary of Final ANOVA Model for Walking Self-Efficacy by Group (Walking vs. Breaks) and Time (pre and post)

Variable	**Source**	**df**	**SS**	**MS**	**F**	**p-value**	**Power (1-β)**	**Effect Size partial η^2**
Walking self-efficacy	<u>Between Subjects</u>							
	Group	1	0.197	0.197	0.814	0.393	0.126	0.092
	Error	8	1.937	0.242	-	-	-	-
	<u>Within Subjects</u>							
	Time	1	2.279	2.279	5.143	0.053	0.514	0.391
	Time*Group	1	0.038	0.038	0.086	0.777	0.058	0.011
	Error	8	3.545	0.443	-	-	-	-

Significant differences likely were not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the time effect was relatively large (partial $\eta^2 > 0.13$), while the time*group interaction and group effects were small and moderate (partial η^2 = 0.011 and 0.092, respectively). Mean values for walking self-efficacy of both groups decreased from baseline to post-test (WG: week 0 = 4.4, week 12 = 3.8; BG: week 0 = 4.7, week 12 = 3.9). This survey was created for the purpose of the current study because self-efficacy is behavior-specific. There were, however, not enough participants to validate the survey.

Sedentary Self-Efficacy

Average sedentary self-efficacy values were compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Five participants in the BG and six participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix V). There was no time-by-group interaction [F (1) = 0.086, p = 0.776] or group effect [F (1) = 3.835, p = 0.082] (see Table 12). There was however, a significant decrease in sedentary self-efficacy over time [F (1) = 10.396, p = 0.010]. The means significantly decreased following the intervention, although the "equality of groups" assumption was broken because the baseline means between groups were significantly different (See Table 3).

Table 12. Summary of Final ANOVA Model for Sedentary Self-Efficacy by Group (Walking vs. Breaks) and Time (pre and post)

Variable	**Source**	**df**	**SS**	**MS**	**F**	**p-value**	**Power (1-β)**	**Effect Size partial η^2**
Sedentary self-efficacy	Between Subjects							
	Group	1	0.971	0.971	3.835	0.082	0.417	0.299
	Error	9	2.279	0.253	-	-	-	-
	Within Subjects							
	Time	1	2.224	2.224	10.396	0.010	0.818	0.536
	Time*Group	1	0.018	0.018	0.086	0.776	0.058	0.009
	Error	9	1.926	0.214	-	-	-	-

Significant differences between groups likely were not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8), except for the time effect (Power = 0.818). The effect size for the time effect was relatively large (partial $\eta^2 > 0.13$), while the time*group interaction had a small effect size (partial η^2 <

0.01), and the group effect was also large (partial $\eta^2 > 0.13$). Mean values of sedentary self-efficacy for both groups decreased from baseline to post-test (WG: week 0 = 4.4, week 12 = 3.8; BG: week 0 = 4.9, week 12 = 4.2). The significant decrease over time was likely due to the fact that the participants experienced difficulty in actually taking the number of breaks that the intervention recommended through the day and because taking breaks interrupted their focus at work. This survey also was created for the purpose of the current study because self-efficacy is behavior specific. However, there were not enough participants to validate the survey.

Blood Glucose Control

Blood Glucose

Average fasting blood glucose values were compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Seven participants in the BG and six participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix W). There was no significant time-by-group interaction [$F(1) = 0.040$, $p = 0.845$], time effect [$F(1) = 0.356$, $p = 0.563$], or group effect [$F(1) = 0.939$, $p = 0.353$] (see Table 13).

Significant differences likely were not observed due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the time effect was moderate (partial $\eta^2 > 0.06$), while the time*group interaction and group effects were small (partial $\eta^2 = 0.004$ and 0.079, respectively). Mean values of fasting blood glucose for both groups decreased from baseline to post-test (WG: week 0 =

129.7mg/dL, week 12 = 124.5; BG: week 0 = 154.7, week 12 = 152.1), but the decrease was greater for the WG. This could be due to greater program adherence in the WG

Table 13. Summary of Final ANOVA Model for Fasting Blood Glucose by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Fasting blood glucose	Between Subjects							
	Group	1	4484.770	4484.770	0.939	0.353	0.144	0.079
	Error	11	52517.85	4774.350	-	-	-	-
	Within Subjects							
	Time	1	96.726	96.726	0.356	0.563	0.085	0.031
	Time*Group	1	10.880	10.880	0.040	0.845	0.054	0.004
	Error	11	2987.27	271.570	-	-	-	-

compared to the BG or simply that increasing PA is more related to glucose control than interruption of sedentary time.

Physical activity did appear to have an impact on blood glucose control for these participants. Not all participants who completed PA measurements were able to make each of the health screening to get blood glucose measured. Those who completed all measures showed mixed results. Regardless of group membership, some participants increased MVPA during pre-, mid-, and post- measurements while fasting blood glucose stayed the same or increased (participants 2, 15, 21). Others increased MVPA and decreased blood glucose (participants 7, 11, 16, 22). A larger sample size may have produced less equivocal results.

Overall, mean values of fasting glucose for both groups decreased slightly from pre-test to post-test, but not significantly. A similar decrease in fasting blood glucose was observed in the combined data of pedometer and non-pedometer walking groups at one month into a walking program, and the improvement was maintained through the duration of the six-month program.[23] A similar 12-week randomized controlled trial found no significant changes in blood glucose following a walking program for patients with T2DM.[20]

Hemoglobin A1c

Average hemoglobin A1c (HbA1c) values were compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Seven participants in the BG and seven participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix X). There was no significant time-by-group interaction [F (1) = 0.115, p = 0.741] or group effect [F (1) = 1.226, p = 0.290], but there was a significant decrease in HbA1c over time [F (1) = 5.834, p = 0.033] (see Table 14).

Table 14. Summary of Final ANOVA Model for Hemoglobin A1c by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
HbA1c	Between Subjects							
	Group	1	7.929	7.929	1.226	0.290	0.175	0.093
	Error	12	77.627	6.469	-	-	-	-
	Within Subjects							
	Time	1	17.443	17.443	5.834	0.033	0.603	0.327
	Time*Group	1	0.343	0.343	0.115	0.741	0.061	0.009
	Error	12	35.879	2.990	-	-	-	-

Significant differences likely were not observed for the interaction and group effect due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the time effect was large (partial $\eta^2 > 0.13$), while the effect size for group was moderate (partial $\eta^2 > 0.06$) and the time*group interaction was small (partial $\eta^2 = 0.009$). Mean values of HbA1c for both groups decreased from baseline to post-test (WG: week 0 = 7.5%, week 12 = 6.2%; BG: week 0 = 8.8%, week 12 = 7.0%).

There was a significant decrease over time for HbA1c for both groups combined. Individual results are difficult to interpret because some participants have drastic changes in HbA1c while others had smaller changes, which were not related to MVPA measured pre- and post- intervention. Participant 22 increased MVPA far beyond any other participant, yet had an increase in HbA1c of 1.5%. However, blood glucose dropped significantly across the same measuring points for the same participant. Another member of the WG (participant 21) who significantly increased MVPA also had an increase in HbA1c of 0.6%. The blood glucose also increased slightly for this participant. Participant 18 in the WG increased MVPA by only four minutes per day from pre- to post-intervention, yet had a 4.7% decrease in HbA1c. A participant in the BG (participant 17) recorded a slight decrease in MVPA following the intervention, but showed a 4.2% decrease in HbA1c. The reliability and validity of the HbA1c measurement technique for this study has not been established and may not compare to a standard blood draw method.

Mean changes for HbA1c were similar to those in some previous literature. Following one three-month intervention, the combined total for HbA1c decreased by 1.6% from pre- to post-test. In another study, participation in a pedometer-based walking intervention was associated with a 1.6% decrease in HbA1c, which was statistically significant.[19] Another study found a 0.32% decrease in HbA1c following participation in a 12-week pedometer-based walking program that included individual consultation for patients with T2DM. However, these findings were not statistically significant.[20] Likewise, the results from a 12 week walking program that involved health-coaching in older adults were not found to be significant.[22]

Other Measures

Relationships between Predictors and Outcomes

The relationship between predictor and outcome variables was not assessed due to a failure to find significant changes in either group of variables.

Total to HDL Cholesterol Ratio

Average cholesterol ratios (Total/HDL) were compared between and within groups using a repeated measures ANOVA that included baseline and post-intervention (week 12) measures. Seven participants in the BG and six participants in the WG recorded measurements for the two time points and were included in the analysis (See Appendix Y). There was no time-by-group interaction [F (1) = 0.043, p = 0.840], time effect [F (1) = 3.115, p = 0.105], or group effect [F (1) = 0.006, p = 0.938] (see Table 15).

Table 15. Summary of Final ANOVA Model for Cholesterol Ratio (Total/HDL) by Group (Walking vs. Breaks) and Time (pre and post)

Variable	Source	Df	SS	MS	F	p-value	Power (1-β)	Effect Size partial η^2
Cholesterol Ratio (Total/HDL)	Between Subjects							
	Group	1	0.011	0.011	0.006	0.938	0.051	0.001
	Error	11	19.324	1.757	-	-	-	-
	Within Subjects							
	Time	1	1.015	1.015	3.115	0.105	0.364	0.221
	Time*Group	1	0.014	0.014	0.043	0.840	0.054	0.004
	Error	11	3.586	0.326	-	-	-	-

Significant differences likely were not seen due to a small sample size that resulted in the study being underpowered (Power < 0.8). The effect size for the time effect was large (partial $\eta^2 > 0.13$), while the time*group interaction and group effects were small (partial $\eta^2 = 0.004$ and 0.001, respectively). Mean values of cholesterol ratios for both groups increased from baseline to post-test (WG: week 0 = 3.9, week 12 = 4.3; BG: week 0 = 3.8, week 12 = 4.3), but these increases were not statistically significantly.

Summary of Results

A summary of the quantitative results included in the statistical analysis is provided below (Table 16).

Table 16. Baseline Values for Study Variables

Variable	Group[1]	n	Pre Mean (SD)	Post Mean (SD)
Physical Activity	WG	6	16.0 (8.3)	41.2 (37.8)
(accel. MVPA minutes)	BG	6	16.17 (13.1)	24.3 (18.4)
Physical Activity	WG	4	3181.5 (1740.7)	6931.3 (7532.7)
(pedometer steps)	BG	7	4497.0 (1330.6)	5404.1 (3518.5)
Sedentary Hours	WG	6	11.3 (1.2)	10.6 (1.6)
(accelerometer)	BG	6	11.9 (1.1)	11.6 (0.76)
Sedentary Time Breaks	WG	6	5.0 (2.1)	4.3 (1.4)
(accelerometer)	BG	6	6.5 (1.8)	6.0 (0.63)
Exercise Self-Efficacy	WG	5	4.4 (0.43)	4.3 (0.86)
	BG	4	4.9 (0.14)	4.1 (0.89)
Walking Self-Efficacy	WG	6	4.4 (0.39)	3.8 (0.85)
	BG	4	4.7 (0.29)	3.9 (0.54)
Sedentary Self-Efficacy	WG	6	4.4 (0.52)	3.8 (0.56)
	BG	5	4.9 (0.08)	4.2 (0.56)
Fasting blood Glucose	WG	6	129.7 (37.9)	124.5 (22.0)
	BG	7	154.7 (63.7)	152.1 (60.0)
Hemoglobin A1c	WG	7	7.5 (1.8)	6.2 (2.1)
	BG	7	8.8 (2.8)	7.0 (1.8)
Total/HDL Cholesterol	WG	6	3.9 (0.67)	4.3 (1.1)
	BG	7	3.8 (0.96)	4.3 (1.2)

[1] WG – Walking Group, BG – Breaks Group

Process Evaluation

Detailed records were kept through the duration of the study to evaluate the effectiveness of how the intervention was implemented. During the pretest visit, a checklist was made and kept for each visit for all participants. Important items of instruction and distribution of pedometers, accelerometers, and activity logs were tracked directly following each pretest visit. All participants received all materials and instruction as intended, and if any instructional points were missed, they were emailed to the participant later that same day. Emails were tracked with a time and date for each participant for each intervention point and reminder. Weekly motivational emails were tracked to ensure delivery and to determine whether participants read each email. All emails were confirmed to be delivered and a majority of them were confirmed as "read" by participants. The number of participants confirming that they read the emails tapered off as the program progressed and only about two to three participants consistently responded throughout the intervention to questions asked in the emails about self-efficacy and goals for improvement.

Accelerometers and pedometers were collected by the researcher or dropped off at the lab by participants. Most devices were received on the day appointed for collection after each measurement period. Two participants were required to wear the devices again during pre- and mid-testing due to insufficient wear-time or invalid data. At post-testing, three participants turned in measurement devices a month or more following measurement because of environmental and/or personal circumstances.

It appeared to be a difficult task for participants to turn in the walk and break logs throughout the study. There was a linear decrease in the number of participants who turned in walk logs over the duration of the study. This may have been due to the amount of effort required to write down total steps and breaks taken throughout the day and to email this log each week to the researchers. A more efficient tracking system that automatically tracks and transmits PA levels may address this issue in future studies.

Phone calls were made every other week during the intervention and interviews were conducted at the conclusion of the study. Of the 16 participants remaining at the conclusion of the study, six turned in the exit interview survey and comments were very brief. It appeared that throughout this intervention, the use of emails and online surveys were less effective than in-person contacts. It would take more time to administer surveys and interviews in person, but when participants in this study were allowed to complete them on their own time, the quality and completion rates were significantly lower than rates obtained during pilot testing.

Participants were generally satisfied with the intervention, but stated that it was hard to make time to meet the recommendations for the total amount of steps and breaks every day. Twenty-two participants volunteered and were eligible for the intervention. Six participants dropped out of the program due to non-compliance, personal injury, or inability to complete the entire program. During post-testing, inclement weather prevented three participants from completing post-test measures. Also, as the study began early in the year, it was cold and participants commented that it was difficult to walk outside because of the temperature. As the weather improved during the study, participants seemed more excited to get out and be active.

Chapter V: Conclusions

Hypotheses

The Research Hypotheses included:

H_R1: Participation in a 12-week minimal contact walking program for 12 weeks will result in a significantly greater increase in measures of self-efficacy (exercise and walking) pre- to post-intervention as compared to a 12-week breaks only intervention in inactive T2DM patients, while participation in a breaks only intervention will significantly increase measures of sedentary break self-efficacy pre- to post-intervention compared to a 12-week minimal contact walking program in inactive T2DM patients.

H_R2: Participation in a 12-week minimal contact walking program will result in a significantly greater increase in the number of steps/day, minutes in moderate and vigorous intensity PA, MET minutes associated with PA compared to a 12-week breaks only intervention in inactive T2DM patients, while participation in a breaks only intervention will significantly decrease sedentary time pre- to post-intervention compared to a 12-week minimal contact walking program in inactive T2DM patients.

H_R3: Participation in a 12-week minimal contact walking program will result in a significantly greater decrease fasting blood glucose, HbA1c, fasting blood lipids (Total/HDL) pre- to post-intervention as compared to a 12-week breaks only intervention in inactive T2DM patients.

H_R4: If there is a significant change in PA and sedentary time from pre-to post-intervention, exercise and walking self-efficacy will predict changes in PA level and sedentary self-efficacy will predict changes in sedentary time.

The null hypothesis was retained for all research questions except for changes in MVPA measured by accelerometer (time), sedentary break self-efficacy (time), and Hemoglobin A1c (time). Physical activity measured by accelerometer, combined across groups, increased following both interventions while pedometer and survey measured PA did not change. Sedentary break self-efficacy was significantly decreased for both groups combined, while the exercise and walking self-efficacy did not change. Hemoglobin A1c was significantly decreased across both groups combined following both interventions, while fasting glucose and total:HDL cholesterol did not change. Failure to identify significant differences between groups could have been due to an insufficient sample size, possible lack of adherence to all study protocols, and failure to complete all testing requirements.

Strengths and Limitations

There were many strong points to this 12-week walking intervention. A study that included the two intervention groups used in this study had not been attempted previously in participants with T2DM. Because of this, study results could be useful in understanding alternative methods of intervention to improve glycemic control. This minimal contact program did not require an extensive staff to administer the program, which is important for reducing time and costs in treating large numbers of patients. The design was community-based and could easily be replicated in a workplace or hospital setting. The design also allowed for all participants to participate in an intervention group as opposed to being randomized to a no-intervention, control group condition.

