THE EFFECTS OF PEDOMETER-METERED WALKING ON BODY COMPOSITION, WAIST-TO-HIP RATIO, BLOOD PRESSURE, BLOOD GLUCOSE, AND DIET CHOICES IN COLLEGE-AGED PARTICIPANTS-A PILOT STUDY

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THESIS: THE EFFECTS OF PEDOMETER-METERED WALKING ON BODY COMPOSITION, WAIST-TO-HIP RATIO, BLOOD PRESSURE, BLOOD GLUCOSE, AND DIET CHOICES IN COLLEGE-AGED PARTICIPANTS-A PILOT STUDY

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ABSTRACT

Physical activity reduces fat mass, but if not practiced, the risk of obesity-associated health problems and associated health care costs increase. The purpose of this study was to determine the effects of pedometer-metered walking in college-aged participants on body composition, waist-to-hip ratio (WHR), blood pressure (BP), fasting blood glucose (FBG), and diet choices within a four-week period. Following informed consent, participants (N=29; 18.5< BMI <25.0) wore a pedometer for four weeks and recorded the number of daily steps. Body composition, waist and hip measurements, BP, and FBG were performed at baseline, week 1, and week 4. Three randomized 3-day diet records were collected from participants. Daily motivational quotes were provided to a subset of participants (N=19) to determine if the number of steps changed. Significant decreases in waist (77.1cm ± 2.23cm to 74.5cm ± 2.03cm, p=0.002) and hip (99.8 ± 1.74cm to 99.0 ± 1.78, p=0.03) measurements were found. Results were not significant for BP, FBG, those receiving motivational quotes and body composition, but a decrease in fat free mass approached significance (p=0.06). Decreased fruit intake was observed in the second (p=0.007) and third (p=0.023) diet records. Waist and hip measurements decreased significantly at the end of the study, suggesting that monitored walking through the use of a pedometer may result in physical abdominal changes. More research is needed to determine the effects of pedometer-metered walking on diet choices as well as the effects of external motivation on physical activity.
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CHAPTER 1

INTRODUCTION

Statement of the Problem

The incidence of obese (body mass index; BMI > 30 kg/m²) and overweight (BMI > 25 kg/m²) adults and children in the United States (US) has dramatically increased in the past three decades (77% for adults and 46-49% for children)\(^1,2,3,4\). Data analysis in 2009 from the National Health and Nutrition Examination Survey (NHANES) on obesity rates in children and adolescents (ages 2-19 years old) revealed that the percentage of morbid obesity (BMI ≥ 99\(^{th}\) percentile) has increased by at least 300% since 1976 and by 70% since 1994 for this age group\(^2\). Based on observed trends, the projected prevalence of obesity by 2030 will be 86.3% for adults and nearly 92% for children\(^1\). These dramatic increases in overweight and obesity prevalence increase health risks associated with obesity, such as coronary heart disease, myocardial infarction, cardiovascular disease (CVD), stroke, and type 2 diabetes\(^3,4\). Abdominal obesity has specifically increased among both men and women within the past fifteen years in the US\(^3\). Research has shown that abdominal obesity measured by waist circumference is positively associated with heart failure as well as cardiovascular disease risk\(^5,6\). Central obesity increases the risk of cardiovascular problems by increasing the synthesis of cholesterol through the production of lanosterol, the precursor to cholesterol\(^7,8\). High levels of low-density lipoprotein cholesterol (LDL-C) are associated with increased oxidative stress through the production of superoxide as well as decreased endothelial function, which both contribute to coronary artery disease (CAD) and increase the risk of coronary heart disease\(^9,10\).
In addition to obesity increasing the risk of CVD, studies support that obesity is a risk factor for ischemic stroke, not only in the elderly but in younger adults as well\textsuperscript{11,12}. Elevated levels of LDL-C, synthesized from lipid particles, contribute to (CAD) as previously stated, which increases the risk of cerebrovascular diseases such as stroke\textsuperscript{11,13}. Not only does obesity increase the risk of stroke through LDL cholesterol production, but it is also associated with increased blood pressure (BP), which has been demonstrated to be positively correlated with stroke risk\textsuperscript{14,15,16}. Obesity disrupts the autonomic nervous system balance and increases sympathetic nervous system activity, which results in elevated BP\textsuperscript{16}. Obesity affects glucose homeostasis as well as cardiovascular and cerebrovascular health, specifically through hormonal regulation in the mediobasal hypothalamus (MBH)\textsuperscript{17,18}. Adipose tissue releases adipokines that upregulate the production of leptin and resistin, which control glucose uptake and increase insulin resistance, leading to the development of type 2 diabetes\textsuperscript{17,18,19}. Collectively, obesity is a risk factor for several categories of diseases (cardiovascular, cerebrovascular, and metabolic), displaying the multiple adverse effects of this condition.

Not only does the high prevalence of obesity increase the risk of chronic diseases, but it also raises health care costs in the US, with a projected 860.7 to 956.9 billion dollar expenditure by 2030 (16-18% of total health care costs)\textsuperscript{1}. Using projected trends, it is estimated that 65 million adult obesity cases will occur by 2030\textsuperscript{1,20}. Research has shown that increases in globalization are positively associated with increases in obesity rates in the US, most notably through political globalization\textsuperscript{21}. The results from such research demonstrate the importance of the government in supporting healthy habits aimed at reducing obesity. Other countries, such as Australia, have implemented tools to increase
obesity prevention by developing the Obesity Action Award\textsuperscript{22}. The Obesity Action Award is given to the states displaying the highest and lowest obesity rates, in hopes of motivating the individual states to increase the use of obesity prevention measures that are successful\textsuperscript{22}. Health objectives aimed at decreasing the increasing obesity prevalence need to be implemented by the government to increase the motivation of individual states to reduce their obesity risk.

Physical activity (PA) is a supported method for fighting the increased prevalence of obesity by increasing weight and fat mass (FM) loss and reducing the risk of chronic diseases in individuals through a dose-response relationship\textsuperscript{23,24}. The energy expended during PA results in a negative energy balance in the body, resulting in FM utilization and reduction over time\textsuperscript{23,25}. Decreased FM reduces cholesterol levels and blood pressure while increasing sensitivity to the hormone insulin, resulting in improved glucose tolerance and decreased risk of CVD and type 2 diabetes\textsuperscript{26,27}. Not only does PA reduce obesity risk and improve cardiovascular and metabolic health, but it also improves the economic health of the country by reducing preventable health care costs. Inadequate PA is associated with 11.1\% of health care costs in the US\textsuperscript{28}.

Although the benefits of PA have been established, many Americans do not engage in PA on a regular basis due to lack of motivation and confidence to start and maintain an exercise program\textsuperscript{29}. The amount of PA required for a decrease in weight to occur is modest, being comparable to 30 minutes of brisk walking five days a week as established by the American College of Sports Medicine and the Center for Disease Control and Prevention\textsuperscript{29,30}. Walking is a universal form of PA that can be practiced practically anywhere at no cost, and it is a perfect method for transitioning from a
sedentary lifestyle to a more active lifestyle due to the low rate of injury associated with this exercise\textsuperscript{29}. Even though walking is established as a low-impact method of exercise, motivation is still needed in order to start and maintain a walking program, especially if one has been sedentary and feels self-conscious regarding their appearance. It is estimated that 50\% of people who start an exercise program quit in the first six months due to lack of motivation\textsuperscript{31}. Research has shown that different types of motivation are effective in helping people start and maintain exercise, such as autonomous and external motivation\textsuperscript{32,33}. The key to success of any motivational method for engaging in PA is perceived confidence in one’s ability to perform the PA\textsuperscript{32,34}.

Walking programs designed for weight loss have incorporated the use of pedometers as a means of autonomous motivation to engage in PA and maintain an exercise regime\textsuperscript{35}. A meta-analysis of walking programs incorporating pedometers examined nine studies with 307 total participants to determine the effectiveness of the length of the walking intervention on weight change\textsuperscript{35}. The walking interventions lasted at least 4 weeks, and the participants were sedentary and overweight or obese (BMI >25 kg/m\textsuperscript{2}) adults at baseline\textsuperscript{35}. On average, participants lost 0.05 kg per week with the walking interventions, with greater reductions in weight loss occurring with longer interventions\textsuperscript{35}. Such programs have resulted in modest weight loss without dietary intervention\textsuperscript{35}. Other walking studies have investigated the effectiveness of walking with dietary intervention\textsuperscript{36}. A 12-week clinical weight loss study was conducted on mixed racial overweight (mean BMI = 34.26 +/- 6.61 kg/m\textsuperscript{2}) women (N=56) to compare the effects of a low fat ad-libitum (LFAL) diet combined with 30 minutes of daily walking to the same diet combined with 60 minutes of daily walking and to the same diet with no
physical activity component. Reductions in body weight were greater for the women who were on the LFAL diet in combination with the low and high daily PA requirements compared to the women on the diet alone, demonstrating the importance of PA for weight loss. Interestingly, changes in weight and other health variables tested, such as blood lipid content and BP, were similar for the women who walked 30 minutes per day compared to those who walked 60 minutes per day. These results signify the adequacy of 30 minutes of walking per day for healthy cholesterol and cardiovascular changes to occur.

Previous research has shown that weight and (FM) loss occurs in overweight individuals who walk for at least 30 minutes per day for at least four weeks, and that the number of weeks spent walking is positively correlated with the amount of weight lost. Prior studies have also have tested the relationship between walking as a method of PA and waist circumference (WC), BP, diet change, and blood glucose levels without the use of pedometers in separate studies. A 10-week intervention study (N=214) examined the effect of work-place walking on WC and found that as the number of steps walked per day increased, WC measurements decreased. A meta-analysis of 16 studies with 650 subjects examining the effects of walking on BP revealed that in studies lasting greater than four weeks in duration, resting BP significantly decreased. A recent study examined the relationship between diet choices and PA, food self-efficacy, food involvement, demographics, and food poverty in 168 young people (ages 15-25 years old). The results of the study revealed a correlation between diet choices and food involvement and food self-efficacy, but no significant association was found between PA and diet choices. Research has also studied the effect of walking on blood glucose.
levels in persons with type 2 diabetes and demonstrated that walking decreased blood glucose levels, thereby improving insulin resistance\textsuperscript{40,41,42}. Previous research, however, has not examined the relationship between the use of a pedometer while walking and the effects on weight loss and other body composition variables in addition to waist-to-hip ratio (WHR), BP, fasting blood glucose (FBG) levels, and diet choices in healthy (18.5< BMI<25.0), college-aged adults (18-45 years old) during a four-week period.

**Hypotheses**

The first objective of this exploratory study is to discover if pedometer-metered walking has a significant effect on the following health characteristics within a four-week period in college-aged (18-45 years old) participants exhibiting a healthy BMI (18.5< BMI<25.0): body composition (fat mass and fat free mass), WHR, BP, FBG, and diet choices. The second objective of the study is to test if receiving daily motivational quotes (intervention group) results in a significant increase in the number of steps per day compared to solely using a pedometer as a motivational source. Several hypotheses were developed for this study. The first hypothesis is that pedometer-metered walking results in significantly decreased body fat composition, increased FFM, decreased WHR, decreased BP, decreased FBG, and a positive change in diet choices. By a positive change in diet choices, the hypothesis included an increase in fruit, vegetable, protein, calcium, and potassium intake with a decrease in total caloric, carbohydrate, simple sugar, fat, and sodium intake. The null for the first hypothesis is that pedometer-metered walking has no significant effect on body fat composition, WHR, BP, FBG, and diet choices.
The second hypothesis is that additional motivation provided by daily quotes (intervention group) significantly increases the average number of steps taken per day compared to the control group who do not receive additional motivation outside of the pedometer. The null for the second hypothesis is that the intervention group receiving motivational quotes has no effect on the number of steps taken per day compared to the control group. The final hypothesis is that a correlation exists between the average number of steps completed per day and body fat composition, WHR, BP, FBG, and diet choices. The null for the final hypothesis is that no correlation exists between the average number of steps completed per day and body fat composition, WHR, BP, FBG, and diet choices. Participants with a healthy BMI (18.5 ≤ BMI ≤ 25.0) will receive a pedometer and record their step count per day for four weeks. Testing of the following variables will be performed at baseline, week one, and week four: body fat composition (percent body fat, FM, FFM), waist and hip circumference, BP, and FBG. Three 3-day diet records will be collected from participants at random time points to assess usual dietary intake. For the first objective, a 2 treatment (intervention vs. control) x 2 time (pre vs. post) two-tailed paired T-test will be used to detect main effects and interactions for all dependent variables except for dietary records. A 2 treatment x 3 time two-way repeated measures ANOVA will be used to analyze dietary records. For the second objective, an independent t-test will be used to detect mean differences between treatments (external motivation vs. no motivation) for number of steps completed. Significance will be set at \( p \leq 0.05 \) and the statistical program utilized will be SPSS v. 20 (Chicago, IL).
Significance of the Study

If using a pedometer to track the number of steps taken per day motivates healthy adults (18.5< BMI<25.0) to increase the amount of steps completed per day, resulting in increased weight loss and positive changes in body fat composition, WHR, BP, FBG and diet choices, then the guidelines for PA requirements for chronic disease prevention may potentially change from being based on the amount of time spent per day exercising to the amount of steps taken per day. Providing an alternate measure for the PA guidelines may motivate more individuals to start and maintain an exercise program. Studies on weight loss and positive changes in body fat composition, WHR, BP, FBG, and diet using individuals with healthy weights are needed to support the preventative side of PA as a method for reducing obesity-related diseases before the point of obesity is reached.

This exploratory study adds to the body of research on the cardiovascular and metabolic health benefits of pedometer-metered walking during an acute (four week) study period, analyzing the length of time it takes for such health benefits to be observed. Knowledge of the how long an exercise program must be practiced in order for health benefits to be observed also helps motivate individuals to exercise when they have temporal goals in mind. The results of this study aim to increase participation in PA by pedometer-metered walking, thereby decreasing physical inadequacy and the risk of developing obesity within the US.
CHAPTER 2
LITERATURE REVIEW

Many studies that tested the effects of walking on body composition and health variables associated with obesity have substantiated the physiological rationale behind the objective, hypotheses, and design for this study. In addition, studies have examined the effectiveness of using pedometers to increase motivation to walk as well as other motivational methods in a variety of different populations. This review of the literature will present the following research: the effects of walking interventions on body composition (body weight, FM, and waist and hip circumference), BP, and blood glucose, the relationship between PA and diet choices, and the results of using pedometers and other motivational methods for increasing PA levels.

Body Composition

Previous research has tested the effects of walking for different durations on total body weight, percent body fat, BMI, and waist and hip circumference using different sample populations (Table 1). The results of the research collectively support that walking as a method of PA has a positive effect on body composition variables, which plays a role in reducing obesity risk. One of the first published studies testing the effects of walking on body composition was conducted by Pollock and colleagues in 1971. Pollock and colleagues conducted a 20-week walking intervention, testing body composition and cardiovascular function in sedentary men of healthy weight between the ages of 40 and 56 years old. After walking for forty minutes, four days per week for 20 weeks, the intervention group displayed significantly decreased percent body fat and total body weight compared to the non-exercise control (p<0.05). This study set the stage for
future studies analyzing the effects of walking on body composition in different populations to see if similarly positive results would occur. In 2005, Hornbuckle and colleagues conducted a short pedometer-based walking intervention (seven days) using sedentary African American women (mean age: 52 years old)\textsuperscript{44}. The results of the research showed that as the number of steps walked per day increased, percent body fat, BMI, and waist and hip circumference decreased as negative correlates (p<0.05)\textsuperscript{44}. Such research provides insight into the acuteness of the effects of walking on body composition in middle-aged African-American women.

