Fall 12-18-2010

# 3000 steps in 30 minutes, five days per week yields metabolic improvements compared to 150 weekly minutes

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# 3000 Steps in 30 Minutes, Five days per Week Yields Metabolic Improvements Compared to 150 Weekly Minutes

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A thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

Partial Fulfillment of the Requirements

For the degree of

Master of Sciences

Health Sciences

December 2010

## Dedication

I dedicate this thesis to Jeff:

This work could have never been done without your patience, understanding, support, and most of all love.

**Acknowledgements**

It is a pleasure to thank the many people who made this thesis possible.

First, I'd like to thank my advisor and supervisor Dr. David Wenos. Without your time and energy this work would never have been possible. I am thankful for the supervision, advice, and guidance you gave me but also the freedom to work independently. It was an honor to work for you and with you. You have helped me grow as a student, a writer, and a researcher. The knowledge I have gained from you is irreplaceable.

I would like to thank Dr. Michael Deaton for your help in getting me through the analysis portion of this project. I appreciate your help in organizing this data and helping me understand the statistics.

Dr. Jeremy Akers, thank you for your support and sharing your knowledge of research. Your time and guidance was more appreciated then you will ever know.

Next I would like to thank Dr. Tammy Wagner for your emotional support. You helped me realize that I could successfully make it through this project.

Dr. M. Kent Todd, thank you for your constant suggestions and improvements to this research. Your advice and willingness to help is truly appreciated.

I am forever grateful for Nick, Kristina, and Taylor and your help with data collection and supervision of walking groups. Your time is appreciated more than you know. I would have never kept my sanity without you being there.

To my fellow graduate assistants, Erica and Tracey, thank you for your support throughout this entire project. I would have never made it through without you. I could always count on you to help me when I was stuck and I appreciate your willingness to listen and make me laugh when I needed it the most.

I would like to thank the best brothers anyone could ask for, David and Adam. I am thankful for all the love and laughter you bring to my life and you always eased the stress. I appreciate you going out for runs with me and never letting me beat you in a race.

Mom and Dad, you have taught me the wisdom, patience, and perseverance to accomplish all that I set out to do. Thank you for always listening to me and giving me support where I needed it most. I could have never made it through graduate school without your "words of wisdom" and am eternally grateful for your love and support through this entire process.

Most importantly, Jeffrey Matthews, words fail me when I attempt to express the gratitude I have for the selfless love and compassion you showed me through this journey. Thank you for being so understanding and supportive and putting up with my long hours and sleepless nights. I could have never done it without you and for that I am forever indebted to you.

## Table of Contents

## List of Tables

## List of Figures

**Abstract**

The physical activity recommendation for U.S. adults is to engage in moderate-intensity exercise for at least 150 minutes per week. Pedometers have gained popularity as a tool for motivating and estimating daily physical activity. Recently it was suggested 3000 steps in 30 minutes may be equivalent to moderate-intensity walking. To date, this recommendation has yet to be examined over an extended period of time. **PURPOSE**: To evaluate changes in cardiorespiratory fitness, body composition, blood lipids, blood glucose, and CRP from 150 minutes of free living weekly exercise compared to pedometer measured 3000 steps in 30 minutes, five days per week. **METHODS**: Subjects were randomly divided into two interventions (free living and pedometer) for 12 weeks. A free living (FL) group (n=12) accumulated 150 minutes moderate-intensity physical activity per week. A pedometer (P) group (n=13) attended three 30-min supervised walking sessions and walked two 30-min sessions independently. Metabolic variables were measured pre- and post-intervention. **RESULTS**: Twenty-five subjects began the study and nineteen FL (n=8) and P (n=11) subjects completed the study. Adherence was 77.9% and 85.2% in FL and P groups, respectively. SBP (-8.24 ± 11.3; $p<0.05$) and glucose (-7.2 ±11.8mg/dl; $p<0.05$) were significantly lower in P pre/post. Mean changes in CRP (-1.6 mg/dl, $p = 0.11$), LM (0.14 kg, $p = 0.19$), and $VO_{2max}$ (1.6 mg/kg/min, $p = 0.2$) approached significance in P only. In contrast, FL pre/post measurements did not significantly differ in any parameter. HR, BP, GLU, LM, and BMD improved in both groups. CRP and $VO_{2max}$ improved in P only. **CONCLUSION**: Evidence suggests the general recommendation of 150 minutes per week does not successfully improve metabolic variables or promote adherence. Additionally, there is a

dose response to 3000 steps in 30 minutes on metabolic variables compared with 150 minutes per week. This gives a practical application for the use of pedometers and metronomes to monitor intensity and motivate adherence. Further, results indicate walking 3000 steps in 30 minutes is an appropriate proxy for meeting the 150 minutes per week recommendation.

# Chapter One

## Introduction

The obesity epidemic has prompted researchers (Chan, Ryan, & Tudor-Locke, 2004; Coleman et al., 1999) and agencies (Haskell, Lee, Pate, Powell, & Blaire, 2007) to recommend modes of exercise that are familiar and easily incorporated into daily routine. It is suggested U.S. adults engage in moderate-intensity physical activity for at least 150 minutes per week. This is equivalent to 30 minutes per day, five days per week (Haskell et al., 2007). More than 50 percent of Americans do not engage in adequate physical activity, and about one quarter does not participate in any leisure time physical activity (Garrett, Brasure, Schmitz, Schultz, & Huber, 2004). Achieving the recommended amount of exercise is related to reduced chronic conditions such as coronary artery disease (CAD), hypertension, stroke, insulin sensitivity, osteoporosis, and depression (Alevizos, Lentzas, Kokkoris, Mariolis, & Korantzopoulos, 2005; Miller, Balady, & Fletcher, 1997). Additionally, the surging cost of health care due to the lack of healthy lifestyle has become a serious public health concern (Garrett et al., 2004). Evidence suggests there is a need to increase physical activity which can be achieved through external devices. Health professionals use various tools to measure exercise intensity such as heart rate monitors, pedometers, or rating of perceived exertion (RPE). With proper knowledge, these tools may be used as a motivator for exercise.

Individuals who lack exercise experience may find it confusing to calculate heart rate range or determine RPE. Additionally, heart rate monitors are associated with a high cost. Conversely, pedometers have gained popularity as a relatively inexpensive and user friendly tool for motivating and estimating daily physical activity. They are small tools that are worn at the hip and designed to count the number of steps taken per day (Craig, Tudor-Locke, & Bauman, 2006). The current step recommendation is to accumulate 10,000 steps per day (Hanto, 1993) without specific recommendations for intensity (Tudor-Locke & Bassett, 2004). One study reported that this recommendation encouraged weight loss and showed improvements in lipid profiles and blood pressure (Schneider, Bassett, Thompson, Pronk, & Bielak, 2006). Another study showed that 73% of participants who obtained a minimum of 30 minutes of moderate- intensity activity also accumulated 10,000 steps in the same day (Welk et al., 2000). Evidence suggests that step goals increase physical activity but may be overwhelming for some individuals (Tudor-Locke & Bassett, 2004) and does not integrate activity intensity (Marshall et al., 2009).

Exercise frequency and duration is easily measured but evidence suggests many individuals are unable to gauge what moderate-intensity exercise should feel like when they hear or read about it (Rice, Heesch, Dinger, & Fields, 2008). It seems the use of pedometers to monitor the steps taken in 30 minutes could be a widely accepted tool for obtaining 30 minutes of moderate-intensity exercise (Marshall et al., 2009). Two studies used indirect calorimetry to validate step rate associated with moderate-intensity walking (Marshall et al, 2009; Tudor-Locke, Colova, Lee, & Swan, 2005). Step count per minute was determined by walking at three metabolic equivalents (METSs). These studies suggested 100 steps per minute are equivalent to moderate-intensity activity. In order to adhere to the guideline, individuals should engage in 3000-4000 steps in 30 minutes, five days per week (Marshall et al., 2009).

## Statement of the Problem

It is unknown whether 3000 steps in 30 minutes, five days per week is a useful proxy for improving metabolic variables. Step count per minute is a less precise alternative to measuring METs but could be a helpful health promotion recommendation. Additionally, these studies were conducted on a treadmill under controlled conditions which reduces their practical validity (Marshall et al., 2009; Tudor-Locke et al., 2005). Therefore, the purpose of the proposed study is to evaluate if 150 minutes of free living weekly exercise compared to the utility of pedometers to measure 3000 steps in 30 minutes, five days a week will improve cardiorespiratory fitness, body composition, lipid profile, and c-reactive protein (CRP) in sedentary adults.

## Null Hypothesis

It is hypothesized that walking a minimum of 3000 steps in 30 minutes five days per week will not significantly improve blood pressure, body weight, cardiorespiratory fitness, body composition, bone mineral density, lipid profile, serum blood glucose, and c-reactive protein in sedentary adults.

## Assumptions

The assumptions for this study are:

1. The physical activity guidelines set forth by the Center for Disease Control (CDC) and American College of Sports Medicine (ACSM) are an accurate standard to classify sedentary behavior.
2. Participants are realistic in their self-assessment of their physical activity behaviors and correctly categorized themselves as sedentary.

3. Subjects will follow pre-exercise protocols including; avoid exercise, caffeine, and any food and liquid consumption 12 prior to testing.
4. Subjects are realistic about their eating habits and accurately record their diet for three days.
5. Subjects accurately record their physical activity time and steps during independent exercise.

## Delimitations

The delimitations of the study were:

1. Subjects are limited to a sedentary adult population from the James Madison University and Harrisonburg, Virginia communities.
2. Participants used New Lifestyles Digi-Walker SW-401 pedometers.
3. A standardized pace of 55 beats per minute as set by a metronome were used during supervised walking sessions

## Limitations

The limitations of the study are:

1. Subjects are a sedentary population
2. CDC/ACSM Physical Activity Guidelines are used to determine physical activity level
3. Subjects are non-smokers and apparently healthy and able to complete a walking treadmill maximal test were included in the study

## Significance of the Study

This is the first known study to evaluate the effect of 3000 steps in 30 minutes on metabolic variables including; body weight, body composition, bone mineral density, lipid profile, serum glucose, and maximal exercise capacity. Two previous studies used indirect calorimetry to validate step rate associated with moderate-intensity walking (Marshall et al, 2009; Tudor-Locke et al., 2005). From these studies, it was recommended individuals engage in 3000-4000 steps in 30 minutes, five days per week (Marshall et al., 2009, Tudor-Locke et al., 2005). Additionally, these studies were conducted on a treadmill under controlled conditions which reduces their practical validity (Marshall et al., 2009; Tudor-Locke et al., 2005). It is unknown whether these guidelines are useful in improving physiological indices after twelve weeks.

## Definition of Terms

**Dual-energy x-ray absorptiometry** (DXA): Uses low-level radiation and is used to assess total bone mineral and estimates bone, fat, and lean tissues. DXA uses x-ray to measure whole body or segments at certain places on the body (ACSM, 2006).

**Maximal Oxygen Uptake ($VO_{2max}$):** Used as a measure of cardiorespiratory fitness and defined as the highest amount of oxygen that can be transported and used to achieve a maximal physical work (ACSM, 2006).

**Rating of Perceived Exertion (RPE)**: A subjective rating based on general fatigue for exercise intensity (ACSM, 2006). Typically, these ratings correspond to heart rate and can be used to determine how the subject is feeling during a maximal exercise test.

**C-Reactive Protein (CRP)**: CRP is a protein released from the liver in response to inflammation. A high sensitivity C-reactive protein (hsCRP) test can measure the blood level of CRP and may predict coronary events. These levels increase in smokers, obese, physically inactive individuals, and diabetics (ACSM, 2006).

# Chapter Two

## Literature Review

### Introduction

It is suggested U.S. adults engage in moderate-intensity physical activity for at least 150 minutes per week. This is equivalent to 30 minutes per day, five days per week (Haskell et al., 2007). Pedometers have gained popularity as a tool for motivating and estimating daily physical activity (Craig et al., 2006). Evidence suggests that step goals increase physical activity but may be overwhelming for some individuals (Tudor-Locke & Bassett, 2004) and does not integrate activity intensity (Marshall et al., 2009).

It seems the use of pedometers to monitor the steps taken in 30 minutes could be a widely accepted tool for obtaining 30 minutes of moderate-intensity exercise (Marshall et al., 2009). Two studies used indirect calorimetry to validate step rate associated with moderate-intensity walking (Marshall et al, 2009; Miller et al., 1997). These studies suggested 100 steps per minute or 3000-4000 steps in 30 minutes, five days per week (Marshall et al., 2009). It is unknown whether these findings are useful for improving metabolic variables. Therefore, the purpose this study is to determine if 3000 steps in 30 minutes is sufficient in improving metabolic variables compared to 150 minutes of free living weekly exercise. Metabolic variables will be measured to evaluate if this recommendation will improve blood pressure, lipid profile, serum glucose, serum c-reactive protein, cardiorespiratory fitness, body composition in sedentary adults.

### Metabolic Effects of Exercise

The following studies report on the metabolic benefits of exercise. One study found significant decreases in the sum of skinfolds, waist and hip circumferences, diastolic blood pressure(DBP), total cholesterol (TC), triglyceride concentrations and a significant increase in high density lipoprotein cholesterol (HDL) ($p < 0.05$) in a 6 week intervention in middle aged adults. They accumulated 30 minutes, five days per week. One group exercised for 30 minutes, five days a week and the other exercised for three 10-minute bouts. Both groups showed significant improvements in the aforementioned physiological variables (Murphy, Nevill, Nevill, Biddle, & Hardman, 2002). Another study found similar response to blood pressure (BP) in newly diagnosed hypertension patients. Subjects participated in a six month intervention walking an extra 30 minutes per day using a pedometer to measure steps. While, systolic blood pressure (SBP) decreased by 9% and 2.3% in the  intervention and control groups, DBP decreased by 7.4% in the intervention group only (Sohn, Hasnain, & Sinacore, 2007). Colemen and et al. (1999) reported increased cardiorespiratory fitness ($VO_{2max}$) and decreased DBP after a 16-week supervised intervention. Subjects were assigned to one of three groups and walked 30 minutes, six days per week. The first group walked 30 continuous minutes, the second group walked three 10-minute bouts, and the third group had the choice to walk in any combination of bouts as long as each bout was at least five minutes for 30 minutes. Fitness levels were measured using a YMCA submaximal cycle ergometer test. After 16-weeks, $VO_{2max}$ improved from by 2.7, 2.1, and 2.1 ml/kg/min and DBP decreased by 3.4, 1.3, 0.9 mmHg in the three groups respectively. At the 32 week follow-up, $VO_{2max}$ improve by ~5 ml/kg/min, DBP decreased by ~5 mmHg, and SBP ~7 mmHg in all groups. Body fat percentage showed significant improvements ($p = 0.03$) of 0.7, 0.8, and 0.2% in the 30 minute, 10-minute bouts, and choice group (Coleman et al., 1999).

