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Comparison of Physical Activity Recommendations in Previously Inactive Women

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To the Graduate Council:

I am submitting herewith a thesis written by Cherilyn N. Hultquist entitled "Comparison of Physical Activity Recommendations in Previously Inactive Women." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Exercise Science.

Dixie L. Thompson, Major Professor

We have read this thesis and recommend its acceptance:

Edward T. Howley, David R. Bassett, Jr.

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Comparison of Physical Activity Recommendations in Previously Inactive Women

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Cherilyn N. Hultquist

May 2004

Dedication

This thesis is dedicated to my parents Steve and Diane Hultquist and to my grandfather, Rudy Krejci, who have always believed in me and supported my academic pursuits. Their constant support, encouragement, and love, have given me the strength to pursue challenges and to always believe in myself. Their continual dedication to me means more than words can ever express.

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Abstract

The main objective of this study was to compare the number of steps accumulated weekly by individuals given the recommendation to walk 10,000 steps per day with those told to take a brisk 30 minute walk on most, preferably all, days of the week. Average steps per day were compared for 58 sedentary women (mean age 45.0 ± 6.0 y) who were randomly assigned to one of the following physical activity groups, (1) walk 10,000 steps per day or (2) take a brisk 30 minute walk on most, preferably all, days of the week. After measuring height, weight, body composition, blood pressure, and waist and hip circumference, subjects wore a sealed pedometer for two weeks for a baseline physical activity assessment. If the subjects averaged ≤ 7000 steps/day they were randomly assigned to one of two physical activity groups for a four week intervention. All subjects wore a sealed pedometer capable of storing 7 days of data. Subjects reported to the laboratory each week so that investigators could gather step counts. The 10,000 steps per day group wore a second pedometer for viewing steps accumulated throughout the day. There were no differences between the groups at baseline testing. A statistically significant difference between groups was observed with average step accumulation over four weeks. The 30 minute group walked 8270 ± 354 steps per day and the 10K group walked 10,159 ± 292 steps per day. The 30 minute group averaged 9505 ± 326 steps per day on the days that a 30 minute walk occurred and 5597 ± 363 steps per day on the days that no walk occurred. The 10K group averaged 11,775 ± 207 steps on days when they walked at least 10,000 steps and 7780 ± 231 steps

on days that their target was not achieved. This study compared the recommendation to engage in 30 minutes of moderate intensity physical activity on most, preferably all days of the week with the recommendation to walk 10,000 steps per day. The 10,000 steps per day recommendation led to more weekly walking with less day-to day fluctuation in accumulated steps. The 30 minute group was close to accumulating 10,000 steps per day on the days that they took a 30 minute walk. This study shows that sedentary, middle-aged women accumulate more daily physical activity when given the recommendation to walk 10,000 steps per day compared to the recommendation of taking a brisk 30 minute walk on most, preferably all, days of the week.

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Chapter 1

Introduction

Current statistics indicate that nearly 400,000 deaths in the United States each year are attributed to poor diet and physical inactivity, and that this combination of factors may soon become the leading cause of death in the United States (30). This number is up from 300,000 deaths attributed to poor diet and physical inactivity from statistics reported in 1993 (29). Physical inactivity is linked to several negative health conditions including coronary heart disease, type 2 diabetes, hypertension and hyperlipidemia, and in many instances these conditions occur in combination (48). While these disease states are not caused solely by sedentary behavior, inactive individuals are at a higher risk of occurrence. Conversely, many of these conditions can be improved by increasing levels of daily physical activity. Research has shown a strong and consistent inverse relationship between physical activity and several disease states as well as all-cause mortality (23, 26, 34, 35).

Obesity is a condition that has been directly associated with physical inactivity (53). The occurrence of obesity is increasing at an alarming rate in the United States. Nearly two-thirds of adults in the United States are overweight, and approximately 30.5% are obese, according to data from the 1999-2000 National Health and Nutrition Examination Survey (NHANES) (12). Additionally, from 1991 to 1998, obesity is known to have increased in all 50 states, in both genders, and across all races/ethnicities, age groups, educational levels, and smoking statuses (31). Since many negative health implications are associated with obesity, it is important to treat those suffering and prevent it in those at risk. An increase in physical activity may create the necessary energy expenditure to facilitate a decrease in body fat stores. Recent studies have shown that an increase in daily physical activity is associated with a reduced occurrence of obesity (3, 54). One key to successful weight control and improved overall health is making physical activity a part of daily life. Bassett et al. (3) examined the daily physical activity of an Old Order Amish farming community. With labor intensive farming as the preferred occupation, men reported an average of 18,425 steps per day and women reported an average of 14,196 steps per day. With these very high levels of activity, only 25% of the men and 27% of the women were classified as overweight based on body mass index, and only 9% of women were classified as obese with no men meeting that classification (3). This study provides insight into the major impact that modern technology makes on the daily accumulation of physical activity and obesity rates in US adults.

Despite the increasing information available that links health benefits to physical activity, current physical activity statistics show that most American adults are sedentary and if they are active, they are not physically active at levels that can promote health (24). It is estimated that approximately 25% of Americans do not engage in any form of physical activity (6). Forty-four percent of adults participate in some form of exercise, but it is not performed regularly enough or at a high enough intensity to experience the physiological benefits of the physical activity (24, 25). With the high prevalence of physical inactivity, an important responsibility of health and fitness professionals is to create activity programs that are feasible, motivating, and effective for individuals. While research has shown that an increase in physical activity is associated with several benefits to overall health (23, 26, 34, 35), the best recommendation for physical activity has yet to be determined. When establishing physical activity guidelines, walking should be considered as a viable option for many Americans. It is known to be a popular mode of physical activity, and it is estimated that nearly 4 in 10 US adults walk for exercise (37). For most walkers (56.7%), walking was their only leisure-time physical activity (37).

In addition to developing exercise recommendations that are both feasible and effective, public health professionals face the challenge of assessing daily physical activity. Recent research has shown that pedometers can be a valid and reliable measure of daily ambulation (9, 38, 39). Additionally, these devices are typically low cost and user friendly. The basic function of a pedometer is to count steps but pedometers may also provide daily motivation to exercising individuals by providing continual feedback regarding the accumulation of daily physical activity.

There are a number of recommendations aimed at getting people to live more active lives. The American College of Sports Medicine (ACSM), Centers for Disease Control and Prevention (CDC) and the Surgeon General currently recommend at least 30 minutes of moderate-intensity physical activity on most, preferably all, days of the week (36, 48). This recommendation aims to increase physical activity, thereby lowering disease risk in sedentary adults. However, there is little quantitative data on how much physical activity results when people begin an exercise program with these guidelines. In addition, it is difficult to know whether a compensatory decline in physical activity results when people begin this type of program. An alternative physical activity recommendation that has received recent attention is that of achieving 10,000 steps per day. Hatano (14) suggests that the accumulation of 10,000 steps per day is comparable to achieving 30 minutes of physical activity per day. The 10,000 steps per day recommendation has distinct advantages, including the use of pedometers to quantify ambulatory activity. Welk et al. (49) observed that 73% of individuals who met a physical activity criterion of 30 minutes reached 10,000 steps. A study by Wilde et al. (52) found that inactive women accumulated approximately 10,000 steps per day when given the instruction to walk for an additional 30 minutes above normal daily activity. Recent studies have also shown that accumulating 10,000 steps per day can improve health risk factors such as hypertension and glucose tolerance (20, 32, 41).

Purpose

The purpose of this study was to compare the number of steps accumulated weekly by individuals given the recommendation to walk 10,000 steps per day with those told to take a brisk 30 minute walk on most, preferably all, days of the week.

Hypothesis

There will be no statistically significant difference in the weekly accumulated steps between a group told to walk 10,000 steps per day and a group told to take a brisk 30 minute walk on most, preferably all, days of the week.

Chapter 2

Review of Literature

Physical Inactivity-Current Trends

Although the benefits of exercise have been widely studied, an increasing number of people are suffering from diseases that can be directly related to inactivity. Many studies have shown a significant inverse relationship between physical activity and several disease states (23, 26, 29, 35). In a recent report from the CDC, it is estimated that the prevalence of no leisure-time physical activity declined among US adults from 32% to 25% between 1996 and 2002 (6). Among US adult men this decline went from 29% to 22% and in women from 32% to 28% during the same years (6). Although it is encouraging that fewer Americans are completely inactive, these statistics clearly show that despite significant efforts on the part of health and fitness promoters, a large percentage of US adults remain physically inactive.

ACSM, CDC & Surgeon General Recommendation for Physical Activity

In 1995, a group of experts were brought together by the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC) to review scientific evidence and develop a message about physical activity for the general public (36). This meeting resulted in the consensus that every US adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week.

The recommendation was meant to encourage sedentary individuals to be active for 30 minutes above and beyond activities of daily living most days of the week.

Pate et al. (36) suggest that one way to meet this activity standard is to walk two miles briskly most days of the week. Other options for achieving this recommendation include cycling, swimming, and jogging (36). While no specific mode of exercise is best, walking is one activity that is available to most people and requires little skill on the part of the participant. Pate et al. (36) also suggested that the low physical activity participation rate may be due to the misperception of many people that in order to experience health benefits, one must engage in vigorous exercise (18). Pate et al. (5) also suggested that sedentary individuals were expected to benefit most from increasing their activity to the recommended level. Several studies have shown health benefits from walking (17, 18, 26, 27). Manson et al. (27) examined the role of walking, as compared to vigorous exercise, in the prevention of coronary heart disease in 72,488 female nurses between the ages of 40 and 65. Walking was inversely associated with the risk of coronary events, and sedentary women who became active in middle adulthood or later, had a lower risk of coronary events compared to the women who remained sedentary (27). A later study by Manson et al. (26) found that brisk walking and vigorous exercise were associated with similar reductions in risk of both coronary events and total cardiovascular events in 73,743 postmenopausal women in the Women's Health Initiative Observational Study. A prospective study by Hu et al. (17) found that moderate intensity physical activity, such as walking, was associated with a substantial reduction in the risk of type 2 diabetes in 70,102 female nurses from the Nurse's Health Study. Another study by Hu et al. (18) examined the relationship between physical activity and cardiovascular events in 5125 female nurses with diabetes from The Nurse's Health Study. This prospective study showed that moderately intense physical activity, such as walking, is strongly associated with a lower risk for cardiovascular disease in women with diabetes (18).

The recommendation of 30 minutes of moderate-intensity physical activity on most, preferably all, days of the week, is currently endorsed by ACSM, the CDC and the Surgeon General. In 1996, the Surgeon General's report (48) supplied an abundance of evidence supporting the 30 minute recommendation. This 1996 report emphasized moderate intensity physical activities that could vary according to personal preference and life circumstances in hopes of encouraging more people to make physical activity part of everyday life. The report focused on the role of physical activity in preventing disease and on the status of interventions to increase physical activity. Some major conclusions of the report include that people of all ages, both male and female, benefit from regular physical activity, and that significant health benefits can be obtained by including a moderate amount of physical activity on most, preferably all, days of the week (48).