There were several limitations to this study that should be considered when planning future interventions. The three-month follow-up measure occurred on the first week of the fall semester, when many of the participants were highly involved in the academic environment. Because of that, data collected at that time point may not represent a normal lifestyle. Seasonal changes such as cold temperatures and tornadoes cannot be controlled, but did influence measurements and participation in the program. On the first day of post-testing a tornado in a neighboring city prevented two participants from being able to obtain their post-intervention measurements. Additionally, having some form of incentive could have allowed for a higher number of participants and increased retention and program adherence. Access to additional participants may have allowed for inclusion of a no-intervention control group. This was difficult because the blood draws were sponsored and paid for by the Healthy Sooners program and were therefore used to support OU faculty and staff and not other surrounding community members. This also required that blood draws were taken on pre-determined days, which prevented a rolling enrollment.

Significance of Study

This study was meaningful because it was the first to test the possible effect of an intervention that was designed to break up sedentary time in patients with T2DM compared to a “standard care” intervention (i.e. walking). A one-week feasibility study has been conducted to increase breaks in sedentary time, but this study assessed feasibility and impact of a three-month intervention with breaks assigned throughout the entire day for all sedentary time. Implications from this study could help guide future interventions focused on decreasing sedentary time in a manner more suitable to participants and/or allowing for additional options to intervene beyond a standard walking program.

Recommendations

Results from this 12-week walking intervention provide useful insights that can be applied in future programs. Physical activity as measured using multiple methods can be increased with a minimal contact walking program, but finding methods to facilitate maintenance of activity consistently throughout the entire program is essential. Methods of tracking behavior should be improved to minimize workload on participants and to allow for provision of more individualized feedback and motivation. Sending the same messages to everyone through emails did not appear to be effective because many of the participants said they became monotonous and they did not choose to look at them anymore.

Decreasing sedentary time may be less effective in impacting clinical outcomes than increasing PA. Many of the participants worked for a majority of the day at jobs in which taking many breaks to walk was not feasible. In phone conversations and interviews, they spoke about the stress of always thinking about the timing of their next break, which turned out to be a distraction. An alternative method may be needed to increase breaks during sedentary time.

By making the program more effective, the clinical and psychosocial variables would be more likely to improve significantly. If participants are able to consistently meet their intervention's recommendations and protocols (either increase PA or decrease sedentary time), they would be more likely to be able to improve their blood glucose and HbA1c levels. These study participants with T2DM were willing and excited to participate in this intervention and wanted to improve their health. Taking their suggestions and concerns into account when redesigning the intervention for future implementation and testing may produce more effective results.

Future Research Directions

Conclusions and recommendations from this study may help guide future research involving interventions designed to increase PA and/or decrease sedentary time in individuals with T2DM. Future interventions should be designed so that record keeping and behavioral tracking require less work on the part of the participants. This may result in better adherence. These changes could include the use of technology to track and transmit data from participants to a central database where that data could be viewed in real-time by the participant and the intervention/program staff. For example, devices such as the Jawbone UP25 and fitbit automatically transmit activity data via a smart phone to a central data site. These data can be viewed by the person wearing the device and may be shared with others. Future studies should provide compensation for participants in order to add incentive to both joining and remaining in the study so that an adequate sample size can be established.

Giving members of the BG a specific goal in terms of number of breaks/day and the length of breaks instead of just a recommendation to take breaks every hour of sitting time may also increase compliance. Taking breaks during sedentary time after work (i.e. watching television, computer time, etc.) may be easier to manage than taking breaks during the busiest times when people are at their jobs. Specifically, the intervention could be modified to recommend fewer but longer breaks during the working day.

Including participants in a pre-intervention focus group may also allow for increased adherence by allowing participants to suggest specific strategies that they would be willing to follow. Continued research will lead to more time and cost effective strategies to improve health and quality of life outcomes for patients with T2DM.

References

1. American Diabetes Association. http://www.diabetes.org/. Accessed May 28, 1012.
2. National Diabetes Fact Sheet, 2011. *2011 National Diabetes Fact Sheet.* 2011:1.
3. Winnick JJ, Sherman WM, Habash DL, et al. Short-term aerobic exercise training in obese humans with type 2 diabetes mellitus improves whole-body insulin sensitivity through gains in peripheral, not hepatic insulin sensitivity. *J Clin Endocrinol Metab.* Mar 2008;93(3):771-778.
4. Rogers MA. Acute effects of exercise on glucose tolerance in non-insulin-dependent diabetes. *Med Sci Sports Exerc.* Aug 1989;21(4):362-368.
5. Devlin JT, Hirshman M, Horton ED, Horton ES. Enhanced peripheral and splanchnic insulin sensitivity in NIDDM men after single bout of exercise. *Diabetes.* Apr 1987;36(4):434-439.
6. Rogers MA, Yamamoto C, King DS, Hagberg JM, Ehsani AA, Holloszy JO. Improvement in glucose tolerance after 1 wk of exercise in patients with mild NIDDM. *Diabetes Care.* Sep 1988;11(8):613-618.
7. Paternostro-Bayles M, Wing RR, Robertson RJ. Effect of life-style activity of varying duration on glycemic control in type II diabetic women. *Diabetes Care.* Jan 1989;12(1):34-37.
8. Boule NG, Haddad E, Kenny GP, Wells GA, Sigal RJ. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. *JAMA.* Sep 12 2001;286(10):1218-1227.

9. Swartz AM, Strath SJ, Bassett DR, et al. Increasing daily walking improves glucose tolerance in overweight women. *Prev Med.* Oct 2003;37(4):356-362.

10. Miyatake N, Nishikawa H, Morishita A, et al. Daily walking reduces visceral adipose tissue areas and improves insulin resistance in Japanese obese subjects. *Diabetes Res Clin Pract.* Nov 2002;58(2):101-107.

11. Mshunqane N, Cohen D, Kalk JK. Effects of an exercise programme on non-insulin dependant diabetes mellitus. *South African Journal of Physiotherapy.* 2004;60(4):26.

12. Shenoy S, Guglani R, Sandhu JS. Effectiveness of an aerobic walking program using heart rate monitor and pedometer on the parameters of diabetes control in Asian Indians with type 2 diabetes. *Prim Care Diabetes.* Apr 2010;4(1):41-45.

13. Albright A, Franz M, Hornsby G, et al. Exercise and type 2 diabetes. *Medicine & Science in Sports & Exercise.* 2000;32(7):1345-1360.

14. Hordern MD, Dunstan DW, Prins JB, Baker MK, Singh MA, Coombes JS. Exercise prescription for patients with type 2 diabetes and pre-diabetes: a position statement from Exercise and Sport Science Australia. *J Sci Med Sport.* Jan 2012;15(1):25-31.

15. Funk M, Taylor EL. Pedometer-based walking interventions for free-living adults with type 2 diabetes: a systematic review. *Current Diabetes Reviews.* 2013;9(6):462-471.

16. Tudor-Locke C, Bell RC, Myers AM, et al. Controlled outcome evaluation of the First Step Program: a daily physical activity intervention for individuals with type II diabetes. *Int J Obesity.* Jan 2004;28(1):113-119.

17. Vincent D. Culturally tailored education to promote lifestyle change in Mexican Americans with type 2 diabetes. *J Am Acad Nurse Pract.* Sep 2009;21(9):520-527.

18. Johnson ST, Bell GJ, McCargar LJ, Welsh RS, Bell RC. Improved cardiovascular health following a progressive walking and dietary intervention for type 2 diabetes. *Diabetes Obes Metab.* Sep 2009;11(9):836-843.

19. Diedrich A, Munroe DJ, Romano M. Promoting physical activity for persons with diabetes. *Diabetes Educ.* Jan-Feb 2010;36(1):132-140.

20. De Greef K, Deforche B, Tudor-Locke C, De Bourdeaudhuij I. Increasing physical activity in Belgian type 2 diabetes patients: a three-arm randomized controlled trial. *Int J Behav Med.* Sep 2011;18(3):188-198.

21. De Greef KP, Deforche BI, Ruige JB, et al. The effects of a pedometer-based behavioral modification program with telephone support on physical activity and sedentary behavior in type 2 diabetes patients. *Patient Educ Couns.* Aug 2011;84(2):275-279.

22. Engel L, Lindner H. Impact of using a pedometer on time spent walking in older adults with type 2 diabetes. *Diabetes Educator.* Jan-Feb 2006;32(1):98-107.

23. Bjorgaas MR, Vik JT, Stolen T, Lydersen S, Grill V. Regular use of pedometer does not enhance beneficial outcomes in a physical activity intervention study in type 2 diabetes mellitus. *Metabolism-Clinical and Experimental.* May 2008;57(5):605-611.

24. Katzmarzyk PT. Physical activity, sedentary behavior, and health: paradigm paralysis or paradigm shift? *Diabetes.* 2010;59(11):2717-2725.

25. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc.* Sep 2000;32(9 Suppl):S498-504.

26. Owen N, Sugiyama T, Eakin EE, Gardiner PA, Tremblay MS, Sallis JF. Theme: The science of sedentary behavior: Adults' Sedentary Behavior. Determinants and Interventions. *American Journal of Preventive Medicine.* 2011;41:189-196.

27. Gardiner PA, Eakin EG, Healy GN, Owen N. Feasibility of reducing older adults' sedentary time. *Am J Prev Med.* Aug 2011;41(2):174-177.

28. De Greef KP, Deforche BI, Ruige JB, et al. The effects of a pedometer-based behavioral modification program with telephone support on physical activity and sedentary behavior in type 2 diabetes patients. *Patient Education & Counseling.* 2011;84(2):275-279.

29. Chen KY, Bassett DR, Jr. The technology of accelerometry-based activity monitors: current and future. *Med Sci Sports Exerc.* Nov 2005;37(11 Suppl):S490-500.

30. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* Mar-Apr 1985;100(2):126-131.

31. Bassett DR, Jr., Ainsworth BE, Leggett SR, et al. Accuracy of five electronic pedometers for measuring distance walked. *Med Sci Sports Exerc.* Aug 1996;28(8):1071-1077.

32. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc.* May 2009;41(5):998-1005.

33. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review.* 1977;84:191-215.

34. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care.* 2004;27(5):1047-1053.

35. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. *Diabetes Care.* 1998;21(9):1414-1431.

36. Economic costs of diabetes in the U.S. in 2012. *Diabetes Care.* 2013;36(4):1033-1046.

37. Nyenwe EA, Jerkins TW, Umpierrez GE, Kitabchi AE. Management of type 2 diabetes: evolving strategies for the treatment of patients with type 2 diabetes. *Metabolism.* 2011;60:1-23.

38. Inzucchi SE, Bergenstal RM, Buse JB, et al. Management of Hyperglycemia in Type 2 Diabetes: A Patient-Centered Approach: Position Statement of the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care.* 2012;35(6):1364-1379.

39. Funnell MM, Brown TL, Childs BP, et al. National Standards for diabetes self-management education. *Diabetes Care.* 2011;34:S89-96.

40. Cheong SH, McCargar LJ, Paty BW, Tudor-Locke C, Bell RC. The First Step First Bite Program: Guidance to Increase Physical Activity and Daily Intake of Low–Glycemic Index Foods. *Journal of the American Dietetic Association.* 2009;109(8):1411-1416.

41. Goldhaber-Fiebert JD, Goldhaber-Fiebert SN, Tristan ML, Nathan DM. Randomized controlled community-based nutrition and exercise intervention improves glycemia and cardiovascular risk factors in type 2 diabetic patients in rural Costa Rica. *Diabetes Care.* Jan 2003;26(1):24-29.

42. Van Rooijen AJ, Christa MV, Piet JB. A daily physical activity and diet intervention for individuals with type 2 diabetes mellitus: a randomized controlled trial. *South African Journal of Physiotherapy.* 2010;66(2):9-16.

43. Yamanouchi K, Shinozaki T, Chikada K, et al. Daily walking combined with diet therapy is a useful means for obese NIDDM patients not only to reduce body weight but also to improve insulin sensitivity. *Diabetes Care.* 1995;18(6):775-778.

44. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States, 2000. *JAMA: Journal of the American Medical Association.* 2004;291(10):1238-1245.

45. *Physical activity and health : a report of the Surgeon General.* Atlanta, Georgia, U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion : President's Council on Physical Fitness and Sports ; Pittsburgh, PA.; 1996.

46. Centers for Disease Control and Prevention. http://apps.nccd.cdc.gov/brfss/index.asp. Accessed June 8, 2012.

47. Pratt M, Macera CA, Wang G. Higher direct medical costs associated with physical inactivity. *Physician & Sportsmedicine.* 2000;28(10):63.

48. Morris JN, Heady JA, Raffle PA, Roberts CG, Parks JW. Coronary heart-disease and physical activity of work. *Lancet.* 1953;265(6795):1053-1057.

49. Paffenbarger RS, Wing AL, Hyde RT. Physical activity as an index of heart attack risk in college alumni. *American Journal of Epidemiology.* 1978;108(3):161-175.

50. 2008 Physical Activity Guidelines for Americans. U.S. Department of Health and Human Services. Washingon DC, U.S.: Government Printing Office; 2008.

51. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation.* 2007;116(9):1081-1093.

52. Wei M, Gibbons LW, Kampert JB, Nichaman MZ, Blair SN. Low cardiorespiratory fitness and physical inactivity as predictors of mortality in men with type 2 diabetes. *Ann Intern Med.* Apr 18 2000;132(8):605-611.

53. Lakka TA, Laaksonen DE. Physical activity in prevention and treatment of the metabolic syndrome. *Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme.* Feb 2007;32(1):76-88.

54. Dutton GR, Johnson J, Whitehead D, Bodenlos JS, Brantley PJ. Barriers to physical activity among predominantly low-income African-American patients with type 2 diabetes. *Diabetes Care.* May 2005;28(5):1209-1210.

55. Pham DT, Fortin F, Thibaudeau MF. The role of the Health Belief Model in amputees' self-evaluation of adherence to diabetes self-care behaviors. *Diabetes Educ.* Mar-Apr 1996;22(2):126-132.

56. Ford ES, Heath GW, Mannino DM, Redd SC. Leisure-time physical activity patterns among US adults with asthma. *Chest.* Aug 2003;124(2):432-437.

57. Hays LM, Clark DO. Correlates of physical activity in a sample of older adults with type 2 diabetes. *Diabetes Care.* May 1999;22(5):706-712.

58. Di Loreto C, Fanelli C, Lucidi P. Make your diabetic patients walk; long-term impact of different amounts of physical activity on type 2 diabetes. *Diabetes Care.* 2005;28:1295-1302.

59. Hamilton MT, Hamilton DG, Zderic TW. Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc Sport Sci Rev.* Oct 2004;32(4):161-166.

60. Sedentary Behaviour Research N. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". *Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme.* 2012;37(3):540-542.

61. Owen N, Healy GN, Matthews CE, Dunstan DW. Too Much Sitting: The Population Health Science of Sedentary Behavior. *Exercise & Sport Sciences Reviews.* 2010;38(3):105-113.

62. Hu FB, Li TY, Colditz GA, Willett WC, Manson JE. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes

mellitus in women. *JAMA: Journal of the American Medical Association.* 2003;289(14):1785-1791.

63. Dunstan DW, Barr EL, Healy GN, et al. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation.* Jan 26 2010;121(3):384-391.

64. Ekelund U, Brage S, Froberg K, et al. TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study. *PLoS Med.* Dec 2006;3(12):e488.

65. Healy GN, Dunstan DW, Salmon J, et al. Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care.* Apr 2008;31(4):661-666.

66. Sisson SB, Camhi SM, Church TS, et al. Leisure time sedentary behavior, occupational/domestic physical activity, and metabolic syndrome in U.S. men and women. *Metab Syndr Relat Disord.* Dec 2009;7(6):529-536.

67. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev.* Jul 2010;38(3):105-113.

68. Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes.* Nov 2007;56(11):2655-2667.

69. Bey L, Hamilton MT. Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity. *J Physiol.* Sep 1 2003;551(Pt 2):673-682.

70. Bouchard C. Physical inactivity and health: Introduction to the dose-response symposium. Vol 332001:S347-S350.

71. Kesaniemi YA, Danforth Jr E, Jensen MD, Kopelman PG, Lefebvre P, Reeder BA. Dose-response issues concerning physical activity and health: an evidence-based symposium. / Problemes de la relation dose-effet concernant l ' activite physique et la sante: un congres base sur des observations. *Medicine & Science in Sports & Exercise.* 2001;33(6 Suppl):S351-s358.

72. Kitajima S, Morimoto M, Liu E, et al. Overexpression of lipoprotein lipase improves insulin resistance induced by a high-fat diet in transgenic rabbits. *Diabetologia.* Jul 2004;47(7):1202-1209.

73. Koike T, Liang J, Wang X, et al. Overexpression of lipoprotein lipase in transgenic Watanabe heritable hyperlipidemic rabbits improves hyperlipidemia and obesity. *J Biol Chem.* Feb 27 2004;279(9):7521-7529.