Data was obtained from the National Health and Nutrition Examination Survey III from 13,748 male and female adults on the effect of exercise on c-reactive protein (CRP).

Responses from the survey reported leisure- time physical activity including the frequency of participation in walking, jogging or running, bicycling outside or on a stationary bicycle, swimming, aerobics or aerobic dancing, other dancing, calisthenics, gardening or yard work, and lifting weights. Percentage of participants who had elevated CRP concentration were 21%, 17%, 13%, and 8% for those who participated in none, light, moderate, and vigorous physical activity respectively. The odds ratio for having elevated CRP concentration was 0.98 (95% CI = 0.78-1.23), 0.85 (0.70-1.02), and 0.53 (0.40-0.71) when age, sex, ethnicity, education, work status, smoking status, cotinine concentration (a metabolite in nicotine), hypertension, body mass index (BMI), waist-to-hip ratio (WHR), HDL, and aspirin use were adjusted for. When adjusted for age, the odds ratio for having elevated CRP was 0.78 (95% CI = 0.64-0.96), 0.59 (0.49-0.70), and 0.30 (0.22-0.41) in lightly active, moderately active, and vigorously active participants compared to sedentary participants. Evidence suggests leisure time physical activity is inversely related to CRP concentration in a dose-response fashion (Ford, 2002). Conversely, Zoppini et al. (2006) reported that moderate-intensity exercise twice a week did not reduce plasma biomarkers of inflammation and endothelial function in type II diabetic patients. CRP and soluble tumour necrosis factor (TNF)-α receptor (a cytokine involved in systemic inflammation) also did not change. There was an increase in HDL. Additionally, $HbA1_C$ (the average blood glucose concentration over two to three months), triglycerides, LDL, body weight, and waist circumference decreased but there was no change in BP (Zoppini et al., 2006). In order to see metabolic benefits, the evidence suggests 30 minutes of exercise greater than two days per week.

## Exercise Intensity and Volume

The following studies evaluate the metabolic effect of both moderate and vigorous intensity exercise. O'Donovan et al. (2005) reported high-intensity exercise elicited greater improvements in lipid profiles during a supervised exercise sessions in previously sedentary men. Both groups exercised three days a week for 24 weeks and expended 400-kcal per session. The moderate-intensity group exercised at 60% of $VO_{2max}$ and the high-intensity group exercised at 80% of $VO_{2max}$. Assuming an energy cost of 5 kcal/l of oxygen, energy expenditure was determined from $VO_2$. An example from the author explained that an individual with a $VO_{2max}$ of 3.0 l/min uses 9.0 kcal/min when exercising at 60% of $VO_{2max}$ and will expend 400 kcal in 44.4 minutes (400/9). Both groups showed improvement in TC, LDL, and HDL but the high-intensity group showed significant improvements in TC and LDL. The moderate- intensity group improved TC, LDL, and HDL by -0.19, -0.17, and 0.1 mmol/l and the high-intensity group improved each by -0.54, -0.52, and 0.01 mmol/l (O’Donovan et al., 2005). Further, two studies showed a greater reduction in body fat percentage after 16 weeks (Tremblay, Simoneau, & Bouchard, 1994) and 15 weeks (Irving et al., 2008) of high-intensity exercise. Irving et al. (2008) reported a significant reduction in abdominal fat from high-intensity exercise only and significant improvements in cardiorespiratory fitness in both low-intensity and high-intensity exercise. The low-intensity group exercised at or below their lactate threshold (RPE 10-12) and the high-intensity group exercised midway between lactate threshold and $VO_{2peak}$ (RPE 15-17) three days a week, and at or below their lactate threshold (RPE 10-12) two days a week. Abdominal fat circumference decreased from 683 $cm^2$ to 625 $cm^2$ ($p< 0.001$) after 16 weeks of high-intensity exercise training. Low-intensity exercise elicited a 1.8 ml/kg/min improvement and high-intensity exercise improved by 3 ml/kg/min in cardiorespiratory fitness (Irving et al., 2008). Trembley et al. (1994) had an endurance training (ET) group that progressed to 85% of heart rate reserve (HHR) for 45 minutes, five days a week and a high-intensity intermittent-training (HIIT) group progressed to 19 short- and 16 long- interval sessions of 15 bouts of 30 second (60% HHR) and five bouts of 90 second (70% HHR) intervals (Tremblay et al., 1994). The ET group exercised for 20 weeks and the HIIT group exercised for 15 weeks. Significant decreases in suprailliac skinfold and the sum of three trunk skinfolds (subscapular, suprailliac, and abdomen) was found in both programs. Sum of trunk skinfold measurements reduced by 6.3mm ($p<0.05$) after endurance training and 8.7mm ($p<0.01$) after the HIIT program (Tremblay et al., 1994). Davis et al. (2008) reported on the acute effects of exercise after both low (50% $HR_{max}$) and high-intensity (70% $HR_{max}$) exercise in 12 postmenopausal women. Blood samples were taken immediately pre- and post-exercise, one hour, and 24 hours post- exercise. From pre- to 24-hours post exercise, serum triglycerides concentration significantly decreased from 1.3 to 1.2 mmol/l at both walking intensities (Davis et al., 2008).

Evidence from another study reported that volume and not intensity showed greater improvements in insulin sensitivity in 154 overweight or obese male and female subjects. There were three training groups; low volume-high intensity (115 min/wk), low volume-moderate intensity (170 min/wk), and high volume-high intensity (170 min/wk). Results showed ~40%, ~90%, ~80% relative change in insulin sensitivity index in each group respectively. All groups showed improvements in insulin sensitivity after six months but the groups that exercised 170 min/wk had more substantial improvements

(Houmard et al., 2003). This is concurrent with American College of Sports Medicine and American Heart Association (ACSM/AHA) physical activity and public health recommendation of 150 minutes of exercise per week by (Haskell et al., 2007). Greater adherence was observed in subjects who walked three days a week verses five days a week in a 24-week free-living study. Subjects were randomly assigned to either a control or one of two treatment groups. Lipid profile, BMI, WHR, and skinfolds improved in both groups but a greater reduction was reported in the 3-day per week group, who also had greater exercise volume. The 5-day walk group showed improvement in weight, WHR, BMI, and HDL from baseline to 12-weeks. From baseline to 24-weeks they gained an average of 3 lbs, increased their LDL, by 6 mg/dl, decreased their HDL by 4 mg/dl, and increased their cholesterol by 3 mg/dl. The dropout rate in the 5-day walk group was 12%. All members in the 3-day walk group completed the study. The 5-day group became increasingly non-adherent after the 12-weeks. The 3-day per week group walked an average of 88 minutes per week and the 5-day per week group walked an average of 85 minute per week. The 3-day walk group lost an average of 2.3 lbs, decreased LDL by 11 mg/dl, increased HDL by 3 mg/dl, and decreased total cholesterol by 9 mg/dl (Keller & Trevinao, 2001).

A cohort of 73,473 postmenopausal women with cardiovascular disease or cancer participated in the Women's Health Initiative Observational Study. These women had less cardiovascular events from both moderate and vigorous exercise. There was no difference in health parameters from walking verses vigorous exercise (Manson et al., 2002). Another study also found reduced risk in coronary heart disease (CHD) from moderate (4-6 METS) and vigorous (6-12 METS) exercise. Additionally, a brisk walking pace for 30 minutes per day was associated with an 18% reduction in CHD risk (Tanasescu, Rimm, Willett, Stampfer, & Hu, 2002). Both authors suggest high intensity exercise if tolerable but a reduced CHD risk is achieved through moderate-intensity exercise (Manson et al., 2002; Tanasescu et al., 2002).

## Pedometers

Pedometers are useful tools in motivating daily physical activity. Results from a survey showed that those who owned a pedometer walked more. They reported that ownership was related to inexpensive cost and ease of use (Craig et al., 2006). The current step recommendation is to accumulate 10,000 steps per day (Hanto, 1993; Schneider et al., 2006, Tudor-Locke, Hatano, Pangarzi, Kang, 2008; Welk et al., 2000). According to one study, those who wear a pedometer walk an average of 11,603 steps per day. Additionally, 73% of those participants who obtained a minimum of 30 minutes of moderate-intensity activity also accumulated 10,000 steps in the same day (Welk et al., 2000). One free-living study evaluated the 10,000 step recommendation in 56 overweight or obese men and women. Participants were asked to accumulate 10,000 steps per day. Thirty-eight participants completed the study and 19 adhered to the recommendation. At baseline, steps per day were an average of 5,123 steps, and 9,324 and 9117 steps at 20- and 36-weeks. Participants (34 subjects) who completed the study lost 2.4 kg (5.28 lbs), HDL increased by 3 mg/dl, body fat percentage decreased by 1.9%, and DBP decreased by 2 mmHg. Those who adhered to the goal lost 4.5 kg (9.9 lbs), decreased body fat percentage by 3.2%, increased HDL by 4 mg/dl, and decreased DBP by 2 mmHg. It should be noted that those who did not adhere still increased baseline steps by 2,500, however great health benefits were achieved by accumulating 10,000 steps (Schneider et al., 2006). Another study also showed that women who walked greater than 10,000 steps had normal BMI, and lower body fat percentage and WHR. Subjects wore a pedometer for 7-days and were asked to maintain their typical work and leisure routines. They were categorized as inactive (<6000 steps/day), somewhat active (6000-9000 steps/day), and regularly active (≥10,000 steps/day). BMI was 29.3 kg/m2, 25.6 kg/m2, and 23.6 kg/m2 for those were inactive, somewhat active, and regularly active respectively (Thompson, Rakow, & Perdue, 2004). Dwyer et al (2006) measured steps per day for two days in 609 female subjects and 517 male subjects. At baseline a questionnaire on physical activity and television time was collected. They also measured waist circumference and BMI. From the two days, greater steps per day were associated with subjects who had lower BMI. Those with a normal BMI (<25 kg/m2) walked an average of 12,400 steps per day and those classified as obese (BMI >30 kg/m2) walked an average of 9,000 steps per day. Both authors conclude that those with regular activity also had normal BMI (Dwyer et al., 2007; Thompson et al., 2004).

A pilot study for The First Step Program showed steps per day were increased even when the pedometer was sealed in nine male and female subjects with recently diagnosed type II diabetes. They participated in a month long intervention to practice exercise with goal setting. They then practiced for a month with limited phone contact while wearing a sealed pedometer. Finally, there was a two month follow-up after pedometers had been returned and there was no further contact. Steps per day increased from ~6,500 to ~9,000 at baseline to follow-up. During supervised sessions (weeks 1-4) steps increased to ~10,500 steps per day. Time spent exercising was 34.3 minutes per day during the intervention. Exercise time was 23.6 minutes per day during limited phone contact. During the two month follow up, subjects continued regular exercise (mean = 22.6 min/d). Weight, WHR, and blood pressure all improved from baseline measurements. Waist girth showed a significant decrease of 107.7 to 103.3 cm from baseline to follow-up. There was a significant decrease in systolic blood pressure of 139.3 to 128.8 mmHg and diastolic blood pressure decreased from 86.3 to 80.5 mmHg (Tudor-Locke, Wilde, Sidman, & Corbin, 2001). In another study, Chan et al. (2004) implemented The First Step Program protocol (4 week adoption phase, 8 week adherence phase) and showed that physical activity increased in 106 sedentary subjects. Steps per day increased from 7,029 to 10,480 and decreases in BMI, WHR, and resting heart rate were reported (Chan et al., 2004). Pedometer use was sufficient in changing exercise behavior (Schneider et al., 2003; Tudor-Locke et al., 2002).

## Validity and Reliability of Pedometers

The present study will use the New Lifestyles Digi-Walker SW-401 pedometers manufactured by Yamax which is shown to be both valid and reliable. All Digi-Walkers models have an internal sensor mechanism using a coiled spring-suspended lever arm. The following studies discuss the validity and reliability of various pedometers. When compared to an accelerometer the Yamax SW-200 (manufactured by Yamax) was the most valid compared to Omron HJ-105 and Sportline 330 during 24 hour free-living and controlled conditions. The Sportline underestimated steps taken in both conditions. The Omron was valid under controlled conditions but not during free living conditions (LeMasurier, Lee, & Tudor-Locke, 2004).

When comparing step count on either an outdoor track or treadmill, the Yamax Digi-Walker showed no difference in step count on the track verses the treadmill when worn on the right hip (Welk et al., 2000). When comparing pedometers on the left or right hip, the Kenz Lifecorder, New Lifestyles, and Yamax Digi-Walker were the most reliable. The Sportline and Omron were the least reliable. These results were measured by walking 400 m around an outdoor track (Schneider, Crouter, Lukajic, & Bassett, 2003).