For health and fitness professionals to successfully promote the ACSM/CDC and Surgeon General's recommendation for physical activity (36, 48), they must understand who is not meeting the recommendation and why. In 1998 Jones et al. (22) identified the prevalence of adults who met the

ACSM/CDC and Surgeon General physical activity recommendation from data collected during the 1990 National Health Interview Survey. Participants were 16,890 women and 12,272 men who were asked about their leisure-time physical activity. The main objective of this study was to identify how many of these adults had a pattern of leisure-time activity that would meet the current physical activity recommendation. The data indicated that 32% of these respondents met the recommendation based on the reported amount of leisure-time physical activity. Additionally, this survey showed that men were more active than women, and activity level decreased with age (22).

In 2000, Martin et al. (28) investigated the factors related to meeting the ASCM/CDC physical activity guidelines. A national computerized random-digit-dial telephone survey of US adults revealed that 68.1% of those surveyed did not meet the ACSM/CDC recommendation of accumulating at least 30 minutes of moderate-intensity physical activity on most, preferably all, days of the week. Women were less likely to engage in physical activity compared to men, with only 28.6% of women and 37.1% of men meeting the recommendation. The researchers suggest another factor that may influence whether a person engages in enough physical activity to meet current recommendations is how an individual perceives the importance of physical activity and its relation to health. Of the 623 respondents who reportedly met the ACSM/CDC guidelines, 362 (58.1%) thought physical activity was a very important health risk factor. The data from this study clearly support the need for physical activity interventions for both genders, with special attention towards the needs of women and those who do not view physical activity as a priority (28).

When examining the efficacy of the ACSM/CDC recommendation, it is important to consider the growing population of obese individuals. Weyer et al. (50) assessed the efficacy of the traditional ACSM exercise recommendation (20-60 minutes of vigorous exercise at least three times per week) and the current broader ACSM/CDC recommendation (30 minutes of moderate intensity activities on most days of the week) in an obese population. In this prospective dietary intervention study, 109 obese subjects consumed approximately 1000 kilocalories per day and were assigned to either meet the traditional ACSM exercise recommendation, the ACSM/CDC physical activity recommendation, or remain sedentary based on random group assignment. After a mean follow-up of 16.3 weeks, meeting either recommendation was associated with greater weight loss compared to being sedentary. Additionally, there was no significant difference in weight reduction between the traditional exercise and the ACSM/CDC physical activity recommendation (50). This study provided early evidence that an obese population could benefit from 30 minutes of moderate intensity physical activity on most, preferably all, days of the week.

Dunn et al. (11) conducted a randomized clinical trial that demonstrated how the ACSM/CDC physical activity recommendation can positively affect cardiovascular disease risk factors. The 235 sedentary subjects in this study were divided into two physical activity intervention groups. One group was assigned to “structured” exercise, which consisted of exercising at a vigorous intensity (50-85% of maximal aerobic power) for 20-60 minutes, 3-5 days per week. The second intervention was a "lifestyle" group that was advised to accumulate at least 30 minutes of moderate intensity physical activity on most, preferably all, days of the week, in a way uniquely adapted to each participant's lifestyle. After six months of the exercise intervention, both groups had significant decreases in total cholesterol, systolic blood pressure, diastolic blood pressure and body composition compared to baseline. Although each of these measures was decreased significantly for both groups, there was no significant difference between the groups in the amount of reduction (11). This finding leads to the conclusion that accumulated physical activity is a viable approach for improving cardiovascular health in previously sedentary adults.

Although the standard public health approach recommends the accumulation of at least 30 minutes of moderate intensity activity on most, preferably all, days of the week, a recent report by experts suggests this may be inadequate for weight control (19). An expert panel assembled by the Institute of Medicine recommends that adults accumulate 60 minutes of moderate-intensity physical activity (19). This recommendation is based primarily on reports indicating that this level of physical activity is likely to prevent excessive weight accumulation and thereby yield health benefits. This higher level of physical activity is supported by reports of those who have been successful at weight loss (55). Additionally, the ACSM position stand on weight loss and weight maintenance recognizes that more than 30 minutes of exercise per day may be optimal for weight control (21). In contrast, some physical activity researchers suggest less exercise is actually needed to control body weight. Hill et al. (16) examined the factors driving the obesity epidemic in the United States. They found that the current environment in the US encourages consumption of energy and discourages expenditure of energy. Activities of daily living have been severely minimized due to advances in technology. With the growing number of individuals suffering from obesity, Hill et al. (16) identified a physical activity strategy that may lower the prevalence of obesity when coupled with reducing caloric intake. He proposed walking as little as one mile, and this walking could be accumulated throughout the day (16). The evidence supporting this minimalist approach has yet to be published. Even though 30 minutes of physical activity per day clearly yields health benefits, controversy exists concerning whether this message is the best way to "package" the exercise message to the general public.

10,000 Steps Per Day Physical Activity Recommendation

The recommendation of accumulating 10,000 steps per day has recently received attention as a method for achieving health benefits through increasing daily physical activity. Although this recommendation has only recently gained popularity in the US, its origin can be traced back to Japan nearly 40 years ago (14). In 1993, Hatano (14) suggested that walking 10,000 steps per day was equivalent to energy expenditures of between 300 and 400 kcals/day depending on walking speed and body size. When looking at the total amount of daily walking of various individuals, he found that practically no one averaged 10,000 steps per day, thus concluding that most modern humans must have intentional physical activity to achieve 10,000 steps. He also advocated that taking 10,000 steps per day would reduce the risk for cardiovascular disease (14). Specifically, he found that those who walked 10,000 or more steps per day had lower systolic blood pressure and skinfold thickness than those who walked less (13).

Based on a recent review by Tudor-Locke and Bassett (45), the physical activity recommendation of walking 10,000 steps per day may be a reasonable target for currently sedentary individuals to accomplish in order to gain health benefits of increased physical activity (45). A challenge with this recommendation however, is to determine how many steps per day are representative of a sedentary lifestyle. Based on current available evidence, Tudor-Locke and Bassett (45) suggest that achieving <5000 steps per day may be classified as "sedentary," 5000-7499 steps per day is "low active," 7500-9999 steps per day is "somewhat active," and ≥ 10,000 steps per day in considered "active" and individuals who take > 12,500 steps per day are likely to be classified as "highly active." It is possible however, that these classifications are not appropriate across the age spectrum for both sexes.

Wilde et al. (52) found that originally inactive women accumulated approximately 10,000 steps per day when given the instruction to walk for an additional 30 minutes above normal daily activity. On average, the women accumulated 7220 steps per day when no purposeful exercise was performed. The walking days, however, produced an average of 3100 additional steps, which increased the mean steps per day to 10,030. The researchers found that accumulating 10,000 steps per day would be a challenge for sedentary women to meet without purposefully increasing their daily physical activity; therefore, accumulating 10,000 steps per day in a sedentary population is indicative that extra activity has been performed. The generalizability of this study is limited, however, by the fact that only 32 women participated and the study lasted only four days (2 walking days and 2 non-walking days).

Several studies have shown that pedometer-monitored walking programs, where approximately 10,000 steps per day are accumulated, are successful in significantly improving health markers (20, 32, 41). A study by Moreau et al. (32), found that a 24-week walking program, monitored by pedometers, significantly lowered systolic blood pressure and mean arterial blood pressure. Twenty-four post-menopausal women with borderline to stage 1 hypertension (systolic blood pressure of 130-159 mmHg and/or diastolic blood pressure of 85-99 mmHg) were studied. Fifteen women were randomly assigned to an exercise group while the remaining subjects served as a control group. Women in the exercise group were provided with a target number of steps to accumulate each day that would lead to meeting the ACSM/CDC recommendation of roughly two miles of walking (36). The women walked at a self-selected pace and were allowed to accumulate their steps throughout the day. The exercise group increased daily steps from 5400 at baseline to approximately 9700 during the intervention. The control group also wore a pedometer, but was asked not to change their daily activity. The systolic blood pressure of women in the walking group fell by an average of 11 mmHg after 24 weeks of the walking program. This study demonstrated that when previously sedentary, post-menopausal, hypertensive women increased their daily steps to approximately 10,000, they experienced a decrease in systolic blood pressure (32). The women also experienced a 1.3 kg drop in body mass (32).

Iwane et al. (20) found that thirty hypertensive individuals reduced their systolic blood pressure from 149 mmHg to 139 mmHg and reduced their diastolic blood pressure from 98.5 mmHg to 90 mmHg by walking more 13,510 ± 837 steps per day over a twelve week period. The researchers concluded that walking 10,000 steps per day, irrespective of exercise intensity or duration, is effective in lowering blood pressure (20).

A study by Swartz et al. (41), found that the 10,000 steps per day recommendation resulted in improved glucose tolerance and a reduction in systolic and diastolic blood pressure in overweight women at risk for type 2 diabetes. Eighteen women with a family history of type 2 diabetes completed a 4-week control period during which they did not change their physical activity. This period was followed by an 8-week physical activity intervention. The intervention consisted of the subjects being advised to accumulate 10,000 steps per day. The average steps per day increased from 4972 steps/day during the control period to an average of 9213 steps/day during the physical activity intervention. This increase in physical activity was associated with an 11% decrease in two-hour plasma glucose levels, a decrease in systolic blood pressure from 136 mmHg to 130 mmHg, and a decrease in diastolic blood pressure from 89 mmHg to 83 mmHg. Swartz et al. concluded that accumulating

10,000 steps per day was effective at improving glucose tolerance and lowering blood pressure in overweight, inactive women (41).

A study by Whitt et al. (51) examined the physical activity patterns in African-American women compared to the ACSM/CDC recommendation. A total of eight days of physical activity data were collected over two separate 4-day periods. The subjects wore an accelerometer and a pedometer and kept activity logs, while going about their normal routine. Only 5% of the 55 women in this study accumulated ≥ 30 minutes of physical activity on at least 5 days. In an analysis of pedometer determined walking, those with a lower BMI (< 25.0 kg·m^2) had a higher average step count (9997 steps/day) compared to those with a higher BMI (25.0-29.9 kg·m^2 = 7595 steps/day; ≥ 30.0 kg·m^2 = 6210 steps/day). Although not the main focus of this study, the findings support the idea that walking 10,000 steps per day is associated with a more favorable body composition.

In a study specifically designed to examine the relationship between walking and body composition, Thompson et al. (42) found a significant correlation between average steps per day and body fat percentage, body mass index, waist circumference, hip circumference, and waist to hip ratio in middle-aged women. Subjects included eighty women between the ages of 40 and 66 years. The subjects wore a pedometer throughout the day for seven consecutive days while they followed their normal physical activity patterns. The subjects were categorized as inactive (<6000 steps/day), somewhat active (6000-9999 steps/day), and regularly active (≥10,000 steps/day). When examined by activity group, there was a significant difference in the body fat percentage of all activity groups, with the higher fat percentages seen in the less active groups. Additionally, the highest values for all measured body composition variables were seen in the least active group (42). Approximately 50% of the variation seen in percent body fat was explained by the number of steps accumulated each day. Also, the average BMI of those who walked at least 10,000 steps per day was in the recommended range. These findings show a clear inverse association between body composition variables and daily accumulated steps in middle-aged women (42).

Tudor-Locke et al. (44), examined the relationship between pedometer-determined physical activity (steps/day) and body composition measurements, including BMI and percentage body fat. The subjects wore a pedometer for 21 consecutive days and were instructed to record the total number of steps taken each day in a physical activity log each night before retiring. Subjects were encouraged to not alter their normal physical activity during the three week study. The data indicate that individuals with values greater than approximately 9000 steps per day were more frequently classified as normal weight for height. Individuals with values less than approximately 5000 steps per day were more frequently classified as obese. The inverse relationship between pedometer-assessed steps per day for both BMI ($r= -0.27$) and body fat percentage ($r= -0.30$) was found to be significant ($p<0.01$) (44).