74. Alicia AT, Neville O, Maike N, David WD. Theme: The science of sedentary behavior: Sedentary Behaviors and Subsequent Health Outcomes in Adults. A Systematic Review of Longitudinal Studies, 1996–2011. *American Journal of Preventive Medicine.* 2011;41:207-215.

75. Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity.* 2008;5(56).

76. Guiraud T, Granger R, Gremeaux V, et al. Original article / Article original: Accelerometer as a tool to assess sedentarity and adherence to physical activity

recommendations after cardiac rehabilitation program. *L'accéléromètre comme outil d'évaluation de la sédentarité et de l'observance aux recommandations d'activité physique après un programme de rééducation cardiaque (French).*

77. Chen KY, Bassett DR, Jr. The technology of accelerometry-based activity monitors: current and future. *Medicine & Science in Sports & Exercise.* 2005;37(11):S490-500.

78. Tudor-Locke CE, Myers AM. Challenges and opportunities for measuring physical activity in sedentary adults. *Sports Med.* Feb 2001;31(2):91-100.

79. Schneider PL, Crouter SE, Lukajic O, Bassett DR, Jr. Accuracy and reliability of 10 pedometers for measuring steps over a 400-m walk. *Med Sci Sports Exerc.* Oct 2003;35(10):1779-1784.

80. Tudor-Locke C, Williams JE, Reis JP, Pluto D. Utility of pedometers for assessing physical activity: convergent validity. *Sports Med.* 2002;32(12):795-808.

81. Bravata DM, Smith-Spangler C, Sundaram V, et al. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA.* Nov 21 2007;298(19):2296-2304.

82. Tudor-Locke C. *Taking steps toward increased physical activity [electronic resource] : using pedometers to measure and motivate.* Washington, D.C. : President's Council on Physical Fitness and Sports, [2002]; 2002.

83. Schneider PL, Crouter SE, Bassett DR. Pedometer measures of free-living physical activity: comparison of 13 models. *Med Sci Sports Exerc.* Feb 2004;36(2):331-335.

84. Crouter SE, Schneider PL, Karabulut M, Bassett DR, Jr. Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. *Med Sci Sports Exerc.* Aug 2003;35(8):1455-1460.

85. Swartz AM, Bassett DR, Jr., Moore JB, Thompson DL, Strath SJ. Effects of body mass index on the accuracy of an electronic pedometer. *Int J Sports Med.* Nov 2003;24(8):588-592.

86. Sallis JF, Saelens BE. Assessment of physical activity by self-report: status, limitations, and future directions. *Research Quarterly for Exercise & Sport.* 2000;71(2 Suppl):1-7.

87. Ainsworth BE, Montoye HJ, Leon AS. Methods of assessing physical activity during leisure and work. *In, Bouchard, C. (ed.) et. al., Physical activity, fitness and health: international proceedings and consensus statement, Champaign, Ill, Human Kinetics Publishers, 1994, p. 146-159.* United States1994.

88. Warnecke RB, Johnson TP, Chavez N, et al. Improving question wording in surveys of culturally diverse populations. *Annals of epidemiology.* Jul 1997;7(5):334-342.

89. Baranowski T. Validity and Reliability of Self Report Measures of Physical-Activity - an Information-Processing Perspective. *Res Q Exercise Sport.* Dec 1988;59(4):314-327.

90. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise.*2003, 35(8):1381-1395.

91. Marshall SJ, Merchant G. Advancing the science of sedentary behavior measurement. *American Journal Of Preventive Medicine.* 2013;44(2):190-191.

92. Lyden K, Petruski N, Mix S, Staudenmayer J, Freedson P. Direct Observation is a Valid Criterion for Estimating Physical Activity and Sedentary Behavior. *Journal Of Physical Activity & Health.* 2013.

93. Kozey-Keadle S, Libertine A, Lyden K, Staudenmayer J, Freedson PS. Validation of wearable monitors for assessing sedentary behavior. *Medicine And Science In Sports And Exercise.* 2011;43(8):1561-1567.

94. Moreau KL, Degarmo R, Langley J, et al. Increasing daily walking lowers blood pressure in postmenopausal women. *Medicine & Science in Sports & Exercise.* 2001;33(11):1825-1831.

95. Chan CB, Ryan D, Tudor-Locke C. Health benefits of a pedometer-based physical activity intervention in sedentary workers. *Preventive Medicine.* 2004;39:1215-1222.

96. Hultquist CN, Albright C, Thompson DL. Comparison of walking recommendations in previously inactive women. *Medicine & Science in Sports & Exercise.* 2005;37(4):676-683.

97. Wilson DB, Porter JS, Parker G, Kilpatrick J. Anthropometric Changes Using a Walking Intervention in African American Breast Cancer Survivors: A Pilot Study. *Preventing Chronic Disease.* 2005(2).

98. Richardson CR, Buis LR, Janney AW, et al. An online community improves adherence in an internet-mediated walking program. Part 1: results of a randomized controlled trial. *J Med Internet Res.* 2010;12(4):e71.

99. Walker KZ, Piers LS, Putt RS, Jones JA, O'Dea K. Effects of regular walking on cardiovascular risk factors and body composition in normoglycemic women and women with type 2 diabetes. *Diabetes Care.* Apr 1999;22(4):555-561.

100. McKay HG, King D, Eakin EG, Seeley JR, Glasgow RE. The diabetes network internet-based physical activity intervention: a randomized pilot study. *Diabetes Care.* Aug 2001;24(8):1328-1334.

101. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. 2002.

102. van Rooijen AJ, Rheeder P, Eales CJ, Becker PJ. Effect of exercise versus relaxation on haemoglobin A1C in Black females with type 2 diabetes mellitus. *QJM : monthly journal of the Association of Physicians.* Jun 2004;97(6):343-351.

103. Praet SF, van Rooij ES, Wijtvliet A, et al. Brisk walking compared with an individualised medical fitness programme for patients with type 2 diabetes: a randomised controlled trial. *Diabetologia.* May 2008;51(5):736-746.

104. Furber S, Monger C, Franco L, et al. The effectiveness of a brief intervention using a pedometer and step-recording diary in promoting physical activity in people diagnosed with type 2 diabetes or impaired glucose tolerance. *Health promotion journal of Australia : official journal of Australian Association of Health Promotion Professionals.* Dec 2008;19(3):189-195.

105. Hordern MD, Coombes JS, Cooney LM, Jeffriess L, Prins JB, Marwick TH. Effects of exercise intervention on myocardial function in type 2 diabetes. *Heart.* Aug 2009;95(16):1343-1349.

106. Morton RD, West DJ, Stephens JW, Bain SC, Bracken RM. Heart rate prescribed walking training improves cardiorespiratory fitness but not glycaemic control in people with type 2 diabetes. *Journal Of Sports Sciences.* 2010;28(1):93-99.

107. Negri C, Bacchi E, Morgante S, et al. Supervised walking groups to increase physical activity in type 2 diabetic patients. *Diabetes Care.* Nov 2010;33(11):2333-2335.

108. Araiza P, Hewes H, Gashetewa C, Vella CA, Burge MR. Efficacy of a pedometer-based physical activity program on parameters of diabetes control in type 2 diabetes mellitus. *Metabolism.* Oct 2006;55(10):1382-1387.

109. Richardson CR, Mehari KS, McIntyre LG, et al. A randomized trial comparing structured and lifestyle goals in an internet-mediated walking program for people with type 2 diabetes. *Int J Behav Nutr Phys Act.* 2007;4:59.

110. Brawley LR. The practicality of using social psychological theories for exercise and health research and intervention. *Journal of Applied Sport Psychology.* 1993;5(2):99-115.

111. Marks DF. The quest for meaningful theory in health psychology. *Journal of Health Psychology*. 2008;13(8):977-981.

112. Painter JE, Borba CPC, Hynes M, Mays D, Glanz K. The use of theory in health behavior research from 2000 to 2005: A systematic review. *Annals of Behavioral Medicine.* Jun 2008;35(3):358-362.

113. Bandura A. Health promotion by social cognitive means. *Health Education & Behavior.* 2004;31(2):143-164.

114. Glanz K, Rimer BK, Lewis FM, eds. *Health Behavior and Health Education.* Third ed: Jossey-Bass; 2002.

115. Leary MR, Tangney JP. *Handbook of self and identity / edited by Mark R. Leary, June Price Tangney.* New York : Guilford Press, c2012.

2nd ed.; 2012.

116. Laviolle B, Froger-Bompas C, Guillo P, et al. Relative validity and reproducibility of a 14-item semi-quantitative food frequency questionnaire for cardiovascular prevention. *Eur J Cardiovasc Prev Rehabil.* 2005;12:587-595.

117. Sallis JF, Pinski RB, Grossman RM, Patterson TL, Nader PR. The development of self-efficacy scales for health- related diet and exercise behaviors. *Health Education Research.* 1988;3(3):283.

118. Miyake M. Relation of generalized self-efficacy to changes in task-specific self-efficacy. *Jpn J Educ Psychol.* Mar 2000;48(1):42-51.

119. Nieman DC. *Exercise testing and prescription: a health related approach. 5th ed.* Boston; United States: McGraw-Hill; 2003.

120. Volgyi E, Tylavsky FA, Lyytikainen A, Suominen H, Alen M, Cheng S. Assessing body composition with DXA and bioimpedance: effects of obesity, physical activity, and age. *Obesity (Silver Spring).* Mar 2008;16(3):700-705.

121. Mally K, Trentmann J, Heller M, Dittmar M. Reliability and accuracy of segmental bioelectrical impedance analysis for assessing muscle and fat mass in older Europeans: a comparison with dual-energy X-ray absorptiometry. *European journal of applied physiology.* Aug 2011;111(8):1879-1887.

122. Herman Hansen B, Børtnes I, Hildebrand M, Holme I, Kolle E, Anderssen SA. Validity of the ActiGraph GT1M during walking and cycling. *Journal Of Sports Sciences.* 2013.

123. Silva P, Mota J, Esliger D, Welk G. Technical Reliability Assessment of the Actigraph GT1M Accelerometer. *Measurement in Physical Education & Exercise Science.* 2010;14(2):79-91.

124. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine And Science In Sports And Exercise.* 1998;30(5):777-781.

125. Cunningham JB, McCrum-Gardner E. Power, effect and sample size using GPower: practical issues for researchers and members of research ethics committees. *Evidence Based Midwifery.* 2007;5(4):132-136.

126. Cohen J. *Statistical power analysis for the behavioral sciences (2nd ed.).* New York: Academic Press; 1988.

127. De Greef K, Deforche B, Tudor-Locke C, De Bourdeaudhuij I. A cognitive-behavioural pedometer-based group intervention on physical activity and sedentary behaviour in individuals with type 2 diabetes. *Health Education Research.* 2010;25(5):724-736.

128. Rzewnicki R, Vanden Auweele Y, De Bourdeaudhuij I. Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutrition.* 2003;6(3):299-305.

Appendix A: Demographics Survey

Demographics Survey

Please answer the following questions honestly and to the best of your ability.

1. What is your current age? _____
2. What is your gender?
    a. Male
    b. female
3. What do you perceive to be your ethnicity? (Check all that apply)
    a. White
    b. Black or African American
    c. Asian
    d. Native Hawaiian or Other Pacific Islander
    e. American Indian or Native Alaskan
    f. Hispanic or Latino
4. What is your annual household income from all sources?
    a. Less than $10,000
    b. $10,000 to less than $15,000
    c. $15,000 to less than $20,000
    d. $20,000 to less than $25,000
    e. $25,000 to less than $35,000
    f. $35,000 to less than $50,000
    g. $50,000 to less than $75,000
    h. $75,000 or more
5. What is the highest grade or year of school you completed?
    a. Never attended school or only attended kindergarten
    b. Grades 1-8 (elementary)
    c. Grades 9-11 (some high school)
    d. Grade 12 or GED (High school graduate)
    e. College 1 year to 3 years (some college)
    f. College 4 years or more (college graduate)
6. What is your marital status?
    a. Married
    b. Divorced
    c. Widowed
    d. Separated
    e. Never married
    f. Member of an unmarried couple
7. Do you currently smoke? YES / NO
    a. If YES, how many years have you smoked? _________
        i. If you have quit smoking, how many years did you smoke _________
        ii. How many months/years ago did you quit? _________

Appendix B: Health History Form

Health History Form

Functional Performance Laboratory

Department of Health & Exercise Science - University of Oklahoma

ID#: ____________________________ **Date:** ____________________________

Gender M F **Age:** ____________________________

Please consider each question carefully and answer every question honestly.

1. In general how would you describe your current, overall state of health?
   a. Excellent b. Good
   c. Fair d. Poor
2. Do you currently have any of the following have been diagnosed by health professional?
   a. Heart trouble
   b. Chronic asthma or bronchitis
   c. High blood pressure
   d. Back problem
   e. Cataract or other vision disorder
   f. Osteoporosis
   g. Parkinsons
   h. Stroke
   i. Diabetes
   j. Foot problem
   k. Arthritis
   l. severe arthritis
   m. Other health problems
   Specify _______________
3. Are you currently limited in the type or amount of physical activity (work or leisure) you can do because of injury, illness or disability?
   a. No
   b. Yes, because of temporary illness (example: flu or fracture)
   Please specify: ____________________________
   c. Yes, because of long term illness, injury or disability (example: arthritis, diabetes, heart disease, back problem) Please specify:
   ____
4. Has a physician ever said you have a heart condition and you should only do physical activity recommended by a physician?
   a. Yes b. No
5. When you are physically active, do you feel pain in your chest?
   a. Yes b. No
6. Do you ever lose you consciousness or do you lose your balance because of dizziness?
   a. Yes b. No
7. Do you have a joint or bone problem that may be made worse by a change in your physical activity?
   a. Yes b. No
8. Has your doctor ever told you that you should limit lifting or stair climbing?

a. Yes b. No

9. Has your physician prescribed medication for blood pressure or a heart condition?
   a. Yes b. No
10. Are you currently enrolled in any other physical activity classes or groups?
    a. No
    b. Yes What type: ______________________________
    Number of times per week: ________________

If you have answered yes to any of the above question, you may be required to obtain clearance from your doctor BEFORE you can volunteer for this study. We can assist you in this process. If you have answered no to all questions, you can be reasonably positive that you can safely participate without physical risk. However, if you are concerned, we encourage you to obtain clearance to participate from your physician.

I have read these items carefully and answered all questions truthfully.
Participants Signature: ________________________________
Date: ____________________

Appendix C: Diabetes History

Please answer the following questions honestly and to the best of your ability.

1. What type of diabetes do you have?
   a. Type 1
   b. Type 2
   c. Other

2. How long have you been diagnosed with diabetes? ______________________

3. Do you currently take medications for diabetes treatment? YES / NO

   If yes, please list below:

   ____

   ____

   ____

   ____

4. Do you currently take insulin as part of your treatment? YES / NO

Appendix D: Food Frequency Questionnaire

Food Frequency Questionnaire – Please answer the questions about your diet over the past seven (7) days honestly and to the best of your ability.

1. Do you eat cheese (1 portion = 1/8 of a camembert = 30 g)?
   - ☐ Less than 2 portions a week
   - ☐ 3 to 6 portions a week
   - ☐ 1 portion a day
   - ☐ 2 portions a day
   - ☐ 3 or more portions a day

2. Do you eat red meat (apart from poultry) or variety meats (liver, kidneys…)?
   - ☐ Less than 3 times a week
   - ☐ 3 to 6 times a week
   - ☐ 7 or more times a week

3. Do you eat fresh or canned fish (such as canned sardines or tuna)?
   - ☐ Less than once a week
   - ☐ Once a week
   - ☐ 2 to 3 times a week
   - ☐ 4 or more times a week

4. Do you eat delicatessen (including sausages, cassoulet, sauerkraut with its trimmings) except lean ham?
   - ☐ Less than twice a week
   - ☐ 2 to 3 times a week
   - ☐ 4 to 6 times a week
   - ☐ 7 or more times a week

5. Do you eat salted pies, pizzas, rolls or commercial sandwiches?
   - ☐ Less than twice a week
   - ☐ 2 to 3 times a week
   - ☐ 4 or more times a week

6. Do you eat French fries?

   Frequency: ………a week
   - ☐ Home made French fries cooked with vegetable oil, kind of oil:………………………..
   - ☐ Home made French fries cooked with solid fat (Vegetaline®…)
   - ☐ Oven cooked frozen French fries
   - ☐ Restaurants or fast food French fries

7. Do you eat viennoiseries, cakes and pastries?
   - ☐ Less than twice a week
   - ☐ 2 to 4 times a week
   - ☐ 5 or more times a week

8. Do you eat fruit or fruit juice (1 portion = 1 averaged fruit = 1 glass of 200 ml fruit juice)?
   - ☐ Less than 3 portions a week
   - ☐ 3 to 6 portions a week
   - ☐ 7 to 13 portions a week (at least 1 fruit a day)
   - ☐ 14 or more portions a week (at least 2 fruits a day)

9. At present, do you eat nuts?
   - ☐ Yes, daily consumption:…………………………………………..
   - ☐ No

10. Do you eat cooked vegetables or vegetable soup (1 portion = 1 plate or 1 bowl)?
    - ☐ Less than 3 portions a week
    - ☐ 3 to 7 portions a week
    - ☐ 8 or more portions a week

11. Do you eat raw vegetables or salads?
    - ☐ Less than 3 portions a week
    - ☐ 3 to 7 portions a week
    - ☐ 8 or more portions a week

12. Do you eat butter and cream (1 portion = 1 individual block of 10 to 15 g)?
    - ☐ Never
    - ☐ Raw, 1 portion a day
    - ☐ Raw, 2 portions a day
    - ☐ Raw, 3 portions a day
    - ☐ Raw and used for cooking (that is to say more than 3 portions a day)

13. Apart from butter, do you use other kinds of fat (like margarine)?

To spread, to season your cooked dishes?