One study evaluated step count reliability using the Yamax SW-200 (manufactured by Yamax) among three different BMI categories: normal (<25 kg/m2), overweight (25 – 29.9 kg/m2), and obese (≥30 kg/m2). They walked on a treadmill for 3 minutes at 54, 67, 80, 94, and 107 m/min. Pedometers were placed on the front, side, and back. BMI did not affect step count at any placement. Further, placement on the waistband did not significantly affect step count (Swartz, Bassett, Moore, Thompson, & Strath, 2003). Another study investigated the validity of 10 pedometers (Yamasa Skeletone, Sportline 330 and 345, Omron, Yamax Digiwalker SW-701, Kenz Lifecorder, New Lifestyles 2000, Oregon Scientific , Freestyle Pacer Pro (FR), and Walk4Life LS 2525) at the same aforementioned speeds. Most pedometers underestimated steps at 54 m/min. Accuracy improved at faster speeds and overestimated at slower speeds (Crouter, Schneider, Karabulut, & Bassett, 2003).

## Measuring Intensity with Pedometers

The current ACSM position stand for physical activity is 30 minutes on five days each week or vigorous-intensity aerobic physical activity for 20 minutes on three days each week (Haskell et al., 2007). Moderate-intensity exercise is defined as 3 to 6 metabolic equivalents (METs) which is equivalent to 3 to 4 mph (Haskell et al., 2007). The inability to properly identify moderate-intensity exercise was presented by Rice et al.

(2008). All participants were shown a mass media description of moderate physical activity and half were randomized to practice an accurate walking pace. Those who received no practice had significantly less success in walking at a moderate-intensity pace for 10 minutes than those who did (Rice et al., 2008). The research suggests the need for a tool to measure moderate-intensity exercise. Marshall et al. (2009) suggests 3000 steps in 30 minutes could be a useful heuristic to accumulate 30 minutes of moderate-intensity exercise. Only two studies have determined steps per minute at a moderate-intensity pace (Marshall et al., 2009; Tudor-Locke et al., 2005). Both found about 100 steps per minute is moderate-intensity exercise. This is about 3000 steps in 30 minutes or 1,000 steps in 10 minutes. The authors concluded that METs could not be determined by step count per minute but might be a good health promotion recommendation (Marshall et al., 2009).

## Conclusion

Health professionals continue to find recommendations and tools for motivating physical activity. Moderate-intensity exercise five days a week has been determined the minimum for health benefits. Physical inactivity leads to several health risk factors such as cardiovascular disease, obesity, and type II diabetes. Most individuals are unable to demonstrate a moderate-intensity pace if they hear or read about it (Rice et al., 2008) and external motivators and goals aid in compliance.

As reported by Keller and Trevinao (2006) it is difficult for individuals to accumulate 30 minutes of exercise 5-days a week. This free-living study showed low adherence for those who were asked to walk 5-days a week. Perhaps motivation to exercise can be enhanced through the use of external devices. Pedometers are accurate and inexpensive devices for measuring physical activity. The current step recommendation of 10,000 steps per day has been reported as difficult to achieve. Thompson et al. (2004) reported a 50% dropout rate when participants were asked to accumulate 10,000 steps per day. Recent research suggests the use of pedometers to measure the amount of steps taken during a specific duration in order to motivate intensity and MET level (Marshall et al., 2009).

It is suggested that adults engage in moderate-intensity physical activity for at least 150 minutes per week. In order to achieve this recommendation, recent research suggests taking 3000 the steps in 30 minutes (Marshall et al., 2009). This suggestion has yet to be implemented over an extended length of time and could be a helpful public health recommendation. The evidence is clear; physical activity improves metabolic parameters, achieving 30 minutes per day has added benefits, and individuals are continually seeking external motivators to help reach their goals. The lack of research on this recommendation and the lack of adherence reported by other studies confirm the need to determine if 3000 steps in 30 minutes are enough to cause changes in physiological responses and motivate exercise.

# Chapter Three

# Methodology and Procedures

## Subject Selection

Subjects were recruited for this study through mass email to James Madison University (JMU) faculty, staff, and students and by word of mouth to the surrounding community of Harrisonburg and Rockingham County. Subjects were required to be sedentary with a score of less than or equal to 3 on the CDC/ACSM Physical Activity Guidelines (Martin, Morrow, Jackson, & Dunn, 2000) (Appendix A). Participants completed a medical history which was reviewed by a faculty physician (Appendix B) and signed an informed consent (Appendix C). The physician was present in the building if the participant was determined to be at a moderate risk level for exercise testing. All forms were reviewed and approved by the JMU Institutional Review Board. Twenty-five (21 women, 4 men) began the program during April 2010. Testing occurred at baseline and after 12 weeks.

## Instrumentation

*Height*

Height was measured without shoes to the nearest 0.5 centimeter with a stadiometer (Novel Products Inc, Rockton, IL).

*Weight*

Weight was measured to the nearest 0.1 kg with minimal clothing on a balance scale (Sunbeam Products Inc Health-O-Meter, Boca Raton, FL).

*Resting Heart Rate and Blood Pressure*

Resting heart rate (HR) and blood pressure were measured using an automated blood pressure monitor (Cosmed Tango, Rome, Italy). Subjects were asked to take the elevator to the Human Performance Laboratory where they rested five minutes before measurements are taken.

*Assays*

Total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides, and glucose, were measured using a blood lipid plus glucose cassette in the Cholestech LDX analyzer (Cholestech Corporation, Hayword, CA). C-reactive protein (CRP) was also be measured by the Cholestech LDX analyzer in a high-sensitivity c-reactive protein (hs-CRP) cassette. Each lot of Lipid Profile plus Glucose cassettes and hs-CRP cassettes were calibrated for high and low serum prior to testing. The Cholestech LDX system was calibrated prior to each test day using an optics disk check procedure and comparing the results against normal values. Subjects were asked to fast for 8-12 hours prior to the test and to report to hydrated to increase blood flow. All blood samples were collected via fingerstick. The finger was cleaned with an alcohol prep pad and pricked using a Tenderlet lancet. The blood sample was collected using a capillary tube. The sample was dropped into a cassette tape and inserted into the Cholestech LDX. Values for all assays were recorded in the subject's file.

*Body Composition and Bone Mineral Density*

Lean mass (LM), fat mass (FM) and bone mineral density (BMD) were measured using the Lunar Prodigy Primo dual-energy X-ray absorptiometry (DXA) (GE Healthcare, Madison, WI). The DXA was calibrated according to manufacturer's instructions each day before a scan was performed. Subjects were asked to wear comfortable clothing and remove any metal prior to the scan. Subjects were placed supine on the scan table, with palms facing medially. A Velcro strap was placed around the ankles and thighs to minimize movement. A whole body scan was conducted lasting approximately 8-10 minutes each. According to the manufacture's specifications, one DXA scan exposes subjects to 1.5 mrem of radiation. The exposure to radiation during a single chest x-ray (i.e., 5 mrem) is more than 3 times greater than radiation from DXA. Also, the radiation from one DXA scan is equivalent to 1.5 days of natural background radiation in the United States. A full body densitometry and full body composition report were printed at the conclusion of the scan.

*Volitional Maximal Exercise Test*

A walking test to volitional exhaustion ($VO_{2max}$) was performed on a motorized treadmill (h/p Cosmos, Cosmed, Rome, Italy). Prior to treadmill testing, subjects were oriented to walking on a treadmill with expired air channeled to a metabolic cart. The subject warmed-up for three minutes prior to the test at a self selected walking speed less than 2.0 miles per hour (mph). The treadmill protocol consisted of a fixed self selected walking speed which increased in grade by 2.5% at three minute intervals until volitional exhaustion was met. Oxygen uptake was continuously recorded using the Quark $b^2$ Pulmonary Gas Exchange system (Cosmed, Rome, Italy). Once volitional exhaustion was met, the subject cooled down for three minutes. Subjects were required to rest in the Human Performance Laboratory until heart rate was below 100 beat per minute. Subjects were instructed to refrain from heavy exercise the remainder of the day and avoid a hot shower and large meal three hours following the test.

*Three-Day Food Record*

Nutritional intake was measured with a three-day diet analysis. Subjects were asked to record two week days and one weekend day (Appendix D). Calorie intake and macronutrient percentage (carbohydrates, fat, and protein) were analyzed using Diet Analysis Plus, version 8.0.

## Experimental Design

Subjects were randomly assigned to two groups, free living and pedometer. The interventions were twelve weeks in duration. The free living group was asked to accumulate 150 minutes of exercise and record their time and type of exercise. They were given the definition of moderate-intensity exercise; exercise from 3 to 6 METs. Examples were given, which included walking (3-4 mph), heavy cleaning (washing windows, mopping, vacuuming, etc), bicycling on flat surface or stationary bike, ballroom dancing, leisure swimming, recreational basketball, and volleyball (Haskell et al., 2007). The pedometer group was given a New Lifestyles Digi-Walking SW 401 pedometer and asked to attend three 30 minute supervised walking sessions and walk two 30 minute walking sessions independently. The pedometer was worn on the waist in-line with the mid-thigh. During the supervised walking sessions, subjects walked to the beat of metronome set at 55 beats per minute to ensure a minimum of 3000 steps. Subjects were instructed to land on the same foot for each beat. Total steps taken for each session were recorded in a log kept by the researcher. All sessions were conducted on the JMU outdoor track or JMU University Recreation indoor track. Subjects wore the same pedometer but walked without the metronome during independent walks and self-recorded steps taken.

Subjects were required to attend an orientation session and two testing sessions at the beginning and end of the twelve weeks. Both groups were given logs to record three-day diet and exercise. Three day diet records were collected at after the first week of exercise and exercise logs were collected at the end of the 12 weeks. A second three day food record was given as an email attachment so subjects could record intake during their last week of exercise. Subjects increased their exercise from 60 minutes in week one, 90 minutes in week two, 120 minutes in week three, and 150 minutes weeks four through twelve.

## Statistical Analysis

SPSS 18.0 (student version) was used to analyze responses of physiological variables (HR, systolic blood pressure, diastolic blood pressure, TC, LDL, HDL, triglycerides, glucose, CRP, FM, LM, BMD, $VO_{2max,}$ calories, and percent carbohydrate, protein, and fat) pre and post intervention. A repeated measures ANOVA was used to compare the physiological responses between the free living and pedometer group. A paired samples t-test and nonparametric sign test was used to compare change in physiological variables from pre and post the intervention. A prior significance was established at $p < 0.05$.

# Chapter Four

# Results

## Subjects

The purpose of this study was to determine if walking five days a week at a pace of 3000 steps in 30 minutes would elicit an improvement on metabolic variables including blood pressure (BP), cardiorespiratory fitness ($VO_{2max}$), body composition, lipid profile, blood glucose, and c-reactive protein (CRP). This recommendation was compared to a free living intervention of 150 minutes of a moderate intensity per week. Twenty-five participants began the study (12 free living subjects and 13 pedometer subjects). Nineteen participants completed the study (8 free living subjects and 11 pedometer subjects). All participants were sedentary according to the ACSM/CDC physical activity guidelines, "I am trying to start to exercise or walk, or I exercise or walk infrequently." Out of the 19 participants who completed the study, 16 were female and 3 were male. The demographic information can be found in Tables 1 and 2.

**Table 1: Demographic Information (Means ± Standard Deviation)**

| | |
|---|---|
| Participants | 19 (16 female, 3 male) |
| Age (yr) | 43.98 ± 13.42 |
| Height (cm) | 166.42 ± 6.90 |
| Weight (kg) | 88.22 ± 25.08 |

**Table 2: Demographic Information by Group (Means ± Standard Deviation)**

| | Pedometer | Free Living |
|---|---|---|
| Participants | 11 (8 female, 3 male) | 8 (8 female) |
| Age (yr) | 45.18 ± 13.08 | 42.13 ± 14.59 |
| Height (cm) | 168.36 ± 8.27 | 163.59 ± 2.99 |
| Weight (kg) | 86.66 ± 20.32 | 90.36 ± 31.91 |

## Adherence

The attrition rate was 33% (12 to 8 subjects) in the free living group versus 15% (13 to 11 subjects) in the pedometer group. Free living subjects exercised at a moderate intensity for 150 minutes per week. Average minutes per week were 106.78 ± 22.6. Adherence was 77.9%. The pedometer group met with supervised group sessions three times per week and walked independently twice a week. Adherence during supervised sessions was 79.1% and adherence for independent walking was 91.9%. Total adherence for independent and supervised walking was 85.2%. Average steps during supervised sessions was 3164.94 ± 302 steps and average steps during independent walking sessions was 3230.38 ± 362 steps.

## Physiological Variables

In order to measure the metabolic benefits of the walking program, physiological data was taken at baseline and 12 weeks. Changes in weight, heart rate (HR), BP, lean mass (LM), fat mass (FM), bone mineral density (BMD), blood lipids, blood glucose, c-reactive protein (CRP), and $VO_{2max}$ were recorded. The difference between groups was analyzed using repeated measures ANOVA. Results in LDL showed a statistically significant difference between groups ($p < 0.05$). There were no differences between groups in any other measurement. The differences between pre and post measurements were analyzed using a paired samples t-test and non parametric sign test. The results for each group are found in Tables 4 and 5. Systolic blood pressure (SBP) and blood glucose was significantly lower in the pedometer group ($p<0.05$). SBP was found to be significant from both the t-test and sign test. Glucose was found to be significant from the sign test only. Low density lipoprotein cholesterol (LDL) was significantly higher in free living group ($p<0.05$; t-test). There were no significant differences in other parameters. Although not statistically significant, 8 out of 11 subjects improved lean mass (LM) in the pedometer group. Additionally, 6 out of 11 subjects showed improvement in CRP but due to the sensitivity of the testing procedure any value <0.3 or >10 mg/dl is not detected. One subjected had <0.3 and one subject was >10 mg/dl from baseline to week 12. In the free living group 6 out of 8 subjects showed improvements in SBP and HR. HR (Fig. 1), SBP (Fig. 2), diastolic blood pressure (DBP) (Fig. 3), high density lipoprotein cholesterol (HDL) (Fig. 6), and blood glucose (Fig. 8) decreased in both groups. Total cholesterol (TC) (Fig. 4), LDL (Fig. 5), triglycerides (Fig. 7), FM (Fig. 11), LM (Fig. 12), and BMD (Fig. 13) increased in both groups. $VO_{2max}$ (Fig. 10) increased in the pedometer group and decreased in the free living group. CRP (Fig. 9) decreased in the pedometer group and increased in the free living group.