Accumulating Physical Activity throughout the Day

A question that emerges is whether steps that are accumulated throughout the day are as beneficial for health outcomes as are sustained bouts of walking. Coleman et al. (8) found that providing sedentary adults with choices for meeting their walking goals resulted in significant changes in health-related outcomes and physical activity levels. The study focused on the accumulation of 30 minutes of walking per day by either 1 x 30 minutes, 2 x 15 minutes, or by any combination of time with no less than 5 minutes per interval. The study was designed to test different ways of meeting the ACSM/CDC recommendation of obtaining 30 minutes of moderate-intensity activity on most days of the week (36). During the 16 weeks of the study, 32 subjects walked for 3 days per week, then 4 days per week and finally 6 days per week. Exercise intensity was monitored with a polar heart rate monitor and exercise time was self-reported in weekly walking logs. The results indicated that 30 minutes of moderate intensity exercise on at least 5 days per week can improve cardiovascular fitness and body composition. This study was also able to provide evidence that these 30 minutes could be accumulated using walking bouts as short as 5 minutes. Participants also noted that it was not the exercise bout duration, but rather "making walking part of my lifestyle" that was the most important factor in maintaining their walking habits over time (8).

A more recent study by Murphy et al. (33) compared the effectiveness of different patterns of brisk walking on fitness, risk factors for cardiovascular disease and psychological well being in previously sedentary adults. Twenty-one sedentary adults (14 women), with an average age of 44.5 years, were randomly assigned to two different six-week programs of brisk walking in a cross-over design. One program consisted of taking one 30-minute walk per day, 5 days per week and the other consisted of taking three 10-minute walks per day, 5 days per week. The subjects were randomly assigned to the two different programs and there was a wash-out period of two weeks in between programs. All walking was done at an intensity of 70-80% of predicted maximal heart rate. There was not a significant difference between the two walking programs when examining increases in aerobic fitness, which was measured by maximal oxygen consumption, or improving blood lipid profiles. Additionally, the sum of four skinfolds, waist and hip circumference, and diastolic blood pressure all decreased significantly with both programs. Psychological well-being was measured by three psychometric inventories and feelings of tension and anxiety were decreased significantly ($p<0.05$) with no difference between treatments. The results of this study provide support that physical activity can be accumulated throughout the day, and does not have to be performed in one exercise bout in order to reduce cardiovascular risk factors and enhance the psychological well-being sedentary adults (33).

Pedometer-monitored Daily Physical Activity

The challenges and opportunities for measuring physical activity in sedentary adults has been a topic of interest due to the growing concern of the effect that physical inactivity has on health-related risk factors. Current direct measures of physical activity include calorimetry, doubly labeled water, motion sensors, observation, diaries, logs and records. Indirect measures of physical activity include various fitness measures, anthropometric measures, metabolic measures, heart rate telemetry, surveys and questionnaires (47). When considering measurement options, pedometers have been found to be an acceptable method for quantifying walking-related physical activity. While some self-report methods are practical for obtaining data on large samples, pedometers may offer more precision when quantifying physical activity in the form of walking. This is important considering the popularity of walking as a form of exercise. Pedometers are typically worn on the belt or waistband at the midline of the thigh and respond to vertical accelerations of the hip during gait cycles. While pedometers do not measure all types of physical activity, they have been shown to be accurate for measuring walking which is the most common type of physical activity (9, 38, 39). This type of measurement puts little burden on the participant. Pedometers appear to be the most practical and feasible measurement tool in quantifying physical activity in the form of walking (46).

In order to use a device to measure daily physical activity for research purposes, it must be both reliable and valid. Several studies have been performed to determine if the use of pedometers is both reliable and valid for quantifying ambulation (2, 4, 9, 38, 43). These studies have led to the conclusion that pedometers are an acceptable way to track an individual's steps per day (38), and are generally considered a practical alternative for measuring physical activity (45).

An early study by Bassett et al. (2) examined the accuracy of five electronic pedometers for measuring distance walked. Subjects wore five different pedometers during three different walking conditions including outdoor sidewalk walking, treadmill walking, and walking on an outdoor rubberized track. Actual steps were counted using a hand-tally counter. The major findings in this study were that there was no significant difference in pedometer accuracy on different walking surfaces when counting steps and that pedometers are more accurate at intermediate speeds (80 m/min) compared to slower and faster speeds (54 m/min and 107 m/min respectively) where steps were underestimated.

A recent study by Crouter et al. (9) examined the accuracy and reliability of 10 electronic pedometers for measuring steps taken, distance traveled, and kilocalories expended at various treadmill walking speeds. Five male and five female participants had their stride length measured before testing began. They then walked on a treadmill at speeds of 54, 67, 80, 94, and 107 meters per minute for five minutes each while wearing one of the ten pedometers. An investigator tallied actual steps with a hand counter. The investigators found that six models, including the New Lifestyles NL-2000 electronic pedometer, were among the most accurate at measuring steps at speeds of 80 meters per minute and above and gave mean values that were within ± 1% of actual steps.

Schneider et al. (39) investigated the accuracy and reliability of the same 10 pedometers as Crouter et al. (9) over a 400 meter walk. Ten male and ten female participants walked at their own pace for 400 meters while wearing two pedometers of the same model on the waistband or belt at the mid-line of the thigh. The actual steps taken were determined by a researcher walking behind the participant using a hand-tally counter. With the average self-selected pace of 96.5 meters per minute, the New Lifestyles NL-2000, the Kenz Lifecorder and the Yamax Digi-walker SW-701 were the three pedometers that were the most accurate in counting steps. The values recorded by the pedometers were within ± 3% of the actual steps taken, 95% of the time. The inter-device reliability of the NL-2000 was also exceptionally high with an intra-class correlation (ICC) of >0.99. The researchers concluded that these three pedometers appear to be suitable for use in research studies (39).

Schneider et al. (38) also studied the accuracy of pedometers to measure free-living physical activity. The main objective of this study was to compare the step values of multiple brands of pedometers over a 24-hour period against a criterion pedometer, the Yamax SW-200, which had performed well in previous validation studies (9, 39). All subjects wore the criterion pedometer on their left side and a comparison pedometer on their right side for a 24-hour period. Of the 13 pedometers tested, the New Lifestyles NL-2000 was one of 5 pedometers that yielded mean values that were not significantly different from the criterion. Among those five pedometers, the NL-2000 yielded results closest to the steps measured with the criterion pedometer. It was concluded that the NL-2000 is a suitable tool for applied physical activity research (38).

A study by Swartz et al. (40) found that the electronic pedometer accurately assessed steps taken at 80, 94, and 107 meters per minute, and that

BMI did not alter the accuracy of the pedometer. Sixty-six participants wore three pedometers placed at the waist level, one on the anterior mid-line of the thigh, one on the mid-axillary line, and one on the posterior mid-line while walking on a treadmill at 54, 67, 80, 94, and 107 meters per minute for three minutes each. Subjects were classified as normal BMI (<25 kg·m^{-2}), overweight (25-29.9 kg·m^{-2}), or obese (≥ 30 kg·m^{-2}), and the data showed that category of BMI did not significantly affect the pedometer scores at any speed. During the treadmill protocol, the actual number of steps was determined by observation and a hand-tally counter. The pedometers did significantly underestimate the manually counted steps at 54 and 67 meters per minute. The results of this study suggest that the Yamax SW-200 can be used to monitor walking for research purposes (40).

A preliminary study to determine pedometer responsiveness to change in a walking program (43), found that pedometers did indeed detect changes in daily ambulation that were not accounted for on activity logs. In this small study, 9 obese, sedentary participants wore a sealed pedometer and concurrently monitored their physical activity in an activity log. A 3-day baseline measurement of steps per day was obtained followed by a 4-week walking intervention. It was apparent that the physical activity log lacked responsiveness to changes in walking behavior. Based on pedometer data, subjects increased their walking by approximately 3700 steps/day. The physical activity logs did not indicate the same increase in physical activity when analyzed for average energy expenditure with both baseline and post-intervention values of approximately 45 kcal/kg/day.

Based on timed walks during the intervention, it was determined that the participants took approximately 800 to 1200 steps in ten minutes of continuous walking. The increase in pedometer steps per day from baseline to post-intervention roughly converted to 30-45 minutes of extra walking per day. Without knowing the walking intensity, this increase was still considered substantial as it brought these previously sedentary individuals to the current ACSM/CDC recommendation (43). While this study did not attempt to validate the use of a pedometer, it did show that a pedometer is simple to use and is capable of detecting increases in physical activity resulting from a walking-based intervention (43).

Until recently, self-report methods, including logs, surveys or questionnaires, were used to quantify daily physical activity. Bassett et al. (4) administered a physical activity questionnaire to 48 men and 48 women between the ages of 25 and 70 years. After the questionnaire was administered, participants were given a pedometer to wear for seven days. In an effort to quantify the amount of walking that the participants did during their daily lives, they were instructed to wear the pedometer at all times except when sleeping, showering, or during sports/recreation. Bassett et al. (4) found that the questionnaires resulted in an underestimation of physical activity, in particular, walking was under-estimated by 16%. The correlation between pedometer measured steps per day and the questionnaire was low, but statistically significant, for both men and women with $r = 0.346$ ($p=0.02$) and $r = 0.481$ ($p = 0.001$), respectively. While questionnaires continue to be a convenient measurement tool of physical activity for large epidemiological based research, pedometers provide a more direct and objective method of measuring daily walking activity. Since pedometers have been found to be reliable and accurate for walking (9, 38, 39), they are a solution for a low cost, objective monitoring tool of daily physical activity (4).

Tudor-Locke et al. (47) reviewed 25 articles on the convergent validity of pedometers against accelerometers, observation and self-reported measures of physical activities. Based on accumulated evidence, pedometers were found to perform well against observation when walking was the primary physical activity. The lowest correlation (r= 0.33) was seen between self-reported physical activity logs and pedometers. The researchers concluded that pedometers are a valid option for assessing physical activity. The researchers also concluded that pedometers are practical, non-invasive and user-friendly (47). When determining the appropriateness of using a pedometer to measure daily ambulation however, one should always consider the purpose of the study, proposed methodology and budget.

Walking as a Form of Physical Activity

Walking is a popular form of physical activity. It requires no equipment and can be done nearly anywhere. Data analysis performed by Rafferty et al. (37), from the 1998 Behavioral Risk Factor Surveillance System (BRFSS) estimated the prevalence of walking for physical activity and the proportion of walkers who met current public health physical activity recommendations. The data revealed that the prevalence of walking for exercise during leisure-time was

38.6% (37). The prevalence increased with age, educational level, income, and among women. Additionally, the 1998 BRFSS revealed that 4 out of 10 U.S. adults walked for exercise and that for the majority of walkers (56.7%), walking was their only leisure-time physical activity. However, only 1 in 5 walkers usually walked five or more times per week for 30 minutes (37). Therefore, although many people report leisure-time walking, few walk at levels recommended by the ACSM and CDC.