- ☐ No
- ☐ Yes, kind of fat:……………………………………
  - 1 meal a day (that is 1 individual block)
  - 2 meals a day (that is 2 individual blocks)
  - 3 or more portions a day (more than 3 individual blocks)

For cooking?

- ☐ No
- ☐ Yes, kind of fat:……………………………………
  - 1 meal a day (that is 1 individual block)
  - 2 meals a day (that is 2 individual blocks)

14. Do you eat oil?

For cooking?

- ☐ No
- ☐ Yes, kind of oil:……………………………………
  - 1 meal a day (about 1 tablespoon)
  - 2 meals a day (about 2 tablespoons)

For salad dressing?

- ☐ No
- ☐ Yes, kind of oil:……………………………………
  - Once a day (about 1 tablespoon)
  - Twice a day (about 2 tablespoons)
  - 3 or more times a day (more than 2 tablespoons)

Appendix E: Exercise Confidence Survey

Below is a list of things people might do while trying to increase or continue regular exercise. We are interested in exercises like running, swimming, brisk walking, bicycle riding, or aerobics classes.

Whether you exercise or not, please rate how confident you are that you could really motivate yourself to do things like these consistently, *for at least six months*.

Please circle one number for each question.
How sure are you that you can do these things?

I know I Maybe I I know I
Does not
cannot can can
apply

21.	Get up early, even on weekends, to exercise.	1	2	3	4	5
22.	Stick to your exercise program after a long, tiring day at work.	1	2	3	4	5
23.	Exercise even though you are feeling depressed.	1	2	3	4	5
24.	Set aside time for a physical activity program; that is, walking, jogging. swimming, biking, or other continuous activities for at least 30 minutes, 3 times per week.	1	2	3	4	5
25.	Continue to exercise with others even though they seem too fast or too slow for you.	1	2	3	4	5
26.	Stick to your exercise program when undergoing a stressful life change (e.g., divorce, death in the family, moving).	1	2	3	4	5
27.	Attend a party only after exercising.	1	2	3	4	5
28.	Stick to your exercise program when your family is demanding more time from you.	1	2	3	4	5
29.	Stick to your exercise program when you have household chores to attend to.	1	2	3	4	5
30.	Stick to your exercise program even when you have excessive demands at work.	1	2	3	4	5
31.	Stick to your exercise program when social obligations are very time consuming.	1	2	3	4	5
32.	Read or study less in order to exercise more.	1	2	3	4	5

Reference: Sallis JF, Pinski RB, Grossman RM, Patterson TL, Nader PR. The development of self-efficacy scales for health- related diet and exercise behaviors. *Health Education Research.* 1988;3(3):283.

Appendix F: Vigorous Walking Confidence Survey

Below is a list of things people might do while trying to increase or continue vigorous walking. We are interested in planned and unplanned vigorous walking in bouts of at least 10 minutes.

Whether you walk vigorously or not, please rate how confident you are that you could really motivate yourself to do things like these consistently, *for at least six months*.

Please circle one number for each question.
How sure are you that you can do these things?

		I know I cannot		Maybe I can		I know I can	Does not apply
21.	Get up early, even on weekends, to walk vigorously.	1	2	3	4	5	
22.	Stick to your vigorous walking program after a long, tiring day at work.	1	2	3	4	5	
23.	Walk vigorously even though you are feeling depressed.	1	2	3	4	5	
24.	Set aside time for a physical activity program; that is, walking, jogging. swimming, biking, or other continuous activities for at least 30 minutes, 3 times per week.	1	2	3	4	5	
25.	Continue to walk vigorously with others even though they seem too fast or too slow for you.	1	2	3	4	5	
26.	Stick to your vigorous walking program when undergoing a stressful life change (e.g., divorce, death in the family, moving).	1	2	3	4	5	
27.	Attend a party only after walking vigorously.	1	2	3	4	5	
28.	Stick to your vigorous walking program when your family is demanding more time from you.	1	2	3	4	5	
29.	Stick to your vigorous walking program when you have household chores to attend to.	1	2	3	4	5	
30.	Stick to your vigorous walking program even when you have excessive demands at work.	1	2	3	4	5	
31.	Stick to your vigorous walking program when social obligations are very time consuming.	1	2	3	4	5	
32.	Read or study less in order to get more vigorous walking.	1	2	3	4	5	

Reference: Modified from Exercise Confidence Survey (Appendix E)

Appendix G: Sedentary Behavior Confidence Survey

Below is a list of things people might do while trying to increase or continue taking breaks to interrupt sedentary time. We are interested in planned and unplanned breaks of at least 2 minutes for every half hour of sedentary time (i.e., sitting, watching TV, sitting in a vehicle, sitting at a desk or computer).

Whether you interrupt your breaks or not, please rate how confident you are that you could really motivate yourself to do things like these consistently, *for at least six months*.

Please circle one number for each question.
How sure are you that you can do these things?

		I know I cannot		Maybe I can		I know I can	Does not apply
21.	Interrupt sitting comfortably on the couch watching your favorite TV show or movie to stand or take a break.	1	2	3	4	5	
22.	Stick to your plan to take a break every half hour, even during a tiring day at work.	1	2	3	4	5	
23.	Get up and take a break even though you are feeling depressed.	1	2	3	4	5	
24.	Making a clear commitment to take a break in your sedentary behavior (i.e., standing up, taking a walk, getting a drink, going to the bathroom) for at least 2 minutes every half hour.	1	2	3	4	5	
25.	Continue to take a break every half hour even though your friends never move from a sitting position all day.	1	2	3	4	5	
26.	Stick to your plan to get up every half hour when undergoing a stressful life change (e.g., divorce, death in the family, moving).	1	2	3	4	5	
27.	Do something fun only if you have taken breaks in your sitting time throughout the day.	1	2	3	4	5	
28.	Stick to your plan to get up every half hour when your family environment does not make it easy.	1	2	3	4	5	
29.	Stick to your plan to get up every half hour when you have household chores that require you to sit.	1	2	3	4	5	
30.	Stick to your plan to take a break every half hour even when you have excessive demands at work.	1	2	3	4	5	
31.	Stick to your plan of standing up and taking a break every half hour when your friends or family are all sedentary.	1	2	3	4	5	
32.	Read or study less in order to take a break in your sedentary time.	1	2	3	4	5	

Reference: Modified from Exercise Confidence Survey (Appendix E)

Appendix H: IPAQ – Long Form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (October 2002)

LONG LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L.

(2000). *Assessment of Physical Activity: An International Perspective.* Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

   ☐ Yes

   ☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

   _____ **days per week**

   ☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

   _____ **hours per day**

   _____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity ➡ ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**

_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking ➡ ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**

_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle ➡ ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**

_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**

_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days *walking* ***from place to place?***

_____ **hours per day**

_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**

_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**

_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**

_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**

_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**

_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ **hours per day**

_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**

_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**

_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.

Appendix I: Walk Log

STEP LOG

Pedometer Data Sheet for Week ___

The overall goal of the program is to get **10,000 steps/day**. You also need to include **at least 30 minutes** of moderate intensity (breathing hard, increased heart rate, exertion) walking on **at least 5 days/week**. You are encouraged to walk more than that if you are able, and the walking sessions can be broken up into bouts of at least 10 minutes in length. If you haven't reached that goal of 10,000 steps yet, it is time to set your weekly step goal! To do this, use your average steps per day from last week and increase that by 1,000 steps to determine what your minimum step goal should be this coming week. Write it down below. Make sure you fill out the table below every day.

My goal is to take _________ steps each day this week.

Day	Time On (am/pm)	Time Off (am/pm)	Total Steps	Calib. Steps	Glucose	Comments
1						
2						
3						
4						
5						
6						
7						

* Reset your pedometer at the end of each day.
* If you did not wear your pedometer at any time during a day, write "Did not wear from (time of day) to (time of day)" or "Did not wear at all" in the "**Comments**" section.
* If you exercise in a form other than walking, your pedometer may not reflect the amount of activity you did. If you do an activity that you do not feel is accurately measured with a pedometer (biking, for example), please indicate what you did in the "**Comments**" section
* If you have questions, comments or concerns, please contact Merrill at the Department of Health and Exercise Sciences University of Oklahoma Norman Campus at 405-325-1372 or merrillfunk@ou.edu

Appendix J: Break Log

WALK LOG

Data Sheet for Week ___

You should take at least a 2 minute break (walk around) for every hour where you are sedentary (watching TV, computer time, sitting). Make a mark every time you take a break. The breaks should include at least 2 minutes of continuous, moderate intensity walking (not including just going to the bathroom, getting a drink, etc. unless you have to walk for 2 minutes to get there). Also record your daily fasting glucose levels and an approximate number of hours you were sitting each day.

Day	2min. breaks/ 30 mins.	Sitting Hours	Fasting Glucose	Comments
1				
2				
3				
4				
5				
6				
7				

* If you exercise or sit an unusual amount more than usual please make a brief note of what you did in the "**Comments**" section
* If you have questions, comments or concerns, please contact Merrill at the Department of Health and Exercise Sciences University of Oklahoma Norman Campus at 405-325-1372 or **merrillfunk@ou.edu**

Appendix K: Weekly Emails

Walking-Only E-mails

*Emails were piloted during two 8-week walking programs for adults at risk for type II diabetes and cardiovascular disease.

Week 1

Hello___________!
As part of the walking program you are participating in, you will be receiving weekly emails from me. I hope you will be able to use the tips I include each week. Thank you so much for your participation! Have a great week and don't forget to fill out your Activity Log this week!

- **Physical Activity**: It can be helpful to set goals about choosing physical activity instead of another activity (like watching TV). An example would be to set a goal of substituting a short walk for your least favorite TV show. It may be helpful to set a specific time and/or a place each day that you are able to walk.

What strategy could you use next week to be successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 2

Hey guys!

I hope your week went well last week. Make sure you turn in the Activity Log each week as soon as you finish every Sunday. Just a reminder, don't forget to fill out your Activity Log this week!

- **Physical Activity:** When you are trying to achieve your weekly goals for walking time, choose a specific time that you feel confident that you can achieve but try to make an improvement from what you are doing now to reach the specified goal. Remember, the overall goal is to get 10,000 steps per day as soon as possible.

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 3

Hey_________!
I hope your week is going well, and don't forget to fill out your Step Log this week! Here is the tip for this week:

- **Reward:** When you reach your daily goal for walking this week, choose a small reward for yourself that you will do or get if you achieve your goal every day. The reward can be something that you go buy like that book you have been wanting to read or something that is free like a nice bubble bath.

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 4

Hey everyone!

I hope your week is going well so far (especially if you have Spring break). Make sure you turn in the Step Log from last week if you haven't! Have a great week and don't forget to fill out your log this week! I will likely be calling on Monday of next week because many are out of the office this week.

- **Physical Activity:** Remember to be getting those steps in EVERY DAY! Keep on improving! Invite a friend or family member on a walk with you. It will give you somebody to talk to. Who knows, it may become a routine for both of you!

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 5

Hey everyone!
I hope your week is going well! Make sure you turn in the Activity Log from last week if you haven't already done so. Have a great week and don't forget to fill out your Activity Log this week!

- **Physical Activity:** You have passed the four-week mark and are still working hard! When the weeks get difficult and you don't think you can finish, look at your past weeks and remember your best week yet! Keep moving no matter what! Any progress is good progress!

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!
REMINDER: At the end of week 6 (next week) I will email everyone and will be passing out the accelerometers for our mid-test measure which will take place during week 7.

Merrill Funk

Week 6

Hey everyone!
I hope this week is going well and you are looking forward to nice weather this weekend! Make sure you turn in the Activity Log from last week if you haven't yet. Have a great rest of the week!

- **Physical Activity:** Look at how far you have come! You have gone for half of the program now and are still doing GREAT! Keep sticking with your walking just as you have been doing for the past month! Keep up the good work!
- **Remember:** Any improvement is good!!

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 7

Hi everyone!
I hope your week is going awesome now that the weather is nice. Make sure you turn in the Activity Log from last week if you haven't already.
Here is your tip for the week:

- **Physical Activity:** Don't compare your walking to other people. Instead, compete with yourself. Do better this week than you did last week. Do better today than you did yesterday! Any progress is good!

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful remainder of your week!

Merrill Funk

Week 8

Hey guys!
Thanks for wearing the accelerometers again! I hope your week is going well this week. Make sure you turn in the Activity Log from last week if you haven't yet. Have a great week and don't forget to fill out your Activity Log this week!

- **Physical Activity:** Although walking is considered such a great form of exercise due to its ease and flexibility, any exercise program is difficult to begin and maintain. Even if you aren't as active as you would like to be, you are still reading the emails. That means you are still headed in the right direction. You have accomplished something great by starting this program and I encourage you to keep pushing forward!

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful rest of your week!

Merrill Funk

Week 9

Hey everyone!
I hope your week is going great! A quick reminder to turn in the Activity Log from last week if you haven't already.
Here is your tip for the week:

- **Physical Activity:** Think ahead as this program nears the end. Schedule your walking into your day and set goals for when you have walked 3, 5, 10 or even 20 days in a row. Then you can look back and see your successes and see your habit forming.

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have an awesome rest of your week!

Merrill Funk

Week 10

Good Afternoon Everyone!
I hope your week is going wonderfully. Make sure you turn in the Activity Log from last week if you haven't already. Just a quick thought for today,

- **Physical Activity:** Remember, don't compare your walking to other people. Instead, compete with yourself.

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation and have a great rest of your week!

Merrill Funk

Week 11

Hey Everyone!
It was great to talk to all of yall these last couple days! I hope your week is going wonderfully. Make sure you turn in the Activity Log from last week if you haven't already. Just a quick thought for today,

- **Physical Activity:** You are now about to start your last week and you have accomplished something great. Even though you may or may not have achieved the goals you set in the beginning, you are still reading these emails, which means you still care about your fitness journey! Remember that long-term change is usually a slow process done with small, consistent steps in the right direction.

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful weekend!

Merrill Funk

Week 12

Hey Everyone,
I hope your final week is going well! Make sure you turn in the Activity Log from last week if you haven't already. Here is a thought for this week and a couple reminders:

- **Physical Activity:** Although walking is considered such a great form of exercise due to its ease and flexibility, any exercise program is difficult to begin and maintain. I say, you have accomplished something great by starting this program and I encourage you to continue your journey!
- **Remember to wear the accelerometer each day through Sunday (at least 10hrs/day for it to count)**
- **Blood draws next week (I'll send another reminder the day before) and that is where you will bring the accelerometer**
- **Remember to finish the surveys this weekend if you can**

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! See you next week!

Merrill Funk

Appendix L: Weekly Emails

Breaks Only E-mails

*Emails were created specifically for this intervention based on the walking emails (Appendix K).

Week 1

Hello___________!
As part of the walking program you are participating in, you will be receiving weekly emails from me. I hope you will be able to use the tips I include each week. Thank you so much for your participation! Just a reminder, don't forget to fill out your Walk Log this week!
Here is your tip for this week!

- It could be helpful to use a device such as a timer or watch to beep once an hour as you are sitting at work or at home to remind you to get up and take a 2 minute walk.

What strategy could you use next week to be successful in reaching your goal to reduce sitting time?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 2

Hey guys!

I hope your week went well last week. Make sure you turn in the Activity Log each week as soon as you finish every Sunday. Just a reminder, don't forget to fill out your Activity Log this week!

Here are your tips for this week!

Computer Use: When you are using the computer at work**,** try setting an alarm to remind you to move after a specified period of time. At home, you can also start a load of laundry so that you have to get up periodically while working at the computer. It is also helpful to avoid playing games on computer for a long time. Do the best you can!

Were you successful at taking breaks every half hour of sedentary time?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful rest of your week!