## Power Calculation

A power calculation was completed to determine the probability of detecting an ideal clinical change for various sample sizes. Results are in Table 3. It is likely that a larger sample size would have identified if statistically significant differences would have occurred between groups and from pre to post tests.

**Table 3: The Probability of Detecting a Clinical Change for Various Sample Sizes**

| **Number of Subjects** | **5** | **10** | **15** | **20** | **25** | **30** |
|---|---|---|---|---|---|---|
| HR (bpm) | 0.26 | 0.59 | 0.8 | 0.91 | 0.96 | 0.98 |
| SBP (mmHg) | 0.51 | 0.91 | 0.99 | 0.99 | 1 | 1 |
| DBP (mmHg) | 0.08 | 0.14 | 0.19 | 0.24 | 0.3 | 0.35 |
| TC (mg/dL) | 0.09 | 0.16 | 0.24 | 0.31 | 0.38 | 0.45 |
| LDL (mg/dL) | 0.09 | 0.17 | 0.25 | 0.33 | 0.4 | 0.47 |
| HDL | 0.07 | 0.11 | 0.16 | 0.2 | 0.24 | 0.28 |
| Triglycerides (mg/dL) | 0.06 | 0.07 | 0.09 | 0.11 | 0.12 | 0.14 |
| Glucose (mg/dL) | 0.57 | 0.94 | 0.99 | 1 | 1 | 1 |
| CRP (mg/dL) | 0.5 | 0.9 | 0.99 | 0.99 | 1 | 1 |
| FM (kg) | 0.17 | 0.37 | 0.54 | 0.68 | 0.79 | 0.86 |
| LM (kg) | 0.11 | 0.22 | 0.33 | 0.43 | 0.52 | 0.6 |
| VO2max (ml/kg/min) | 0.16 | 0.35 | 0.52 | 0.65 | 0.76 | 0.83 |

**Table 4: Physiological Responses in Pedometer Group from Baseline to Week 12**

| | Baseline | Week 12 | Mean Change (post-pre) | Std. Deviation (post-pre) | Std. Error Mean (post-pre) | 2-tailed significance |
|---|---|---|---|---|---|---|
| Heart Rate (bpm) | 76 | 75 | -0.545 | 11.52 | 3.48 | 0.88 |
| SBP (mmHg) | 129 | 121 | -8.273 | 11.3 | 3.41 | 0.04* |
| DBP (mmHg) | 77 | 75 | -1.636 | 9.64 | 2.91 | 0.57 |
| TC (mg/dl) | 192 | 198 | 5.091 | 19.36 | 5.84 | 0.4 |
| LDL (mg/dl) | 113.5 | 113.9 | 0.333 | 12.95 | 4.32 | 0.94 |
| HDL (mg/dl) | 48 | 46 | -1.667 | 10.15 | 3.38 | 0.64 |
| Trig mg/dl | 115 | 133 | 17.3 | 32.64 | 10.32 | 0.12 |
| Glucose (mg/dl) | 104 | 97 | -7.182 | 11.98 | 3.61 | 0.07 |
| CRP (mg/dl) | 4.2 | 2.6 | -1.6 | 2.433 | 0.86 | 0.11 |
| VO2max (ml/kg/min) | 29.9 | 31.5 | 1.6 | 3.74 | 1.18 | 0.21 |
| Fat Mass (kg) | 35.9 | 36 | 0.1 | 1.29 | 0.39 | 0.72 |
| Lean Mass (kg) | 47 | 47.6 | 0.6 | 1.4 | 0.42 | 0.19 |
| BMD (g/cm2) | 1.259 | 1.262 | 0.002 | 0.0169 | 0.0051 | 0.77 |

* Statistically significant ($p < 0.05$)

**Table 5: Physiological Responses in Free Living Group from Baseline to Week 12**

| | Baseline | Week 12 | Mean Change (post-pre) | Std. Deviation (post-pre) | Std. Error Mean (post-pre) | 2-tailed significance |
|---|---|---|---|---|---|---|
| HR (bpm) | 71 | 70 | -1.5 | 2.976 | 1.052 | 0.197 |
| SBP (mmHg) | 126 | 119 | -6.9 | 11.051 | 3.907 | 0.122 |
| DBP (mmHg) | 76 | 73 | -3.1 | 8.184 | 2.894 | 0.316 |
| TC (mg/dl) | 175 | 178 | 2.5 | 8.184 | 4.563 | 0.6 |
| LDL (mg/dl) | 98 | 110 | 12 | 11.81 | 4.464 | 0.04* |
| HDL (mg/dl) | 54 | 47 | -7.3 | 10.525 | 3.721 | 0.09 |
| Trig mg/dl | 122 | 127 | 5 | 50.73 | 19.18 | 0.8 |
| Glucose (mg/dl) | 104 | 102 | -1.8 | 8.102 | 2.864 | 0.56 |
| CRP (mg/dl) | 4.6 | 5.2 | 0.6 | 2.003 | 0.818 | 0.49 |
| VO2max (ml/kg/min) | 31.5 | 30.9 | -0.5 | 4.984 | 2.035 | 0.8 |
| Fat Mass (kg) | 41.2 | 41.3 | 0.08 | 1.354 | 0.479 | 0.89 |
| Lean Mass (kg) | 44.9 | 45.3 | 0.3 | 2.185 | 0.772 | 0.67 |
| BMD (g/cm2) | 1.239 | 1.254 | 0.016 | 0.023 | 0.008 | 0.1 |

*Statistically significant ($p < 0.05$)

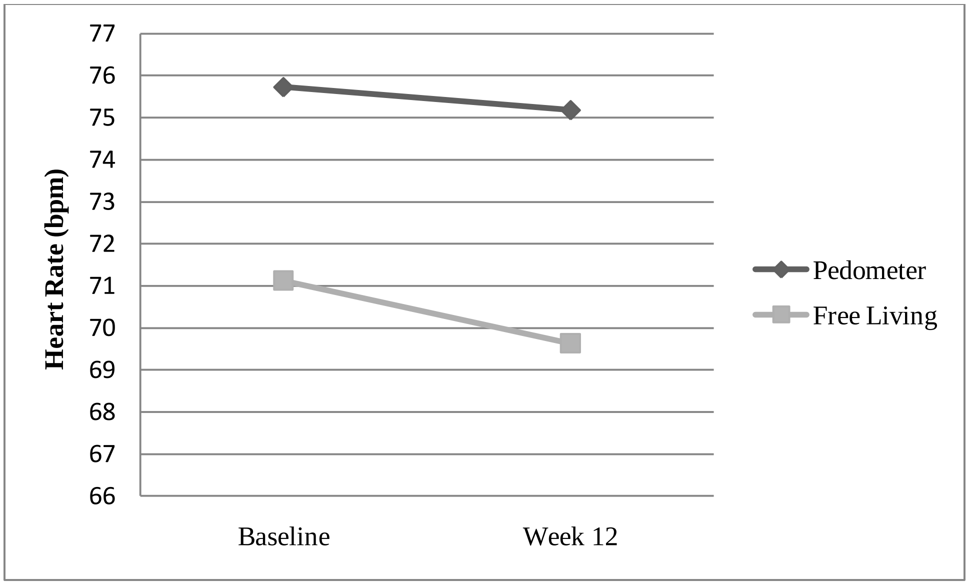


**Figure 1: Heart rate between groups from baseline to week 12**

Note: Group and time interaction p= 0.90; Post-pre mean effect p=0.26;
Pedometer post-pre p = 0.88; Free Living post-pre p= 0.20

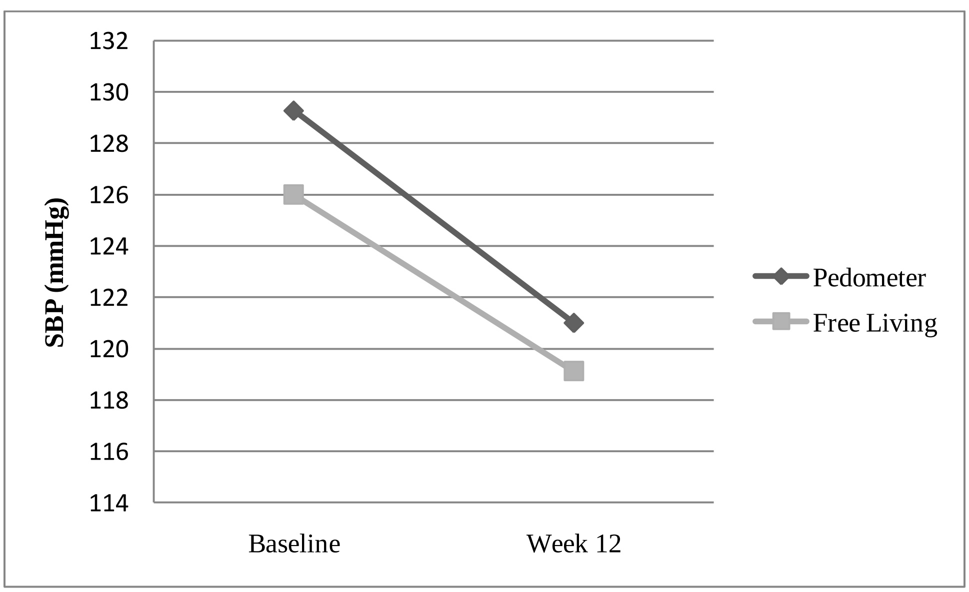


**Figure 2: Systolic blood pressure between groups from baseline to week 12**

Note: Group and time Interaction p=0.8; Post-pre mean effect p =0.38;
Pedometer post-pre p=0.04*; Free Living post-pre p =0.12

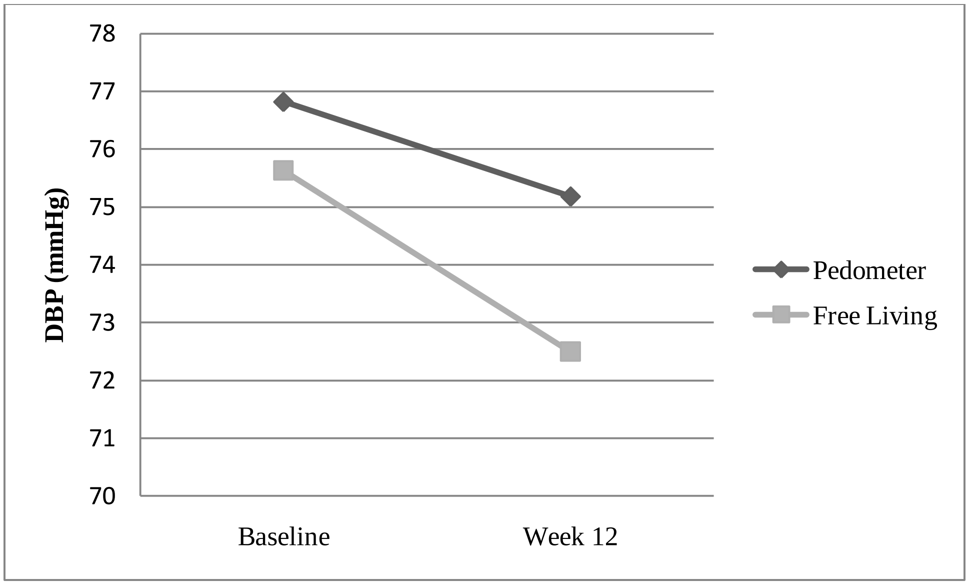


**Figure 3: Diastolic blood pressure between groups from baseline to week 12**

Note: Group and time interaction p= 0.83; Post-pre mean effect p= 0.73; Pedometer p=0.57; Free Living p= 0.32

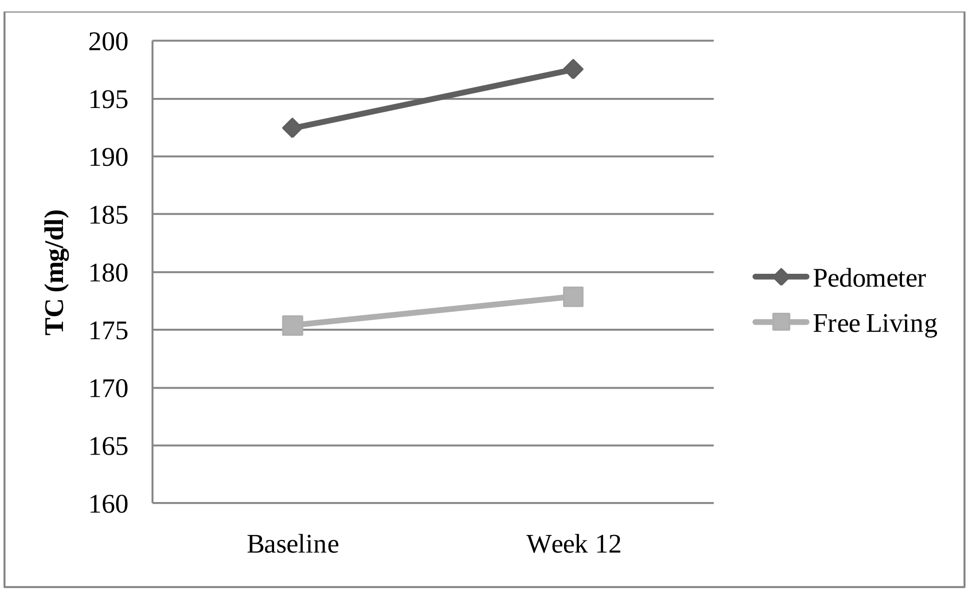


**Figure 4: Total cholesterol between groups from baseline to week 12**

Note: Group and time interaction p= 0.90; Post-pre mean effect p= 0.81; Pedometer p= 0.40; Free Living p= 0.60