In a study by Duncan et al. (10), researchers examined whether the quantity and intensity of walking necessary to decrease the risk of cardiovascular disease among women differed from that required to improve cardiorespiratory fitness. A group of previously sedentary women were divided into three different groups defined as aerobic walkers (8.0 km/hr), brisk walkers (6.4 km/hr), and strollers (4.8 km/hr). Each group walked a distance of 4.8 kilometers per day, 5 days per week for 24 weeks. The subjects were 59 premenopausal, non-smoking, sedentary women aged 20 to 40 years who were randomly selected from a pool of volunteers and then randomized into one of the walking groups or a control group. The data indicated that speed of walking did not have an effect on the blood lipid profiles which were used to determine risk of cardiovascular disease. The volume of walking performed by these women was adequate for improving blood lipid profiles and thereby reducing the risk of cardiovascular disease. Speed of walking, however, had a dose-response effect on change in aerobic fitness levels which was measured via maximal oxygen consumption. The volume of walking performed by these women was adequate for improving blood lipid profiles. It can be concluded from this study that previously sedentary women who are seeking improvement in cardiovascular risk factors may benefit from walking at any pace (10). However, Hu et al. (17) found that, when walking volume was held constant, the risk of developing type 2 diabetes was related to walking pace. The controversy surrounding the relative importance of exercise volume versus exercise intensity remains.

Chapter 3

Manuscript

Abstract

Purpose: To compare the number of steps accumulated weekly by individuals given the recommendation to walk 10,000 steps per day with those told to take a brisk 30 minute walk on most, preferably all, days of the week.

Methods: Average steps per day were compared for 58 sedentary women (mean age 45.0 ± 6.0 y) who were randomly assigned to either walk 10,000 steps per day or take a brisk 30 minute walk on most, preferably all, days of the week. After measuring height, weight, body composition, and blood pressure, subjects wore a sealed pedometer for two weeks for a baseline physical activity assessment. If the subjects averaged ≤ 7000 steps per day, they were randomly assigned to a physical activity group for a 4-week intervention. All subjects wore a sealed pedometer capable of storing 7 days of data and reported to the laboratory each week so that investigators could gather step counts. The 10,000 steps per day group wore a second pedometer for viewing steps accumulated throughout the day.

Results: There were no differences between the groups at baseline testing. During the 4-week intervention, there was a significant difference between groups in daily steps. The 30 minute group walked 8270 ± 354 steps per day and the 10K group walked 10,159 ± 292 steps per day. The 30 minute group averaged 9505 ± 326 steps per day on the days that a 30 minute walk occurred

and 5597 ± 363 steps per day on the days that no walk occurred. The 10K group averaged 11,775 ± 207 steps on days when they walked at least 10,000 steps and 7780 ± 231 steps on days that their target was not achieved.

Conclusions: Sedentary, middle-aged women accumulate more daily physical activity when given the recommendation to walk 10,000 steps per day compared to the recommendation of taking a brisk 30 minute walk on most, preferably all, days of the week. On days when women took a 30 minute walk, their average step count was near 10,000 steps.

Key Words: 10,000 STEPS/DAY, PEDOMETERS, EXERCISE, WALKING

Introduction

Current physical activity statistics show that many American adults are sedentary and a large percentage are not physically active at levels that can promote health (6, 24). In a recent report from the Centers for Disease Control and Prevention (CDC), it was estimated that the prevalence of no leisure-time physical activity for US adults is 25% (6). Recent statistics place poor diet and physical inactivity as the second leading cause of death in the United States, with nearly 400,000 deaths attributed to this combination of factors (30). This increase from 300,000 deaths reported in 1993 (29) occurred in spite of an abundance of evidence linking health benefits to regular exercise (18, 23, 26, 34, 35). Many studies have shown a significant inverse relationship between physical activity and several disease states (23, 26, 29, 35); still approximately one quarter of U.S. adults abstain from any form of leisure-time physical activity (6).

With the high prevalence of physical inactivity, an important responsibility of health and fitness professionals is to create activity programs that are feasible, motivational, and effective for individuals. While research has shown that an increase in physical activity is associated with several benefits to overall health (23, 26, 34, 35), debate about the optimal physical activity recommendation continues. When establishing physical activity guidelines, walking should be considered as a viable option for most Americans. Walking is a popular mode of physical activity, and it is estimated that nearly 4 in 10 US adults walk for exercise (37). For most walkers (56.7%), walking is their only leisure-time physical activity (37).

Numerous approaches have been advocated for increasing physical activity. The American College of Sports Medicine (ACSM), CDC, and the Surgeon General currently recommend accumulating at least 30 minutes of moderate-intensity physical activity on most, preferably all, days of the week (36, 48). This recommendation aims to increase physical activity, thereby lowering disease risk in sedentary adults. However, there is little quantitative data on how much physical activity results when people begin an exercise program with these guidelines. In addition, it is difficult to know whether a compensatory decline in routine physical activity results when people begin structured exercise.

The ACSM/CDC recommendation allows the accumulation of physical activity throughout the day, and some advocate approaches which use pedometers to quantify accumulated daily activity. Hatano (14) suggests that accumulation of 10,000 steps per day is comparable to achieving 30 minutes of physical activity per day. Additionally, Wilde et al. (52) found that when sedentary women add a 30 minute walk to their normal routine, they accumulate approximately 10,000 steps. The 10,000 steps per day recommendation has distinct advantages, including the use of pedometers as an accurate measure of ambulatory activity. Research has shown that a digital pedometer can be a useful tool for monitoring the accumulation of daily moderate activity (9, 38, 39). Therefore, the purpose of this study was to compare the number of steps accumulated by women given the recommendation to walk 10,000 steps per day with those told to take a brisk 30 minute walk on most, preferably all, days of the week.

Methods

Subjects: Seventy-three sedentary, non-smoking females between the ages of 33 and 55 (44.8 ± 6.0 years) volunteered for this study. All procedures were reviewed and approved by the Institutional Review Board (IRB) at the University of Tennessee. Prior to participation, each subject was informed of potential risks and benefits, and signed an informed consent form (see Appendix A) approved by the University of Tennessee IRB. Potential subjects were excluded if they reported cardiovascular, pulmonary or metabolic disease. Subjects were included in the study if their body mass index (BMI) was ≤ 40.0 kg·m^{-2}, blood pressure was $\leq 160/100$ mmHg , average baseline steps were ≤ 7000 steps per day, and if they did not have any orthopedic limitations to walking.

Baseline Testing: Subjects reported to the lab after an overnight fast (with the exception of water) and were told to refrain from any exercise for twelve hours prior to testing. Upon arriving at the lab, subjects were seated for at least 5-10 minutes prior to taking blood pressure. During this time all testing procedures were explained to the subject and an informed consent and a health history questionnaire (see Appendix B) were completed. After the rest period, blood pressure measurements were taken three times using a stethoscope and a mercury sphygmomanometer with two minutes between each trial (7). The average of the three trials was then used as the baseline resting blood pressure.

Height was measured using a wall-mounted stadiometer (Seca Corporation, Columbia, MD). For body composition testing, all subjects wore a lycra swimsuit and were told to remove all jewelry and metal. Body mass and body fat percentage were assessed using the Bod Pod® body composition system (Life Measurement Instruments, Concord, CA). Subjects wore a lycra swimcap and testing was performed according to the manufacturers specifications. A female-specific equation, assuming a fat-free tissue density of 1.097 $kg \cdot l^{-1}$, was used to estimate percentage of body fat (15). Standing waist and hip circumference were measured in duplicate using a Gulick fiberglass measuring tape with a tension handle (Creative Health Products, Inc., Plymouth, MI), and mean values were used in calculations. The waist measurement was taken at the narrowest part of the torso between the rib cage and the iliac crest, after normal expiration. Hip circumference was measured at the greatest gluteal protuberance while the subject stood with feet together. BMI was calculated by dividing the weight in kilograms by the height in meters squared ($kg \cdot m^{-2}$).

Baseline activity was determined by measuring daily steps for 14 consecutive days. Steps per day were measured using the New Lifestyles NL-2000 (New Lifestyles Inc., Kansas City, MO), which has been shown to be accurate in measuring steps over a 24-hour period (38). The pedometers were sealed so that subjects were not able to see how many steps they were accumulating each day. Pedometer placement was standardized on the belt or waistband, in the midline of the thigh, consistent with the manufacturer's recommendation. Subjects were instructed to wear the pedometer during all waking hours except for when showering and to continue with their normal activity patterns for the 14-day baseline testing. The NL-2000 is capable of storing 7 days of activity, therefore subjects returned to the lab on days 7 and 14 so that steps per day could be recorded. Sixty-two subjects met the final inclusion criteria of averaging ≤ 7000 steps per day, and were included in the physical activity intervention portion of the study.

Physical Activity Intervention: The physical activity intervention lasted for four weeks, and subjects were randomly assigned to intervention groups. Approximately one half of the subjects were instructed to "take a brisk 30-minute walk on most, preferably all, days of the week." These subjects wore a sealed NL-2000 pedometer in the same manner as baseline testing, and were unaware of how many steps they were accumulating per day. Activity logs, which included the time that the pedometer was worn and any significant physical activity throughout the day, were kept by the subjects. The remainder of the subjects were instructed to "walk 10,000 steps per day." This group wore both a sealed

NL-2000 pedometer and a Yamax Digiwalker DW-200 (New Lifestyles Inc., Lees Summitt, MO) pedometer. The DW-200 pedometer was not sealed so that the subjects were able to track their steps throughout the day. A daily activity log was kept, which included the time the pedometers were worn, the number of steps accumulated per day, and any significant physical activity that was performed in order to achieve the 10,000 steps per day recommendation. Subjects were instructed to reset the DW-200 pedometer each morning. All subjects returned to the lab every 7 days to have data from the NL-2000 pedometer retrieved and activity logs collected. For data analysis, the number of steps recorded by the NL-2000 was used.

Statistical Analyses: Statistical analyses were performed using SPSS for Windows version 12.0 (SPSS, Inc., Chicago, IL). Descriptive statistics were calculated for all baseline measurements, and independent t-tests were used to compare the baseline characteristics of the two groups. A repeated measures analysis of variance (ANOVA) was used to compare steps per day over time and between groups. For each group, repeated measures ANOVA was used to compare steps per day at baseline, on days when recommendations were met (10K or 30 min), and on days when targets were not achieved. Repeated measures ANOVA was also used to determine if the groups differed in accumulated steps on days when the recommendations were met and when they were not met.

Results

Subject Characteristics: Of the 62 subjects that met inclusion criteria, four subjects from the 30 minute (30 min) group chose to discontinue the study. One subject dropped out due to an orthopedic issue and three participants stated that they did not care for their physical activity recommendation. Results are reported on the remaining 58 subjects, with 27 subjects in the 30 min group and 31 subjects in the 10,000 steps per day (10K) group. There were no statistically significant differences between groups in subject characteristics at baseline (Table 1). Subjects were generally overweight (BMI = 29.6 ± 6.1, body fat % = 41.8 ± 8.5%), middle-aged (45.0 ± 6.0 years) women with low activity levels (baseline steps = 5760 ± 1143 steps per day).