Merrill Funk

Week 3

Hey everyone!
I hope your week is going well so far, and don't forget to fill out your Walk Log this week!
Here is your tip for this week!

- **Reading:** When you are sitting reading, try standing up and walking after you have finished a chapter or a section of the newspaper.

Were you successful at taking breaks every hour of sedentary time?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 4

Hey everyone!
I hope your week is going well! Make sure you turn in the Log from last week if you haven't, and don't forget to fill out your Activity Log this week! I will likely be calling on Monday of next week because many are out of the office this week.

Here are your tips for this week!

- **Socializing:** When socializing, stand up and get refreshments for others instead of waiting for them to serve you. Tell your friends and family as well about the study so they can remind you to get up and move. Try walking while talking on the telephone. It could also be better to walk to visit coworkers' desks instead of calling them on the telephone.

Were you successful at taking breaks every half hour of sedentary time?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 5

Hi everyone!
I hope your week is going well! Make sure you turn in the Activity Log from last week if you haven't done so already. Just a reminder, don't forget to fill out your Activity Log this week!
Here are your tips for this week!

- **Physical Activity:** You have passed the four-week mark and are still working hard! When the weeks get difficult and you don't think you can finish, look at your past weeks and remember your best week yet! Keep moving no matter what! Any progress is good progress!

- **Hobbies:** When you are busy having fun with puzzles or doing crafts like cutting fabric for quilting or if you are sitting at an easel to paint, try interrupting these hobbies by standing up and moving around. When listening to music, try walking around or dancing. Just make it a habit!

Were you successful at taking breaks every half hour of sedentary time?
Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!
REMINDER: At the end of week 6 (next week) I will email everyone and will be passing out the accelerometers for our mid-test measure which will take place during week 7.

Merrill Funk

Week 6

Hey everyone!
I hope this week is going well and you are looking forward to nice weather this weekend! Make sure you turn in the Activity Log from last week if you haven't yet. Have a great rest of the week!
Here are your tips for this week!

- **Physical Activity:** Look at how far you have come! You have completed half of the program now and are still doing GREAT! Keep sticking with your walking just as you have been doing for the past 6 weeks! Keep up the good work!
- **Remember:** Any improvement is good!!

Were you successful at taking breaks every half hour of sedentary time?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 7

Hi everyone!
I hope your week is going awesome now that the weather is nice. Make sure you turn in the Activity Log from last week if you haven't already.
Here are your tips for this week!

- **Household Activities:** When doing household chores, try splitting-up these chores and extending the time it takes to complete each task to allow for more breaks (e.g., put away each item of ironing after completion, doing small parts of cleaning in segments). Try also using your free time to do the chores that you have been avoiding (e.g., walking to deliver or pick up something).

Were you successful at taking breaks every half hour of sedentary time?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful remainder of your week!

Merrill Funk

Week 8

Hey guys!
Thanks for wearing the accelerometers again! I hope your week is going well this week. Make sure you turn in the Activity Log from last week if you haven't yet. Have a great week and don't forget to fill out your Activity Log this week!
Here are your tips for this week!

- Although walking is considered such a great form of exercise due to its ease and flexibility, any exercise program is difficult to begin and maintain. Even if you aren't as active as you would like to be, you are still reading the emails. That means you are still headed in the right direction. You have accomplished something great by starting this program and I encourage you to keep pushing forward!

Were you successful at taking breaks every half hour of sedentary time?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful week!

Merrill Funk

Week 9

Hey everyone!

I hope your week is going great! A quick reminder to turn in the Activity Log from last week if you haven't already.

Here is your tip for the week:

- **Goal Setting:** Think ahead as this program nears the end. Schedule your breaks into your day as much as you can and set goals for when you have reached a certain number of breaks on 3, 5, 10 or even 20 days in a row. Then you can look back and see your past successes and see your habit forming.

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have an awesome rest of your week!

Merrill Funk

Week 10

Good Afternoon Everyone!

I hope your week is going wonderfully. Make sure you turn in the Activity Log from last week if you haven't already. Just a quick thought for today,

- **Breaks:** Remember, don't compare how active you are to other people. Instead, compete with yourself.

Were you successful in achieving last week's goal?

Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?

If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?

Please e-mail your response back to me as soon as you are able. Thank you so much for your participation and have a great rest of your week!

Merrill Funk

Week 11

Hey Everyone!
It was great to talk to all of ya'll these last couple days! I hope your week is going wonderfully. Make sure you turn in the Activity Log from last week if you haven't already. Just a quick thought for today,

- **Breaks:** You are now about to start your last week and you have accomplished something great. Even though you may or may not have achieved the goals you set in the beginning, you are still reading these emails, which means you still care about your fitness journey! Remember that long-term change is usually a slow process done with small, consistent steps in the right direction.

Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful

If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! Have a wonderful weekend!

Merrill Funk

Week 12

Hey Everyone,

I hope your final week is going well! Make sure you turn in the Activity Log from last week if you haven't already. Here is a thought for this week and a couple reminders:

- **Physical Activity:** Although walking is considered such a great form of exercise due to its ease and flexibility, any exercise program is difficult to begin and maintain. I say, you have accomplished something great by starting this program and I encourage you to continue your journey!
- **Remember to wear the accelerometer each day through Sunday (at least 10hrs/day for it to count)**
- **Blood draws next week (I'll send another reminder the day before) and that is where you will bring the accelerometer**
- **Remember to finish the surveys this weekend if you can**

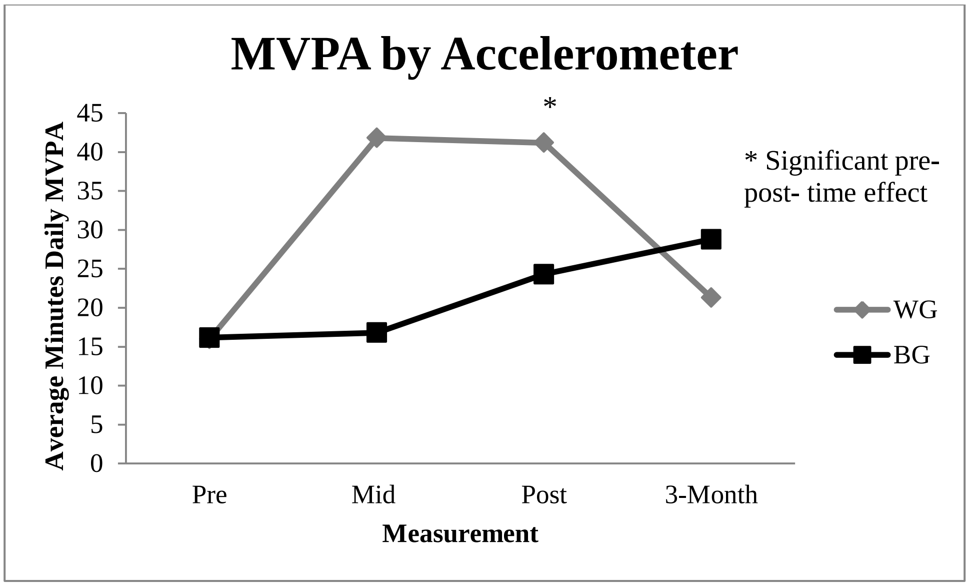
Were you successful in achieving last week's goal?
Unsuccessful 1 2 3 4 5 Successful
If successful, what strategies did you use to reach your goal?
If unsuccessful, what strategy could you use next week to be more successful in reaching your walking goal?
Please e-mail your response back to me as soon as you are able. Thank you so much for your participation! See you next week!
Merrill Funk

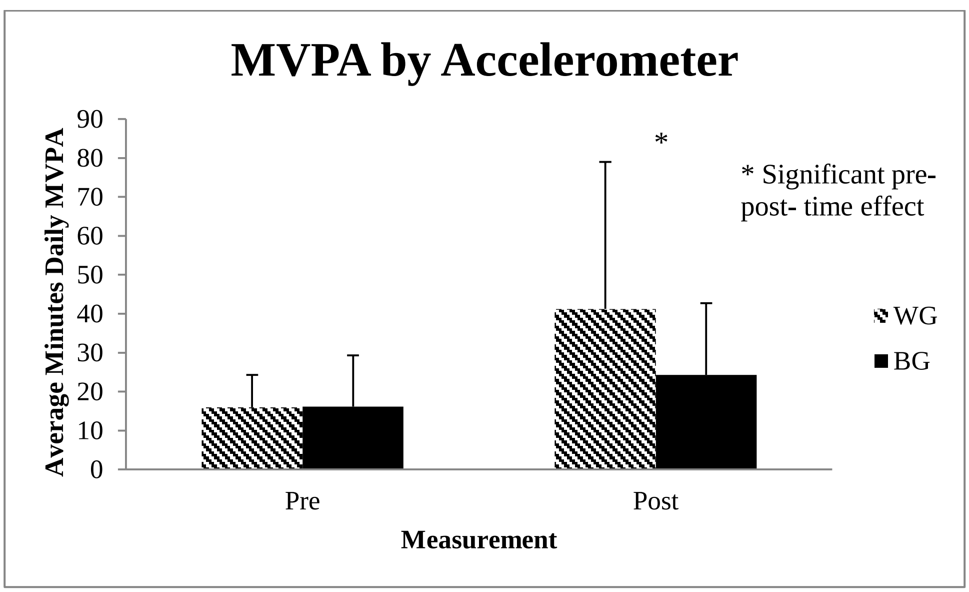
Appendix M

Accelerometer average moderate/vigorous minutes of PA per day

Participant Number/Group	(Pre) Week 0	(Mid) Week 7	(Post) Week 12	(Follow-up) 3-months post
1	63			
2BG	11	13	28	18
3BG	12	9	12	7
4WG	32	75	83	48
5WG	15	27	12	15
6WG		12	13	
7WG	12	19	15	12
8BG				
9				
10BG				
11BG	7	10	10	49
12WG	21	32		
13BG	32			65
14BG	29			
15BG	42	40	53	61
16BG	17	16	37	33
17BG	8	13	6	5
18WG	8	20	12	3
19WG		9		
20				
21WG	16	45	30	35
22WG	13	65	95	15
Walking Mean (SD)	16.0 (8.3)	41.8 (23.9)	41.2 (37.8)	21.3 (16.7)
Breaks Mean (SD)	16.17 (13.1)	16.8 (11.6)	24.3 (18.4)	28.8 (22.9)
Combined Mean (SD)	16.1 (10.5)	29.3 (22.2)	32.8 (29.7)	25.1 (19.5)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.
Dark shaded regions represent baseline values due to missing data.


MVPA by Accelerometer
Average Minutes Daily MVPA
45
40
35
30
25
20
15
10
5
0
*
* Significant pre-post- time effect
WG
BG
Pre
Mid
Post
3-Month
Measurement

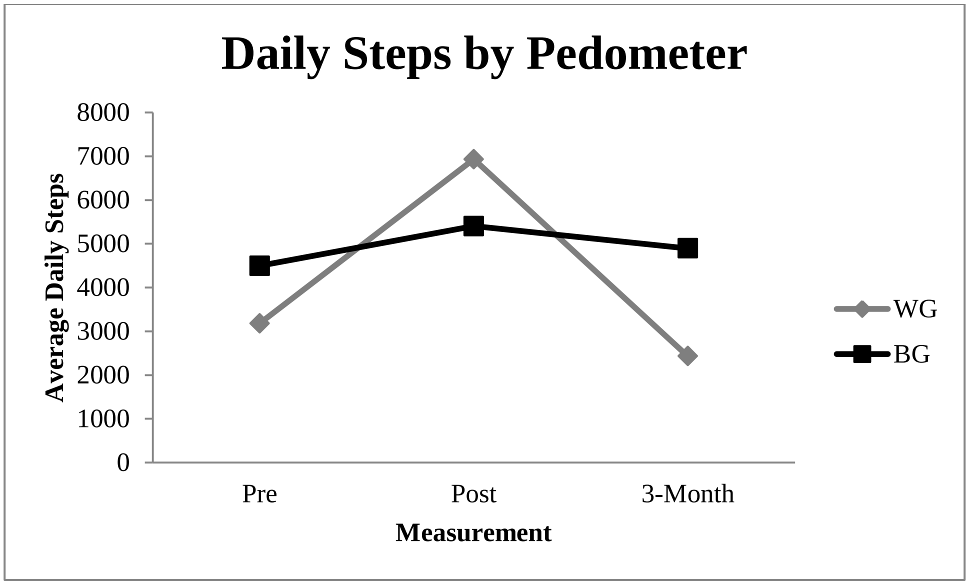

MVPA by Accelerometer
Average Minutes Daily MVPA
90
80
70
60
50
40
30
20
10
0
*
* Significant pre-post- time effect
WG
BG
Pre
Post
Measurement

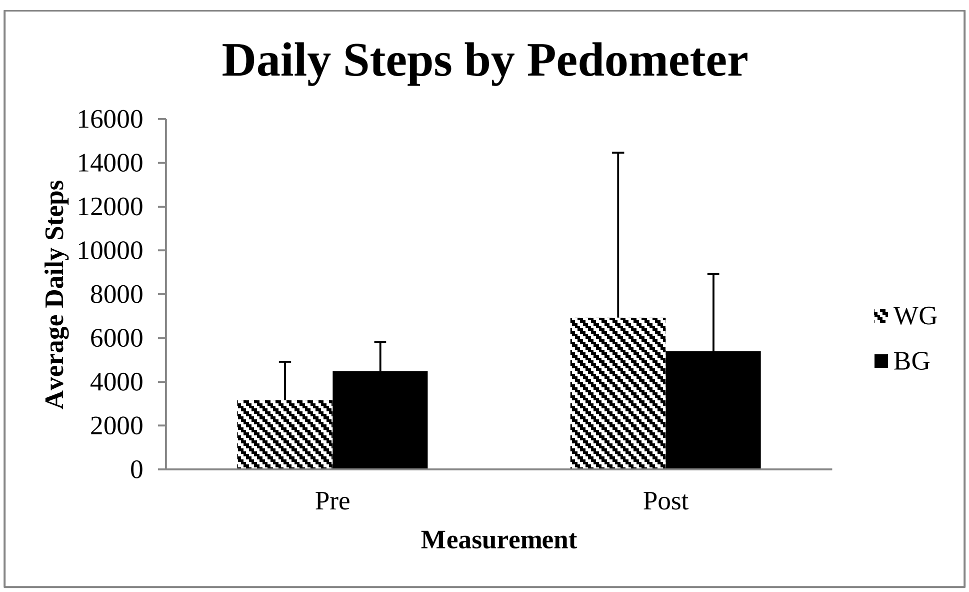
Appendix N

Average pedometer step counts during measurement periods

Participant Number/Group	(Pre) Week 0	(Mid) Week 7	(Post) Week 12	(Follow-up) 3-months post
1				
2BG	4698	4224	2857	6248
3BG	4386	4454	4522	3679
4WG	6362			6459
5WG	6199			
6WG	1474	902	1914	1474
7WG	3981	6155	2185	1774
8BG	8306			
9				
10BG				
11BG	4222		3365	9232
12WG	5446	5231		
13BG	3881		3302	2471
14BG				
15BG	6981		9880	6225
16BG	2531	988	2852	2688
17BG	4780		11051	3719
18WG	4375			1933
19WG				
20				
21WG	2035	5695	5695	3563
22WG	5236	8702	17931	2907
Walking Mean (SD)	3181.5 (1740.7)		6931.3 (7532.7)	2429.5 (975.6)
Breaks Mean (SD)	4497.0 (1330.6)		5404.1 (3518.5)	4894.6 (2450.1)
Combined Mean (SD)	4018.6 (1553.0)		5959.5 (5004.4)	3998.2 (2331.1)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.
Dark shaded regions represent baseline value (for participant 6) and mid value (for participant 21) due to missing data.