Other studies have conducted walking interventions of longer duration using other study populations. In 2013 Blain and colleagues performed a 6-month walking intervention on sedentary women of healthy weight between the ages of 60 and 76 years old\textsuperscript{45}. The study tested exercise endurance and BMI, and the results showed a significant increase in exercise endurance and a significant decrease in BMI compared to the non-exercising control (p<0.05)\textsuperscript{45}. Positive body composition results were seen with the walking intervention of longer duration in this study. In addition to studying older populations, walking interventions have also been conducted using children to see if positive body composition results occur in this age group. Ford and colleagues (2013) conducted a 15-week walking intervention using primary school aged-children (between 5-11 years old)\textsuperscript{46}. The results from the study showed that percent body fat and (FM) decreased significantly at the end of the study in the walking group compared to the control (p<0.05)\textsuperscript{46}. This study demonstrates that practicing PA at a younger age can help prevent obesity and its associated diseases later in life.
Body composition research has tested the effects of different amounts of walking as well as continuity of walking. In 2005, Osei-Tutu and colleagues compared the effects of walking continuously for 30 minutes per day to walking intermittently for 10 minutes, three times per day on body composition as well as cardiovascular risk factors in sedentary adults (between 20 and 40 years old) over an 8-week intervention\(^47\). Percent body fat decreased significantly and VO\(_2\)max increased significantly (p<0.05) for the continuous walking group compared to the intermittent walking group\(^47\). The results from this study demonstrate the importance in the continuity of walking as a form of PA in order to affect body composition variables. In addition to testing solely the effects of walking on body composition, research has investigated the effects of walking in combination with other methods of weight loss to determine the effects on body composition. In 2006 Anderson and colleagues tested the effects of solely walking against the effects of walking using abdominal electrical muscle stimulation (EMS) in sedentary women (younger than 60 years old) of healthy weight for an 8-week intervention\(^48\). The outcome for each treatment varied: hip and thigh circumference decreased significantly in the walking only group, whereas waist and hip circumference and BMI decreased significantly in the walking plus EMS group (p<0.05)\(^48\). The outcomes of this study reveal that using other weight loss methods in addition to walking as a form of PA may be useful in producing positive body composition results.
Table 1.

*Literature Review: Walking Effects on Body Composition Variables.*

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Journal</th>
<th>Objective</th>
<th>Methodology</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollock et al., 1971</td>
<td>Journal of Applied Physiology</td>
<td>Test the effects of walking for 40 min/4 days/week on body composition and cardiovascular function variables in healthy, sedentary men (ages 40-56 years old) in a 20 week intervention.</td>
<td>The walking intervention group (n=16) was tested at baseline, week 10, and week 20 for VO2 max, a 1-mile walk, body composition and anthropometric measurements. The control group (n=8) was instructed to not exercise and was tested for body composition and anthropometric measurements pre- and post- intervention.</td>
<td>Total body weight, diastolic blood pressure, and percent body fat ↓ significantly (p&lt;0.05) from baseline to week 20 in the walking intervention group. No significant differences were observed for heart rate or systolic blood pressure, and no significant changes were observed in the control group.</td>
</tr>
<tr>
<td>Hornbuckle et al., 2005</td>
<td>Medicine and Science in Sports &amp; Exercise</td>
<td>Test the effects of pedometer-based physical activity on body composition in African American women (mean age = 52 ± 5 years) in a 7 day intervention.</td>
<td>Women (n=69) wore a pedometer for seven days and recorded their diet for three of the days. Anthropometric and body composition measurements were taken pre- and post-intervention, and the participants were categorized into three physical activity levels: low, medium, and high.</td>
<td>Significant (p&lt;0.05) negative correlations between the number of steps walked per day and BMI, percent body fat, waist circumference, and hip circumference were found post- intervention.</td>
</tr>
</tbody>
</table>
Osei-Tutu et al., 2005, Preventive Medicine
Test the effects of continuous walking (30 min/day) versus intermittent walking (10 min/day, 3x/day) on body composition, cardiovascular risk factors, and mood in healthy, sedentary adults (ages 20-40 years old) in an 8 week intervention. Participants (n=44, 25 men) were randomly assigned to one of three groups: continuous walking (30 minutes per day), intermittent walking (10 minutes per day, 3 times per day), or no exercise. Percent body fat, heart rate, V02max were collected pre- and post-intervention, and the Profile of Mood States was used for assessment pre-, mid-, and post- intervention. Percent body fat ↓ significantly (p<0.05) for the continuous walking group, and V02max and positive mood ↑ significantly for the continuous group. V02max ↑ significantly for the intermittent walking group, but no significant changes were observed in percent body fat or positive mood.

Anderson et al., 2006, Psychology of Sport and Exercise
Test the effects of walking for 30 min/day, 5 days/week with or without abdominal electrical muscle stimulation (EMS) on body composition and self-perception in healthy, sedentary women (ages <60 years old) in an 8 week intervention. Participants (n=37) were randomly assigned to one of three groups: walking only (30 min/day, 5 days/week), walking plus EMS (30 minutes per day, 5 days per week using abdominal EMS), or no exercise. Anthropometric, body composition, and self-perception analyses were performed pre- and post- intervention. Significant (p<0.05) ↓ in hip and thigh circumference occurred in the walking only group, and significant ↓ in hip and waist circumference and BMI occurred in the walking plus EMS group compared to the control. Significant ↑ in self-perception occurred in both the walking only and the walking plus EMS group.
Blain et al., 2013 European Geriatric Medicine

Test the effects of walking 60 minutes 3 days per week on exercise tolerance and BMI in healthy, sedentary women (ages 60-76 years old) in a 6 month intervention.

Elderly women (n=98) were randomly assigned to one of two groups: walking 60 minutes per day, 3x/week or no exercising. Six-minute walking distance (6MWD) test and BMI were assessed pre- and post- intervention.

The 6MWD ↑ significantly (p<0.05) in the walking group, which supports improved exercise tolerance. BMI ↓ significantly (p<0.05) in the walking group compared to the control.

Ford et al., 2013 Journal of Sports Sciences

Test the effects of a walking program on body composition in primary school children (ages 5-11 years old) in a 15 week intervention.

Participants (n=152, 79 boys) were assigned to one of two groups: the intervention group (walked 30 min/day, 3x/week) or the control group (performed usual school activities). Anthropometric and body composition measurements were completed pre- and post- intervention.

Percent body fat and fat mass ↓ significantly (p<0.05) in the intervention group compared to the control post- intervention.
Blood Pressure

The effects of walking on BP have been studied as a means of reducing hypertension and the risk of cardiovascular-related diseases associated with obesity. Collectively the research shows that walking has a positive effect on decreasing BP. Studies similar in experimental design have investigated the effects of different lengths of time walking on BP (Table 2). For example, both Murtagh and colleagues (2005) and Tully and colleagues (2005) performed 12-week walking interventions using sedentary, middle-aged adults of healthy weight but the length of time walking per day varied between the studies\(^49,50\). Murtagh et al. used three test groups: one group walked 20 minutes per day 3 days per week, the second group performed two 10-minute walks 3 days per week, and the third group was the no exercise control\(^49\). Tully et al. used two test groups: one group walked 30 minutes per day 5 days per week and the other group was the no exercise control\(^50\). Interestingly, the results of the two studies differed. The results from Murtagh et al. showed a significant decrease in heart rate (p<0.05) for both of the walking intervention groups with greater decreases observed for the group that walked 20 minutes per day 3 days per week, whereas Tully et al. showed a significant decrease in systolic and diastolic BP in the intervention group compared to the control\(^49,50\). BP only significantly decreased in the study where participants walked 30 minutes per day 5 days per week, revealing that the length of time and frequency of walking has an effect on BP.

Other research has also tested the effects of different walking duration times on BP in adults in different states of health. In 2006 Murphy and colleagues conducted an 8-week walking intervention where sedentary adults (average of 42 years old) walked for 45 minutes per day two days per week\(^51\). The study discovered that systolic BP decreased...
significantly (p<0.05) as well as percent body fat in the walking intervention group compared to the control, supporting the results from Murtagh et al. (2006) and Tully et al. (2006) that longer continuous walking sessions result in significant (p<0.05) BP decreases in healthy adults. Other research has tested if adding more walking time will result in significant decreases in BP. In 2007 Sohn and colleagues tested if walking an additional 30 minutes per day would result in decreased BP in African American adults between the ages of 32 and 54 years old with hypertension in a 6-month intervention. Although BP did not decrease significantly in the study (p>0.05), a 9% decrease in BP did occur in the walking intervention group. This study demonstrates that walking has a positive effect on BP in individuals with clinical hypertension, showing that walking can function as a form of not only prevention but also of treatment for cardiovascular-related diseases such as hypertension. A recent study tested the effects of walking for 30 minutes per day on BP in adults over 18 years of age with intermittent claudication to see if walking functions as a form of treatment. The results of the study showed that BP decreased significantly (p<0.05) during each exercise session compared to the resting control, providing support for walking functioning as treatment for peripheral artery disease by lowering BP.
Table 2.

*Literature Review: Walking Effects on Blood Pressure.*

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Journal</th>
<th>Objective</th>
<th>Methodology</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Murtagh et al.</td>
<td>2005</td>
<td>Preventive</td>
<td>Test the effect of 2 methods of walking per week on cardiovascular disease risk factors in healthy, sedentary adults (mean age=46 ± 9 years old) in a 12-week intervention.</td>
<td>Adults (n=48, 31 women) were randomly assigned to 1 of 3 groups for a 12-week intervention: one 20 min walk 3 days/week, two 10 min walks 3 days/week, or no exercise (control). Anthropometric measurements, BP, a treadmill test, and blood lipid analysis were completed pre- and post-intervention.</td>
<td>Heart rate ↓ significantly (p&lt;0.05) from pre- to post-intervention for both of the intervention groups with greater decreases observed for the group performing one 20 minute walk 3 days per week. No significant differences were found between the three groups for all anthropometric measurements, BP, triglycerides, total cholesterol, and LDL and HDL cholesterol.</td>
</tr>
<tr>
<td>Tully et al.</td>
<td>2005</td>
<td>Preventive</td>
<td>Test the effects of 30 min of walking 5 days/week on coronary artery disease risk factors in healthy, sedentary adults (aged 50-65 years old) in a 12-week intervention.</td>
<td>Adults (n=31, 13 men) were randomly assigned to 1 of 2 groups for a 12 week intervention: walking 30 minutes 5 days/week or no exercise. Anthropometric measurements, BP, functional capacity, and blood lipid analysis were completed pre- and post-intervention.</td>
<td>Systolic and diastolic BP ↓ significantly (p&lt;0.05) from pre- to post-intervention for the walking group and functional capacity ↑ in the walking group. No significant differences were found in anthropometric measurements or lipid levels for either group.</td>
</tr>
<tr>
<td>Study Authors</td>
<td>Study Title</td>
<td>Study Design</td>
<td>Participants</td>
<td>Key Findings</td>
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<tr>
<td>Murphy et al., 2006</td>
<td>Test the effect of walking 45 min 2 days/week on cardiovascular risk factors in healthy, sedentary adults (mean age=42 ± 9 years old) in an 8-week intervention.</td>
<td>Adults (n=37, 24 women) were randomly assigned to 1 of 2 groups for an 8 week intervention: walking 45 minutes 2 days/week or no exercise. Anthropometric measurements, a submaximal graded exercise test, and blood glucose and lipid analyses were performed pre- and post-intervention.</td>
<td>Significant (p&lt;0.05) ↓ in systolic BP and percent body fat observed for the walking intervention group. No significant differences were observed for diastolic BP, blood glucose and lipid levels, body mass index or waist-to-hip ratios.</td>
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Blood Glucose

Research examining the relationship between walking and blood glucose levels has been performed to aid in the prevention and treatment of type 2 diabetes, which is a comorbidity associated with obesity (Table 3). Altogether, the research supports that walking lowers blood glucose levels, exerting a positive effect on reducing and managing type 2 diabetes. In 2010, Shenoy and colleagues tested the effects of an 8-week walking intervention on FBG levels in Asian-Indian adults between 40 and 70 years of age who were diagnosed with type II diabetes. The outcome of the study showed a significant (p<0.05) decrease in fasting blood glucose values in the walking intervention group, supporting the positive effect of walking on blood glucose values in persons with type 2 diabetes. Research has also been performed to determine if pedometer-metered walking interventions actually increase daily step count in persons with type 2 diabetes using a 24-week walking intervention. The results from such research show that daily step count increased significantly (p<0.05) in patients with type 2 diabetes, which further supports the practicality of walking as a method for decreasing blood glucose levels in this population.

In addition to testing if walking affects blood glucose levels in persons with type 2 diabetes, research has investigated whether the timing of walking in relation to meal intake affects blood glucose levels as well. Yamanouchi and colleagues (2002) tested the effects of walking before and after breakfast on blood glucose values in persons with type 1 diabetes, and Colberg and colleagues (2009) tested the effects of walking before and after dinner on blood glucose values in adult (greater than 18 years old) patients with type 2 diabetes. The results from the studies revealed that blood glucose values decreased
when walking after the meal compared to walking prior to the meal, although the decrease was only significant (p<0.05) in the study comparing walking before and after breakfast\textsuperscript{56,57}. These studies provide insight into the effects of time of walking in regards to food intake on blood glucose levels, which is useful for persons with type 1 and type 2 diabetes.

Studies focusing on preventing the development of type 2 diabetes have tested the effects of walking on glucose levels of non-diabetic individuals. In 2012, McNeilly and colleagues tested the effects of a 12-week walking intervention on blood glucose values in middle-aged adults with impaired glucose tolerance (IGT)\textsuperscript{58}. The study outcome showed significant decreases (p<0.05) in blood glucose values in the intervention group, supporting walking as a method of decreasing the risk of type 2 diabetes development\textsuperscript{58}. Another study desired to test the effects of interrupting sitting by walking versus by standing on blood glucose levels in healthy adults (average of 24 years old)\textsuperscript{59}. The results support the positive effects of walking on blood glucose levels in healthy adults, as evidenced by a significant decrease (p<0.05) in blood glucose levels in the group that walked compared to the group that stood\textsuperscript{59}. In summary, walking not only is beneficial in managing blood glucose levels in persons with type 2 diabetes but it is also beneficial in preventing the development of type 2 diabetes by decreasing blood glucose levels.
Table 3.