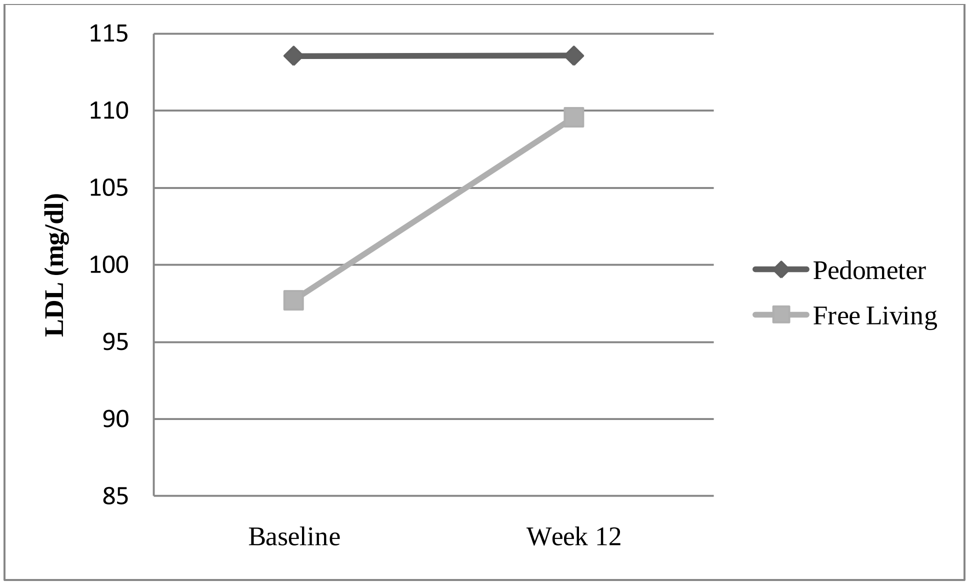


**Figure 5: LDL between groups from baseline to week 12 showed a significant interaction**

Note: Group and time interaction $p<0.05$; Post-pre mean effect p= 0.13; Pedometer p= 0.94; Free Living p= 0.04*

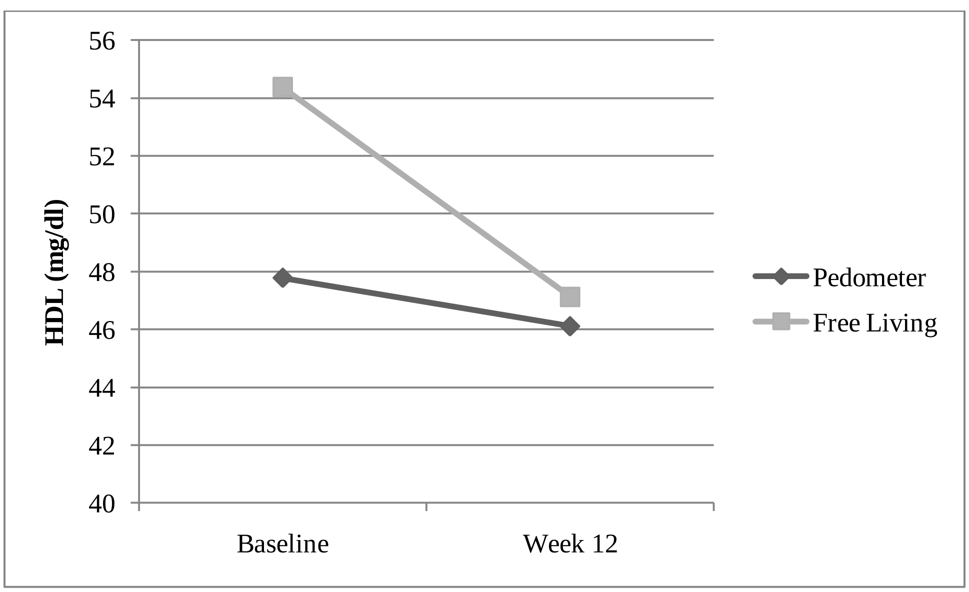


**Figure 6: HDL between groups from baseline to week 12**

Note: Group and time interaction p= 0.32; Post-pre mean effect p= 0.66; Pedometer p= 0.64; Free Living p= 0.09

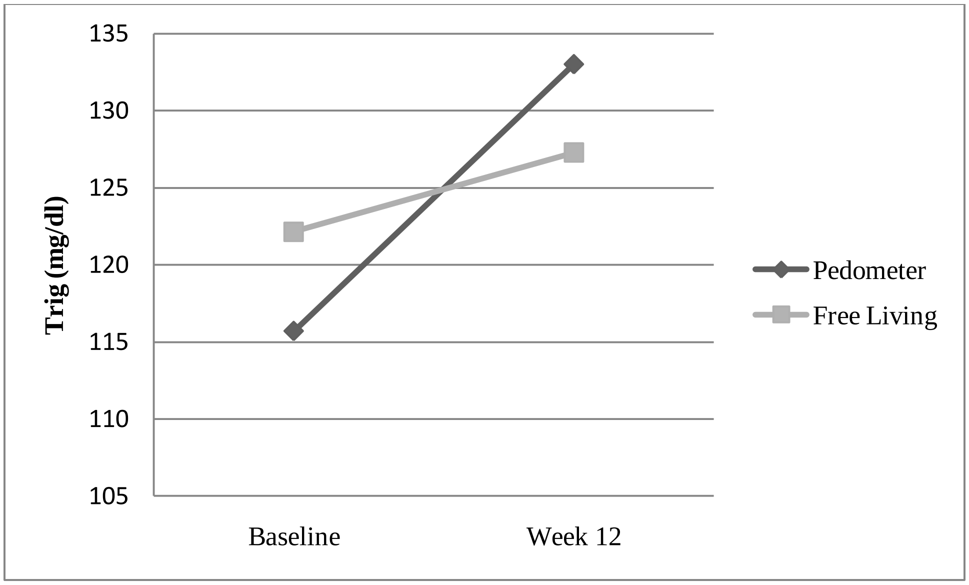


**Figure 7: Serum triglycerides between groups from baseline to week 12**

Note: Group and time interaction p= 0.69; Post-pre mean effect p= 0.59; Pedometer p= 0.12; Free Living p= 0.80

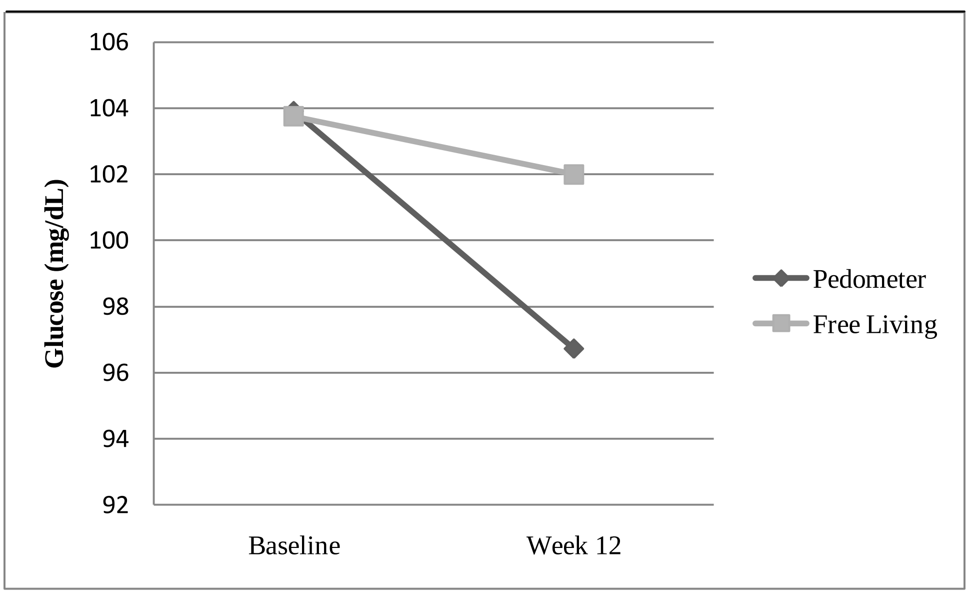


**Figure 8: Blood glucose between groups from baseline to week 12**

Note: Group and time interaction p= 0.37; Post-pre mean effect p= 0.96; Pedometer p= 0.07: Sign p = 0.03; Free Living p= 0.56

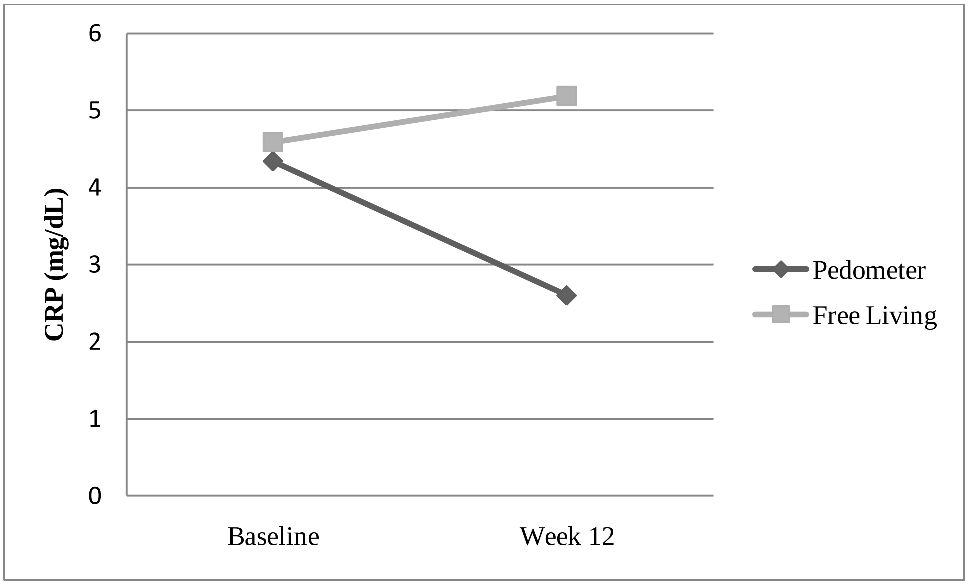


**Figure 9: C-reactive protein between groups from baseline to week 12**

Note: Group and time interaction p= 0.22; Post-pre mean effect p= 0.91; Pedometer p= 0.11
Free Living p= 0.50

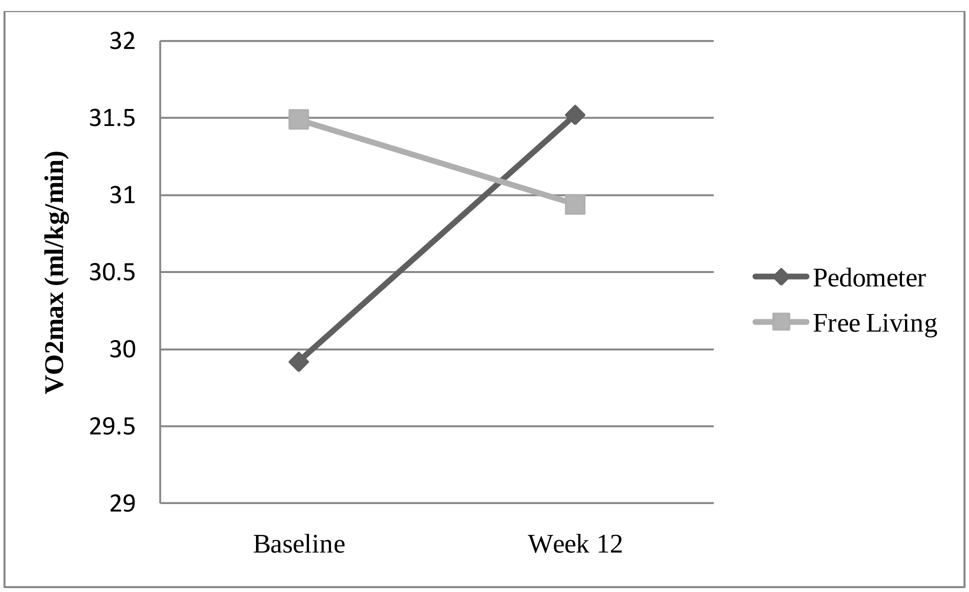


**Figure 10: Maximal oxygen uptake between groups from baseline to week 12**

Note: Group and time interaction p= 0.35; Post-pre mean effect p= 0.70; Pedometer p= 0.21;
Free Living p= 0.80

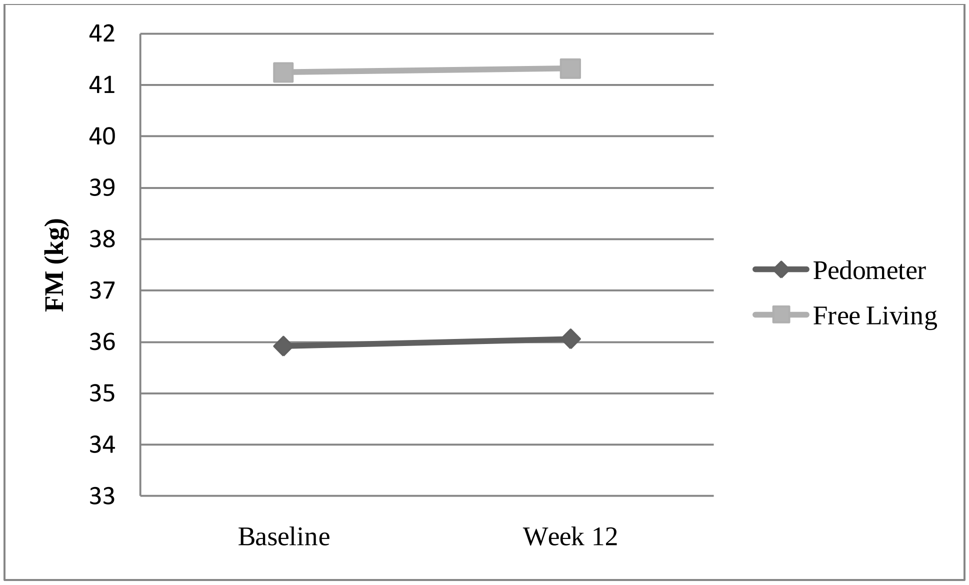


**Figure 11: Fat mass between groups from baseline to week 12**
Note: Group and time interaction p= 0.89; Post-pre mean effect p= 0.08; Pedometer p= 0.72; Free Living p= 0.89