Daily Steps by Pedometer
8000
7000
6000
5000
4000
3000
2000
1000
0
Average Daily Steps
Pre
Post
3-Month
Measurement
WG
BG


Daily Steps by Pedometer
16000
14000
12000
10000
8000
6000
4000
2000
0
Average Daily Steps
Pre
Post
Measurement
WG
BG

Appendix O

Average steps per day on walk logs (walking group only)

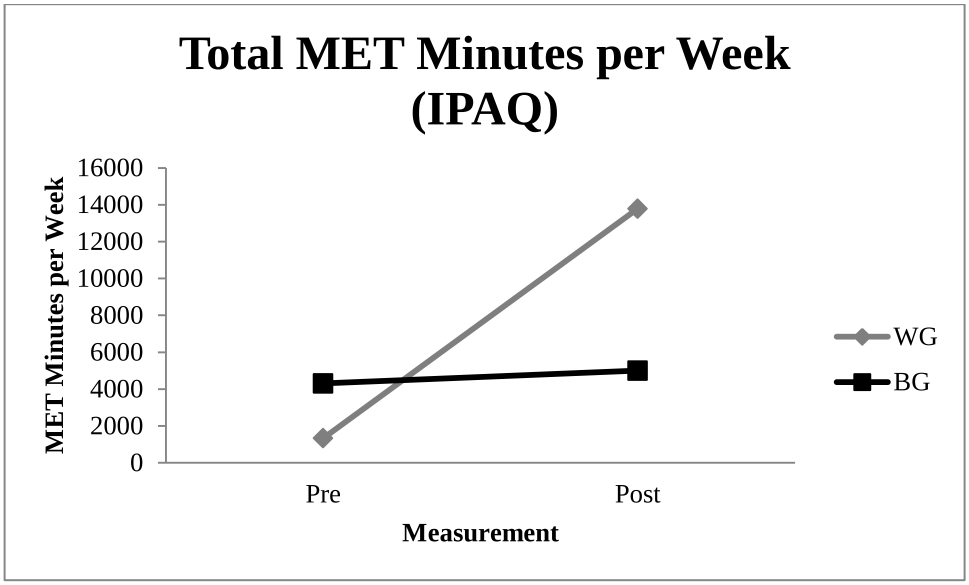
Participant #	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
4	6889	8511	8663	8661	9753	9932		10177	10716	10812		
5	8999	9166	10478	10069								
6	2372	2647	2756	1903	2394	1522	2309	1619	2179	1621	2368	
7	4714	4941	7633	7170	6328	5705	6155	7495	8762			
12	3628	4788	4163	4425	4245	3890	5246		3287			1914
18	5113	5113							6292	5475	6271	
21	2943	5554	4474	3651	5876	5891	5695	5670	5060	5814	5153	
22		8843	12883	10763	11925	9600	8702	12514	13418	12992	14378	17931

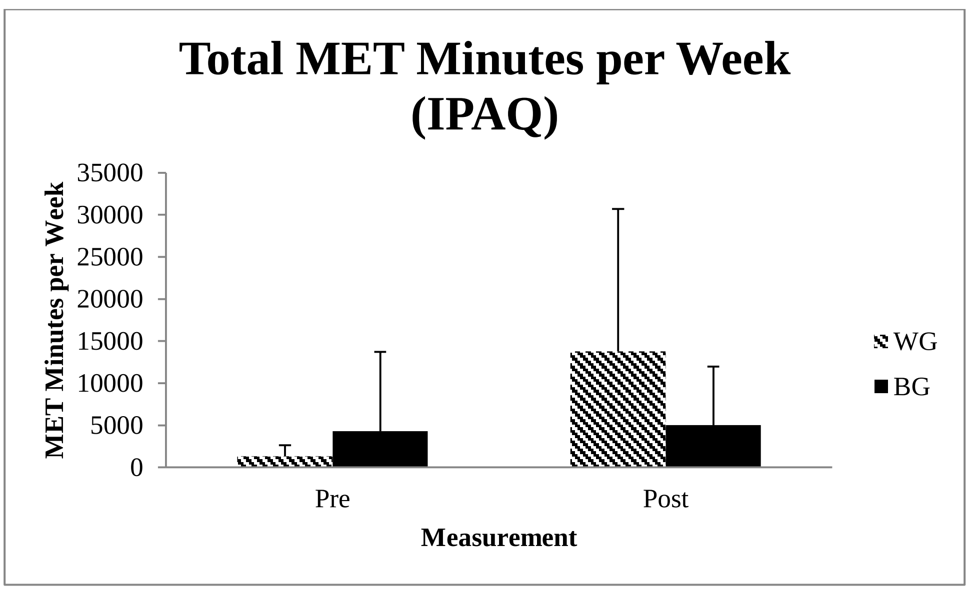
Appendix P

Total moderate/vigorous MET-minutes per week

Participant Number/Group	(Pre) Week 0	(Post) Week 12
1	548	
2BG	180	673
3BG	424	585
4WG	330	924
5WG	450	840
6WG		1968
7WG	60	
8BG		
9		
10BG	10805	
11BG	180	960
12WG	3358	11184
13BG	23495	18120
14BG	594	
15BG	582	1943
16BG	975	7740
17BG	945	
18WG	855	28860
19WG	270	
20		
21WG	453	778
22WG	2580	40135
Walking Mean (SD)	1337.7 (1299.5)	13786.8 (16914.5)
Breaks Mean (SD)	4305.9 (9405.1)	5003.5 (6978.9)
Combined Mean (SD)	2821.8 (6586.2)	9395.2 (13161.5)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.
About 500 MET-minutes per week is equal to 30 minutes of walking or higher intensity activity on 5 days per week. (walking = 3.3METs, moderate activity = 4.0METs, vigorous activity = 8.0METs)


Total MET Minutes per Week (IPAQ)
MET Minutes per Week
16000
14000
12000
10000
8000
6000
4000
2000
0
Pre
Post
Measurement
WG
BG

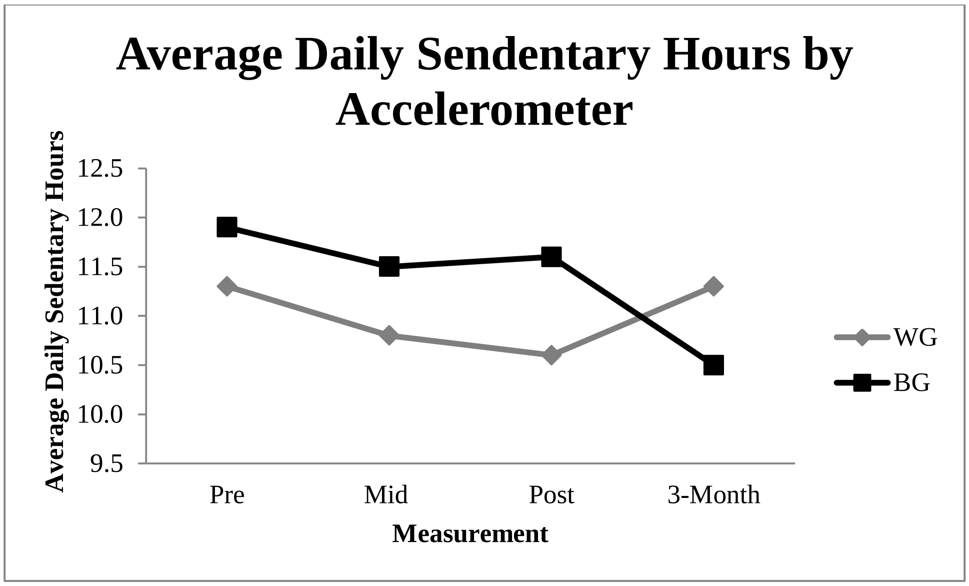

Total MET Minutes per Week (IPAQ)
MET Minutes per Week
35000
30000
25000
20000
15000
10000
5000
0
Pre
Post
Measurement
WG
BG

Appendix Q

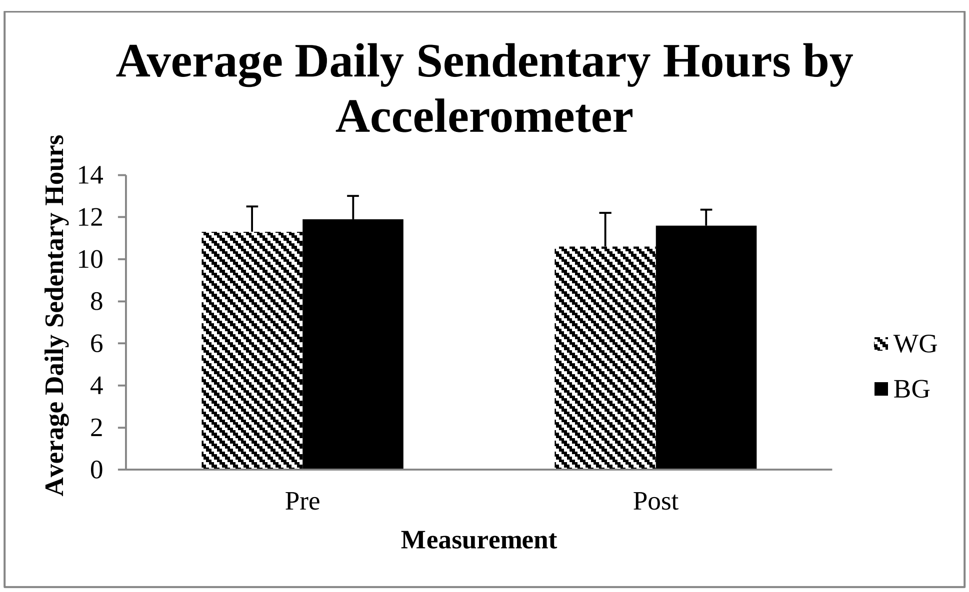
Accelerometer sedentary hours (average per day)

Participant Number/Group	(Pre) Week 0	(Mid) Week 7	(Post) Week 12	(Follow-up) 3-months post
1	10.6			
2BG	13.1	11.7	12.4	11.8
3BG	12.0	11.0	11.4	10.2
4WG	9.9	8.9	9.1	9.7
5WG	12.7	12.9	12.2	12.7
6WG		9.6	9.8	
7WG	12.8	11.9	10.5	12.8
8BG				
9				
10BG				
11BG	9.9	12.5	11.5	10.4
12WG	9.4	9.0		
13BG	9.9			9.8
14BG	9.5			
15BG	12.7	11.0	11.0	9.9
16BG	12.2	11.6	12.6	10.5
17BG	11.7	11.2	10.7	10.1
18WG	10.3	9.1	10.4	10.0
19WG		12.5		
20				
21WG	10.8	11.8	12.5	11.3
22WG	11.5	10.4	8.7	11.2
Walking Mean (SD)	11.3 (1.2)	10.8 (1.6)	10.6 (1.6)	11.3 (1.3)
Breaks Mean (SD)	11.9 (1.1)	11.5 (0.57)	11.6 (0.76)	10.5 (0.68)
Combined Mean (SD)	11.6 (1.2)	11.2 (1.2)	11.1 (1.3)	10.9 (1.1)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.
Dark shaded regions represent baseline values due to missing data.



Average Daily Sendentary Hours by Accelerometer
Average Daily Sedentary Hours
12.5
12.0
11.5
11.0
10.5
10.0
9.5
Pre
Mid
Post
3-Month
Measurement
WG
BG



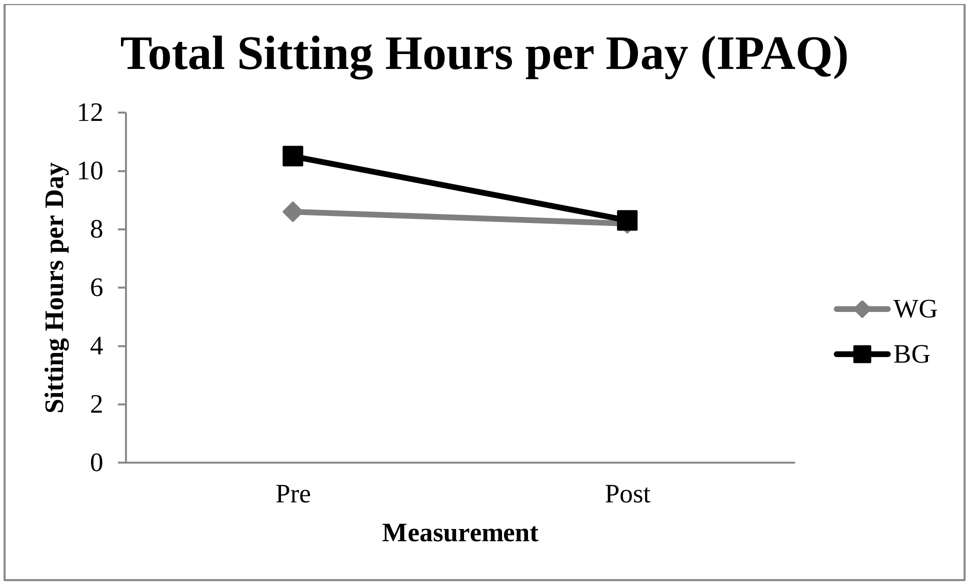
Average Daily Sendentary Hours by Accelerometer
Average Daily Sedentary Hours
14
12
10
8
6
4
2
0
Pre
Post
Measurement
WG
BG

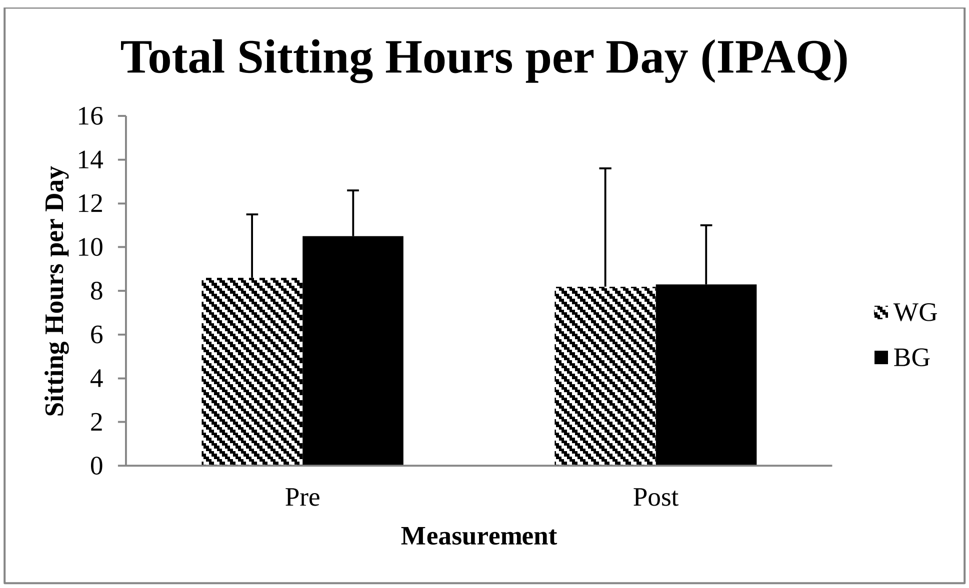
Appendix R

Individual sitting hours with IPAQ (average per day)

Participant Number/Group	(Pre) Week 0	(Post) Week 12
1	8.9	
2BG	12.5	12.4
3BG	12.1	10.1
4WG	7.3	6.6
5WG	11.4	6.4
6WG	8.0	8.0
7WG	7.9	
8BG	13.1	
9		
10BG	2.6	
11BG	10.0	8.9
12WG	7.9	7.4
13BG	6.9	5.1
14BG	6.3	
15BG	10.0	7.7
16BG	11.6	5.7
17BG	9.0	
18WG	3.4	3.7
19WG	4.0	
20		
21WG	10.3	5.0
22WG	12.0	20.0
Walking Mean (SD)	8.6 (2.9)	8.2 (5.4)
Breaks Mean (SD)	10.5 (2.1)	8.3 (2.7)
Combined Mean (SD)	9.5 (2.7)	8.2 (4.2)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Total Sitting Hours per Day (IPAQ)
Sitting Hours per Day
0
2
4
6
8
10
12
Pre
Post
Measurement
WG
BG

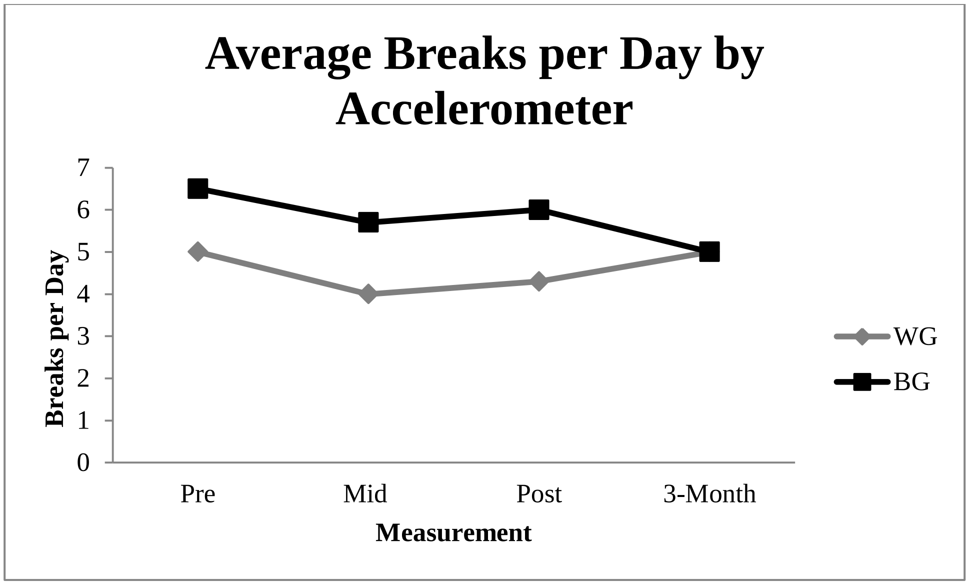

Total Sitting Hours per Day (IPAQ)
Sitting Hours per Day
0
2
4
6
8
10
12
14
16
Pre
Post
Measurement
WG
BG