**Literature Review: Walking Effects on Blood Glucose Levels.**

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<tr>
<th>Author</th>
<th>Year</th>
<th>Journal</th>
<th>Objective</th>
<th>Methodology</th>
<th>Findings</th>
</tr>
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<tbody>
<tr>
<td>Yamanouchi et al., 2002</td>
<td></td>
<td>Diabetes Research and Clinical Practice</td>
<td>Test the effects of walking before and after breakfast on blood glucose</td>
<td>Patients (n=6) were assigned to 1 of 2 groups: the intervention group (walked 30 min before and 30 min after breakfast) or the control group (did not walk prior to or after breakfast). Blood glucose levels were measured before and after breakfast.</td>
<td>Blood glucose values significantly ↓ (p&lt;0.05) after breakfast in the intervention group compared to the control group.</td>
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<tr>
<td>Colberg et al., 2009</td>
<td></td>
<td>Journal of the American Medical Directors Association</td>
<td>Test the effects of walking before and after dinner on blood glucose levels in adults (61 + 3 years old) with type 2 diabetes in 3 experimental trials.</td>
<td>Adults (n=12) participated in a crossover study. The control was a rest day where the participants consumed a standardized dinner, the exercise before dinner group walked for 20 min prior to their meal and the exercise after dinner group walked for 20 min after their meal. Blood glucose samples were taken every half hour during each 4 hour trial.</td>
<td>No significant (p&lt;0.05) differences in blood glucose levels were observed between the three test groups, but a ↓ in blood glucose levels did occur in the walking after dinner group.</td>
</tr>
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</table>
### Shenoy et al., 2010
*Primary Care Diabetes*

Test the effects of a walking program using pedometers and heart rate monitors on fasting blood glucose and cardiovascular health in Asian-Indian adults (40-70 years old) with type 2 diabetes in an 8-week intervention.

Outpatients (n=40) were randomly assigned to 1 of 2 groups: the intervention group (walking program with pedometers and heart monitors) or the control group (received usual diabetic care). FBG, BMI, and a well-being questionnaire assessment were completed pre- and post-intervention.

FBG ↓ significantly (p<0.05) post-intervention and well-being ↑ significantly (p<0.05) post-intervention for the intervention group compared to the control. BMI ↓ by 3.9% in the intervention group compared to the control.

### De Greef et al., 2011
*Patient Education and Counseling*

Test the effects of a pedometer-based PA program on daily step count and sedentary behavior in type 2 diabetic adults (62 ± 9 years old) in a 24-week intervention.

Outpatients (n=92) were randomly assigned to 1 of 2 groups: the intervention group (wore pedometers daily and participated in sessions and phone calls) or the control group (received usual diabetic care). Daily step count and a physical activity questionnaire were administered pre- and post-intervention as well as post 1 year.

At the end of the 24 weeks the intervention group significantly (p<0.05) ↑ the number of steps walked per day by 2744 steps compared to the control. The intervention group also significantly (p<0.05) ↓ their sedentary behavior by 23 minutes per day. The results were also significant post 1 year.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Paper Title and Details</th>
<th>Results and Findings</th>
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<tbody>
<tr>
<td>McNeilly et al., 2012</td>
<td>Test the effects of a walking intervention on glucose tolerance in obese adults (49 ± 9 years old) with impaired glucose tolerance (IGT) in a 12-week intervention.</td>
<td>Adults with IGT (n=11, 6 males) participated in the 12-week walking intervention (30 min/day, 5 days/week). FBG, insulin, and lipid values as well as anthropometric measurements and dietary intake were recorded pre- and post- intervention.</td>
</tr>
<tr>
<td>Bailey &amp; Locke, 2015</td>
<td>Participants (n=10, 7 men) completed each trial in this crossover study. Prior to each trial, the participants consumed two standardized drinks (80.3g carbohydrate, 50 g fat). In the uninterrupted sitting trial the participants sat for 60 min, in the sitting plus standing trial the participants stood for 2 min every 20 min for 60 min, and in the sitting plus walking trial the participants walked for 2 min every 20 min for 60 min. Blood glucose and BP values were assessed hourly.</td>
<td>Participants (n=10, 7 men) completed each trial in this crossover study. Prior to each trial, the participants consumed two standardized drinks (80.3g carbohydrate, 50 g fat). In the uninterrupted sitting trial the participants sat for 60 min, in the sitting plus standing trial the participants stood for 2 min every 20 min for 60 min, and in the sitting plus walking trial the participants walked for 2 min every 20 min for 60 min. Blood glucose and BP values were assessed hourly.</td>
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Physical Activity and Diet Choices

Since PA and diet choices play a role in reducing the development of obesity, research has studied the interactions between these two variables to discover if a relationship exists (Table 4). Since the interaction between PA and diet is a qualitative relationship, questionnaires are utilized to assess how people view these two variables in relation to their health. Studies asking adults whether their diet improves in terms of healthier choices when they increase their levels of PA reveal that a positive correlation exists between increased levels of PA and healthier diet choices\(^6\). Research has also shown that when adults participate in weight management programs, they significantly (p<0.05) increase both their PA levels and healthy food intake, suggesting that adults realize the importance of both of these factors in managing obesity risk\(^6\).

Studies have tested the effects of PA and different types of diet in combination on health outcomes. Martin and colleagues conducted a study in 2001 where older adults (63-73 years old) completed a food frequency questionnaire and performed a 3-meter walk in a 3-month intervention to see if diet affected physical performance\(^6\). The results revealed that significantly (p<0.05) shorter 3-meter walk times were associated with higher intakes of vitamin D and protein, suggesting that healthier diets improve physical performance in older adults\(^6\). In 2011, Snel and colleagues tested the effects of 30 minutes of walking per day in addition to a very low calorie diet (VLCD) on inflammatory markers in obese, middle-aged adults with type 2 diabetes over a period of 16 weeks\(^6\). The study outcome showed that inflammatory markers decreased significantly (p<0.05) in both test groups: the exercise plus VLCD group and the VLCD only group\(^6\). Interestingly, at 18 months follow up after the intervention the
inflammatory markers increased back to baseline in the VLCD only group, displaying the long term effects of healthy diet in combination with exercise on obesity inflammatory markers\textsuperscript{63}. In addition to diet and exercise improving metabolic health, research has supported that the two variables have a positive effect on cardiovascular health as well. A recent study tested the effects of exercise and the Mediterranean diet on cardiorespiratory health in older women (over 60 years of age) in an 8-week intervention and found that cardiorespiratory capacity increased significantly (p<0.05) in the exercise plus Mediterranean diet group to a greater extent than in the exercise alone group\textsuperscript{64}. These studies support the synergistic effect of PA and diet on improving metabolic and cardiorespiratory health.
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<th>Methodology</th>
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<tbody>
<tr>
<td>Pallister et al.,</td>
<td>2009</td>
<td>Journal of Human Nutrition and Dietetics</td>
<td>Test the effects of commercial weight management program (Slimming World) on diet choices, PA, and overall health in adult (mean=42 years old) respondents in a 4-week period.</td>
<td>Members and non-members (n=2812) of the Slimming World organization responded to a survey questionnaire regarding the effectiveness of the weight control program on diet choices, PA levels, and their overall health pre- and post-the 4-week period. The survey was completed either in the magazine or online.</td>
<td>From the self-reported data there was a significant (p&lt;0.05) ↑ in healthier diet choices, in PA levels, and in overall health of the participants who adhered to the weight control program.</td>
</tr>
<tr>
<td>Martin et al.,</td>
<td>2011</td>
<td>Age and Ageing</td>
<td>Test the effects of diet on physical performance in older adults (ages 63-73) belonging to the Hertfordshire Cohort Study.</td>
<td>Adults (n=629, 396 men) completed a food frequency questionnaire (FFQ) over a 3 month period and diet scores were assigned for diet quality. Physical performance was assessed through time to complete a 3-m walk and time to switch from sitting to standing during 5 sessions. At each session, anthropometric measurements and physical performance was assessed.</td>
<td>In men and women, significantly (p&lt;0.05) shorter 3-m walk times were associated with ↑ intakes of vitamin D and protein. In women only, significantly (p&lt;0.05) shorter 3-m walk times and sit-to-stand times were associated with higher antioxidant, beta-carotene, and selenium intake.</td>
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<tr>
<td>Study</td>
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<td>Snel et al., 2011 Food and Chemical Toxicology</td>
<td>Test the effects of adding exercise to a very low calorie diet (VLCD) on low-grade inflammation in obese adults (50-65 years old) with type 2 diabetes in a 16-week intervention.</td>
<td>Patients (n=27, 14 males) were randomly assigned to 1 of 2 groups: the VLCD only group or the VLCD plus exercise group (30 minutes of physical activity/day, 4 days/week). Controls (n=56 healthy lean, n=56 healthy obese) received usual diabetic care. Anthropometric and inflammatory markers were assessed pre- and post-intervention as well as 6 and 18 months follow-up. Post-intervention, inflammatory markers ↓ significantly (p&lt;0.05) and equally in both of the intervention groups. At 18 months follow-up, the inflammatory marker levels ↑ back to baseline in the VLCD only group compared to the VLCD plus exercise group.</td>
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<td>Alkhatib &amp; Klonizakis, 2014 Clinical Hemorheology and Microcirculation</td>
<td>Test the effects of exercise and the Mediterranean diet on cardiorespiratory health in post-menopausal women (&gt;50 years old) in an 8-week intervention.</td>
<td>Sedentary women (n=15) were randomly assigned to 1 of 2 groups: exercise training alone or exercise training plus following the Mediterranean diet for 8 weeks. Cardiorespiratory capacity, upper- and lower-limb endothelial cutaneous vascular conductance (CVC), Acetylcholine Chloride (Ach) and Sodium Nitroprusside (SNP) were assessed pre- and post-intervention. The exercise training group alone showed significant (p&lt;0.05) ↑ in cardiorespiratory capacity, and significant (p&lt;0.05) improvement in microcirculation of CVC for both Ach and SNP. In the exercise plus the Mediterranean diet group, a significantly (p&lt;0.05) stronger improvement in Ach function was observed compared to the exercise alone group.</td>
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Determine whether an implicit relationship exists between diet and exercise in adults (>18 years old) who completed the Portuguese National Health Survey in 2005. Adults (n=33770, 47.5% males) completed the Portuguese National Health Survey in 2005 and the following dependent variables were analyzed using a bivariate probit: the choice to participate in physical activity and the choice to eat healthy snacks.

A positive correlation (rho=0.078) was found between decisions for participating in physical activity and eating a healthy diet. The study also found that unmeasurable variables (such as peer pressure or cultural values) are correlated (rho=0.081) to physical activity and diet decision making.
Physical Activity Motivation

Investigations into methods of increasing levels of PA in different age groups have been completed in order to help individuals attain the metabolic and cardiorespiratory effects of physical activity, specifically by decreasing obesity risk (Table 5). From the literature, intrinsic motivation appears to exert the greatest effect on PA participation across all age groups. For example, motivational factors for PA across 3 different age groups (young adults 18-24, adults 25-44, and middle-aged adults 45-64 years old) was assessed and the results showed that autonomous motivation was a significant positive correlate (p<0.05) with PA for all 3 age groups and that external motivation was a significant negative correlate (p<0.05) with PA. In 2012, Gallagher and colleagues tested if motivation for health goals and leisure-time physical activity (LTPA) differ by age and gender in a 25-day study. The study found that intrinsic motivation was significantly (p<0.05) related to LTPA in females and to LTPA duration in males for all ages. To further investigate gender differences between exercise motivation in males and females, college-aged (18-24 years old) participants completed surveys regarding motivation factors and PA levels. The results revealed that intrinsic motivation was significantly (p<0.05) associated with exercise motivation in both male and female students, with the significance being greater in males compared to females. Since intrinsic motivation has been shown to be associated with exercise motivation to different extents between males and females, studies have examined the factors affecting intrinsic motivation in students ages 12-15 years old. The research showed that social-environmental factors, appearance when exercising, and perceived competence affect intrinsic motivation.
Perceived competence of one’s ability to perform PA successfully is an important facet of intrinsic motivation, and research has supported this claim in different age groups. A study using British students ages 14-16 years old discovered that perceived competence was the main psychological mediator affecting PA participation\textsuperscript{69}. A similar study assessing PA levels and motivational factors in Czech seniors over 60 years old found that perceived self-efficacy was positively correlated (p<0.05) with PA motivation\textsuperscript{70}. Together, these supports reveal that confidence in one’s ability to participate in PA is the main associate with PA participation and that this factor does not change as one ages in life.
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<th>Objective</th>
<th>Methodology</th>
<th>Findings</th>
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<tr>
<td>Ntoumanis</td>
<td>2001</td>
<td>British Journal of Educational Psychology</td>
<td>Test the effects of different motivational methods on PA participation in British students (ages 14-16 years old).</td>
<td>Students (n=424) were administered a questionnaire regarding social factors, psychological mediators, motivational types, and a boredom assessment to measure factors influencing physical activity participation in school. Descriptive statistics were used to analyze the data.</td>
<td>Perceived competence was shown to be the main psychological mediator affecting PA participation. Intrinsic motivation was associated with positive PA outcomes whereas external motivation was associated with negative PA outcomes.</td>
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<tr>
<td>Hassandra et al.,</td>
<td>2003</td>
<td>Psychology of Sport and Exercise</td>
<td>Investigate the factors associated with intrinsic motivation in PA education in students (ages 12-15 years old).</td>
<td>Students (n=254, 143 boys, 111 girls) completed two self-reported questionnaires: the Intrinsic Motivation Inventory and a perceived confidence questionnaire.</td>
<td>Social-environmental factors, such as lesson content, teacher, and facilities were associated with intrinsic motivation for PA education participation. Individual differences in physical appearance and perceived competence were also associated with intrinsic motivation.</td>
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</table>
Brunet and Sabiston, 2011
Psychology of Sport and Exercise

Investigate the relationships and differences between motivational factors for PA in young adults (18-24 years old), adults (25-44 years old), and middle-aged adults (45-64 years old).

Young adults (n=349), adults (n=118), and middle-aged adults (n=80) completed an online survey regarding motivation for PA (the Behavioral Regulation in Exercise Questionnaire). Participants recorded their PA each day for 25 days using the Leisure Time Exercise Questionnaire.

Autonomous motivation was a significant (p<0.05) positive correlate with PA for each of the 3 age groups. In young adults, introjected regulation was a significant (p<0.05) positive correlate with PA and external regulation was a significant (p<0.05) negative correlate with PA.

Gallagher et al., 2012
Preventive Medicine

Investigate the relationship between motivation for health goals and leisure-time physical activity (LTPA) and if the results vary by age and gender in a 25-day study.

Participants (n=710, 405<30 years old, 305>29 years old) completed a questionnaire at baseline regarding their health goals and motivational factors for those goals. Participants then recorded their LTPA for 25 consecutive days. Estimating equations models were used to analyze the data.

For participants who had physical health as a health goal, a significant (p<0.05) relationship was observed between the goal of physical health and ↑ LTPA in adults <30 years old. Intrinsic motivation was significantly (p<0.05) related to ↑ LTPA in females and to ↑ LTPA duration in males. Approach motivation was significantly (p<0.05) related to ↑ LTPA duration in both genders.
<table>
<thead>
<tr>
<th>Mudrak et al., 2014</th>
<th>Investigate the PA levels and associated motivational factors in Czech senior adults (&gt;60 years old).</th>
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<tr>
<td>Kontakt</td>
<td>Adults (n=315) were administered a questionnaire regarding PA level, LTPA, their health status, and motivational scales. Descriptive statistics were used to analyze the data.</td>
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<tr>
<td>Lauderdale et al., 2015</td>
<td>The Physical Educator</td>
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<tr>
<td>Lauderdale et al., 2015</td>
<td>Students (n=96, 33 males) completed a questionnaire consisting of two sections: a self-report of motivational regulations and of PA level.</td>
</tr>
<tr>
<td>Lauderdale et al., 2015</td>
<td>Physical and mental health were positively correlated (p&lt;0.05) with PA levels. Perceived self-efficacy and social support were significantly (p&lt;0.05) correlated to PA as motivational factors. Male students were significantly (p&lt;0.05) more influenced by intrinsic motivation as exercise motivation compared to female students. Intrinsic motivation was significantly associated with PA for both genders.</td>
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Pedometer-Metered Walking

Using pedometers to record daily step counts is a motivational method of increasing PA participation by setting goals for one’s self, which is a form of autonomous motivation. Studies have tested whether using pedometers results in increased PA levels in different populations (Table 6). Collectively, research supports that pedometer use increases engagement in PA. A 3-week pedometer-metered walking intervention using adult participants (over 18 years old) showed that walking, moderate PA, and vigorous PA increased significantly (p<0.05) due to pedometer usage. A 12-week pedometer-metered walking intervention also using adult patients (16-84 years old) revealed a significant increase (p<0.05) in the number of steps walked per day as well. Not only has pedometer usage increased PA in healthy adults, but it has also increased PA in populations with health conditions. A 6-month pedometer-metered walking intervention with adult patients with type 2 diabetes found that daily step count increased significantly (p<0.05) at 3 and 6 months compared to the control. A 3-month pedometer-metered walking intervention studied adult patients over 40 years old with chronic obstructive pulmonary disease (COPD) and demonstrated that for 24 of the 27 patients, daily step count significantly (p<0.05) increased. These studies display how useful the low-impact aspect of walking is for helping patients with health conditions transition from a sedentary to an active lifestyle using a pedometer as motivation.