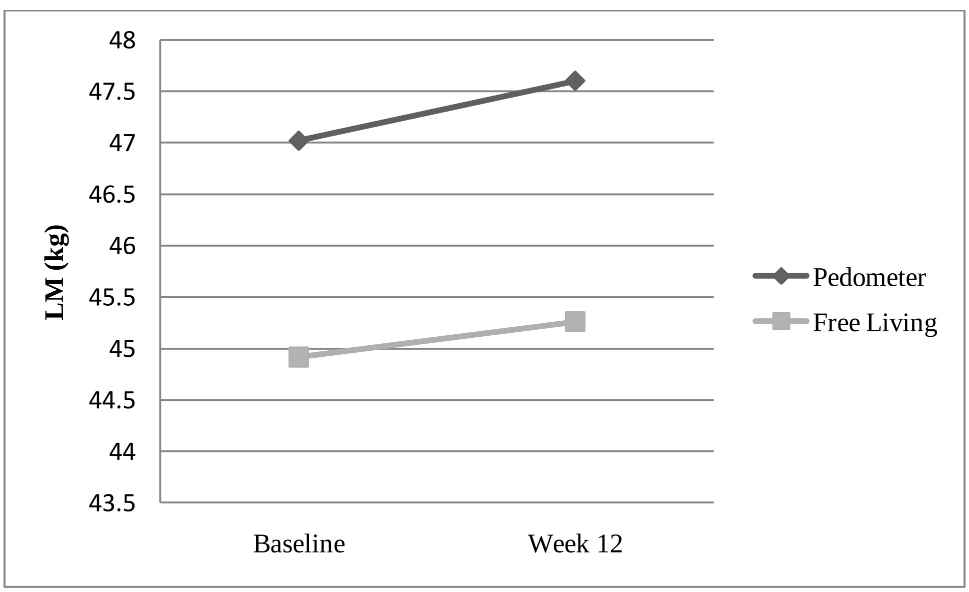


**Figure 12: Lean mass between groups from baseline to week 12**
Note: Group and time interaction p= 0.66; Post-pre mean effect p= 0.06; Pedometer p= 0.19; Free Living p= 0.67

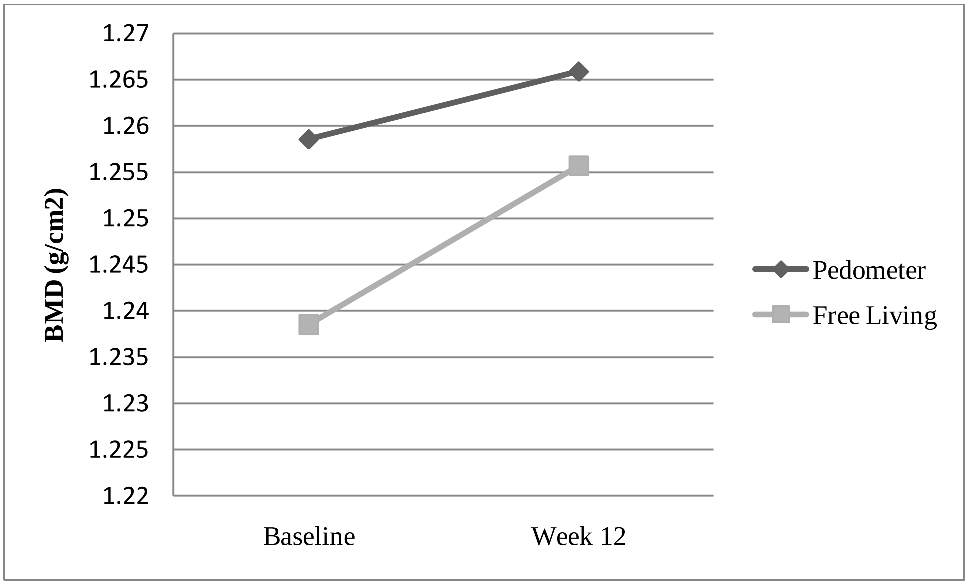


**Figure 13: Bone mineral density between groups from baseline to week 12**
Note: Group and time interaction p= 0.26; Post-pre mean effect p=0.80; Pedometer p=0.77; Free Living p=0.10

## Three Day Diet Analysis

Participants were instructed to record their food and fluid intake for three days (two week days, one weekend day) during their first and last week of physical activity. Diet logs were analyzed for calories (kcal) and energy nutrients (carbohydrate, fat, and protein). Changes within each group were analyzed using a paired sample t-test. Table 6 reports the differences in calories, carbohydrate, fat, and protein consumption for the pedometer group only. There were no significant differences in diet composition at week 1 and week 12 for the either group. Mean differences for carbohydrate (CHO), fat (FAT), and protein (PRO) consumption are found in Table 6 for pedometer group and Tables 7 for free living group.

**Table 6: Mean Calorie Intake and Macronutrient Differences in Pedometer Group (n=8)**

| | Mean Change (post-pre) | Std. Deviation (post-pre) | Std. Error Mean (post-pre) | 2-tailed significance |
|---|---|---|---|---|
| Kilocalories | -352.38 | 739.58 | 261.48 | 0.22 |
| Carbohydrate (%) | -3.88 | 9.64 | 3.41 | 0.29 |
| Protein (%) | 1.5 | 2.62 | 0.93 | 0.15 |
| Fat (%) | 2.75 | 7.48 | 2.64 | 0.33 |

**Table 7: Mean Calorie Intake and Macronutrient Differences in Free Living Group (n=7)**

| | Mean Change (post-pre) | Std. Deviation (post-pre) | Std. Error Mean (post-pre) | 2-tailed significance |
|---|---|---|---|---|
| Kilocalories | -19.43 | 434.89 | 164.37 | 0.91 |
| Carbohydrate (%) | -0.57 | 7.14 | 2.7 | 0.84 |
| Protein (%) | 1.86 | 4.81 | 1.82 | 0.35 |
| Fat (%) | -2.43 | 6.83 | 2.58 | 0.38 |

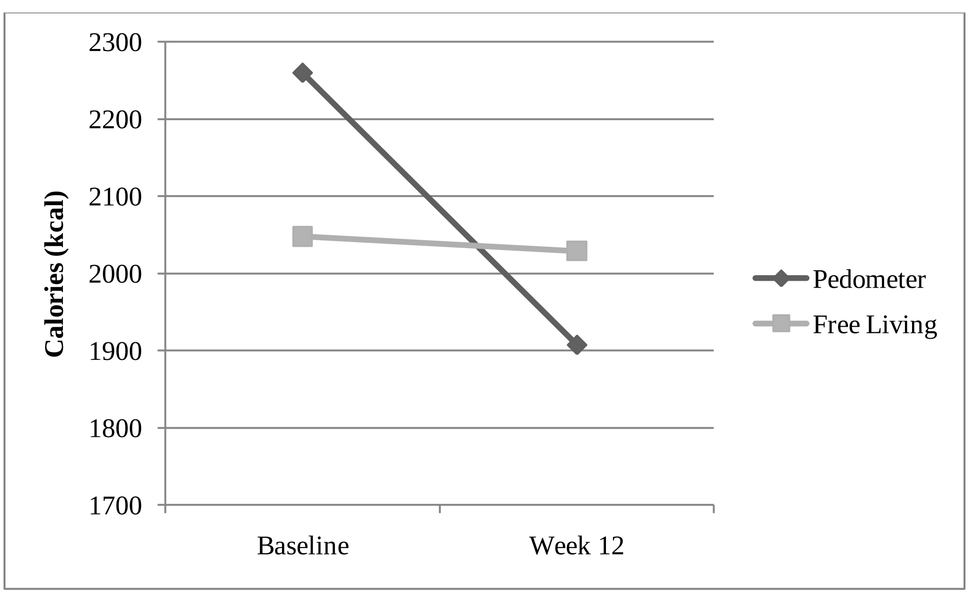


**Figure 14: Calorie intake between groups from baseline to week 12**
Note: Group and time interaction p= 0.23; Post-pre mean effect p=0.34; Pedometer p=0.22; Free Living p=0.91

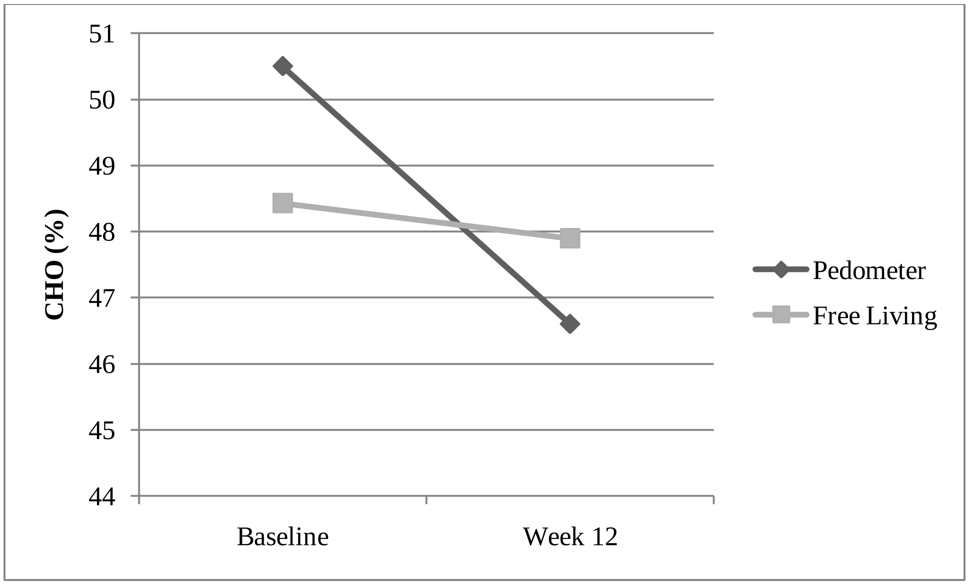


**Figure 15: Carbohydrate intake between groups from baseline to week 12**
Note: Group and time interaction p= 0.55; Post-pre mean effect p=0.87; Pedometer p=0.29; Free Living p=0.84

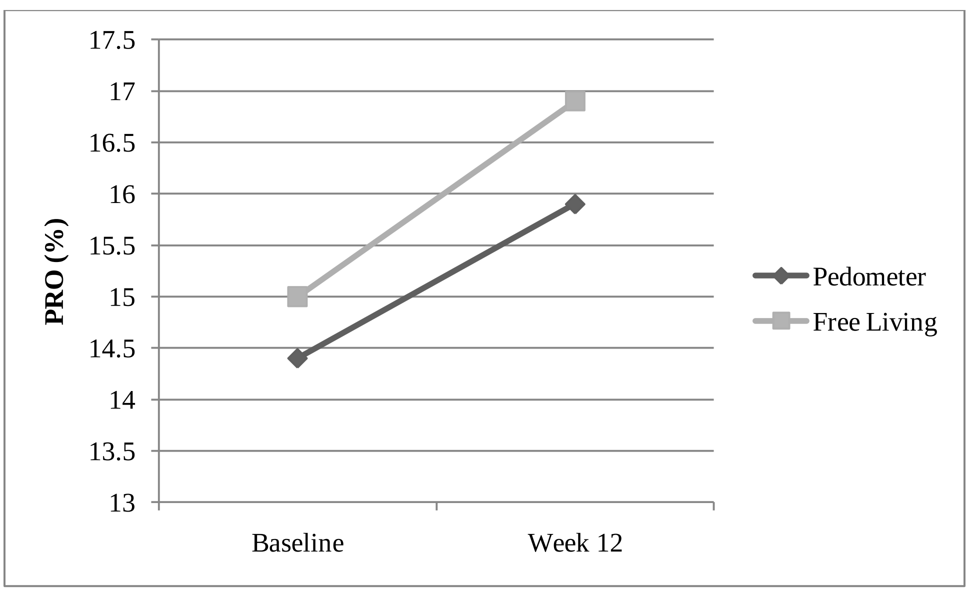


**Figure 16: Protein intake between groups from baseline to week 12**
Note: Group and time interaction p= 0.99; Post-pre mean effect p=0.08; Pedometer p=0.15; Free Living p=0.35

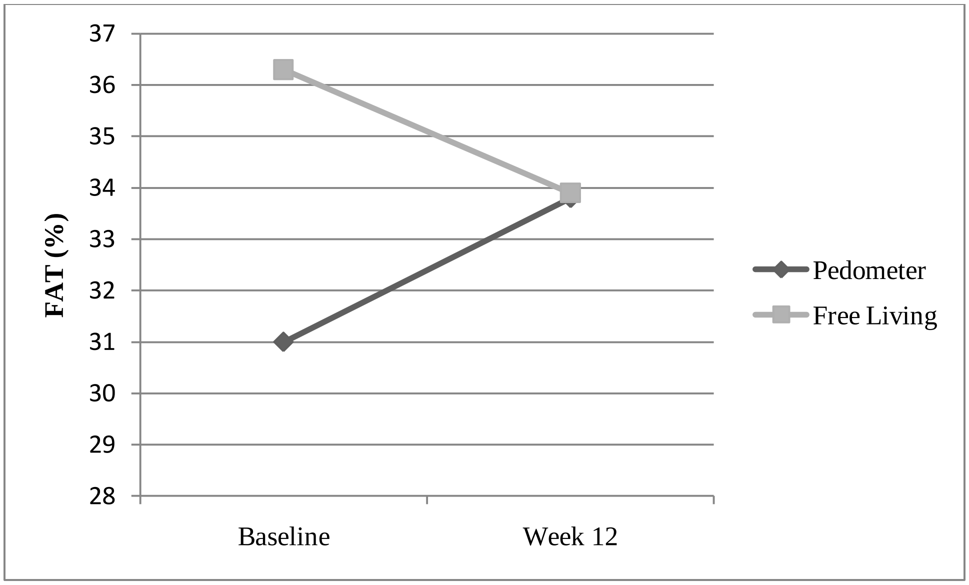


**Figure 17: Fat intake between groups from baseline to week 12**
Note: Group and time interaction p= 0.20; Post-pre mean effect p=0.37; Pedometer p=0.33; Free Living p=0.38

# Chapter Five

# Discussion

## Introduction

The purpose of this study was to compare walking 3000 steps in 30 minutes five days per week to 150 minutes of moderate-intensity physical activity per week. To date this is the first known study to evaluate the dose response of the current recommendation of 3000 steps in 30 minutes (Marshall, et al 2009; Tudor-Locke et al, 2005). The results of this study will provide practical application of pedometer use to monitor walking intensity. Additionally, it applies the potential use of metronomes to maintain step pace, and therefore walking intensity, to serve as a suitable proxy for exercise intensity.