Physical Activity Recommendation Comparisons: Table 2 and Figure 1 show average steps per day by group for each week of the intervention. A statistically significant difference ($p<0.005$) was found between groups in the average number of daily steps at each week of the intervention and overall. Over the 4-week intervention, the 30 min group accumulated an average of 8270 ± 354 steps per day and the 10K group accumulated 10,159 ± 292 steps per day. Figure 2 shows the difference in accumulated steps for the 30 min group on the days that a 30 minute walk occurred compared to the days when no walk was recorded in the physical activity logs. On average, they walked 9505 ± 326 steps per day on the days that a 30 minute walk occurred and an average of

Table 1. Baseline characteristics of participants (mean ± SD).

Measure	30 min (n=27)	10K (n=31)
Age(y)	46.3 ± 6.4	43.8 ± 5.5
Height (m)	1.66 ± 0.04	1.65 ± 0.06
Body mass (kg)	80.7 ± 17.2	82.0 ± 17.1
BMI (kg/m2)	29.0 ± 5.8	30.0 ± 6.4
Waist circumference (cm)	90.7 ± 15.5	91.7 ± 14.5
Hip circumference (cm)	111.1 ± 12.2	113.0 ± 14.0
WHR	0.81 ± 0.07	0.81 ± 0.07
Body Fat (%)	41.1 ± 9.0	42.5 ± 8.0
Systolic blood pressure (mmHg)	118 ± 11	119 ± 15
Diastolic blood pressure (mmHg)	82 ± 6	81 ± 7
Baseline steps (steps/day)	5940 ± 1049	5603 ± 1214

BMI = body mass index.
WHR = waist to hip ratio.
30 Min = group assigned to take a brisk 30 min walk on most, preferably all, days of the week.
10K = group assigned to walk 10,000 steps per day.

Table 2. Comparison of average steps per day during 4-week intervention (mean ± SE).

Week	30 Min (n=27)	10K (n=31)
1	8042 ± 365*	10299 ± 344
2	8499 ± 427*	10006 ± 312
3	8183 ± 373*	10002 ± 343
4	8357 ± 435*	10329 ± 328
4 week average	8270 ± 354*	10158 ± 292

* =Significant difference between groups (p< .005).
30 Min = group assigned to take a brisk 30 min walk on most, preferably all, days of the week.
10K = group assigned to walk 10,000 steps per day.

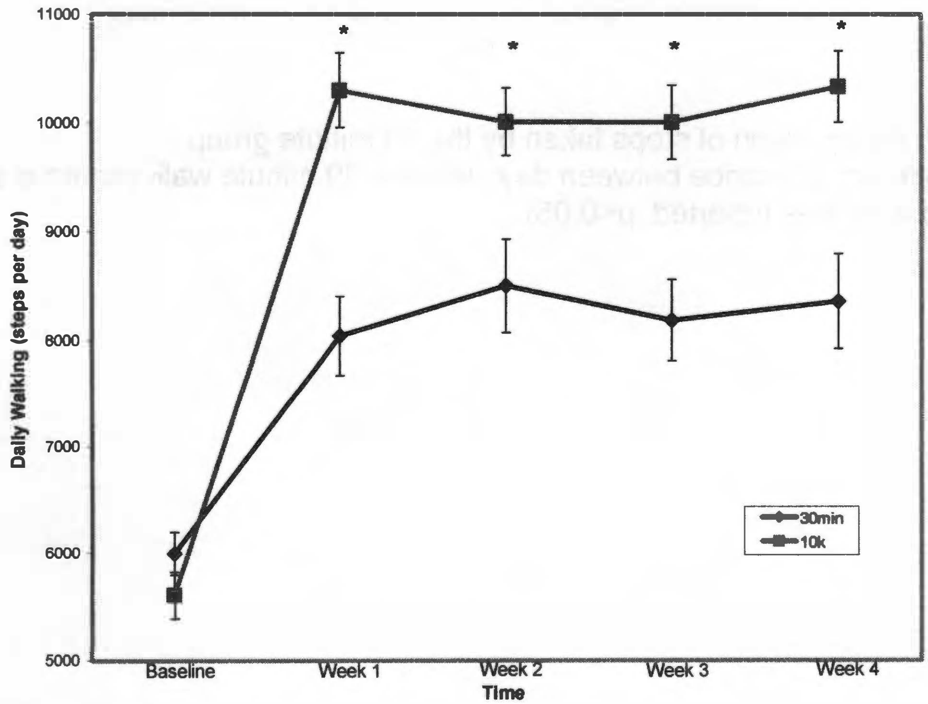

Figure 1. Comparison of average accumulated steps per day between groups (* = significant between group difference, p<0.005).

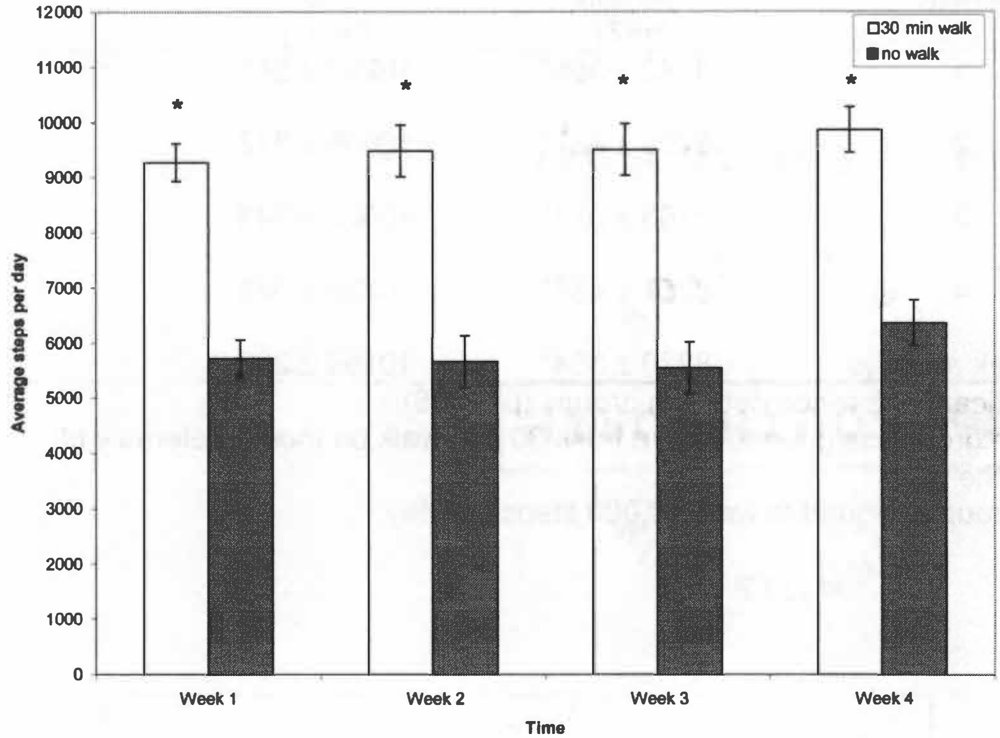

Figure 2. Comparison of steps taken by the 30 minute group.
(* = significant difference between days when a 30 minute walk occurred and when no walk was reported, p<0.05).

5597 ± 363 steps per day were taken on the days that no walk occurred. This difference between steps accumulated on 30 minute walk days compared to non-walk days was statistically significant ($p<0.05$). The 30 min group reached their recommendation an average of 4.4 days per week during the intervention.

Figure 3 shows the difference from baseline steps that each group accumulated on days that the assigned goals were met compared to the days that they were not met. For the 30 min group (Panel A), there was no statistically significant difference between their baseline steps and the average step count on the days that they did not take a 30 minute walk. However, the 10K group (Panel B) took significantly more steps everyday, even on the days when the 10,000 steps target was not achieved ($p<0.05$). Additionally, there was a significant difference ($p<0.05$) between steps accumulated on the days that the target was met compared to the days that it was not met, for both groups. Figure 4 shows a direct comparison between the groups on the days that each group met their target and the days that they did not. There was a significant difference ($p<0.05$) between the groups for days that they met their recommendations and the days that they did not. The 10K group averaged 11,775 ± 207 steps per day on the days they met their target compared to 9505 ± 326 steps per day for the 30 min group. Additionally, the 10K group averaged 7780 ± 231 steps per day on the days that they did not meet their target compared to 5597 ± 363 steps per day when the 30 min group did not report a 30 minute walk.

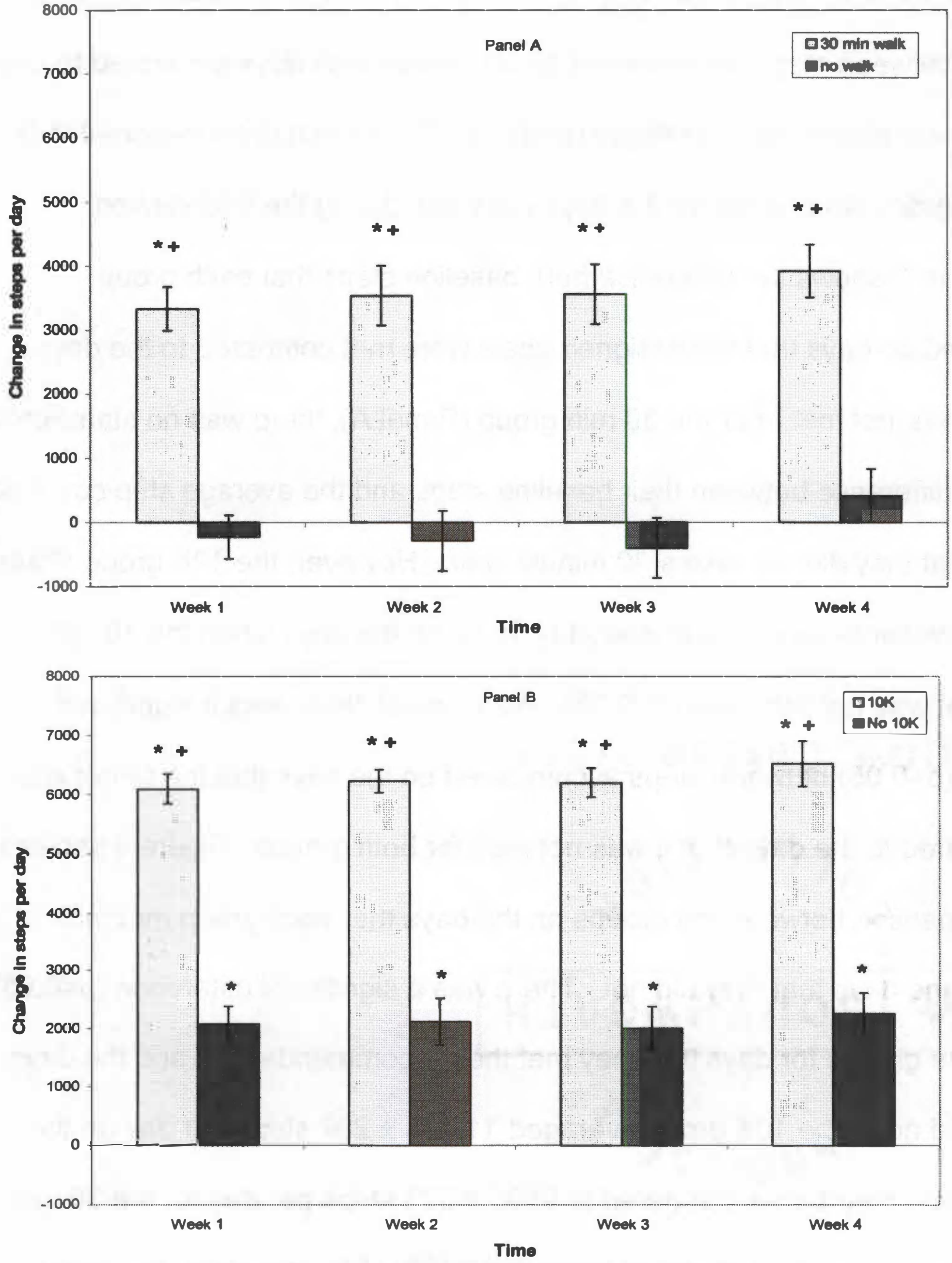

Figure 3. Difference from baseline steps for 30 minute walk vs. no 30 minute walk (Panel A) and 10K vs. no 10K days (Panel B).
(* = significantly different from baseline steps, p<0.05).
(+ = significantly different from days when recommendation was not met, p<0.05).