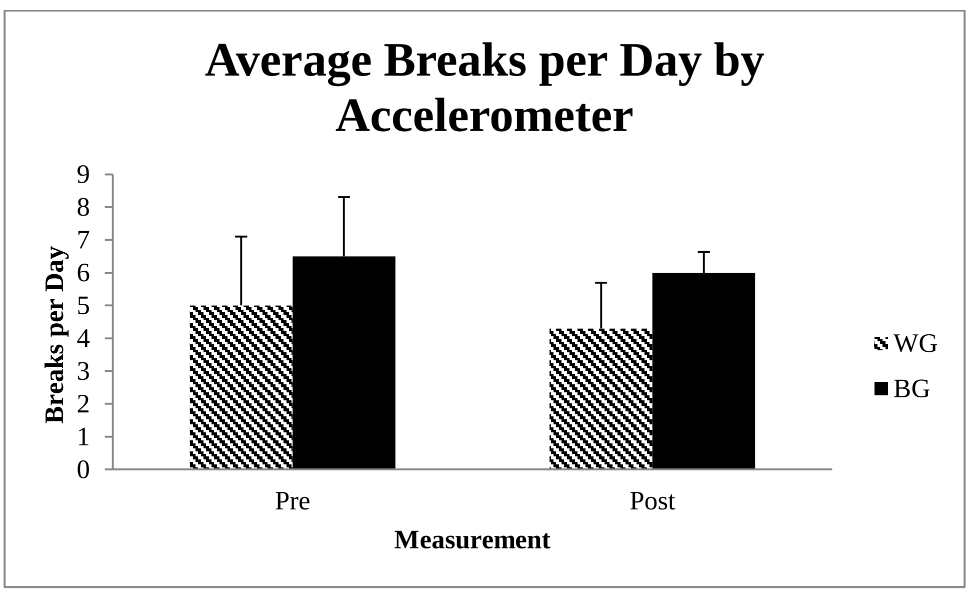
Appendix S

Accelerometer breaks (average per day)

Participant Number/Group	(Pre) Week 0	(Mid) Week 7	(Post) Week 12	(Follow-up) 3-months post
1	5			
2BG	9	5	6	6
3BG	8	8	7	7
4WG	3	3	4	3
5WG	7	6	6	7
6WG		1	4	
7WG	8	4	6	8
8BG				
9				
10BG				
11BG	5	7	6	4
12WG	5	5		
13BG	4			5
14BG	1			
15BG	5	4	5	3
16BG	5	5	6	4
17BG	7	5	6	6
18WG	4	3	4	2
19WG		6		
20				
21WG	5	4	3	4
22WG	3	4	3	6
Walking Mean (SD)	5.0 (2.1)	4.0 (1.1)	4.3 (1.4)	5.0 (2.4)
Breaks Mean (SD)	6.5 (1.8)	5.7 (1.5)	6.0 (0.63)	5.0 (1.5)
Combined Mean (SD)	5.8 (2.0)	4.8 (1.5)	5.2 (1.3)	5.0 (1.9)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.
Dark shaded regions represent baseline values due to missing data.


Average Breaks per Day by Accelerometer
Breaks per Day
7
6
5
4
3
2
1
0
Pre
Mid
Post
3-Month
Measurement
WG
BG

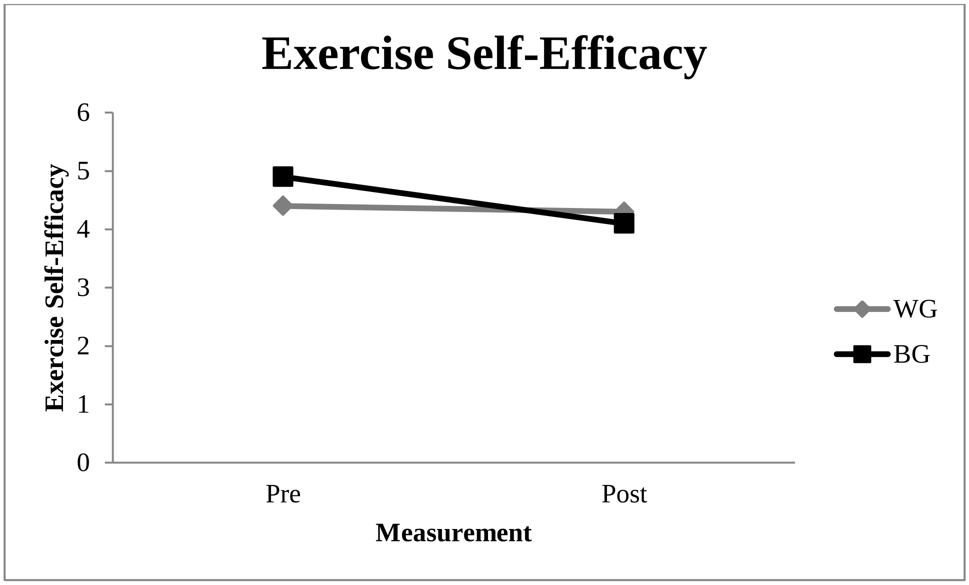

Average Breaks per Day by Accelerometer
Breaks per Day
9
8
7
6
5
4
3
2
1
0
Pre
Post
Measurement
WG
BG

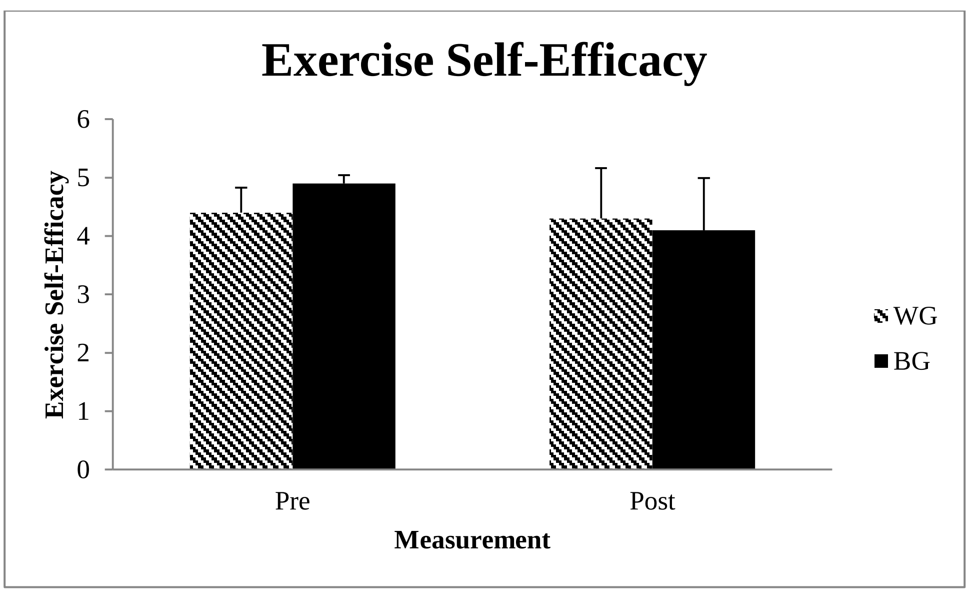
Appendix T

Individual averages for exercise self-efficacy

Participant Number/Group	(Pre) Week 0	(Post) Week 12
1	3.0	
2BG	4.2	
3BG	4.9	3.1
4WG	4.9	4.8
5WG	4.6	
6WG	4.8	2.8
7WG	3.9	
8BG	3.5	
9		
10BG	4.0	
11BG	4.7	4.6
12WG	4.0	
13BG	5.0	5.0
14BG	4.0	
15BG	4.9	
16BG	5.0	3.5
17BG	4.6	
18WG	4.0	4.8
19WG	4.7	
20		
21WG	4.5	4.1
22WG	4.0	4.8
Walking Mean (SD)	4.4 (0.43)	4.3 (0.86)
Breaks Mean (SD)	4.9 (0.14)	4.1 (0.89)
Combined Mean (SD)	4.6 (0.40)	4.2 (0.82)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Exercise Self-Efficacy
6
5
4
3
2
1
0
Exercise Self-Efficacy
Pre
Post
Measurement
WG
BG

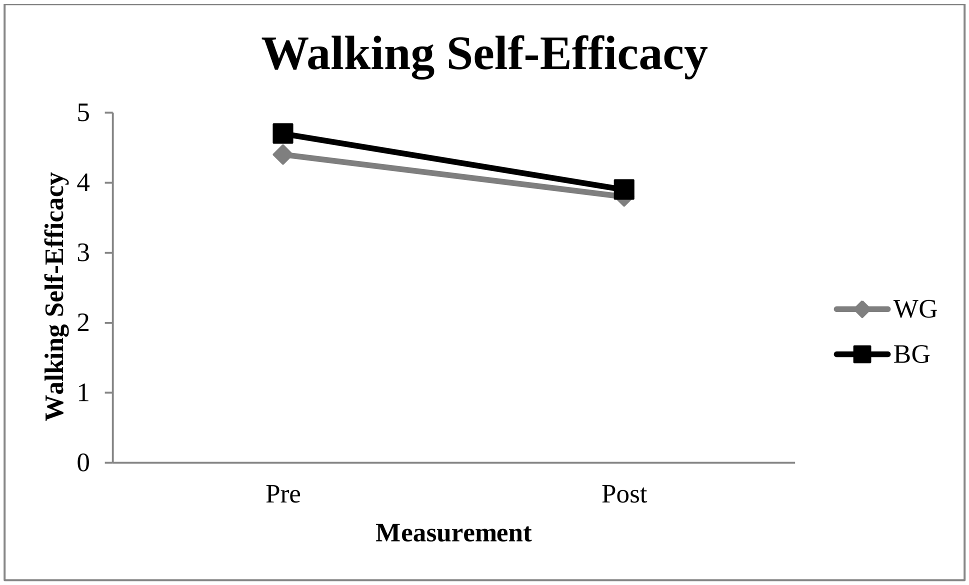

Exercise Self-Efficacy
6
5
4
3
2
1
0
Exercise Self-Efficacy
Pre
Post
Measurement
WG
BG

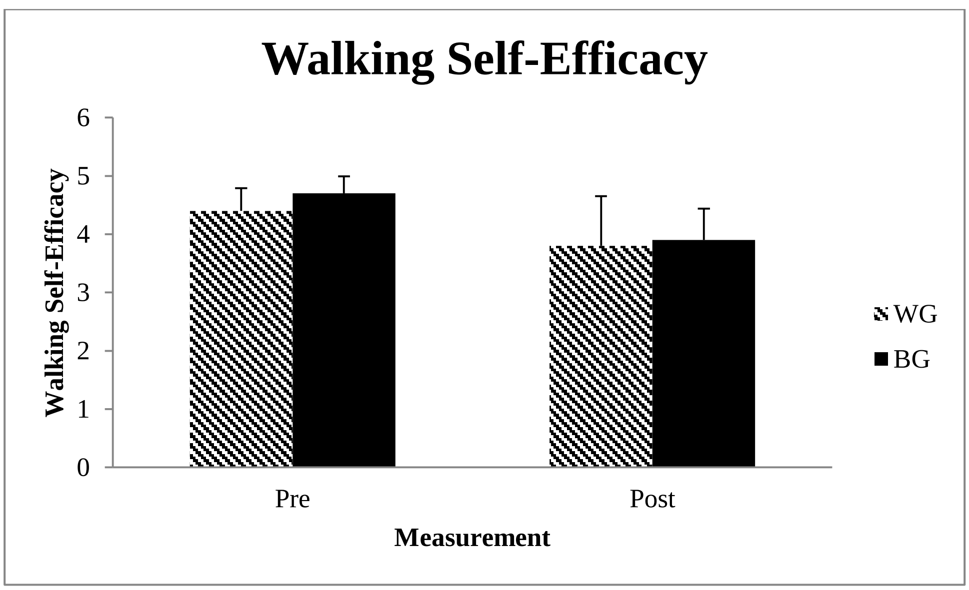
Appendix U

Individual averages for walking self-efficacy

Participant Number/Group	(Pre) Week 0	(Post) Week 12
1	3.1	
2BG	4.3	4.4
3BG	4.9	3.5
4WG	4.9	4.8
5WG	4.7	2.8
6WG	4.7	2.8
7WG	3.8	
8BG	3.8	
9		
10BG	5.0	
11BG	4.8	4.4
12WG	3.9	
13BG		5.0
14BG	4.8	
15BG	4.7	
16BG	4.9	3.5
17BG	4.2	
18WG	4.0	4.6
19WG	4.8	
20		
21WG	4.3	3.9
22WG	4.0	4.0
Walking Mean (SD)	4.4 (0.39)	3.8 (0.85)
Breaks Mean (SD)	4.7 (0.29)	3.9 (0.54)
Combined Mean (SD)	4.6 (0.37)	3.9 (0.71)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Walking Self-Efficacy
Walking Self-Efficacy
5
4
3
2
1
0
Pre
Post
Measurement
WG
BG

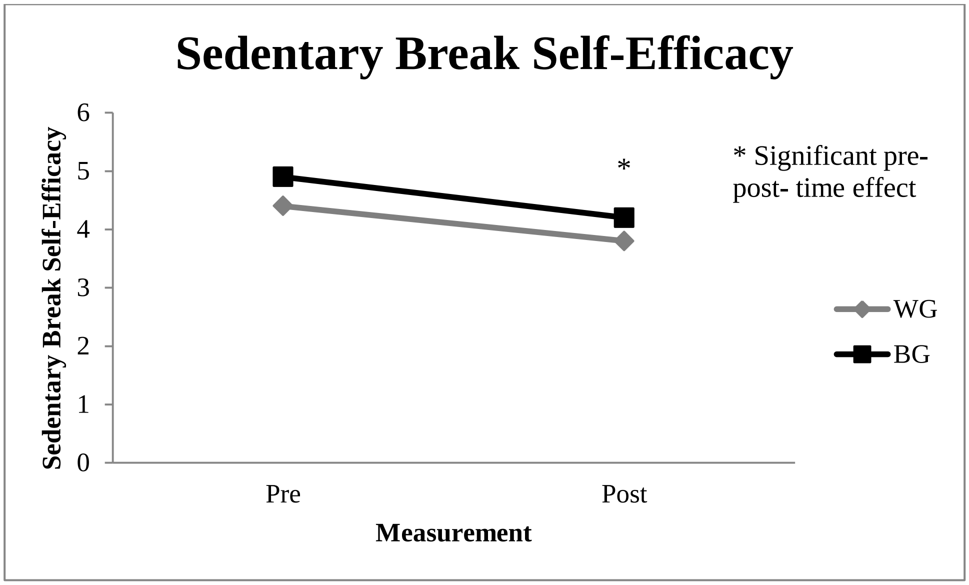

Walking Self-Efficacy
Walking Self-Efficacy
6
5
4
3
2
1
0
Pre
Post
Measurement
WG
BG

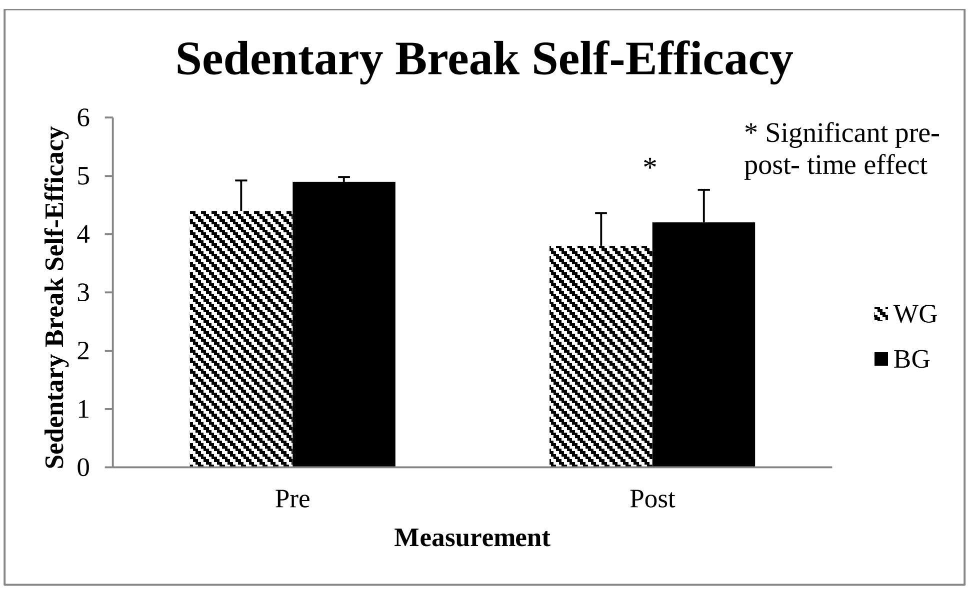
Appendix V

Individual averages for sedentary self-efficacy

Participant Number/Group	(Pre) Week 0	(Post) Week 12
1	3.3	
2BG	4.8	4.5
3BG	4.9	3.6
4WG	5.0	4.8
5WG	4.8	3.1
6WG	4.8	3.5
7WG	4.3	
8BG	5.0	
9		
10BG	4.7	
11BG	4.8	3.9
12WG	3.7	
13BG	5.0	5.0
14BG	4.8	
15BG	4.8	
16BG	4.9	3.9
17BG	4.5	
18WG	4.0	3.8
19WG	3.4	
20		
21WG	3.8	3.8
22WG	4.0	4.0
Walking Mean (SD)	4.4 (0.52)	3.8 (0.56)
Breaks Mean (SD)	4.9 (0.08)	4.2 (0.56)
Combined Mean (SD)	4.6 (0.45)	4.0 (0.56)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Sedentary Break Self-Efficacy
Sedentary Break Self-Efficacy
6
5
4
3
2
1
0
Pre
Post
Measurement
*
* Significant pre-post- time effect
WG
BG