In order to compare the step recommendation to the 150 minutes per week, subjects were randomly assigned to a free living and pedometer group. The free living group accumulated 150 minutes of moderate intensity exercise per week. The pedometer group attended three supervised groups per week and walked independently twice a week. During the supervised sessions, subjects walked to the beat of a metronome set at 55 beats per minute in order to maintain a minimum of 3000 steps in 30 minutes. They were instructed to land on the same foot for each beat. Additionally, a three-day diet record was completed during the first and last week of physical activity and subjects were asked to keep diet consistent during the entire study. All data was analyzed using repeated measures ANOVA to compare metabolic responses of 150 minutes a week verses 3000 steps in 30 minutes five days per week. A paired samples t-test and nonparametric sign test analyzed the change from baseline to week 12 measurements of each group.

## Adherence

Overall adherence was 77.9% in the free living group and 85.2% in the pedometer group. In the free living group, attrition was 33% (12 to 8 subjects) versus (13 to 11 subjects) 15% in the pedometer group. Additionally, the free living group became progressively non-adherent from week 6 to week 12 (average minutes 147 ± 96 min vs. 89.62 ± 96 min). One subject reported zero physical activity during the study and another subject reported zero physical activity after week 7.

In the pedometer group, adherence during supervised sessions was 79.1% and adherence for independent walking was 91.9%. Four subjects were 100% adherent and only two subjects were less than 75% adherent (70% and 57%). None of the participants were 100% adherent during supervised sessions but walked extra days on their own when they missed a session.

Keller & Trevinao (2001) reported a dropout rate of 12% when subjects were asked to walk 30 minutes, five days a week. This is similar to the attrition rate in the pedometer group in this study. Conversely, they reported that subjects became progressively non-adherent (Keller & Trevinao, 2001) whereas subjects in this study were 85.2% adherent. Motivation to continue exercising may be attributed to supervision.

A pilot study for The First Step Program showed exercise time increased during supervised sessions. Steps increased from 6,500 to approximately 10,500 steps per day and time spent exercising was 34.3 minutes per day. When subjects were then asked to practice walking on their own, with limited contact, walking time was 23.6 minutes per day. During a two month follow up, subjects continued regular exercise (mean = 22.6 min/d) (Tudor-Locke, 2001).

**150 Minutes per Week**

The free living group exercised 150 minutes a week at a moderate intensity. The American College of Sports Medicine, Centers for Disease Control and Prevention, and American Heart Association suggest that adults engage in moderate-intensity physical activity for at least 150 minutes per week. Moderate-intensity exercise is defined as exercise between 3 to 6 metabolic equivalents (METs) and examples include walking (3-4 mph), heavy cleaning (washing windows, mopping), bicycling on flat surface, ballroom dancing, leisure swimming, and volleyball (Haskell et al., 2007). In the present study, the free living group showed no statistically significant improvements in any metabolic parameters. Heart rate (HR) (-1.5 bpm, $p = 0.19$), systolic blood pressure (SBP) (-6.88mmHg, $p = 0.12$), diastolic blood pressure (DBP), blood glucose, lean mass (LM), and bone mineral density (BMD) improved. All other parameters worsened and low density lipoprotein cholesterol (LDL) showed a statistically significant increase (11.86 mg/dl, $p < 0.05$). Some of these results may be skewed due to one subject reporting zero physical activity during the study and another subject reporting zero physical after week 7.

Houmard et al. (2003) reported that volume and not intensity showed greater improvements in insulin sensitivity in overweight or obese male and female subjects. The study included three training groups; low volume-high intensity (115 min/wk), low volume-moderate intensity (170 min/wk), and high volume-high intensity (170 min/wk). All groups showed improvements in insulin sensitivity (~40%, ~90%, ~80% relative change per group respectively) after six months but the groups that exercised 170 min/wk had more substantial improvements (Houmard et al., 2003). Other studies have shown improvements in HR, BP, $VO_{2max}$, and body composition from 150 minutes of physical activity per week but the majority of the evidence is from structured activity such as 30 minutes, five days a week (Murphy et al, 2002; Sohn et al, 2007; Coleman et al., 1999; Ford, 2002). Similar to the evidence reported by Houmard et al., our study showed improvements in serum glucose concentration in the free living group but it seems a structured program aids in the improvement of other metabolic indices.

**Pedometers & Metronomes: 3000 Steps in 30 Minutes**

Moderate-intensity exercise is defined as 3 to 6 METs which is equivalent to 3 to 4 mph (Haskell et al., 2007). It is suggested 3000 steps in 30 minutes could be a useful recommendation for motivation to accumulate 30 minutes of moderate-intensity exercise. Two studies reported that about 100 steps per minute is considered moderate-intensity exercise (3 METs). This is equivalent to 3000 steps in 30 minutes or 1,000 steps in 10 minutes (Tudor-Locke et al., 2005, Marshall et al., 2009). In this study, average steps during supervised sessions were 3164.94 ± 302 and 3230.38 ± 362 during independent walking sessions.

Pedometers are useful tools in motivating daily physical activity (Craig et al., 2006). Results from a survey showed that those who owned a pedometer walked more. They reported that ownership was related to inexpensive cost and ease of use (Craig et al., 2006). Another study reported that 73% of the participants who obtained a minimum of 30 minutes of moderate-intensity activity also accumulated 10,000 steps in the same day (Welk et al., 2000), the current step recommendation (Hanto, 1993). This study did not measure total steps per day but in addition to group supervised sessions, pedometers may have been associated with compliance to the exercise program. Additionally, it seems to be an appropriate tool to measure 3000 steps in 30 minute and elicit a moderate intensity walking pace.

To better adhere to the step recommendation, subjects walked to the beat of a metronome three days per week and practiced the pace on their own twice a week. Since there was no difference between supervised and independent average steps, participants were able to keep the pace on their own. Other studies successfully used metronomes to improve gait in newly diagnosed Parkinson's patients (Howe, Lovgreen, Cody, Ashton, Oldham, 2003) or to improve walking speed during a progressive exercise test (Wise & Brown, 2005). These results suggest that the addition of metronomes may improve walking pace and therefore moderate-intensity exercise.

**Thirty Minutes, Five Days per Week**

In this study, the pedometer group walked for 30 minutes, five days per week. SBP (-8.27 mmHg, $p< 0.05$) and blood glucose (-7.18 mg/dl, $p< 0.05$) were significantly lower from baseline to week 12. Other parameters showed improvements that approached significance including c-reactive protein (CRP) (-1.6 mg/dl, $p = 0.11$), lean mass (LM) (0.14 kg, $p = 0.19$), and $VO_{2max}$ (1.6 mg/kg/min, $p = 0.2$). Other statistically insignificant improvements were seen in HR, DBP, and BMD.

One study reported significant decreases in the sum of skinfolds, waist and hip circumferences, and DBP after a six week intervention of 30 minutes, five days a week (Murphy et al., 2002). Sohn et al. (2007) found similar response to blood pressure in newly diagnosed hypertension patients after six months of walking 30 minutes per day using a pedometer to measure steps. There was a 9% reduction in SBP and DBP decreased by 7.4%. These findings are not statistically significant and can be a result of the small sample size (n=8) (Sohn et al., 2007).

Similar to our study, Coleman et al. (1999) reported increased $VO_{2max}$ and decreased DBP after a 16-week supervised intervention. Subjects were assigned to one of three groups and walked 30 minutes, six days per week; (1) 30 continuous minutes, (2) three 10-min bouts, or (3) the choice of any combination of bouts as long as each bout was at least five minutes. $VO_{2max}$ improved from by 2.7, 2.1, and 2.1 ml/kg/min and DBP decreased by 3.4, 1.3, 0.9 mmHg in the three groups respectively (Coleman et al., 1999).

In our study, it seems the dose-response of 3000 steps in 30 minutes is appropriate to elicit improvements in CRP. Due to the lack of sensitivity in the testing procedure one subject was below 0.3 mg/dl and one subject was above 10 mg/dl at baseline and after the pedometer intervention and it is unknown whether there were improvements. Conversely, fat mass increased in our study. Total calorie and macronutrient intakes did not significantly differ from baseline to week 12 which further ensures physiological responses were not attributed to differences in diet. There are conflicting views on whether the decrease in CRP is a result of increased cardiorespiratory fitness (Ford, 2002, Hammlett et al., 2006) or decreased fat mass (Tchernof, Nolan, & Sites, 2002). Evidence from one study showed leisure time physical activity was inversely related to CRP concentration in a dose-response fashion (Ford, 2002). Conversely, Houfman et al (2006) reported six months of aerobic exercise training was not resultant of significant change in CRP in an at-risk population. One study found no significant decrease in CRP concentration after an exercise program where body fat remained unchanged and $VO_{2max}$ was improved by 18% (Hammlett et al., 2006). Tchernof et al (2002) reported decreased fat mass was a significant predictor of decreased CRP concentration from calorie-restricted weight loss in postmenopausal women. Due to the conflicting evidence, further research should be completed on the effect of physical activity on plasma CRP concentration.

## Conclusion

Based on the results of this study, walking 3000 steps in 30 minutes is an appropriate recommendation for meeting the 150 minutes per week recommendation. These findings confirm the 3000 steps in 30 minutes recommendation made by Marshall et al. (2007) and Tudor Locke et al. (2002). In our study, evidence suggests that the general recommendation of 150 minutes per week does not successfully improve metabolic variables or promote adherence. Adherence may be improved with the use of pedometers and metronomes as external motivators and through attending supervised groups to meet the 150 minutes per week recommendation.

Additionally, there is a dose response to 3000 steps in 30 minutes in metabolic variables compared with the general recommendation of 150 minutes per week. This study agrees with previous findings that 30 minutes of moderate-intensity walking improves metabolic variables (Murphy et al, 2002; Sohn et al, 2007; Coleman et al., 1999; Ford, 2002). Our study adds to the body of research by giving a practical application for the use of pedometers and metronomes to monitor intensity and motivate adherence.

## Conclusions

1. Unsupervised moderate-intensity exercise 150 minutes a week showed statistically insignificant improvements in HR, BP, blood glucose, LM, and BMD. All other variables worsened.

2. There are statistically significant improvements in SBP and serum blood glucose and CRP, LM, and $VO_{2max}$ approached significance from walking 3000 steps in 30 minutes, five days per week.

3. There is a dose response to 3000 steps in 30 minutes to improve metabolic variables compared to the general recommendation of 150 minutes per week.

4. Walking 3000 steps in 30 minutes is an appropriate proxy for meeting 150 minutes of moderate-intensity exercise per week.

5. The use of pedometers and metronomes promote adherence to the goal of 3000 steps in 30 minutes

6. Supervised sessions to practice the use of pedometers improves adherence to the goal of 3000 steps in 30 minutes.

## Recommendations

1. Some metabolic variables approached significance, which suggests that a study with a larger sample size and more adherences to the walking goals may produce more significant results after the 12 weeks of walking

2. A study longer in duration may also show significant improvements in metabolic variables.

3. Evaluating either a male or female only population would control the outcome of the study and differences in physiological measures that could be related to gender.

4. Further research should evaluate the use of metronomes as an external motivator on independent walking

5. In this study subjects walked on a flat surface, future studies should evaluate the use of metronomes to keep pace on a varied terrain

# Appendices

# Appendix A

## CDC/ACSM Physical Activity Guidelines

1. I do not exercise or walk regularly now, and do not intend to start in the near future.

2. I do not exercise or walk regularly, but I have been thinking of starting.

3. I am trying to start to exercise or walk, or I exercise or walk infrequently.

4. I am doing vigorous exercise less than 3 times per week or moderate physical activity less than 5 times per week.

5. I have been doing moderate physical activity 5 or more times per week (or than 2 ½ hours per week) for the last 1-6 months.

6. I have been doing moderate physical activity 5 or more times per week (or more than 2 ½ hours per week) for 7 months or more.

7. I have been doing vigorous exercise 3 to 5 times per week for 1-6 months.

8. I have been doing vigorous exercise 3 to 5 times per week for 7 months or more.

Moderate Physical Activity: brisk walking, gardening, slow cycling, dancing, or hard work around the house

Vigorous Physical Activity: basketball, jogging, running fast, step aerobics, swimming laps, or singles tennis.