Not only has pedometer-usage aided PA engagement in adults, but it has also been utilized in children, typically through school health programs. In 2015 Suchert and colleagues tested the effects of wearing a pedometer and class competitions on PA level in 8th grade students 12-17 years old in a 12-week intervention. The results of the study...
showed that PA levels increased significantly (p<0.05) in the intervention group, which further supports that autonomous motivation is effective at all age levels for PA engagement\textsuperscript{75}. A study by Zizzi and colleagues in 2006 studied the effects of a 3-week pedometer-metered walking intervention on daily step count and PA attitudes in healthy high school students ages 14-17 years old\textsuperscript{76}. In contrast, the study found no significant differences in daily step count or PA attitudes in the intervention group compared to the control group\textsuperscript{76}. Since social-environmental factors have been shown to affect intrinsic motivation, a possibility to explain the results could be that peer-pressure discouraged the participants from engaging in the pedometer-metered walking intervention. In addition to pedometer-metered studies testing effects in different age groups, such studies have been tested the same effects in adults of different weights. For example, in 2007 Clemes et al. performed a 4-week pedometer-metered walking intervention using healthy weight, overweight, and obese adults to see if daily step count differed between the weight groups\textsuperscript{77}. The results of the study showed that average step count was higher in the normal weight group compared to the overweight and obese group\textsuperscript{77}. Such results demonstrate the increased motivation need for overweight and obese individuals to increase their PA levels, whether it is through intrinsic or external sources.

Based on the review of the literature presented in this paper, it was determined that a lack of research exists on the effects of pedometer-metered walking collectively on body composition, WHR, BP, FBG, and diet choices in a single study. In addition, few body composition studies use participants of healthy weight for their studies. Therefore, the population chosen for the study and the objectives for the study were determined from the current scan of the research in this area. The hypotheses and research design for the
study were created based on similar studies previously published, and it is hoped that this paper will increase the body of knowledge of pedometer-metered walking interventions using healthy college-aged participants.
Table 6.

*Literature Review: The Use of Pedometers for Increasing Physical Activity Levels.*

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<th>Author</th>
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<tbody>
<tr>
<td>Zizzi et al., 2006</td>
<td></td>
<td>American Journal of Health Education</td>
<td>Test the effects of wearing a pedometer on the number of steps walked/day and on attitudes towards PA in healthy high school students (ages 14-17 years old) in a 3-week intervention.</td>
<td>Students (n=165, 109 females) were given a pedometer and encouraged to wear the pedometer every day and increase their daily step count. All students recorded the number of steps they walked/week. The students were randomly stratified to a group that set a daily number of steps goal and a group that did not engage in goal setting. A survey of PA attitude was administered pre- and post-intervention.</td>
<td>No significant (p&gt;0.05) differences in daily step count or attitudes towards PA were found after the 3 week intervention for both the goal setting group and the control pedometer group.</td>
</tr>
<tr>
<td>Clemes et al., 2007</td>
<td>Preventive Medicine</td>
<td>Test the effects of using a pedometer on physical activity and daily step counts in normal-weight (mean age = 34 ± 12 years old), overweight (mean age = 41 ± 14 years old), and obese (mean age = 41 ± 12 years old) adults in a 4-week intervention.</td>
<td>Normal weight (n=86), overweight (n=91), and obese (n=75) adults were given a pedometer to wear for 4 weeks continuously and record their daily step count. Participants were instructed to not change their daily habits. Body mass and BMI were measured pre- and post-intervention.</td>
<td>Mean step counts for the normal-weight group were significantly (p&lt;0.05) ↑ compared to the overweight and obese group. For all test groups, PA was the lowest on Sundays.</td>
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De Cocker et al., 2008
Patient Education and Counseling

Test the effects of wearing a pedometer in addition to cognitive and behavioral support on PA levels and pedometer attitudes in adults (>18 years old) in a 3-week intervention. Adults (n=103) randomly drawn from a phone book were given a pedometer to wear for 3 weeks continuously and were randomly assigned to one of two groups: the cognitive and behavioral group that received supplemental aids and the control group that did not receive supplemental aids. All participants completed surveys pre- and post-intervention regarding PA levels and pedometer attitudes. Walking, moderate PA, and vigorous PA ↑ significantly (p<0.05) in both the intervention and control group with pedometer use. The use of cognitive and behavioral support ↑ positive attitudes towards pedometer usage compared to the control group.

McKay et al., 2009
Patient Education and Counseling

Test the effects of wearing a pedometer on PA level in general practice adult patients (ages 16-84 years old) who are sedentary in a 12-week intervention. Patients (n=129, 33 females) were given a pedometer and qualitative step data and qualitative PA attitude data were collected at 12 weeks post-intervention. Qualitative data only was collected 6 months post-intervention. A significant (p<0.05) ↑ in the number of steps walked/day occurred at 12 weeks measured quantitatively and at 6 months post-intervention measured qualitatively. Patient views of pedometers were positive post-intervention at 3 and 6 months.
Moy et al., 2012
Respiratory Medicine
Test the effects of using a pedometer with a motivational website program on daily step count in adults (>40 years old) with COPD in a 3-month intervention.

Male adults (n=27) were given a pedometer and an email that provided access to the intervention website at baseline. Participants uploaded their daily step counts weekly and received motivational goals and feedback from the website for the 3 month period. Pre- and post- surveys were administered for dyspnea and exercise self-regulated efficacy.

For 24 of the participants, daily step count ↑ significantly (p<0.05) from baseline to 3 months with an average of 1263 steps/day increase. No significant changes were observed in the dyspnea and exercise self-regulated efficacy questionnaires.

Johnson et al., 2015
Preventive Medicine Reports 2
Test the effects of the pedometer-based Healthy Eating and Active Living for Diabetes (HEALD) intervention on daily step count, blood glucose, lipid, and hemoglobin A1c content, and body composition in adults (≥ 18 years old) with type 2 diabetes over a period of 6 months. The study also tested the cost-effectiveness of the intervention program in comparison to usual care.

Patients (n=186) received a pedometer at baseline and were randomly assigned to 1 of 2 groups: the intervention group (an Exercise Specialist held group sessions and participants set step count goals and received monitoring and social support) or the control group (received usual diabetic care with no instructions for physical activity). Participants recorded their average number of daily steps at baseline, 3 months, and 6 months. Anthropometric measurements, diet records, and blood work were completed at baseline, 3 months, and 6 months.

A significant (p<0.05) ↑ in daily step count occurred in the intervention group compared to the control group at 3 and 6 months. No significant differences were observed in body composition, blood hemoglobin A1c, glucose, and lipid levels, or diet between the 2 groups. The intervention group costs an average of $102 more per person compared to the usual care group, but the intervention group increased their daily step count by about 1,000 steps/day, making the intervention cost effective in terms of PA outcomes.
Suchert et al., 2015

Test the effects of wearing a pedometer and class competitions on PA level in 8th grade students (ages 12-17 years old) in a 12-week intervention.

Adolescents (n=1162, 558 females) were randomly assigned to 1 of 2 groups: the intervention group, which received pedometers and participated in a school competition to create ideas to increase PA, or the control group that did not receive pedometers or participate in the competition. Questionnaires were used pre- and post- intervention to assess PA levels and the 20-m shuttle run test was used to assess cardiorespiratory fitness.

PA levels ↑ significantly (p<0.05) via activities outside of school in the intervention group compared to the control group after 12 weeks. A trend towards a significant ↑ in cardiorespiratory function was observed for the intervention group.
CHAPTER 3
MATERIALS AND METHODS

Participants

This study was approved by the California State Polytechnic University (Cal Poly) Pomona Institutional Review Board (IRB protocol # 14-0469-Appendix A) and informed consent was gathered from all of the participants (Appendix B). Forty healthy males and females between the ages of 18 and 45 years old were recruited using flyers (Appendix C), emails, and word of mouth, and the participants were recruited from the first week of January 2015 through the third week of January 2015 at the Cal Poly Pomona campus. The inclusion criteria for the participants required that they were Cal Poly Pomona students or staff, were healthy males or females between the ages of 18 and 45 years old, had no known chronic diseases, were not pregnant, did not have any injuries that could be exacerbated by walking, and did not have metal plates in their body or a pacemaker. The exclusion criteria for participants was if they had hip, leg, ankle, or foot injuries, if they were pregnant, if they had a known chronic disease, if they had diagnosed trypanophobia, if they were not between the ages of 18 and 45 years old, if they were not enrolled as a Cal Poly Pomona student or staff, and if they had metal plates in their body or a pacemaker, and if they were on a diet plan or were consuming alcohol on a regular basis.

After signing the informed consent, the participants completed a health-screening questionnaire to estimate their current diet and PA levels (Appendix D). The study was a 4-week intervention pilot study and 32 college-aged participants completed the study. The length of the study was determined based on previous research observations of body
composition changes within a 4-week period\textsuperscript{78,79,80}. Three participants were excluded due to failure of adherence to the study protocol. A lead-in week to obtain baseline data was completed (for 20 of the participants, the lead-in week and week 1 data collection were combined due to time constraints). The participants were randomized into two groups using the website: www.randomization.org. Treatment 1 was the intervention group, where the participants received an email every morning through Blackboard\textsuperscript{®} that encouraged the participants to increase the number of steps that they walked per day. The emails consisted of inspirational quotes that included the words “step” or “walking” or ideas for activities to increase the number of steps walked per day (Appendix E). Treatment 2 was the control group, where the participants did not receive daily encouragement to increase the number of steps walked per day.

**Pedometers**

At the beginning of the study, each participant was given a Sportline 340\textsuperscript{®} pedometer to record the number of steps that they walked per day and were also asked to increase the number of steps that they walked during the study period. The participants were instructed to take a picture of their pedometer screen at the end of each day and to upload that picture into a designated folder in the Blackboard\textsuperscript{®} organization entitled “Step Walk Study”.

**Diet Recordings**

The participants were instructed to complete a 3-day diet record (Appendix F) for the lead-in week (for the 20 participants with the combined lead-in week and week 1 data collection, two diet histories (Appendix G) and one 24-hour diet recall (Appendix H) were completed). For all of the participants, they were instructed to complete three 3-day
diet records at random time points during the 4-week study period. Three-day self-reported diet records are utilized as valid predictors of usual dietary intake, however, they still contain human error\textsuperscript{81,82,83}. The time points for the diet data collection were determined using the website: www.randomization.org. After completing each diet record, the participants were instructed to upload their documents into a designated folder in the Blackboard® “Step Walk Study” organization.

**Data Collection and Measurements**

Data collection occurred during the lead-in week, week 1, and week 4 of the study (for 20 of the participants, data collection occurred during week 1 and week 4 only). Data collection was conducted in either the Wellness Center or in the office of Dr. Bonny Burns-Whitmore at Cal Poly Pomona, and it was conducted in the morning hours between 6:30am and 11:00am Monday through Friday during January and February of 2015. Participants were instructed to fast for at least 12 hours prior to each data collection, and each data collection was approximately 20 minutes. Data was collected in the following order: height, waist and hip measurements, body composition, BP, and FBG.

*Height*

During the first data collection only, height was the first variable measured. Participants were instructed to remove their shoes and stand against a stioniometer (Charder HM200P Portstand Portable Statiometer, Northbend, WA) with their heels touching the base of the stioniometer and their head level (Charder HM200P Portstand Portable Statiometer, Northbend, WA). Two measurements were taken by the Principal Investigator (PI). For all of the measurements, the average was taken and more than two
measurements were taken if the two values were greater than 1 cm in difference and the measurement that varied was disregarded.

**Waist and Hip Measurements**

During each data collection, waist and hip circumference were the second variables measured. Participants were instructed to relax their arms and take one deep breath and exhale as the research assistant used a tape measure (Wintape Measuring Tape, Guangdong, China) to measure their waist and hip circumference. The research assistant felt for the lowest rib and used the midpoint between the lowest rib and the iliac crest for the waist measurements. For hip measurements, the research assistant used the widest area of the buttocks. Both waist and hip circumference were measured twice during each data collection. WHRs were calculated from the waist and hip measurements by dividing the waist circumference by the hip circumference. The average of the measurements was taken and if the two measurements differed by more than 3 cm another measurement was taken and the measurement that varied was disregarded.

**Body Composition**

Body composition was measured during each data collection following waist and hip measurements using the Tanita Bioelectrical Impedance Analyzer® (BIA) (Tanita SC 300 S, Tokyo, Japan). The Tanita BIA is a validated method for the accurate measurement of body fat. Participant information (age, height, athlete or non-athlete) was entered into the Tanita BIA prior to their body composition measurement. Participants were instructed to remove their shoes and socks and stand on the indicated metal plates on the Tanita scale. Participants stood on the Tanita scale for 5-10 seconds until the Tanita monitor indicated that the measurement was complete. Body composition
measurements were taken twice by the PI and the average was taken of the two values if the measurements differed.

**Blood Pressure**

BP was measured after body composition during each data collection. Participants sat in a chair and rested their left arm on an adjacent table. A research assistant placed the BP cuff securely around the upper portion of their left arm and then started the BP measurement using an automatic blood pressure monitor (Omron BP629 Automatic Wrist 3 Series®, Warminster, PA). After the BP measurement was completed, the cuff was removed and the participant rested for 5 minutes. The second BP measurement was taken following the 5 minute rest using the aforementioned procedure. The average of the two measurements was taken and if the BP measurements differed by more than 5 mmHg for either systolic or diastolic BP then another measurement was taken and the measurement that varied was disregarded.

**Fasting Blood Glucose**

The final variable tested during each data collection was FBG using a Freestyle Freedom Lite® meter kit (Abbott Diabetes Care Inc., Alameda, CA). Participants sat in a chair and rested their right arm on an adjacent table. A research assistant used an alcohol wipe to clean the middle finger of the right hand of the participant. The participant was instructed to shake their hand in the air for about 30 seconds to increase the blood flow to the fingertip. After the 30 seconds, the research assistant held the middle finger of their right hand tightly and used the lancing device to prick the fingertip. A drop of blood was placed on the test strip of the glucometer and the blood glucose value was measured. Blood glucose measurements were performed two times. The average of the two
measurements was taken, and if the blood glucose values differed by more than 5, then the measurement was taken again and the measurement that varied was disregarded.