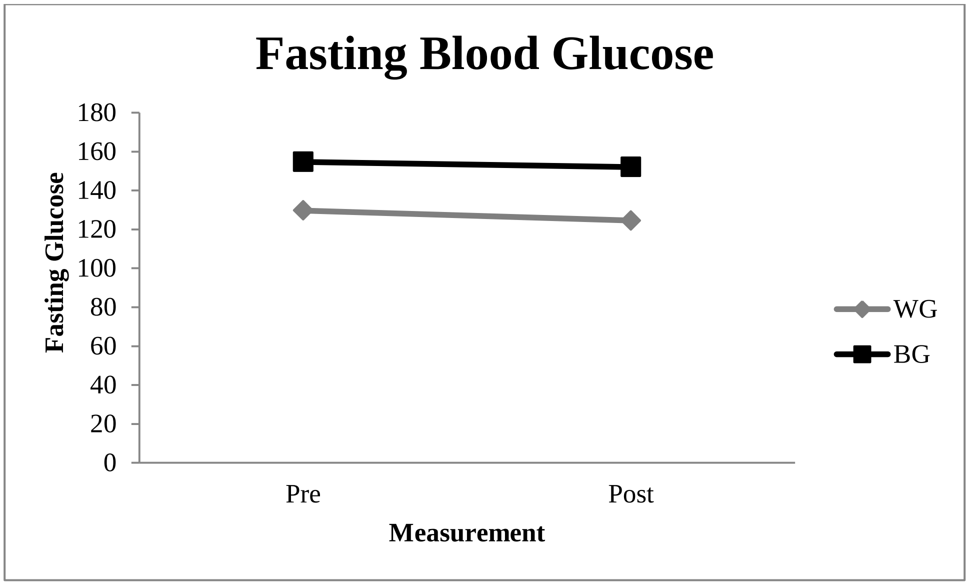

Sedentary Break Self-Efficacy
Sedentary Break Self-Efficacy
6
5
4
3
2
1
0
Pre
Post
Measurement
*
* Significant pre-post- time effect
WG
BG

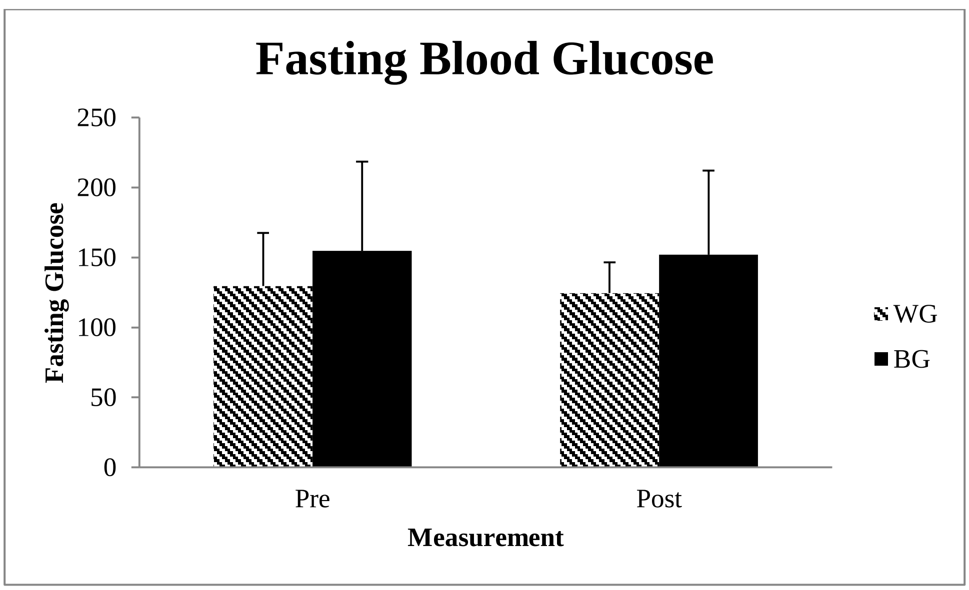
Appendix W

Individual fasting blood glucose levels (mg/dL)

Participant Number/Group	(Pre) Week 0	(Post) Week 12	(Follow-up) 3-months post
1			
2BG	82	83	88
3BG	137	119	162
4WG	134		112
5WG	88	114	
6WG	111	117	
7WG	142	136	134
8BG	138		
9			
10BG	242		
11BG	213	198	168
12WG	170	162	
13BG	250	260	164
14BG	158		
15BG	89	109	
16BG	187	154	171
17BG	125	142	121
18WG	162		129
19WG	113		
20	258		
21WG	93	98	96
22WG	174	120	122
Walking Mean (SD)	129.7 (37.9)	124.5 (22.0)	117.3 (19.4)
Breaks Mean (SD)	154.7 (63.7)	152.1 (60.0)	145.7 (33.7)
Combined Mean (SD)	143.2 (52.9)	139.4 (47.0)	136.2 (31.7)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Fasting Blood Glucose
180
160
140
120
100
80
60
40
20
0
Fasting Glucose
Pre
Post
Measurement
WG
BG

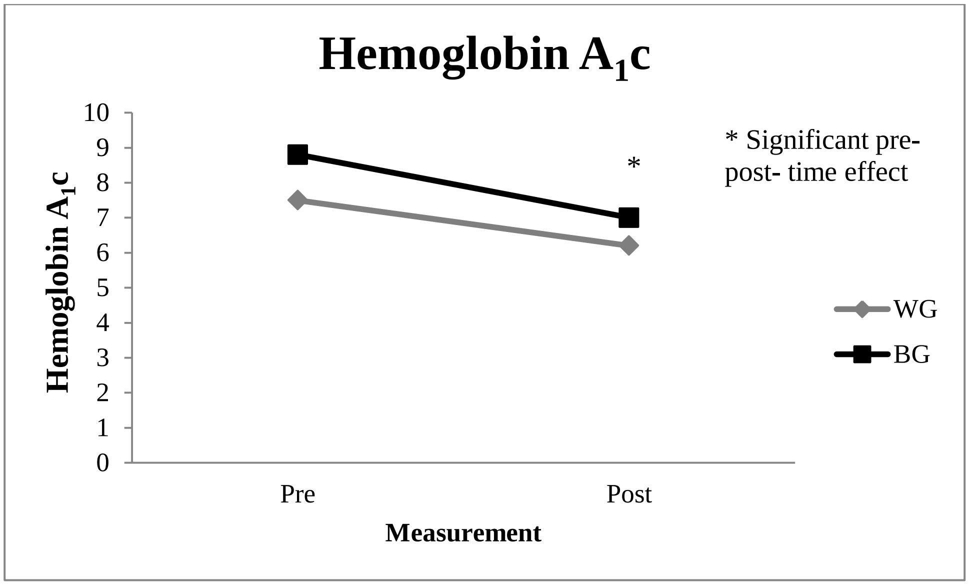

Fasting Blood Glucose
250
200
150
100
50
0
Fasting Glucose
Pre
Post
Measurement
WG
BG

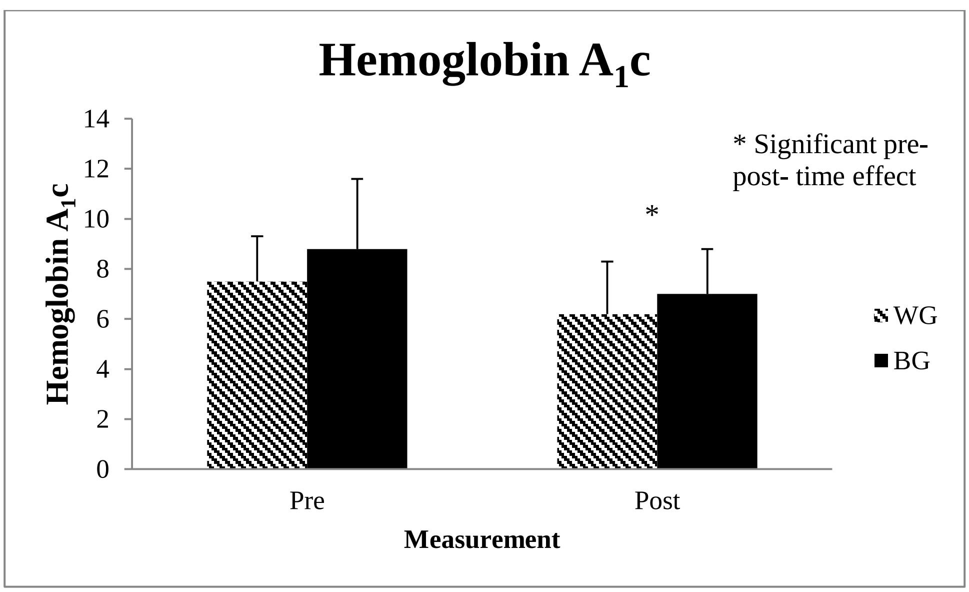
Appendix X

Individual values for Hemoglobin A1C (%)

Participant Number/Group	(Pre) Week 0	(Post) Week 12	(Follow-up) 3-months post
1			
2BG	10.4	5.8	5.8
3BG	5.2	6.5	7.8
4WG	6.1		5.8
5WG	8.2	5.8	
6WG	10.4	6.2	
7WG	6.2	6.6	6.4
8BG	7.9		
9			
10BG	10.6		
11BG	9.6	6	9.4
12WG	9.2	8.5	
13BG	13	10.8	10.7
14BG	5		
15BG	5.8	6	
16BG	7.5	8	8.3
17BG	10.2	6	8
18WG	6.7	2	8.1
19WG	6.1		
20	13		
21WG	5.3	5.9	6.4
22WG	6.7	8.2	9.1
Walking Mean (SD)	7.5 (1.8)	6.2 (2.1)	7.5 (1.3)
Breaks Mean (SD)	8.8 (2.8)	7.0 (1.8)	8.3 (1.6)
Combined Mean (SD)	8.2 (2.4)	6.6 (2.0)	8.0 (1.5)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Hemoglobin A1c
10
9
8
7
6
5
4
3
2
1
0
Hemoglobin A1c
* Significant pre-post- time effect
*
WG
BG
Pre
Post
Measurement

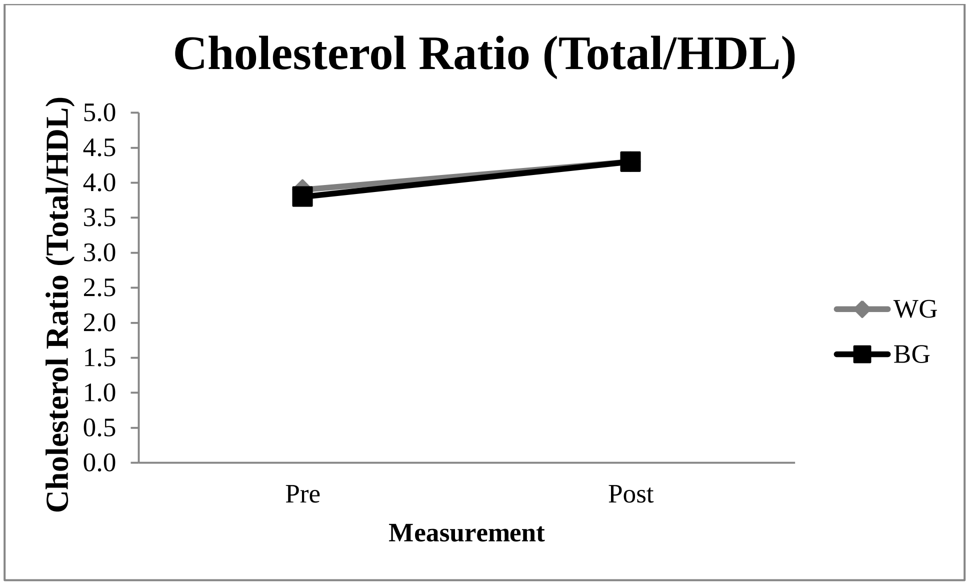

Hemoglobin A1c
14
12
10
8
6
4
2
0
Hemoglobin A1c
* Significant pre-post- time effect
*
WG
BG
Pre
Post
Measurement

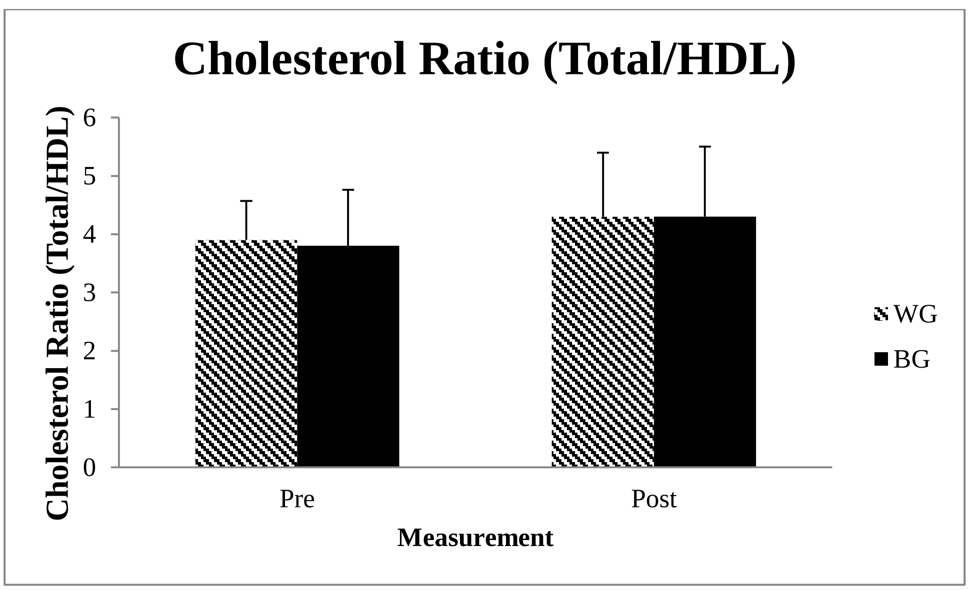
Appendix Y

Individual values for cholesterol ratio (total/HDL)

Participant Number/Group	(Pre) Week 0	(Post) Week 12	(Follow-up) 3-months post
1			
2BG	4.5	3.2	3.1
3BG	4.6	5.7	3.8
4WG	3.4		3.7
5WG	3	3.7	
6WG	4.3	4.2	
7WG	4.7	5.1	3.4
8BG	3.2		
9			
10BG	5.7		
11BG	3	3.1	3.3
12WG	4.2	5.7	
13BG	5.2	6.3	5.8
14BG	3.1		
15BG	3.7	3.9	
16BG	3.2	4.1	
17BG	2.6	3.6	4.3
18WG	5.4		5.9
19WG	3.7		
20	2.5		
21WG	3.2	2.6	2.5
22WG	4.1	4.3	3.4
Walking Mean (SD)	3.9 (0.67)	4.3 (1.1)	3.1 (0.50)
Breaks Mean (SD)	3.8 (0.96)	4.3 (1.2)	4.0 (1.1)
Combined Mean (SD)	3.9 (0.81)	4.3 (1.1)	3.7 (0.98)

Shaded regions were included in analysis.
Group assignment: WG=Walking Group, BG=Breaks Group.


Cholesterol Ratio (Total/HDL)
Cholesterol Ratio (Total/HDL)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Pre
Post
Measurement
WG
BG


Cholesterol Ratio (Total/HDL)
Cholesterol Ratio (Total/HDL)
6
5
4
3
2
1
0
Pre
Post
Measurement
WG
BG