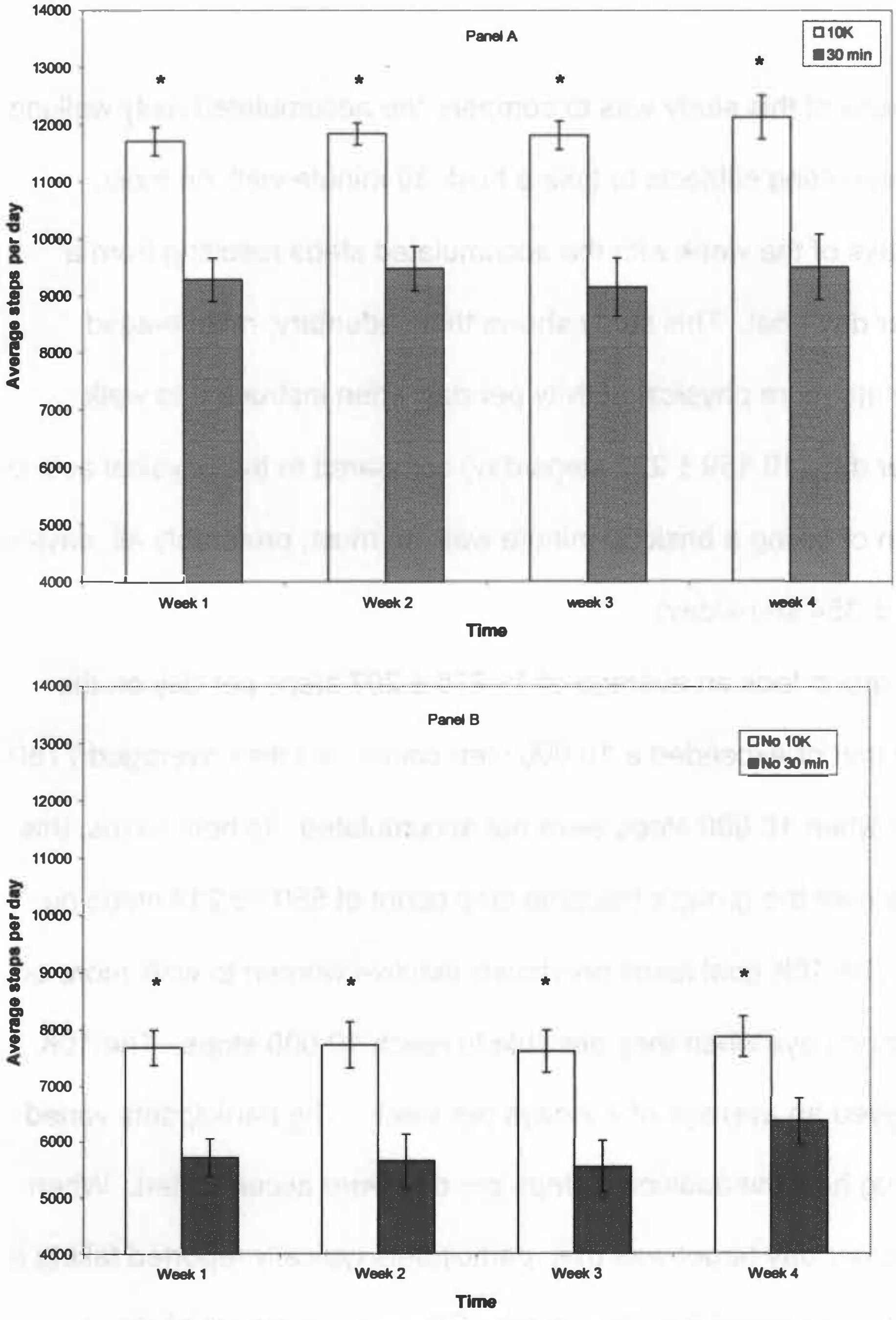

Figure 4. Comparison of average daily steps when subjects met their physical activity assignment (panel A) and when the target was not achieved (panel B). (* = significant difference between groups, p<0.05).

Discussion

The purpose of this study was to compare the accumulated daily walking resulting from instructing subjects to take a brisk 30 minute walk on most, preferably all, days of the week with the accumulated steps resulting from a 10,000 steps per day goal. This study shows that sedentary, middle-aged women accumulate more physical activity per day when instructed to walk 10,000 steps per day (10,159 ± 292 steps/day) compared to the physical activity recommendation of taking a brisk 30 minute walk on most, preferably all, days of the week (8270 ± 354 steps/day).

The 10K group took an average of 11,775 ± 207 steps per day on the days when they met or exceeded a 10,000 step count, and they averaged 7780 ± 231 on the days when 10,000 steps were not accumulated. In both cases, this was an increase over the group's baseline step count of 5603 ± 218 steps per day (Figure 3). The 10K goal leads previously inactive women to walk more on all days, not just on days when they are able to reach 10,000 steps. The 10K target was achieved an average of 4.2 days per week. The participants varied widely in reporting how the additional steps per day were accumulated. When the 10,000 steps per day target was met, participants typically reported taking a deliberate walk lasting from 10 to 75 minutes. The actual amount of steps accumulated during each walk was not recorded, but many subjects reported purposeful daily walking to meet the 10K goal. While most subjects reported extra walking in terms of time, one participant recorded having to walk an additional 2.0 to 2.5 miles on a treadmill to meet the step goal. There were no dropouts in the 10K group; each subject that met the inclusion criteria completed the 4-week intervention. There were no injuries reported in this group.

The subjects that were given the recommendation to take a brisk 30 minute walk on most, preferably all, days of the week reported reaching this target an average of 4.4 days per week, and on these days they accumulated 9505 ± 326 steps per day. This finding is similar to that of Wilde et al. (52) who found that adding a 30 minute walk to daily activities resulted in approximately 10,000 steps. This is also in general agreement with Welk et al. (49), who reported that individuals who engaged in 30 minutes of moderate-intensity activity often walked more than 10,000 steps. Figure 3 shows that when a 30 minute walk was not completed, the number of steps accumulated (5597 ± 363) was similar to the number of steps at baseline (5940 ± 202). It is interesting to note that all of the dropouts in this study were from the 30 min group. Three out of the four dropouts stated they did not care for this recommendation and therefore were unwilling to continue. Each of these dropouts occurred at least two weeks after the intervention began.

The 10,000 steps per day goal does not specifically address the issue of exercise intensity. Therefore, subjects in the 10K group were allowed to accumulate steps in ways that fit their lifestyle. However, walking at speeds consistent with normal ambulation for healthy adults is classified as moderate-intensity activity (1, 36), so we assume most of their walking fell into this category. For the 30 min group, we specifically instructed them to take a "brisk"

30 minute walk. This was in an effort to ensure consistency with the ACSM/CDC focus on moderate-intensity exercise (36). We did not attempt to verify whether the walks were in fact moderate-intensity. This would have required heart rate monitoring, documentation of distance covered, or supervised sessions. This would have interfered with our purpose of understanding how a non-exerciser implements this standard physical activity recommendation into her daily life and how much walking results.

A limitation of this study is that a rather homogenous group of middle-aged, overweight, and previously sedentary women served as subjects. Those who have higher initial steps per day may not see a similar increase in daily walking when given the 10,000 steps per day goal. Although the women in this study were able to achieve the daily 10,000 steps goal without a lead in period, subjects with even lower baseline steps may need to gradually increase their steps in order to reach 10,000 steps per day. Clearly more studies are needed to shed light on how much quantifiable activity results when people implement various physical activity recommendations. Another limitation of this study is that walking was the only activity examined. Because pedometers were the tools used to quantify physical activity, subjects were not given the option to use cycling, swimming, or other non-ambulatory activity for exercise. It is also important to note that this was only a 4-week intervention. Long-term adherence and compliance was not addressed.

With the high prevalence of American adults failing to reach the ACSM/CDC recommended levels of physical activity, it is important to look for ways to help these individuals become more active. Pedometers are easy to use tools that provide immediate feedback to wearers about accumulated walking. We found the popular physical activity goal of accumulating 10,000 steps per day to be both feasible and effective in increasing daily walking in previously inactive women. Our findings demonstrate that prescribing 10,000 steps per day results in greater step accumulation than giving the recommendation to take a brisk 30 minute walk. The use of pedometers and a step count target results in subjects walking more everyday rather than just on days when purposeful exercise is performed. The fact that approximately 9500 steps were taken on days when subjects took a 30 minute walk suggests a general concordance between the public health recommendation and the popular pedometer-monitored goal. As we seek methods for increasing daily physical activity, pedometer-monitored goals should be considered a viable option.

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Appendices

Appendix A

Informed Consent

Informed Consent Form

Investigators: Cherilyn Hultquist and Carolyn Albright
Address:
The University of Tennessee
Department of Health and Exercise Science
1914 Andy Holt Avenue
Knoxville, TN 37966
Telephone: (865) 974-8768/(865) 974-6040

Purpose
You are invited to participate in a research study. The purpose of this study is to determine the effectiveness of the exercise prescription, "Walk 10,000 steps per day." If you give your consent, you will be asked to perform the testing below. This testing will take approximately one hour. You will first complete a health history questionnaire to determine your health status. Body composition, circumference measurements, and blood pressure will be determined in the Applied Physiology Laboratory in the HPER building on the UT campus. You will report to the lab following an overnight fast having abstained from both food and exercise the morning of the test.

Testing
1. Resting blood pressure will be measured using a stethoscope and a mercury sphygmomanometer, much like the blood pressure procedures in a doctor's office. You will be seated for 5-10 minutes in a comfortable position prior to the measurement. This procedure will be repeated 3 times after short rest periods to ensure accuracy.

2. We will measure your height, weight, and the distance around your hips and waist.

3. Your body fat will be determined using the Bod Pod and Bioelectrical Impedance Analysis (BIA). During these tests you will wear either a swimsuit or your undergarments. The Bod Pod is a machine that is able to measure your body size as you sit inside it. You will sit in the Bod Pod chamber for 2 one-minute trials. While in the chamber you will be able to breathe normally and see your surroundings. After the Bod Pod test, you will have your body fat measured with the BIA. This technique measures electrical currents in your body. This instrument is a scale as well as a BIA and you will stand on the scale for a few seconds while your body fat percentage is being determined.

4. A baseline walking assessment will take place for 2 weeks following the lab tests. You will wear a pedometer (step counter) on your belt or waistband in order to count your steps each day. You will return to the lab 7 days and 14 days after the lab tests in order for us to gather information from your pedometer. We do not want you to change your activity levels during this time. At the end of this 2 week period, we will determine whether you fit the activity profile to be included in this study. If you do not, you will still be given all of the health information we have collected and we will help design an individual exercise program for you.