**Statistical Analysis**

All data was tested using the statistical software SPSS 20.0 for Windows (SPSS, Chicago, IL, USA), and significance was set at $p \leq 0.05$. Two-tailed paired T-test statistics were run on week 1 and week 4 body composition, FBG, BP, and WHR mean data to determine if the tested variables significantly changed within four weeks ($N=29$) (Table 7). It was not necessary to control for total body water in the statistical analysis because the body composition output generated total body water content for each measurement. Diet data was entered into a dietary analysis program (ESHA® Food Processor Nutrition Analysis software, Salem, OR, USA) to analyze the nutrient content of the collected diets. Repeated measures analysis of variance (ANOVA) statistical tests were run on the mean nutrient data to determine significant differences between the 3 diet records for total caloric, fruit, vegetable, simple sugar, potassium, calcium, sodium, carbohydrate, fat, and protein intake ($N=20$). The Mann-Whitney U statistical test was performed on the mean number of steps taken by Treatment 1 and Treatment 2 to determine any significant differences within four weeks ($N=29$). The Pearson’s Correlation Coefficient test was run to discover if a relationship exists between the mean number of steps taken per day and body composition, WHR, BP, FBG, and diet choices within 4 weeks ($N=29$).
### Table 7. Study Objectives and their Corresponding Statistical Analyses

<table>
<thead>
<tr>
<th>Objective</th>
<th>Statistical Analysis</th>
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<tr>
<td>Test if pedometer-metered walking has a significant effect on body composition, WHR, BP, and FBG from week 1 to week 4.</td>
<td>Two-tailed paired T-test</td>
</tr>
<tr>
<td>Test if pedometer-metered walking has a significant effect on diet choices from week 1 to week 4.</td>
<td>Repeated measures ANOVA</td>
</tr>
<tr>
<td>Test if external motivation (intervention group) results in a significant increase in the number of steps per day compared to the control group.</td>
<td>Mann-Whitney U test</td>
</tr>
<tr>
<td>Test if a correlation exists between the average number of steps completed per day and body composition, WHR, BP, FBG, and diet choices.</td>
<td>Pearson’s Correlation Coefficient</td>
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</table>
CHAPTER 4

RESULTS

The results of the two-tailed paired T-tests showed significant decreases in waist circumference (77.1 ± 2.23cm to 74.5 ± 2.03cm, p=0.002) (absolute change = -2.6 ± 3.9cm, percent change = -3.1 ± 4.7cm) as well as hip circumference (99.8 ± 1.74cm to 99.0 ± 1.78cm, p=0.030) (absolute change = -0.8 ± 1.9cm, percent change = -0.8 ± 1.9cm) from week 1 to week 4 (Figure 1). There were no significant changes over time for body composition (total body weight, FM and FFM), WHR, BP, FBG, or for the intervention group who received the motivational quotes (p>0.05). However, there was a trend towards a significant decrease for FFM (p=0.06). The results of the repeated measures ANOVA on the diet data revealed a significant decrease in fruit intake in the second (p=0.007) and third (p=0.023) diet records compared to the first diet record and the effect size was 32%. No significant changes over time were observed for intake of vegetables, total calories, simple sugars, potassium, calcium, sodium, carbohydrates, fats, and protein among the three diet records (Table 8).
Figure 1. Significant (*p<0.05) decreases were observed for waist and hip measurements (N=29) over time using the two-tailed paired T-test.

Table 8. Comparison of mean dietary intake records (N=20) at three random time points within the four-week period. Significant decrease in fruit intake was observed between the first diet record compared to both the second (p=0.007) and third (p=0.023) diet records using the repeated measures ANOVA test. No significant changes were observed for the other dietary variables (p>0.05).
The results of the Mann-Whitney U test on the number of steps walked by the intervention group and the control group showed no significant difference in the average number of steps walked by the two groups over time (p>0.05) (See Appendix I for step data). The results of the Pearson’s Correlation Coefficient revealed no significant correlations between the average number of steps walked and body composition, WHR, BP, FBG, and diet choices within the four weeks (p>0.05).
CHAPTER 5

DISCUSSION AND CONCLUSION

Waist and hip measurements decreased significantly at the end of study, suggesting that monitored walking through the use of a pedometer results in physical abdominal changes. The results for the waist and hip measurements supported our hypothesis that pedometer-metered walking results in decreased waist and hip measurements. Although conclusions cannot be drawn regarding the types of physical abdominal changes from the results, a trend towards significance was observed for FFM, suggesting that FFM may be decreasing as a pedometer is used to monitor the amount of steps walked daily. Further pedometer-metered walking studies demonstrating significant decreases in FFM are needed in order to substantiate the aforementioned possibility. In addition, future research would need to control for total body water (TBW) to determine whether it is muscle mass or water mass that is decreasing through the use of a pedometer. TBW was analyzed pre-and post-intervention using two-tailed paired T-tests and no significant differences in TBW were observed (p>0.05) for our study, however, not all of the participants restricted their water intake prior to the data collection time points. A study similar in design to the current study examined the effects of a pedometer-metered intervention on parameters indicative of type 2 diabetes for six weeks and found a trend towards significance for a decrease in waist measurements (p > 0.05)\textsuperscript{87}. Other studies investigating the effects of pedometer-metered walking on body composition over different study durations using different populations support the significant decreases in waist and hip measurements observed in this study\textsuperscript{88,89,90}. One of the studies found a significant negative correlation between the number of steps walked
and percent body fat (p < 0.0001), however, they did not find a significant decrease in percent body fat after seven days of pedometer-metered walking. More research is needed on the effects of pedometer-metered walking on body fat, FFM, and TBW to determine which component decreases as walking increases, resulting in the already observed decreases in waist and hip measurements.

The results of no significant changes for body composition, FBG, and BP did not support our hypothesis that pedometer-metered walking results in significantly decreased body fat composition, increased FFM composition, decreased FBG, and decreased BP. Both longer duration (greater than 12 weeks) and shorter duration (less than 12 weeks) walking interventions have shown significant decreases in BMI and percent body fat using healthy-weight participants, therefore the results from this study were expected to yield similar results. Research on the effects of walking on blood glucose levels revealed that walking interventions of shorter duration (less than 12 weeks) resulted in decreases in FBG in adult participants without diabetes, which is contradictory to the results obtained in the current research study. BP is another outcome that has been tested in walking interventions and the results collectively showed that a significant negative correlation exists between BP and the amount of time spent walking per day. Again, however, the results for BP in this study did not support the results from previous studies.

Possible explanations for the lack of significant changes observed for body fat, FFM, FBG, and BP exist, although none of them are supported and need to be tested. One explanation is that the study duration was too short for significant differences to be observed between week 1 and week 4 of data collection. Another explanation is that the
study population was at a fitness level that was not affected by increasing the amount of walking per day, since all of the participants were nutrition and dietetics majors interested in health and nutrition. The results also could have shown no significance due to the small sample size of the study population (N=29). Future studies are needed to test these possible explanations to determine why no significant changes were observed for body composition, FBG, and BP in this study.

The significant decrease in fruit intake observed from the first diet records to the second and third diet records was an unexpected result that did not support our hypothesis regarding the positive effect of pedometer-metered walking on fruit intake. Research has supported a positive correlation between increased PA levels and healthier diet choices\textsuperscript{60,61}, and previous studies have demonstrated that inadequate PA is associated with low fruit intake\textsuperscript{91,92,93}. Therefore, the results from this study were not consistent with similar research since the participants were engaging in daily PA as recorded by their pedometers. There are several possibilities for why this decrease occurred, although none of the hypotheses are supported and therefore require subsequent research. One possibility is that as the weeks in the quarter progressed, the stress levels of the students increased and resulted in the students spending less time including fruit in their diet compared to the beginning of the quarter. Another possibility is that the fruit selection decreased as the study was conducted during the winter months of January and February, resulting in the participants consuming less fruit due to the decrease in variety and/or availability. A final possibility is that as the participants spent more time walking with their pedometers, they spent less time consuming fruit. Again, separate studies are required in order to support the possibilities to explain the observed decrease in fruit
intake within four weeks and to further understand the effect of pedometer metered walking on fruit intake. Previous research has supported that fruit intake is influenced by autonomous motivation as well as by social support\textsuperscript{94}.

In addition to the fruit intake results not supporting our hypothesis, no significant changes in total caloric, fruit, vegetable, simple sugar, potassium, calcium, sodium, carbohydrate, fat, and protein intake were observed, which also does not support our hypothesis regarding the expected positive effect of pedometer-metered walking on diet choices. As previously mentioned, studies support a positive relationship between increased PA levels and healthier diet choices, which are measured by the nutritional components of the diet\textsuperscript{60,61}. Once again, possibilities exist to explain the observed results but require research to be tested. Since the study participants were all nutrition and dietetics majors, it is possible that the diets of the participants were already at a healthy level at the start of the study and therefore no significant changes were made during the four weeks. In addition, the sample size may have been too small (N=20) and the duration of the study too short for significant differences to be observed, as previously mentioned. Again, research is needed to test the possible theories to address the lack of significant changes in diet choices in this study.

A final conclusion to be drawn from the results is that external motivation to increase the number of steps walked per day as provided through motivational quotes is not effective in increasing the number of steps walked per day. Research has shown that self-motivation leads to increased PA compared to external motivation, therefore this result was not unexpected\textsuperscript{65,66,67,95,96}. When students were given the freedom of choice in their physical activities during their period of physical education, their level of PA
increased compared to when they were instructed to participate in a specific intervention\textsuperscript{95,96}. Therefore, people must be interested and/or perceive the benefit of the PA that they perform in order to increase their PA level. The goal of using pedometers to track the number of steps walked per day is to increase the level of self-motivation to walk, leading to increased levels of PA.

Several limitations exist in this study that are noteworthy. The first limitation is the short study duration. Since walking is a low-intensity form of exercise, physical changes may not occur in as little as four weeks. As previously stated, if the study had been expanded, significant physical changes may have been observed over time. For example, metabolic syndrome markers decreased significantly over a one-year pedometer-metered walking intervention of 316 adult participants\textsuperscript{97}. The second limitation is the low number of subjects in the study. Forty participants were recruited for the study, however, eight dropped out and three were excluded due to violating the inclusion criteria. Statistical analysis could only be performed on a sample size of 29 for the anthropometric and intervention data, and the sample size was even less for the diet data (N=20). The power for the paired-T test statistical analysis was 74\%, which is close to the level of adequate sample power (> 75\%) (www.statpages.org, Iowa, USA). However, the power for the repeated measures ANOVA was far from the level of acceptable sample power at 49\% (www.statpages.org, Iowa, USA). A seven-day pedometer-metered walking intervention of 69 African-American women revealed significant decreases in percent body fat, waist and hip measurements, supporting the need of a large sample size for valid results\textsuperscript{98}. The third limitation is the lack of a control in this study for pedometer use. A control group that does not wear pedometers is
necessary in order to support that the use of pedometers is responsible for the observed outcomes in the study. Therefore, it cannot be concluded with certainty that pedometer-metered walking was responsible for the results in this study. A control group was not incorporated into this study because participants joined the study in order to receive a free pedometer and would not have joined if they did not receive it.

Additional limitations are present in this study. The timing of the study at Cal Poly Pomona may have affected the results. A “Step Wars” competition occurred at the same time as the research study and over fifty percent of the participants were involved in the Step Wars competition. Therefore, motivation to increase the number of steps walked per day may have been due to participation in the competition rather than autonomous pedometer use. A final limitation in the present study was the use of nutrition students as participants. Nutrition students are typically more aware of their health and engage in PA to a greater extent than students from majors not involving health or science. The results may have been different if the participants were from diverse college majors.

Since this was a pilot study and exploratory in nature, there is a great need for further research. To correct for the limitations of the present study, further pedometer-metered walking studies using healthy, college-aged participants need to be conducted using a control group for pedometer use with a longer study duration. In addition, future similar studies need to recruit participants from different college majors to gain a more accurate representation of the college-aged population at large. Similar studies must ensure that their participants are not participating in a walking competition at the same time as the research study. Further studies should utilize more accurate equipment for data collection.
Future studies using the present study as their background can perform the same study using overweight and obese participants and compare the results between pedometer-metered walking for the two populations. Research comparing the effects of pedometer-metered walking on healthy and overweight/obese participants is necessary to determine the effectiveness of using pedometers for increasing the number of steps walked per day for the general population. Additional research could perform a similar study and analyze gender differences to see if gender affects pedometer usage. Only two out of the 32 participants who finished the current study were male, therefore gender differences could not be analyzed. A goal of future pedometer-metered walking studies is for fat mass loss to be observed over time so that a regression analysis can be performed on the data to determine if a threshold number of steps exist that results in significant FM loss over time. Multiple studies supporting pedometer-metered walking resulting in FM loss over time are needed in order for a valid regression analysis to be performed. The determination of a threshold number of steps to walk per day to result in FM loss over time could lead to a change in the PA guidelines for weight loss. Any change that has the potential to motivate individuals to increase their PA level is a tool to decrease the rising obesity rates within the US.
REFERENCES


6. Keihani, S., Hosseinpanah, F., Barzin, M., Serahati, S., Doustmohamadian, S., Azizi, 58


http://www.autonomicneuroscience.com/article/S1566-0702(15)30013-8/abstract


http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4358598/


http://scholarcommons.sc.edu/sph_physical_activity_public_health_facpub/119/?utm_source=scholarcommons.sc.edu/sph_physical_activity_public_health_facpub/119&utm_medium=PDF&utm_campaign=PDFCoverPages


http://www.annfammed.org/content/6/1/69.short

Effect of Walking Exercise on Weight Loss. How Much is Enough? *Int J Obes*  
*Relat Metab Disord, 26*, 1484-1493. Retrieved from:  
http://europepmc.org/abstract/MED/12439651


http://diabetes.diabetesjournals.org/content/36/12/1379.short

and Walking) Effectively Decreases Blood Glucose Levels in Diabetic Patients. 

*Int J Biometeorol, 41*, 125-127. Retrieved from:

http://link.springer.com/article/10.1007/s004840050064


http://www.tandfonline.com/doi/abs/10.1080/02640414.2012.723816


https://www.researchgate.net/profile/Celso_Carvalho2/publication/265124499_PostWalking_Exercise_Hypotension_in_Patients_with_Intermittent_Claudication/links/5608dda208ae8e08c0946540.pdf


60. Tavares, A.I. (2014). Physical Activity and Healthy Diet: Determinants and Implicit


http://www.tandfonline.com/doi/abs/10.1080/19325037.2006.10598875


78. Edholm, D., Kullberg, J., Karlsson, F.A., Haenni, A., Ahlstrom, H., Sundbom, M.


http://dx.doi.org/10.1016/j.clnu.2014.11.004


Pedometer-Based Physical Activity Program on Parameters of Diabetes Control in Type 2 Diabetes Mellitus. *Metabolism, 55*, 1382-1387. Retrieved from:  


APPENDIX A

Institutional Review Board Approval Memorandum

State of California
Memorandum
California State Polytechnic University, Pomona
Office of Research Compliance

Date: 17-Dec-2014
To: Lauren Meeks, BS
College of Agriculture, Department of Human Nutrition and Food Science
From: Dr. Jeffery S. Mio
Chair, IRB (Human Subjects Protection Committee)
cc: IRB file
Bonny Burns-Whitmore, PhD, Corinne Worland, AA, Andy Reynaga
Subject: Protocol number 14-0469

Your new protocol entitled “Stepwalk Study” has been reviewed by the Cal Poly Pomona Institutional Review Board (IRB) by the Expedited process. It was found to be in compliance with applicable federal and state regulations and Cal Poly Pomona policies regarding the protection of human subjects used in research. Thus, the Cal Poly Pomona IRB grants you approval to conduct the research. On its behalf, I thank you for your adherence to established policies meant to ensure the safety and privacy of your study participants. You may wish to keep a copy of this memo with you while conducting your research project.