Print Name: ______________________________

Signature: _______________________________ Date: _____________

Witness: _________________________________ Date: _____________

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# Appendix B

**James Madison University**
**Department of Health Sciences**
**Health Assessment and Promotion**
**Medical History Questionnaire**

Name ________________________________________DOB _______________ Age _________
Address ________________________________Phone _____________Gender M F
______________________________________________Height______________Weight________
Email:_______________________________________________Date______________________

**Stage 1 - Known Diseases (Medical Conditions)**

1. List the medications you take on a regular basis:

| **Medication** | **Purpose** | **Dosage** | **Frequency** |
|---|---|---|---|
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2. Do you have diabetes? No Yes
a) If yes, please indicate if it is insulin dependent diabetes mellitus (IDDM) or non-insulin dependent diabetes mellitus (NIDDM). IDDM NIDDM
b) If IDDM, for how many years have you had IDDM? _____________Years
3. Have you had a stroke? No Yes
4. Has your doctor ever said you have heart disease? No Yes
5. Do you take asthma medication? No Yes
6. Are you, or do you have reason to believe, you may be pregnant? No Yes
7. Is there any other physical reason that prevents you from participating in an exercise program, (e.g., cancer, osteoporosis, severe arthritis, mental illness, thyroid, kidney, or liver disease)? No Yes

a) If yes, please explain:_______________________________________________
_______________________________________________________________

**Stage 2 - Signs and Symptoms**

8. Do you often have pains in your heart, chest, or surrounding areas, especially during exercise?

No Yes

9. Do you often feel faint or have spells of severe dizziness during exercise?

No Yes

10. Do you experience unusual fatigue or shortness of breath at rest or with mild exertion?

No Yes

11. Have you had an attack of shortness of breath that came on after you stopped exercising?

No Yes

12. Have you been awakened at night by an attack of shortness of breath?

No Yes

13. Do you experience swelling or accumulation of fluid in or around your ankles?

No Yes

14. Do you often get the feeling that your heart is beating faster, racing, or skipping beats, either at rest or during exercise?
No Yes
15. Do you regularly get pains in your calves and lower legs during exercise, which are not due to soreness or stiffness?
No Yes
16. Has your doctor ever told you that you have a heart murmur? No Yes

**Stage 3 - Cardiac Risk Factors**
17. Do you smoke cigarettes on a daily basis, or have you quit smoking within the past two years?
No Yes
**If yes**, how many cigarettes per day do you smoke (or did you smoke in the past two years)?

_______per day
18. Has your doctor ever told you that you have high blood pressure? No Yes
19. Have any family members or relatives had a heart attack, stroke, or sudden death before the age of 65years? No Yes
**If yes,**
a) Was the relative male or female? Male Female
b) At what age did he or she suffer the stroke or heart attack? _______Years
c) If they died suddenly, what was the cause? ________________________________________
20. Have you experienced menopause before the age of 45? No Yes
21. If yes, do you take hormone replacement medication? No Yes

**Enter blood pressure and blood lipid values:**

22. What is your systolic blood pressure?
_______mmHg
23. What is your diastolic blood pressure?
_______mmHg
24. What is your serum cholesterol level? _______mmol/L or _________mg/dL
25. What is your serum HDL level? _______mmol/L or __________mg/dL
26. What is your serum triglyceride level? _______mmol/L or __________mg/dL

**Stage 4 - Exercise Intentions**

27. Does your job involve sitting for a large part of the day? No Yes
28. What are your current activity patterns?
a) Frequency: _________exercise sessions per week
b) Intensity: ___Sedentary ____Moderate ___Vigorous
c) History: <3 month 3-12 months >12 months
d) Duration: __________minutes per session
29. What types of exercises do you do?______________________________________________
_____________________________________________________________________________
30. Do you want to exercise at a moderate intensity (e.g., brisk walking) or at a vigorous intensity (e.g., jogging)? Moderate Vigorous

**31. List Your Hospitalization History**

| Age of hospitalization | Reason for Hospitalization | Duration of Stay | Comments |
|---|---|---|---|
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**32. List Any Childhood Diseases**

| Disease | Age |
|---|---|
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**33. Family history of Heart Disease/Stroke**
*Indicate immediate family members (parents, siblings, aunts, uncles) who have diagnosed heart disease/stroke and/or who have died from heart disease/stroke.*

| Relationship | Type of Disease | Age at Diagnosis | Age at Death |
|---|---|---|---|
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34. a. How many hours do you sleep per night (on average)? ____________
35. How would you describe the quality of you sleep?
Good ________ Average ________Poor ______
36. a. Do you consider your day stressful? Yes _______ No ________
37. What is the nature of your stress? ______________________________________________
______________________________________________________________
38. How do you handle your stress? ________________________________________________
______________________________________________________________

39. Do you consider yourself overweight? Yes _______ No ________
40. How long have you been overweight? ____________________________________________
41. How many pounds would you like to lose?________________________________________
42. Do you smoke? Yes _______ No ________
43. What do you smoke? _________________________________________________________
44. How much do you smoke?__________________ How often?_________________________
45. Have you ever smoked in the past? Yes _______ No ________
46. What did you smoke? _______________________________________________________
47. How many years? ___________How much? ______________ How often?_____________
48. When did you stop? __________________________________________________________
49. Why did you stop? ___________________________________________________________
50. Do you drink alcohol? Yes _______ No ________
51. If yes, what kind? ____________________________________________________________
52. How much? __________________________How often? ______________________________
53. Have you ever drunk alcohol in the past? Yes _______ No ________
54. If yes, what kind? ____________________________________________________________
55. How much? ______________________________ How often? __________________________

56. How many years did you drink?___________________________________________
57. When did you stop? ___________________________________________________
58. Why did you stop? ____________________________________________________
59. Any other pertinent information not covered above
_____________________________________________________________________
_____________________________________________________________________

***I agree that the information is true, accurate, and complete to the best of my knowledge, and that I am not withholding any information about my medical or health history that would affect my ability to perform physical activities.***

Participant Signature: ____________________________ Date: ___________________

Witness: ______________________________________ Date: ____________________

***I, ______________________, have reviewed the information contained in this document make the following recommendation for exercise testing:***

□ This individual is able to perform an exercise stress test without any physician supervision.

□ This individual may not perform an exercise stress test unless a physician is within the physical premises.

□ This individual may not perform an exercise stress test unless a physician is directly supervising the test.

Physician's Signature: ____________________________ Date: ________________

## Appendix C

**James Madison University**
Effects of a pedometer based step goal on metabolic indices after 12 weeks
Department of Health Sciences
Consent for Investigative Procedure
(Informed Consent)

### Identifications of Investigators & Purpose of Study

You are being asked to participate in a research study conducted by Valerie Lambert, Dr. David Wenos, Dr. Tammy Wagner, Dr. Michael Deaton, and Dr. Kent Todd from James Madison University. The purpose of this study is to evaluate the utility of pedometers and determine the health benefits from walking 30 minutes, five days a week for twelve weeks in a sedentary adult population. Changes in blood pressure, maximal oxygen uptake (VO2 max), body composition, bone mineral density, c-reactive protein, and lipid profiles (total cholesterol, high density lipoprotein-cholesterol (HDL-C), low density lipoprotein-cholesterol (LDL-C), triglycerides, and glucose) will all be measured. A dietary assessment will also be assessed at the beginning and end of the study. Participants will either exercise on their own or attend a supervised walking group 5 days a week for 30 minutes for 12 weeks.

### Research Procedures

Should you decide to participate in this research study, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. You will be asked to complete a health history questionnaire which will be reviewed by Dr. Diduch, M.D. prior to your participation in the study. Your involvement in the study will involve an orientation session, pre-test measurements, possibility of either a supervised or independent walking program lasting 12 weeks, and post-intervention testing. Only those randomly assigned to the supervised walking group will be required to meet during the week. All other participants will exercise on their own. The orientation session will be held in the Human Performance Lab located in the Health and Human Services building 3009 and will familiarize you with all testing procedures and you will receive a three day diet record. Approximately a week later you will return to the Human Performance Lab for pre-intervention testing. Height, weight, resting heart rate and blood pressure will be taken prior to testing. Lipid profile and c-reactive protein (CRP) blood samples will be taken next, followed by the DXA measurement and treadmill test.

All blood samples will be collected via fingerstick. Participants will be asked to report to the lab hydrated to increase blood flow. The finger will be prepped with an alcohol prep pad and pricked using a Tenderlet lancet and a blood sample will be collected using a capillary tube. The sample will be dropped into a cassette tape and inserted into the Cholestech LDX analyzer. Values for all blood samples will be given through a printout.

Dual-energy x-ray absorptiometry (DXA) will be used to assess bone mineral density as well as estimates of bone, fat, and muscle tissue. A whole body scan will be measured at the beginning and conclusion of the study. The importance of these measurements is to find excess body fat and/or decreased bone mineral density. Each scan will last approximately five minutes. According to the manufacture's specifications, one DXA scan exposes subjects to 1.5 mrem of radiation. The exposure to radiation during a single chest x-ray (i.e., 5 mrem) is more than 3 times greater than radiation from DXA. Also, the radiation from one DXA scan is equivalent to 1.5 days of natural background radiation in the United States.

The treadmill test follows a predetermined protocol to obtain a maximal oxygen uptake. This protocol includes intervals of 2.5% grade that increase every three minutes starting at 0% grade. Speed will remain constant throughout the test. You will be fitted with a heart rate monitor chest strap and a pulmonary face mask. Nonverbal cues will be used to communicate during the test. Hand signals include "yes," "no," and/or "stop the test." We may stop the test at any time due to signs of fatigue or abnormal physiological responses. These may include failure for heart rate to increase with increased workload, dizziness, chest pains, or muscular fatigue. This is a volitional exercise test, so it is important to realize that you may stop the test when you wish because of feelings of fatigue or any other discomfort. Please note that both protocols and procedures are in adherence with the guidelines set forth by the American College of Sports Medicine for exercise testing. You will be permitted to leave once post exercise heart rate drops below 100 beats per minute or resting heart rate level. Avoid a hot shower and a heavy meal for at least an hour after the exercise test.

Should you decide to participate in this research study, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. In addition to the physical health assessment, this study consists of demographic information and dietary records that will be administered to individual participants in the Human Performance Lab, HHS 3009.

**Time Required**

Participation in this study will require approximately 15 weeks. An orientation session will require approximately one hour and will include one lap around the outdoor track. Pre-intervention testing will require approximately an hour and will include height, weight, blood pressure, fingerstick, DXA, and treadmill test. Each walking session will last 30 minutes five days a week for 12 weeks. Post-intervention testing will require approximately an hour and will include height, weight, blood pressure, fingerstick, DXA, and treadmill test.

**Potential Risks**

The investigator does not perceive more than minimal risks from your involvement in this study. The measurements of c-reactive protein, lipids, body composition, bone mineral density, and blood pressure are usual clinical physical health assessments, with no overt risks. Although a volitional maximal graded exercise test includes a risk for a cardiac incident or possible death, to further minimize your risk during exercise testing, Dr. Diduch, M.D. will evaluate your written medical and physical activity history, prior to participation. An orientation session will be conducted prior to any testing. Exposure to radiation during the DXA scan is minimal. According to the manufacture's specifications, one DXA scan exposes subjects to 1.5 mrem of radiation. The exposure to radiation during a single chest x-ray (i.e., 5 mrem) is more than 3 times greater than radiation from DXA. Also, the radiation from one DXA scan is equivalent to 1.5 days of natural background radiation in the United States

**Benefits**

Potential benefits from participation in this study include free testing of cardiorespiratory endurance, body composition, bone mineral density, c-reactive protein, and lipid profile. The investigators expect to see positive metabolic changes for participants that may result in improved health and general well being. Participants will also learn about dietary intake and their percentages of energy nutrients and total caloric intake. Participation in this study will also help investigators understand metabolic responses to long-term exercise and potentially provide a tool for accumulating the recommended amount of daily exercise.

**Confidentiality**

The results of this research will be presented at thesis defense and the American College of Sports Medicine, American Dietetics Association, and Southeast American College of Sports Medicine Conferences. The results of this project will be coded in such a way that the respondent's identity will not be attached to the final form of this study. The researcher retains the right to use and publish non-identifiable data. While individual responses are confidential, aggregate data will be presented representing averages or accessible only to the researcher. Upon completion of the study, all information that matches up individual respondents with their answers will be destroyed. Final aggregate results will be made available to participants upon request.

**Participation & Withdrawal**

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind.

**Questions**

You may have questions or concerns during the time of your participation in this study, or after its completion. If you have any questions about the study, contact Valerie Lambert at lamberva@dukes.jmu.edu or Dr. David Wenos at wenosdl@jmu.edu or 540-568-3928.

**Questions about Your Rights as a Research Subject**

Dr. David Cockley
Chair, Institutional Review Board
James Madison University
(540) 568-2834
cocklede@jmu.edu

**Giving of Consent**

I have read this consent form and I understand what is being requested of me as a participant in this study. I freely consent to participate. I have been given satisfactory answers to my questions. The investigator provided me with a copy of this form. I certify that I am at least 18 years of age.

______________________________________
Name of Participant (Printed)

______________________________________ ______________
Name of Participant (Signed) Date

______________________________________ ______________
Name of Researcher (Signed) Date

# Appendix D

## Food Record

Three Day Food Record Instructions

- Please keep your record for three days on the forms provided.
- The days should include two weekdays and one weekend day.
- Select days that will most closely resemble your eating habits.
- This record should include all meals, snacks, and beverages including water and cocktails. Anything you put in your mouth should be listed.
- If possible, weigh and/or measure your food before you eat it.
- Record what you eat and drink as soon as you can to reduce the chance of forgetting. Be as specific as possible by writing down brand names, food preparation methods and anything added to the foods such as condiments, spices and other seasonings.
- Also record the time you consume each food and the meal (i.e. Breakfast, snack etc.).
- Your food intake will be analyzed using the Diet Analysis + 9.0 Online Access.

Food Record

Subject Number ___________ Date_______________ Day of Week________

| **Time** | **Meal** (Breakfast, Lunch, Supper, Snack) | **Brand Name of Food Product** (Lean cuisine, Nabisco etc.) | **Food/Drink** | **Quantity** | **Preparation** (Broil, Bake, Fried, Sautee etc.) |
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Food Record

Subject Number ___________ Date_______________ Day of Week________

| **Time** | **Meal (Breakfast, Lunch, Supper, Snack)** | **Brand Name of Food Product (Lean cuisine, Nabisco etc.)** | **Food/Drink** | **Quantity** | **Preparation (Broil, Bake, Fried, Sautee etc.)** |
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Food Record

Subject Number ___________ Date_______________ Day of Week________

| **Time** | **Meal**<br>**(Breakfast, Lunch, Supper, Snack)** | **Brand Name of Food Product**<br>**(Lean cuisine, Nabisco etc.)** | **Food/Drink** | **Quantity** | **Preparation**<br>**(Broil, Bake, Fried, Sautee etc.)** |
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