Exercise Training
The exercise training will begin after the 2 week baseline assessment. You will wear 2 digital pedometers on a belt or waistband everyday. One of these pedometers can be opened to check your step count, but the other will stay closed. For 4 weeks you will "Walk 10,000 steps per day." You will keep a daily activity log in which you will record your steps per day and other physical activities at the end of each day. You will report to the lab once per week to have your pedometer checked and re-set and to turn in your daily log sheets. Each visit will last about 5 minutes. At the end of the 4 weeks anthropometric measures, body fat, and blood pressure testing will be repeated. After the initial 4 weeks of the study, you will continue with the exercise recommendation of "Walk 10,000 steps per day" but you will no longer report to the lab each week and you will wear only 1 pedometer. You will however, return to the lab after 3 months and 6 months for anthropometric measures, body fat, and blood pressure testing. You will also continue to record your steps per day and physical activity each day and you will send your daily log sheets to the lab each week. Approximately 1 year after the study ends, we would like for you to return to the lab for follow-up tests which will be the same as previous tests.

Potential Risks
The risks associated with exercising are very slight in a healthy population during submaximal exercise. These risks include abnormal blood pressure responses, musculo-skeletal injuries, dizziness, difficulty in breathing, and in rare cases heart attack or death. If you experience any abnormal feelings while walking such as chest pain or severe breathlessness, you should contact your physician immediately. There are no known risks to the laboratory tests you will complete.

Benefits of Participation
From the results of your tests, you will be told your body fat percentage, blood pressure and circumference measurements. Additionally you will receive valuable information regarding exercise prescription and your average steps per day. Previous studies have shown walking to be important in controlling weight and blood pressure, so you may experience these benefits. After the intervention is over, you will have an opportunity to make an appointment with Cherilyn or Carrie to discuss your exercise goals, and design an exercise program to meet those goals.

Confidentiality
The information obtained from these tests will be treated as privileged and confidential and will consequently not be released to any person without your consent. However, the information will be used in research reports and presentations; however your name and other identity will not be disclosed.

Contact Information
If you have questions at any time concerning the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact either Cherilyn or Carrie. If you have questions about your rights as a participant, contact Research Compliance Services of the Office of Research at (865) 974-3466.

Right to Ask Questions and to Withdraw
You are free to decide whether or not to participate in this study and are free to withdraw from the study at any time.

Before you sign this form, please ask questions about any aspects of the study, which are unclear to you.

Consent
By signing, I am indicating that I understand and agree to take part in this research study.

____________________________ ____________________________
Your Signature Date

____________________________ ____________________________
Researcher's Signature Date

By signing below, I give my permission for you to save my contact information so that I can be contacted for follow-up tests. Signing does not obligate me to return for those tests.

____________________________ ____________________________
Your Signature Date

Informed Consent Form

Investigators: Cherilyn Hultquist and Carolyn Albright
Address:
The University of Tennessee
Department of Health and Exercise Science
1914 Andy Holt Avenue
Knoxville, TN 37966
Telephone: (865) 974-8768/(865) 974-6040

Purpose
You are invited to participate in a research study. The purpose of this study is to determine the effectiveness of the exercise prescription, "Take a brisk 30 minute walk on most, preferably all, days of the week." If you give your consent, you will be asked to perform the testing below. This testing will take approximately one hour. You will first complete a health history questionnaire to determine your health status. Body composition, circumference measurements, and blood pressure will be determined in the Applied Physiology Laboratory in the HPER building on the UT campus. You will report to the lab following an overnight fast having abstained from both food and exercise the morning of the test.

Testing
1. Resting blood pressure will be measured using a stethoscope and a mercury sphygmomanometer, much like the blood pressure procedures in a doctor's office. You will be seated for 5-10 minutes in a comfortable position prior to the measurement. This procedure will be repeated 3 times after short rest periods to ensure accuracy.

2. We will measure your height, weight, and the distance around your hips and waist.

3. Your body fat will be determined using the Bod Pod and Bioelectrical Impedance Analysis (BIA). During these tests you will wear either a swimsuit or your undergarments. The Bod Pod is a machine that is able to measure your body size as you sit inside it. You will sit in the Bod Pod chamber for 2 one-minute trials. While in the chamber you will be able to breathe normally and see your surroundings. After the Bod Pod test, you will have your body fat measured with the BIA. This technique measures electrical currents in your body. This instrument is a scale as well as a BIA and you will stand on the scale for a few seconds while your body fat percentage is being determined.

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still be given all of the health information we have collected and we will help design an individual exercise program for you.

Exercise Training

The exercise training will begin after the 2 week baseline assessment. You will wear a digital pedometer on a belt or waistband everyday. For 4 weeks you will "Take a brisk walk for 30 minutes on most, preferably all, days of the week." You will keep a daily activity log in which you will record your physical activities each day. You will report to the lab once per week to have your pedometer checked and re-set and to turn in your daily log sheets. Each visit will last about 5 minutes. At the end of the 4 weeks anthropometric measures, body fat, and blood pressure testing will be repeated. After the initial 4 weeks of the study, you will continue with the exercise recommendation of "Take a brisk 30 minute walk on most, preferably all, days of the week" but you will no longer report to the lab each week. You will however, return to the lab after 3 months and 6 months for anthropometric measures, body fat, and blood pressure testing. You will also continue to record your steps per day and physical activity each day and you will send your daily log sheets to the lab each week. Approximately 1 year after the study ends, we would like for you to return to the lab for follow-up tests which will be the same as previous tests.

Potential Risks

The risks associated with exercising are very slight in a healthy population during submaximal exercise. These risks include abnormal blood pressure responses, musculo-skeletal injuries, dizziness, difficulty in breathing, and in rare cases heart attack or death. If you experience any abnormal feelings while walking such as chest pain or severe breathlessness, you should contact your physician immediately. There are no known risks to the laboratory tests you will complete.

Benefits of Participation

From the results of your tests, you will be told your body fat percentage, blood pressure and circumference measurements. Additionally you will receive valuable information regarding exercise prescription and your average steps per day. Previous studies have shown walking to be important in controlling weight and blood pressure, so you may experience these benefits. After the intervention is over, you will have an opportunity to make an appointment with Cherilyn or Carrie to discuss your exercise goals, and design an exercise program to meet those goals.

Confidentiality

The information obtained from these tests will be treated as privileged and confidential and will consequently not be released to any person without your consent. However, the information will be used in research reports and presentations; however your name and other identity will not be disclosed.

Contact Information
If you have questions at any time concerning the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact either Cherilyn or Carrie. If you have questions about your rights as a participant, contact Research Compliance Services of the Office of Research at (865) 974-3466.

Right to Ask Questions and to Withdraw
You are free to decide whether or not to participate in this study and are free to withdraw from the study at any time.

Before you sign this form, please ask questions about any aspects of the study, which are unclear to you.

Consent
By signing, I am indicating that I understand and agree to take part in this research study.

______________________________ ______________________________
Your Signature Date

______________________________ ______________________________
Researcher's Signature Date

By signing below, I give my permission for you to save my contact information so that I can be contacted for follow-up tests. Signing does not obligate me to return for those tests.

______________________________ ______________________________
Your Signature Date

Appendix B

Health History Questionnaire

HEALTH HISTORY QUESTIONNAIRE

NAME____________________________ DATE______________________

DATE OF BIRTH____________________ AGE_______________________

ADDRESS____

____

PHONE NUMBERS (HOME)__________________(WORK)_________________

e-mail address:____

When is the best time to contact you?_______________________________________

Please answer the following questions. This information will only be used for research purposes and will not be made public. Please answer the following questions based on physical exercise in which you regularly engage. **This should not include daily work activities such as walking from one office to another.**

1. Do you regularly engage in exercise? Yes/No If yes, please describe.

____

____

2. On average, how many times per week do you engage in exercise training?

0_____1_____2_____3_____4_____5_____6_____7_____

3. On average, how long do you exercise each time?

0-19 minutes_____20-40 minutes_____more than 40 minutes_____

4. How long have you been exercising at this level?

Less than 6 months ________
6 – 12 months ________
1 – 2 years ________
3 or more years ________

MEDICAL HISTORY

Past History:

Have you ever been diagnosed with the following conditions? Please check the appropriate column.

	Yes	No	Don't Know
Rheumatic Fever	( )	( )	( )
Heart Murmur	( )	( )	( )
High Blood Pressure	( )	( )	( )
Any heart problem	( )	( )	( )
Lung Disease	( )	( )	( )
Seizures	( )	( )	( )
Irregular heart beat	( )	( )	( )
Bronchitis	( )	( )	( )
Emphysema	( )	( )	( )
Diabetes	( )	( )	( )
Asthma	( )	( )	( )
Kidney Disease	( )	( )	( )
Liver Disease	( )	( )	( )
Severe Allergies	( )	( )	( )
Orthopedic problems	( )	( )	( )
Hyper- or Hypothyroidism	( )	( )	( )
AIDS	( )	( )	( )
Heparin Sensitivity	( )	( )	( )

Present Symptom Review:

Have you recently had any of the following symptoms? Please check if so.

Chest Pain	( )	Frequent Urination	( )
Shortness of Breath	( )	Blood in Urine	( )
Heart palpitations	( )	Burning sensations	( )
Leg or ankle swelling	( )	Severe headache	( )
Coughing up blood	( )	Blurred vision	( )
Low blood sugar	( )	Difficulty walking	( )
Feeling faint or dizzy	( )	Weakness in arm	( )
Leg numbness	( )	Significant emotional problem	( )

Do you smoke? Yes/No If yes, how many per day?_____________

Are you currently trying to lose weight (through diet, exercise, and/or medication)? Yes/No

Are you taking any medications? Yes/No
If yes, please describe:____
On average, how many alcoholic drinks do you consume per week?________________

Can you walk 1 continuous mile without pain or discomfort?____________________

OTHER INFORMATION
Whom should we notify in case of emergency?

Name ____________________________

Address ____________________________

Phone # ____________________________

I have been given the opportunity to ask questions about any of the above items that were unclear, and I have answered all questions completely and truthfully to the best of my knowledge.

SIGNATURE______________________________________DATE_________________

Appendix C

Physical Activity Logs

Your next appointment is: ____________

Subject #: __________ **Week #:** __________

Date: _______	Date: _______	Date: _______	Date: _______	Date: _______	Date: _______	Date: _______
Day: _______	Day: _______	Day: _______	Day: _______	Day: _______	Day: _______	Day: _______
Time on:	Time on:	Time on:	Time on:	Time on:	Time on:	Time on:
__________	__________	__________	__________	__________	__________	__________
Time off:	Time off:	Time off:	Time off:	Time off:	Time off:	Time off:
__________	__________	__________	__________	__________	__________	__________
Total Steps	Total Steps	Total Steps	Total Steps	Total Steps	Total Steps	Total Steps
__________	__________	__________	__________	__________	__________	__________

Comments:

The pedometer should be worn at all times except for when showering, swimming, or sleeping.
Remember to put your pedometer on as soon as you wake up and record what time it is.
Before you go to bed at night, remove your pedometer and write down how many steps you took that day.