You may initiate the project as of 17-Dec-2014 and it must be completed by 17-Dec-2015. Federal regulations limit the IRB approval of studies for up to one year. If you find the need to renew your protocol, please remember to submit a request to the IRB at least a couple of weeks before this end date to ensure continuous human subjects’ protection and IRB approval. It would be appreciated that you advise the IRB upon the completion of your project involving the interaction with human subjects.

Applicable notes:

Approval is conditional upon your willingness to carry out your responsibilities as the principal investigator under University policy. Your research project must be conducted according to the methods described in the final approved protocol. Should there be any changes to your research plan as described, please advise the IRB, because you may be required to submit an amendment. Additionally, should you or any of your subjects experience any “problems which involve an undescribed element of risk” (adverse events in regulatory terms), please immediately inform the IRB of the circumstances.

If you need further assistance, you are encouraged to contact the IRB administrator, Bruce W. Kennedy
MS RLATG CMAR CPIA at 909-869-4215.

The committee wishes you success in your research endeavors.

Jeffery S. Mio PhD
Professor, Psychology
College of Letters, Arts, and Social Sciences

Federated Assurance 00001790
IRB principles: respect for persons, beneficence, and justice

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You are being invited to participate in a research study, which the Cal Poly Pomona Institutional Review Board (IRB) has reviewed and approved for conduct by the investigators named here. This form is designed to provide you - as a human subject - with information about this study. The Investigator or his/her representative will describe this study to you and answer any of your questions. You are entitled to an Experimental Research Subject’s Bill of Rights and a copy of this form. If you have any questions about your rights as a subject, complaints about the informed consent process of this research study, or experience an adverse event (something goes wrong), please contact the Compliance Office within Cal Poly Pomona’s Office of Research at (909) 869-4215. More information is available at the IRB website, www.csupomona.edu/research/irb.

The effects of pedometer-metered walking on body composition, blood glucose, diet alterations, blood pressure, and waist to hip ratios in college-aged participants-a pilot study

IRB Protocol # 14-0469

RESEARCHERS:

Lauren Meeks (Principal Investigator), Master Student, Food Science and Nutrition Department, California State Polytechnic University, Pomona; lgmeeks@csupomona.edu; (909) 638-5675
Corrine Worland (Co-Investigator), Undergraduate Student, Food Science and Nutrition Department, California State Polytechnic University, Pomona; ceworland@csupomona.edu; (909) 576-8966
Andy Reynaga (Co-Investigator), Undergraduate Student, Food Science and Nutrition Department, California State Polytechnic University, Pomona; apreyanga@csupomona.edu; (805) 727-1433
Dr. Bonny Burns-Whitmore (Co-Investigator), RD, Professor, Department of Human Nutrition and Food Science, California Polytechnic University, Pomona; bburnswhitmo@csupomona.edu; (909) 869-3793

RESEARCHERS’ STATEMENT:

We are asking you to participate in a research study. The purpose of this consent form is to give you the information you will need to help you decide if you would like to participate. The study will begin on the week of January 19th, 2015, and will continue for a total of four weeks. Please read the form carefully. If there is anything that is unclear, please do not hesitate to obtain clarification from the researchers. When we have answered all your questions, please decide if you would like to be included in the study. This process is called “informed consent”. You will be provided with a copy of this form.
for your records. The data from this study will be compiled from both campuses and analyzed. Your name will not appear on any of the data sheets. Data will be stored in locked file cabinets in Dr. Bonny Burns-Whitmore’s office (2-119) for five years.

PURPOSE OF THE STUDY

Our proposed study aims to evaluate whether increasing the quantity of steps taken while walking will affect the levels of fasting glucose, diet alterations, blood pressure, waist to hip ratios and body composition. The study objectives are 1) evaluate the effect of increasing the number of steps performed during walking exercise on body composition, and 2) evaluate the effect of increasing the number of steps during walking exercise on fasting glucose, blood pressure, diet alterations, and waist-to-hip ratios. The study will last for 4 weeks, with the intervention group receiving encouragement from the principal investigator through a Blackboard email account to increase the number of steps walked per day and the control group not receiving the encouragement. We hope to observe the beneficial effects of increased walking exercise on body composition, blood glucose, diet choices, blood pressure, and waist to hip ratios.

Lauren Meeks will study the effects of increased walking exercise on body composition and diet choices. Corrine Worland will examine the effects of increased walking exercise on waist to hip ratios. Andy Reynaga will observe the effects of increased walking exercise on blood glucose and blood pressure. All investigators are CITI certified.

STUDY PROCEDURES—Diagram of the study.

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<td>☐ ☐ ☐ ☐</td>
</tr>
</tbody>
</table>

#= total of 3 randomized food record-collected during the lead in and randomized during the study
* = finger prick for blood
☐ ☐ ☐ Tanita Measurement
! = waist hip measurements
+ = blood pressure
☐ ☐ ☐ height

Participants will be randomized into two groups: Treatment 1 (walking encouragement intervention) and Treatment 2 (no walking encouragement) for four weeks. There will be
a lead-in week to obtain baseline measurement for each participant upon which the results will be adjusted according to the baseline data.

1. After signing the consent form, you will fill out a brief health-screening and qualification questionnaire.
   a. Examples of questions will be:
      - Are you currently suffering from or have you ever been diagnosed with a chronic disease (heart attack, cancer, diabetes, renal failure, asthma)?
      - Do you walk for exercise on a regular basis? Do you track the number of steps walked?
   b. For important safety reasons, you will be asked to answer each and every question on the health-screening questionnaire prior to qualification for the study.

2. You will be instructed about the exercise plan that you will maintain for the duration of the study by the principal investigator. You will be asked to maintain your usual diet and perform 3-day food records at baseline and at three random points throughout the four weeks. You will be provided with a pedometer to track your steps for the duration of the study. These conditions require you to meet with the study personnel a total of three study visits.

3. This study is composed of two distinct experimental treatments for four weeks each:
   a. Treatment 1 (the walking encouragement intervention), in which you will be encouraged to increase the number steps per day recorded on your pedometer. No intervention of diet will occur.
   b. Treatment 2 (no walking encouragement), in which you will not receive encouragement to increase the number of steps per day. No intervention of diet will occur.

4. Before you begin the first experimental phase, you will complete a one-week “lead-in” period in which the background diet will be consumed and we will ask you to complete a 3-day food record.

5. At the beginning and end of the four week study, we will ask you to fast for 12 hours before your finger prick. The blood collected by the finger prick will be assessed for glucose levels by a trained phlebotomist at the Cal Poly Pomona Student Health Center (via appointment). The finger prick will take less than 1 minute.

6. Your body composition will be measured at the beginning and end of the four week study using a Tanita brand bioimpedance analyzer. The body composition measurements will require you to remove your shoes and socks, and stand on a platform while the machine analyzes body composition. The analysis will take approximately 10 minutes.

7. Your blood pressure will be measured at the beginning and end of the four week study using an Omicron blood pressure cuff. The blood pressure measurement will require you to allow us to measure your blood pressure with a wrist cuff that will expand and then deflate, revealing your blood pressure and heart rate. You will be asked to sit down and
have your blood pressure measured using a blood pressure cuff around your left wrist. This will take less than 1 minute.

8. At three random points during the four weeks you will be asked to fill out a 3-day food record.

9. Your waist circumference will be measured using a flexible measuring tape between the middle of the bottom rib (close to your belly button) and iliac crest (top of the hip bone) and recorded to the nearest 0.1 cm. Hip circumference will be measured using a flexible measuring tape around the largest part of the hips (i.e. buttocks) and recorded to the nearest 0.1 cm. It will take no longer than 5 minutes to do both measurements. This measurement will be taken at the beginning and end of the four weeks.

10. Your height will be measured using a stadiometer and recorded to the nearest 0.1 cm. This will take no longer than 5 minutes and will only be done once at the beginning of the study.

INCLUSION CRITERIA

You are qualified to participate in this study if you:
- are between the ages of 18 and 45.
- have not taken any medication for any chronic disease (heart, diabetes, cancer) for 12 weeks or steroids (other than birth control pills).
- are free of any other chronic diseases.
- do not consume alcohol on a regular basis.
- are not currently on a diet plan.
- are not pregnant or plan to become pregnant.
- do not have any metal objects implanted in the body or piercings that are not removeable
- do not have an injury that will be exacerbated by walking.

Do you meet all the criteria listed above? YES ___________ NO ___________

EXCLUSION CRITERIA

You are NOT qualified to participate in this study if you:
- are a child, teenager, woman, or male younger than 18 or older than 45
- are taking any steroid or hormone medication (other than birth control)
- are pregnant or become pregnant.
- are diagnosed with any chronic diseases.
- are currently on a diet plan.
- consume alcohol on a regular basis.
- have a pacemaker or metal pins or plates in the body.
- have a hip, leg, foot, or ankle injury

Do you meet any of the criteria listed above? YES ___________ NO ___________
This study will be conducted from the Cal Poly Pomona campus. You will be required to come to campus three times during the four week study (place and time to be determined as per your schedule) for the baseline testing, testing during week 1, testing during week 4, and three random points throughout the four weeks to complete the 3-day food record. You will be asked to fast for 12 hours before the finger prick during week 1 and week 4 of testing.

**RISKS, STRESS, OR DISCOMFORT**

- There can be a potential risk of infection at the finger prick site if you scratch the site with bare hands after the finger prick. If you experience persistent pain, swelling and redness at the finger prick site, please contact the Health Center or your physician, and Dr. Burns-Whitmore.
- There may be a chance that you will feel nervousness or anxiety when seeing blood during the blood finger pricks. You may not be eligible for the study if you have a diagnosis of trypanophobia, which fear of needles/blood.
- There is a chance of falling while walking, resulting in injury.
- You may feel anxious or stressful to see your body composition, height, weight, waist to hip ratio, blood pressure, and blood glucose results. Feel free to contact Principal Investigators (PI), Dr. Burns-Whitmore, Lauren Meeks, or Corrine Worland or Counseling and Psychological Services (CAPS) to discuss the emotional stress.
- There may be a potential risk for personal identification, as you will provide demographic information such as age, height and weight. We will ensure maintaining confidentiality during the by assigning you an identification number.
- You may feel inconvenience during the course of the study, as you will have to check in with PIs once every week during the treatment periods. Feel free to discuss potential schedule conflicts or concerns with PIs.
- All piercings and metal must be removed before undergoing the body impedance measurements on the Tanita scale. Do not participate in this study if you have implanted metal plates or pacemakers/other electronic devises, because there is a risk of injury or death.

If you experience any of the above mentioned symptoms, intolerances, stress or discomfort in connection with this study, please do not hesitate to get in touch with Principal Investigators Lauren Meeks at (909) 638-5675, or Dr. Burns-Whitmore at (909) 869-3793 and your physician to discuss options.

If more severe or intolerable symptoms are experienced, please contact the Student Health Center at (805) 231-0864-cell, Dr. Burns-Whitmore at (909) 869-3793, the emergency room at the nearest hospital, 911 or your physician and discontinue participation in the study.

Dr. Burns-Whitmore can be contacted at (909) 869-3793 or bburnswhitmo@csupomona.edu. Lauren Meeks can be contacted at (909) 638-5675 or
If your blood values are found to be not within the normal range, we will ask you to have the values re-checked at the Student Health Center. All cost and time associated with necessary further testing are the sole responsibility of the participant and the participant should strongly consider having insurance to pay for such care.

**BENEFITS OF THIS STUDY**

You will receive free blood glucose tests and access to the body composition results at the end of the study. You will also benefit physically from the walking exercise. If you are one of the first 40 participants in this study, you will receive a free pedometer. If you finish ½ of the study, you will be given a certificate stating you finished ½ of the study. Upon completion of the study, participants will be entered into a raffle for one $25 gift card as compensation for their participation. We will choose one ID number from www.randomization.com according to the random number generator, and the winning person will be awarded the card. Dr. Burns-Whitmore will look up the name of the person (from their ID number) and contact that person directly.

**PARTICIPATION IN THE STUDY**

Your participation in this study is voluntary, and declining to participate will involve no penalty or loss of benefits to which you are otherwise entitled, and you may discontinue participation at any time without penalty. If you are one of the first 40 participants in this study you will receive a free pedometer. You will have a chance of winning a $25 gift card as compensation. You will also receive a certificate of completion from the study personnel at the end of the study or a thank you certificate if you cannot complete the study.

**OTHER INFORMATION**

Information provided by you will be confidential. However, in the event that the investigators learn that any participant intends to harm themselves or others or that an individual has been harmed, this information (by law) must be reported to the authorities. University staff sometimes reviews studies to ensure that they are being done safely, legally, and ethically. The reviewers will protect your privacy, and study records will not be used to harm any person or put a person at legal risk.

**COMPENSATION FOR INJURY**

There will be no compensation for lost wages, lost time, walking pain/reactions, adverse reactions, or pain resulting from walking. Payment for care resulting from adverse reactions is the sole responsibility of the participant and they should consider having medical insurance to pay for such care.
SUBJECTS’ STATEMENT

This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have any questions later about the study, I can ask one of the listed researchers listed. If I have questions about my rights as a research subject or a research-related injury, I can call the Compliance Office within Cal Poly Pomona’s Office of Research at (909) 869-4215. I will receive a copy of this consent form.

EXPERIMENTAL RESEARCH SUBJECTS’ BILL OF RIGHTS

California law, under Health & Safety Code Section 24172, requires that any person asked to take part as a subject in research involving a medical experiment, or any person asked to consent to such participation on behalf of another, is entitled to receive the following list of rights written in a language in which the person is fluent. This list includes the right to:

1. Be informed of the nature and purpose of the experiment.
2. Be given an explanation of the procedures to be followed in the medical experiment, and any drug or device to be utilized.
3. Be given a description of any attendant discomforts and risks reasonably to be expected from the experiment.
4. Be given an explanation of any benefits to the subject reasonably to be expected from the experiment, if applicable.
5. Be given a disclosure of any appropriate alternative procedures, drugs or devices that might be advantageous to the subject, and their relative risks and benefits.
6. Be informed of the avenues of medical treatment, if any, available to the subject after the experiment if complications should arise.
7. Be given an opportunity to ask any questions concerning the experiment or the procedures involved.
8. Be instructed that consent to participate in the medical experiment may be withdrawn at any time and the subject may discontinue participation in the medical experiment without prejudice.
9. Be given a copy of the signed and dated written consent form.
10. Be given the opportunity to decide to consent or not to consent to a medical experiment without the intervention of any element of force, fraud, deceit, duress, coercion, or undue influence on the subject’s decision.
APPENDIX C

Study Flyer

STEP WALK RESEARCH STUDY

Approved by Cal Poly Pomona Institution Review Board under protocol #14-0469

RESEARCH TITLE:
The effects of pedometer-mettered walking on body composition, blood glucose, diet alterations, blood pressure, and waist to hip ratios in college-aged participants-a pilot study

WE ARE LOOKING FOR MALE AND FEMALE VOLUNTEERS WHO:
• ARE HEALTHY AND NOT PREGNANT
• BETWEEN 18-45 YEARS OLD
• DO NOT HAVE AN INJURY THAT WILL BE EXACERBATED BY WALKING
* Additional screening required confirming eligibility to participate

PARTICIPATION INVOLVES:
• Increasing number of steps walked per day with a provided pedometer
• Body composition, waist, hip, height, and blood pressure measurements
• Filling out a 3-day food record during the lead-in week and at 3 random times throughout the 4 week study
• Finger prick for blood draw to measure fasting glucose levels during week 1 and week 4
• Approximately 3 visits across the 4 week study
• Free pedometer!!

FOR MORE INFO OR TO SIGN UP, PLEASE CONTACT:
Lauren Meeks: lmeeks@csupomona.edu
Corrine Worland: ceworland@csupomona.edu
Andy Reynaga: aprcyragna@csupomona.edu
Dr. Burns-Whitmore: bbwhitmo@csupomona.edu
APPENDIX D

Step Walk Study Initial Screening Questionnaire

California State Polytechnic University, Pomona IRB #14-0469

Date: _________________

Thank you for taking the time to fill out this questionnaire. Please be sure to read each question carefully, and then check the appropriate box. All information you provide on this form will be kept confidential. After filling out the form, please save a copy on your computer, then submit a hard copy directly to: Lauren Meeks at lgmeeks@csupomona.edu or Dr. Burns-Whitmore at bburnswhitmo@csupomona.edu. One of us will email/call you back and let you know if you qualify. Thank you again!

Name:
________________________________________________________________________
Last    First    MI

Address:
________________________________________________________________________
Number  Street  City  State  Zip Code

Phone:
________________________________________________________________________
Home    Work                                  Mobile/Cell

E-Mail:
________________________________________________________________________

Preferred method of contact:  ☐ Telephone   ☐ E-Mail

1. What is your age? _____ years.

2. What is your gender?
   ☐ Male
   ☐ Female

3. What is your weight? _____ pounds or _____ kilograms.

4. Have you experienced any weight changes in the last year?
   ☐ No
   ☐ Yes: _____ pounds gained or _____ pounds lost over a period of _____ months.

5. What is your height? _____ inches or _____ centimeters.
6. Do you have any current medical problems (ex. high blood pressure, asthma)?
   ☐ No
   ☐ Yes, I have the following:
   ___________________________________________________________

7. Are you currently taking any medications (prescription or over the counter)?
   ☐ No
   ☐ Yes, I am taking:
   ___________________________________________________________

8. How often do you take the following medications?

<table>
<thead>
<tr>
<th>Types of Medication</th>
<th>Never</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Tylenol (Acetaminophen)</td>
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<td>☐</td>
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<tr>
<td>Advil (Ibuprofen)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Naprosin/Naproxin/Aleve</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Steroids/Steroidal drugs</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Hormone supplements</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Statins</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

9. Are you currently taking any supplements (ex. vitamins, plant sterols, fish oil)?
   ☐ No
   ☐ Yes, I am taking:
   ___________________________________________________________

10. Are you a(n):
    ☐ Omnivore
    ☐ Vegetarian
    ☐ Vegan/Strict Vegetarian

11. How long have you followed that diet?
    _____ Days _____ Months _____ Years

12. Do you consume alcohol on a regular basis?
    ☐ No
    ☐ Yes

13. Do you currently have an exercise plan? If no, skip to question #16.
    ☐ No
    ☐ Yes, I exercise every ____ day(s) using the following activities:
    ___________________________________________________________
14. How long have you been following this exercise plan?
   _____ Days _____ Months _____ Years

15. Do you use a pedometer when you exercise?
   ☐ No
   ☐ Yes

16. If you answered no to question #13, state the reason for not exercising.
   ________________________________________________________________.

17. Have you suffered from a physical injury within the past six months? (exercise or non-exercise related)
   ☐ No
   ☐ Yes, I had/have the following injury:
   ________________________________________________________________.
   Date of injury: ____________________.

18. Do you have any pre-existing conditions or injuries that would be exacerbated by walking 10,000 steps per day for four weeks?
   ☐ Yes
   ☐ No

19. Are you willing to come to campus three times during the four week study?
   ☐ Yes
   ☐ No

20. Do you have any metal objects in or on your body that cannot be removed? (Such as non-removable piercings, pacemakers or electrical implants.)
   ☐ Yes
   ☐ No

21. Where did you find out about this study?
   ☐ E-Mail
   ☐ Flyer
   ☐ Friend or coworker
### APPENDIX E

*Table 9.* Motivational quotes/sayings sent to participants via email between 6am and 8am daily during the 4-week study.

<table>
<thead>
<tr>
<th>Day</th>
<th>Motivational quote/saying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Do the difficult things while they are easy and do the great things while they are small. A journey of a thousand miles must begin with a single step. -Lao Tzu</td>
</tr>
<tr>
<td>Day 2</td>
<td>Setting goals is the first step in turning the invisible into the visible. -Tony Robbins</td>
</tr>
<tr>
<td>Day 3</td>
<td>The first step is you have to say that you can. -Will Smith</td>
</tr>
<tr>
<td>Day 4</td>
<td>Step with care and great tact, and remember that Life's a Great Balancing Act. -Dr. Seuss</td>
</tr>
<tr>
<td>Day 5</td>
<td>Trying to think of new ways to walk more? Try parking in the furthest spot in the parking lot!</td>
</tr>
<tr>
<td>Day 6</td>
<td>You will either step forward into growth, or you will step backward into safety. –Maslow</td>
</tr>
<tr>
<td>Day 7</td>
<td>Need another walking idea? During down time between classes, explore the campus!</td>
</tr>
<tr>
<td>Day 8</td>
<td>Develop an attitude of gratitude, and give thanks for everything that happens to you, knowing that every step forward is a step toward achieving something bigger and better than your current situation. -Brian Tracy</td>
</tr>
<tr>
<td>Day 9</td>
<td>Try exercising more often to increase the number of steps you walk per day!</td>
</tr>
<tr>
<td>Day 10</td>
<td>Human progress is neither automatic nor inevitable... Every step toward the goal of justice requires sacrifice, suffering, and struggle; the tireless exertions and passionate concern of dedicated individuals. -Martin Luther King, Jr.</td>
</tr>
<tr>
<td>Day 11</td>
<td>Walking not only benefits your body, but it refreshes the mind and soul.</td>
</tr>
<tr>
<td>Day 12</td>
<td>Life is the most exciting opportunity we have. But we have one shot. You graduate from college once, and that's it. You're going out of that nest. And you have to find that courage that's deep, deep, deep in there. Every step of the way. -Andrew Shue</td>
</tr>
<tr>
<td>Day 13</td>
<td>Competing with friends helps increase your motivation to walk more everyday!</td>
</tr>
<tr>
<td>Day 14</td>
<td>When adversity strikes, that's when you have to be the most calm. Take a step back, stay strong, stay grounded and press on. -LL Cool J</td>
</tr>
<tr>
<td>Day 15</td>
<td>Congratulations! You are more than half way through the 4 week study! Keep up the great work!</td>
</tr>
<tr>
<td>Day 16</td>
<td>The first step towards knowledge is to know that we are ignorant. -Richard Cecil</td>
</tr>
<tr>
<td>Day 17</td>
<td>The vision must be followed by the venture. It is not enough to stare up the steps - we must step up the stairs. -Vance Havner</td>
</tr>
<tr>
<td>Day</td>
<td>Motivational quote/saying</td>
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<tr>
<td>-------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Day 18</td>
<td>Acceptance of what has happened is the first step to overcoming the consequences of any misfortune. -William James</td>
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<tr>
<td>Day 19</td>
<td>Trust is the first step to love. -Munshi Premchand</td>
</tr>
<tr>
<td>Day 20</td>
<td>Have a bias toward action - let's see something happen now. You can break that big plan into small steps and take the first step right away. -Indira Gandhi</td>
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<tr>
<td>Day 21</td>
<td>Congratulations everyone! You only have 1 week left of recording your steps for this study! Let's make the last week the best :)</td>
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<tr>
<td>Day 22</td>
<td>What saves a man is to take a step. Then another step. -Antoine De Saint-Exupery</td>
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<tr>
<td>Day 23</td>
<td>The first step towards success is taken when you refuse to be a captive of the environment in which you first find yourself. -Mark Caine</td>
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<tr>
<td>Day 24</td>
<td>Discontent is the first step in progress. No one knows what is in him till he tries, and many would never try if they were not forced to. -Basil W. Maturin</td>
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<tr>
<td>Day 25</td>
<td>Success will never be a big step in the future, success is a small step taken just now. -Jonatan Martensson</td>
</tr>
<tr>
<td>Day 26</td>
<td>The indispensable first step to getting the things you want out of life is this: decide what you want. -Ben Stein</td>
</tr>
<tr>
<td>Day 27</td>
<td>Don’t be afraid to take a big step if one is indicated; you can't cross a chasm in two small jumps. -David Lloyd George</td>
</tr>
<tr>
<td>Day 28</td>
<td>Congratulations!! Today is your last day recording your steps for this study! You made it through the four weeks and have done an outstanding job. Thank you :)</td>
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</table>
APPENDIX F

Diet Record

Diet Record Instructions

Directions: Record what you eat and drink on the sheets provided. As you record each food, make careful note of the amount and how it was prepared (fried, baked etc.). Estimate the amount to the nearest weight or fluid ounce, quarter cup, tablespoon, or other common measure. It is suggested to bring a measuring cup with you to meals.

In guessing at the sizes of meat portions, it helps to know that a piece of meat the size of the palm of your hand weighs about 3 or 4 ounces. It also helps to know that a slice of cheese (such as sliced American cheese) or a 1 1/2-inch cube of cheese weighs about 1 ounce. If you are unable to estimate serving sizes, measure out servings the size of a cup, tablespoon, and teaspoon onto a plate or into a bowl to see how they look. You will have to break down mixed dishes to their ingredients (for example: burrito = 10 inch whole wheat tortilla, 1/4 cup black beans drained, 1/4 cup Spanish rice, 1 oz. Monterey jack cheese, 2 tbs. chopped tomatoes, 1 tbs. chopped onion, 1/8 medium avocado sliced).

The closer your approximations, the closer your actual intake will be reflected. Some common errors include using weight ounces instead of fluid ounces. Record the liquids as fluid ounces and the solids as weight oz. It is also very helpful to read the labels of the foods you consume. If you eat name brand foods, please also include the name brand of the food or the restaurant chain name if applicable. Be sure to list the actual amounts of foods eaten (ie. don’t include milk left in your bowl after eating cereal. Only count what you have consumed).

Please record any nutrient supplements you take.

Some Common Portion Sizes:

Serving Sizes

<table>
<thead>
<tr>
<th>Everyday Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cup of cereal = a fist</td>
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</table>

94
1/2 cup of cooked rice, pasta, or potato = 1/2 baseball

1 baked potato = a fist

1 medium fruit = a baseball

1/2 cup of fresh fruit = 1/2 baseball

1 1/2 ounces of low-fat or fat-free cheese = 4 stacked dice

1/2 cup of ice cream = 1/2 baseball

2 tablespoons of peanut butter = a ping-pong ball

Food Record #_________ Date:_______________ ID #:_________________
<table>
<thead>
<tr>
<th>Meal (B, L, D) or snack (S)</th>
<th>Food/Beverage (Brand)</th>
<th>Cooking Method</th>
<th>Amount</th>
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<table>
<thead>
<tr>
<th>Supplements Taken Today</th>
<th>Brand</th>
<th>Amount Taken</th>
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</table>
APPENDIX G

Diet History

Diet History Instructions

Directions: Record what you normally eat and drink on the sheets provided. As you record each food, make careful note of the amount and how it was prepared (fried, baked etc.). Estimate the amount to the nearest weight or fluid ounce, quarter cup, tablespoon, or other common measure. It is suggested to bring a measuring cup with you to meals.

In guessing at the sizes of meat portions, it helps to know that a piece of meat the size of the palm of your hand weighs about 3 or 4 ounces. It also helps to know that a slice of cheese (such as sliced American cheese) or a 1 1/2-inch cube of cheese weighs about 1 ounce. If you are unable to estimate serving sizes, measure out servings the size of a cup, tablespoon, and teaspoon onto a plate or into a bowl to see how they look. You will have to break down mixed dishes to their ingredients (for example: burrito = 10 inch whole wheat tortilla, ¼ cup black beans drained, ¼ cup Spanish rice, 1oz. Monterey jack cheese, 2 tbs. chopped tomatoes, 1 tbs. chopped onion, 1/8 medium avocado sliced).

The closer your approximations, the closer your actual intake will be reflected. Some common errors include using weight ounces instead of fluid ounces. Record the liquids as fluid ounces and the solids as weight oz. It is also very helpful to read the labels of the foods you consume. If you eat name brand foods, please also include the name brand of the food or the restaurant chain name if applicable. Be sure to list the actual amounts of foods eaten (ie. don’t include milk left in your bowl after eating cereal. Only count what you have consumed).

Please record any nutrient supplements you take.

Some Common Portion Sizes:

Serving Sizes

<table>
<thead>
<tr>
<th>Serving Sizes</th>
<th>Everyday Objects</th>
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<tbody>
<tr>
<td>1 cup of cereal = a fist</td>
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</table>
1/2 cup of cooked rice, pasta, or potato = 1/2 baseball

1 baked potato = a fist

1 medium fruit = a baseball

1/2 cup of fresh fruit = 1/2 baseball

1 1/2 ounces of low-fat or fat-free cheese = 4 stacked dice

1/2 cup of ice cream = 1/2 baseball

2 tablespoons of peanut butter = a ping-pong ball

Food Record #_______       Date:_______________       ID
#:____________________
<table>
<thead>
<tr>
<th>Meal (B, L, D) or snack (S)</th>
<th>Food/Beverage (Brand)</th>
<th>Cooking Method</th>
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<tr>
<th>Supplements Taken Today</th>
<th>Brand</th>
<th>Amount Taken</th>
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</thead>
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</table>
24-Hour Diet Recall

**Directions:** Record what you eat and drink for one 24 hour period on the sheets provided. As you record each food, make careful note of the amount and how it was prepared (fried, baked etc.). Estimate the amount to the nearest weight or fluid ounce, quarter cup, tablespoon, or other common measure. It is suggested to bring a measuring cup with you to meals.

In guessing at the sizes of meat portions, it helps to know that a piece of meat the size of the palm of your hand weighs about 3 or 4 ounces. It also helps to know that a slice of cheese (such as sliced American cheese) or a 1 1/2-inch cube of cheese weighs about 1 ounce. If you are unable to estimate serving sizes, measure out servings the size of a cup, tablespoon, and teaspoon onto a plate or into a bowl to see how they look. You will have to break down mixed dishes to their ingredients (for example: burrito = 10 inch whole wheat tortilla, ¼ cup black beans drained, ¼ cup Spanish rice, 1 oz. Monterey jack cheese, 2 tbs. chopped tomatoes, 1 tbs. chopped onion, 1/8 medium avocado sliced).

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2 tablespoons of peanut butter = a ping-pong ball

Food Record #_______ Date:_______________ ID 
#:__________________
<table>
<thead>
<tr>
<th>Meal (B, L, D) or snack (S)</th>
<th>Food/Beverage (Brand)</th>
<th>Cooking Method</th>
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</table>

<table>
<thead>
<tr>
<th>Supplements Taken Today</th>
<th>Brand</th>
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</tbody>
</table>

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**APPENDIX I**

*Table 9.* Comparison of mean step count per day between the intervention (N=19) and control group (N=10) using the Mann-Whitney U statistical test.