If you have any questions call 974-6040

Your next appointment is: ____________

Subject #: ________ **Week #:** ________

Date: Time on: ________ Activity: ________________________________
Day: Time off: ________ ________________________________

Date: ________ Time on: ________ Activity: ________________________________
Day: Time off: ________ ________________________________

Date: ________ Time on: ________ Activity: ________________________________
Day: Time off:

Date: ________ Time on: ________ Activity: ________________________________
Day: Time off: ________________________________

Date: ________ Time on: ________ Activity: ________________________________
Day: ________ Time off: ________ ________________________________

Date: Time on: ________ Activity: ________________________________
Day: Time off: ________ ________________________________

Date: ________ Time on: Activity: ________________________________
Day: ________ Time off: ________ ________________________________

Comments:

The pedometer should be worn at all times except for when showering, swimming, or sleeping.
Remember to put your pedometer on as soon as you wake up and record what time it is.
Before you go to bed at night, remove your pedometer and write down how many steps you took that day.

If you have any questions call 974-6040

Appendix D

Instructions to Subjects

You have received an exercise recommendation to walk 10,000 steps per day. This is an easy way for beginners to begin exercise. The pedometer will give you valuable feedback on your accumulated activity throughout the day. The good news is you get credit from your steps throughout the day, including your activity at work. There are activities you can do throughout the day that can add on many steps. The following activities may help you achieve your 10,000 steps.

- ✓ Take the stairs instead of the elevator
- ✓ Don't look for the closest spot, park farther away
- ✓ Take a walk with a spouse, child, or friend
- ✓ Take a 10 minute walk during lunch
- ✓ Take your dog for a walk
- ✓ Engage in an outdoor activity with your kids/grandkids
- ✓ Walk to a neighbor's house instead of phoning or driving
- ✓ When watching TV, get up and walk around during commercials
- ✓ Get up to change the channel
- ✓ Instead of e-mailing or calling a coworker, walk to their desk
- ✓ Window shop
- ✓ Spend time gardening

You have received the exercise recommendation to "take a brisk 30 minute walk on most, preferably all, days of the week." This recommendation is derived from the current recommendation by the American College of Sports Medicine and the Centers for Disease Control and Prevention.

When walking briskly you should notice:

An increase in heart rate
An increase your breathing rate
The onset of perspiration
That you are still able to talk normally

These are all normal occurrences during a moderate-intensity exercise bout, such as brisk walking.

Appendix E

Supplemental Study #1

Supplemental Study #1:
%BF-Bod Pod Compared to %BF-BIA in Middle-aged, Sedentary Females

Introduction

Several methods for assessing body composition currently exist. Technology has made it possible to estimate body fatness while keeping a subject comfortable throughout the procedure. Body composition is important when stratifying data for research or when assessing health risk factors for individuals. It is important to examine the many body composition assessment options available in order to provide the most consistent and accurate estimate with the least amount of discomfort for the subject.

Purpose

The purpose of this study was to compare the %BF estimates from the Bod Pod® utilizing a female-specific body composition equation with estimates from the Tanita® TBF-305 using the adult-female mode in middle-aged, sedentary females.

Methods

Body fat percentage was estimated for 58 middle-aged, sedentary, females using the Bod Pod® and the Tanita® TBF-305 (Tanita Corporation, Tokyo, Japan). The protocol for the Bod Pod® is listed previously in chapter 3 of this document, entitled "Manuscript." Bioelectrical impedance analysis (BIA) estimates were performed according to the manufacturer's specified procedures. Subjects were instructed to remove all jewelry and other accessories and were clothed only in their swimsuit. Gender, height, and “adult” mode were manually entered into the Tanita® keypad. The Tanita® TBF-305 is a foot-to-foot, pressure contact electrode BIA device that resembles a bathroom scale. The Tanita® contains two stainless-steel foot pad electrodes that are divided into anterior and posterior portions. The analyzer measures impedance by sending a small current (500 µA) through the anterior portion of the foot pad electrodes to the posterior portion where the voltage drop (impedance) is determined. Once impedance is measured, the Tanita® then uses a regression equation to estimate body composition.

Results and Discussion

Table A1 contains %BF estimates for 58 middle-aged, sedentary females from both the Bod Pod® and the Tanita® TBF-305. The Tanita® overestimated the %BF compared to the Bod Pod®.

A paired t-test between the two methods revealed a p-value of 0.034. This indicates that there is a significant difference between the two body composition techniques. Because neither method is considered a criterion technique, it is impossible to determine if one method is more accurate than the other. This study shows that more research needs to be done in the area of body composition testing in order to have the most accurate estimate available for research purposes.

Table A1. Comparison of %BF estimates obtained with Bod Pod and BIA adult-female mode (mean ± SD).

Body Composition Model	All Women (n=58)
Bod Pod® female specific equation (%BF)	40.8 ± 8.6*
Tanita® 350-TBF adult-female mode (%BF)	42.0 ± 6.5

* = Significantly different compared to the Tanita TBF-305 ($p<0.05$)

Appendix F

Supplemental Study #2

Supplemental Study #2
Changes in Physical Characteristics Following 4 Weeks of Walking

Introduction

Current statistics indicate that nearly 400,000 deaths in the United States each year are attributed to poor diet and physical inactivity, and that physical inactivity may soon become the leading cause of death in the United States (30). This number is up from 300,000 deaths attributed to poor diet and physical inactivity from statistics reported in 1993 (29). Physical inactivity is linked to several negative health conditions including coronary heart disease, type 2 diabetes, hypertension and hyperlipidemia, and in many instances these conditions occur in combination (48). While these disease states are not caused solely by sedentary behavior, inactive individuals are at a higher risk of occurrence. Conversely, many of these conditions can be improved by increasing levels of daily physical activity. Research has shown a strong and consistent inverse relationship between physical activity and several disease states as well as all-cause mortality (23, 26, 34, 35). Walking has been specifically associated with the improvement of several health risk factors including high blood pressure, glucose tolerance, and body fatness (32, 41, 42). It is important to recognize the benefits that can be generated from walking, but the debate continues regarding the exact amount of walking necessary to see changes.

Purpose

The purpose of this study was to examine changes in physical characteristics in middle-aged, sedentary women after a 4-week physical activity intervention.

Methods

Upon arriving at the lab, subjects were seated for at least 5-10 minutes prior to taking blood pressure. After the rest period, blood pressure measurements were taken three times using a stethoscope and a mercury sphygmomanometer with two minutes between each trial (7). The average of the three trials was then used as the baseline resting blood pressure. For body composition testing, all subjects wore a lycra swimsuit and were told to remove all jewelry and metal. Body mass and body fat percentage were assessed using the Bod Pod® body composition system (Life Measurement Instruments, Concord, CA). Subjects wore a lycra swimcap and testing was performed according to the manufacturers specifications. A female-specific equation, assuming a fat-free tissue density of 1.097 $kg \cdot l^{-1}$, was used to estimate percentage of body fat (15). Standing waist and hip circumference were measured in duplicate using a Gulick fiberglass measuring tape with a tension handle (Creative Health Products, Inc., Plymouth, MI), and mean values were used in calculations. The waist measurement was taken at the narrowest part of the torso between the rib cage and the iliac crest, after normal expiration. Hip circumference was measured at the greatest gluteal protuberance while the subject stood with feet together. BMI was calculated by dividing the weight in kilograms by the height in meters squared ($kg{\cdot}m^{-2}$).

The physical activity intervention lasted for four weeks and subjects were randomly assigned to intervention groups. Approximately one half of the subjects were instructed to "take a brisk 30-minute walk on most, preferably all, days of the week." These subjects wore a sealed NL-2000 pedometer (New Lifestyles Inc., Kansas City, MO) on their waistband, and were unaware of how many steps they were accumulating per day. Activity logs, which included the time that the pedometer was worn and any significant physical activity throughout the day, were kept by the subjects. The remainder of the subjects were instructed to "walk 10,000 steps per day." This group wore both a sealed NL-2000 pedometer and a Yamax Digiwalker DW-200 (New Lifestyles Inc., Lees Summitt, MO) pedometer. The DW-200 pedometer was not sealed so that the subjects were able to track their steps throughout the day. A daily activity log was kept, which included the time the pedometers were worn, the number of steps accumulated per day, and any significant physical activity that was performed in order to achieve the 10,000 steps per day recommendation. Subjects were instructed to reset the DW-200 pedometer each morning.

Subjects returned to the lab after the 4-week intervention at approximately the same time of day that their baseline testing was performed. The subjects were instructed to be fasted overnight, and refrain from exercise for 12 hours. All blood pressure and body composition tests performed at baseline were repeated in the same manner.

Statistical analyses were performed using SPSS for Windows version 12.0 (SPSS, Inc., Chicago, IL). Descriptive statistics were calculated for all baseline measurements, and paired t-tests were used to compare changes in characteristics at pre and post test.

Results and Discussion

Following the intervention, systolic (118 ± 13 vs. 116 ± 12 mmHg) and diastolic (81 ± 7 vs. 79 ± 8 mmHg) blood pressure were significantly reduced ($p<0.05$), with no difference between groups (Table B1). There were no significant changes in weight, BMI, body fat percentage, waist circumference, hip circumference, or WHR (Table B1).

Because this intervention lasted only one month, we did not anticipate seeing changes in physical characteristics. As expected, there was no difference over time for measures including weight, BMI, body fat percentage, waist and hip circumference, and WHR. We anticipate that if subjects continue to follow the exercise recommendations, there will be a change in these variables. Moreau et al. (32) reported a loss of 1.3 kg in women who walked approximately 10,000 steps per day for 24 weeks. The subjects in the current study did experience a significant reduction in both systolic and diastolic blood pressure, with no difference between groups. This finding is similar to other studies that have observed a decrease in blood pressure after increasing walking to approximately 10,000 steps per day in previously sedentary women (32, 41). More walking would be needed to see additional changes in other physical characteristics.

Table B1. Pre and post intervention values for subject characteristics (mean±SD).

Measure	Pre-intervention (n = 58)	Post-intervention (n = 58)
% Body Fat	40.8 ± 8.6	40.5 ± 8.5
Weight (kg)	81.4 ± 17.0	81.0 ± 17.0
BMI (kg.m2)	29.6 ± 6.1	29.4 ± 6.1
Waist Circumference (cm)	91.2 ± 14.9	90.8 ± 14.7
Hip Circumference (cm)	112.1 ± 13.1	111.7 ± 13.4
WHR	0.81 ± 0.07	0.81 ± 0.07
Systolic blood pressure (mmHg)	118.1 ± 13.0*	115.6 ± 12.1
Diastolic blood pressure (mmHg)	81.3 ± 7.0*	79.4 ± 8.4

BMI = body mass index
WHR = waist to hip ratio
* = statistically significant difference between pre and post test ($p < 0.05$)

Vita

Cherilyn Nicole Hultquist was born in California on January 10, 1974 to Steve and Diane Hultquist. She earned her Bachelor of Science degree in Kinesiology/Athletic Training from San Diego State University. While at San Diego State, she was active as a student athletic trainer and a research assistant. While pursuing her Master's degree in Exercise Science at The University of Tennessee, Knoxville, she has worked as a graduate teaching assistant in the Physical Education Activity Program. She was a 2002-2003 recipient of the Hobt Teaching Award for her work as a graduate teaching assistant. She has also recently received the University of Tennessee Chancellor's Honors Award for Professional Promise for her achievements at the University of Tennessee.