<table>
<thead>
<tr>
<th>Intervention Mean Steps/Day</th>
<th>Control Mean Steps/Day</th>
<th>P-Value</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>7648.4 ± 2479.7</td>
<td>9683.8 ± 8373.7</td>
<td>0.780</td>
<td>87.3 ± 182.5</td>
</tr>
</tbody>
</table>
APPENDIX J

Manuscript Format for Movement and Science in Sports and Exercise Journal

Pedometer-Metered Walking Effects on Body Composition in Healthy College Students

Lauren Meeks\textsuperscript{1}, Andy Reynaga\textsuperscript{1}, Corinne Worland\textsuperscript{1}, Edward Jo\textsuperscript{1}, PhD, Sarah Dunn\textsuperscript{2}, PhD, Michelle Wien\textsuperscript{1}, PhD, Bonny Burns-Whitmore\textsuperscript{1}, DrPH

\textsuperscript{1}California State Polytechnic University, Pomona, CA

\textsuperscript{2}University of La Verne, La Verne, CA

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Email: lgmeeks@cpp.edu
ABSTRACT

Purpose: Physical activity reduces fat mass, but if not practiced, the risk of obesity-associated health problems and associated health care costs increase. This study sought to determine the effects of pedometer-metered walking in college-aged participants on body composition, fasting blood glucose (FBG), blood pressure (BP), diet choices, and waist-to-hip ratios (WHR) within a four-week period. Methods: Following informed consent, participants (N=29; 18.5 < BMI < 25.0) wore a pedometer for four weeks and recorded the number of daily steps. Body composition, waist and hip measurements, BP, and FBG were performed at baseline, week 1, and week 4. Three randomized 3-day diet records were collected from participants. Daily motivational quotes were provided to (N=19) participants to determine if the number of steps walked changed. Results: Significant decreases in waist (77.1cm ± 2.23cm to 74.5cm ± 2.03cm, p = 0.002) and hip (99.8 ± 1.74cm to 99.0 ± 1.78, p = 0.03) circumference were found. Results were not significant for BP, FBG, or those receiving motivational quotes or body composition; however, a decrease in fat free mass (FFM) approached significance (p=0.06). Decreased fruit intake (N = 20) was observed in the second (p = 0.007) and third (p = 0.023) diet records.

Conclusion: Waist and hip measurements decreased significantly at end of study, suggesting that monitored walking through the use of a pedometer results in physical abdominal changes. More research is needed to examine the physical abdominal changes and to determine the effects of pedometer-metered walking on diet choices.

Key Words: WALKING INTERVENTION, WAIST-TO-HIP RATIOS, BLOOD PRESSURE, BLOOD GLUCOSE, DIET CHOICES
INTRODUCTION

The incidence of obesity and overweight adults and children (BMI > 25 kg/m²) in the United States (US) has dramatically increased in the past three decades (77% for adults and 46-49% for children) (33,27). Based on observed trends, the projected prevalence of obesity by 2030 will be 86.3% for adults and nearly 92% for children (33). These dramatic increases in overweight and obesity prevalence increase health risks associated with obesity, such as coronary heart disease, myocardial infarction, cardiovascular disease (CVD), stroke, and type 2 diabetes (23,20,8). Not only does the high prevalence of obesity increase the risk of chronic diseases, but it also raises health care costs in the US, with a projected 860.7 to 956.9 billion dollar expenditure by 2030 (16-18% of total health care costs) (33). Using projected trends, it is estimated that 65 million adult obesity cases will occur by 2030 (33,34).

Physical activity (PA) is a supported method for fighting the increased prevalence of obesity by increasing weight and fat mass (FM) loss and reducing the risk of chronic diseases in individuals through a dose-response relationship (28,16). The energy expended during PA results in a negative energy balance in the body, resulting in FM utilization and reduction over time (28,1). Decreased FM reduces cholesterol levels and blood pressure (BP) while increasing sensitivity to the hormone insulin, resulting in improved glucose tolerance and decreased risk of CVD and type 2 diabetes (2,15). Not only does physical activity reduce obesity risk and improve cardiovascular and metabolic health, but it also improves the economic health of the country by reducing preventable health care costs. Inadequate PA is associated with 11.1% of health care costs in the US (7).
Although the benefits of PA have been established, many Americans do not engage in PA on a regular basis due to lack of motivation to start and maintain an exercise program (30). The amount of PA required for a decrease in weight to occur is modest, being comparable to 30 minutes of brisk walking five days a week as established by the American College of Sports Medicine and the Center for Disease Control and Prevention (21,14). Walking is a universal PA that is a perfect method for transitioning from a sedentary lifestyle to a more active lifestyle due to the low rate of injury associated with this exercise (21). Even though walking is established as a low-impact method of exercise, motivation is still needed in order to start and maintain a walking program, especially if one has been sedentary and feels self-conscious regarding their appearance. It is estimated that 50% of people who start an exercise program quit in the first six months due to lack of motivation (30). Research has shown that different types of motivation are effective in helping people start and maintain exercise, such as autonomous and external motivation (9,6). The key to success of any motivational method for engaging in PA is perceived confidence in one’s ability to perform the PA (9,22).

Walking programs designed for weight loss have incorporated the use of pedometers as a means of autonomous motivation to engage in PA and maintain an exercise regime (24). Such programs have resulted in modest weight loss without dietary intervention (24). Previous research has shown that weight and FM loss occurs in overweight individuals who walk for at least 30 minutes per day for at least four weeks, and that the number of weeks spent walking is positively correlated with the amount of weight lost (24,5). Prior studies have also tested the relationship between walking and
other health variables indicative of diseases associated with obesity, specifically waist circumference, BP, diet choices, and blood glucose levels without the use of pedometers in separate studies (11,31). Research has shown that abdominal obesity measured by waist circumference is positively associated with heart failure as well as CVD due to fat depositions (23). The results from separate studies varying in duration and participant health levels collectively support that walking decreases waist circumference, resting BP, and blood glucose levels while walking increases healthier diet choices (11,31). Previous research, however, has not examined the relationship between the use of a pedometer while walking and the effects on weight loss and other body composition variables in addition to WHR, BP, diet choices, and FBG levels in healthy adults (18.5 < BMI < 25.0) during a 4-week period.

The objective of this exploratory study is to discover if pedometer-metered walking has a significant effect on the following health characteristics within a 4-week period in healthy college-aged (18-45 year old) participants: body composition, FBG, BP, diet choices, and WHR. This study also tests if receiving daily motivational quotes (intervention group) as an external motivational source results in a significant increase in the number of steps walked per day compared to solely using a pedometer as a motivational source. Several hypothesis are proposed for this study. The first hypothesis is that pedometer-metered walking results in significantly decreased body fat composition, increased fat free mass (FFM), decreased FBG, decreased BP, decreased WHR, and a change in diet choices. The second hypothesis is that external motivation provided by daily quotes (intervention group) significantly increases the average number of steps walked per day. The final hypothesis is that a correlation exists between the
average number of steps walked per day and body composition, FBG, BP, WHR, and diet choices.

METHODS

Participants

This study was approved as ethical by the California State Polytechnic University Pomona Institutional Review Board (IRB protocol # 14-0469) and informed consent was obtained from all of the participants. Forty healthy males and females between the ages of 18 and 45 years old were recruited using a flyer. Participants were recruited from the first week of January 2015 through the third week of January 2015 using flyers and emails at the Cal Poly Pomona campus. The inclusion criteria for the participants required that they were Cal Poly Pomona students or staff, healthy males or females between the ages of 18 and 45 years old, had no known chronic diseases, were not pregnant, and did not have any injuries that could be exacerbated by walking.

After signing the informed consent, the participants completed a health-screening questionnaire to estimate their current diet and PA levels. The study was a 4-week intervention pilot study and 32 college-aged participants completed the study. The length of the study was determined based on previous research observations of body composition changes within a 4-week period (10,4). Three participants were excluded due to failure of adherence to the study protocol. A lead-in week to obtain baseline data was completed. The participants were randomized into two groups. Treatment one was the intervention group, where the participants received an email every morning through Blackboard that encouraged the participants to increase the number of steps that they walked per day. The emails consisted of inspirational quotes that included the words
“step” or “walking” or ideas for activities to increase the number of steps walked per day. Treatment two was the control group that did not receive daily motivational ideas.

**Pedometer and Diet Recordings**

At the beginning of the study, each participant was given a Sportline 340® pedometer to record the number of steps that they walked per day and were asked to increase the number of steps that they walked during the study period. The participants were instructed to take a picture of their pedometer screen at the end of each day and to upload that picture into a designated folder in the Blackboard® organization entitled “Step Walk Study”. The participants were also instructed to complete a 3-day diet record for the lead-in week as well as three 3-day diet records at random time points during the 4-week study period. Three-day self-reported diet records are utilized as valid predictors of usual dietary intake, however, they still contain human error (18,32). The time points for the diet data collection were determined using the website: www.randomizer.org. After completing each diet record, the participants were instructed to upload their documents into a designated folder in the Blackboard “Step Walk Study” organization. Out of the 32 participants (2 males, 30 females) who completed the study, only 20 (1 male, 19 females) completed the three diet records.

**Data Collection and Measurements**

Data collection occurred during the lead-in week, week 1, and week 4. Data collection was conducted at Cal Poly Pomona, and it was conducted in the morning hours between 6:30am and 11:00am. Participants were instructed to fast for at least 12 hours prior to each data collection. The following data were collected: FBG, BP, height, body composition, and waist and hip measurements. FBG measurements were obtained using a
Freestyle Freedom Lite® glucometer and test strips and only required a finger prick to obtain a small blood sample. BP was measured using an automatic blood pressure monitor (Omron BP629 Automatic Wrist 3 Series®, Warminster, PA, USA). Height was obtained using a stadiometer, and body composition was measured using the Tanita Bioelectrical Impedance Analyzer® (BIA) (Tanita SC 300 S, Tokyo, Japan). The Tanita BIA is a validated method for accurate measurement of body fat (24,12). Waist and hip measurements were obtained using a tape measure and the waist-to-hip ratios were calculated from the waist and hip measurements. Each measurement taken during the data collection was performed in duplicate to reduce human error.

**Statistical Analysis**

All data was tested using the statistical software SPSS 20.0 for Windows (SPSS, Chicago, IL). Two-tailed paired T-test statistics were run on week 1 and week 4 mean body composition, WHR, BP, and FBG data to determine if the tested variables significantly changed within four weeks (N=29). It was not necessary to control for total body water in the statistical analysis because the body composition output generated total body water content for each measurement. Diet data was entered into a dietary analysis program (ESHA® Food Processor Nutrition Analysis software, Salem, OR) to analyze the nutrient content of the collected diets. Repeated measures ANOVA statistical tests were run on the nutrient data to determine significant differences between week 1 and week 4 total caloric, fruit, vegetable, simple sugar, potassium, calcium, sodium, carbohydrate, fat, and protein intake (N = 20). The Mann-Whitney U statistical test was performed on the average number of steps walked by Treatment one and Treatment two to determine any significant differences within four weeks (N = 29). The Pearson’s
Correlation Coefficient test was run to discover if a relationship exists between the average number of steps walked per day and body composition, WHR, BP, FBG, and diet choices within four weeks (N=29). Statistical significance was determined at p ≤ 0.05 for all analyses.

RESULTS

The results of the two-tailed paired T-tests showed significant decreases in waist measurements (77.1cm ± 2.23cm to 74.5cm ± 2.03cm, p = 0.002) (absolute change = -2.6 ± 3.9cm, percent change = -3.1 ± 4.7cm) as well as hip measurements (99.8 ± 1.74cm to 99.0 ± 1.78, p = 0.030) (absolute change = -0.8 ± 1.9cm, percent change = -0.8 ± 1.9cm) from week one to week four (Figure 1). The results of the two-tailed paired T-tests were not significant for body composition (total body weight, percent body fat and FFM), FBG, BP, WHR, or for the intervention group who received the motivational quotes. However, there was a trend towards a significant decrease for FFM (p = 0.06). The results of the repeated measures ANOVA on the diet data revealed a significant decrease in fruit intake in the second (p = 0.007) and third (p = 0.023) diet records compared to the first diet record (Table 1). The results of the repeated measures ANOVA were not significant for intake of vegetables, total calories, simple sugars, potassium, calcium, sodium, carbohydrates, fats, and protein among the three diet records.

The results of the Mann-Whitney U test on the number of steps walked by the intervention group and the control group showed no significant difference in the average number of steps walked by the two groups during the four weeks (p > 0.05). The results of the Pearson’s Correlation Coefficient revealed no significant correlations between the
average number of steps walked and body composition, FBG, BP, WHR, and diet choices within four weeks (p > 0.05).

**DISCUSSION**

Waist and hip circumference decreased significantly at the end of study, suggesting that monitored walking through the use of a pedometer results in physical abdominal changes. The observed results support the hypothesis that pedometer-metered walking results in decreased waist and hip circumference. Although conclusions cannot be drawn regarding the types of physical abdominal changes from the results, a trend towards significance was observed for FFM (p = 0.06), suggesting that FFM may be decreasing as a pedometer is used to monitor the amount of steps walked daily. Further pedometer-metered walking studies demonstrating significant decreases in FFM are needed in order to substantiate the aforementioned possibility. In addition, future research would need to control for total body water (TBW) to determine whether it is muscle mass or water mass that is decreasing through the use of a pedometer although no significant differences (p > 0.05) in TBW pre- and post- intervention were observed in this study. A study similar in design to the current study examined the effects of a pedometer-metered intervention on parameters indicative of type 2 diabetes for six weeks and found a trend towards significance for a decrease in waist measurements (p > 0.05) (3). Other studies investigating the effects of pedometer-metered walking on body composition over different study durations using different populations support the significant decreases in waist and hip measurements observed in this study (17,29).

The significant decrease in fruit intake observed from the first diet records to the second and third diet records was an unexpected result since the hypothesis stated that an
increase in fruit intake would be observed due to pedometer-metered walking. Previous studies have demonstrated that inadequate PA is associated with low fruit intake (13,26). Therefore, the results from this study were not consistent with similar research since the participants were engaging in daily PA as recorded by their pedometers. There are several possibilities for why this decrease occurred, although none of the hypotheses are supported and therefore require subsequent research. One possibility is that the fruit selection decreased as the study was conducted during the winter months of January and February, resulting in the participants consuming less fruit due to the decrease in variety and/or availability. Research on seasonal fruit intake trends in the US needs to be conducted to substantiate this possibility. Another possibility is that as the weeks in the quarter progressed, the stress levels of the students increased and resulted in the students spending less time including fruit in their diet compared to the beginning of the quarter. Previous research has supported that fruit intake is influenced by autonomous motivation as well as by social support, which are known to affect stress levels (19).

A final conclusion to be drawn from the results is that external motivation provided through motivational quotes is not effective in increasing the number of steps walked per day. This result did not support our hypothesis that receiving motivational quotes would result in an increase in the number of steps walked per day, and it contradicts the previous research demonstrating that external motivation increases participation in PA (9). Although these results do not support previous studies, a possibility to explain the observed outcome is that the participants in this study were motivated by autonomous motivation rather than external motivation.
Several limitations exist in this study that are noteworthy. The first limitation is the short study duration. Since walking is a low-intensity form of exercise, body composition changes may not occur in as little as four weeks. If the study had been expanded, significant physical changes may have been observed over time. The second limitation is the low number of subjects in the study. Statistical analysis could only be performed on a sample size of 29 for the anthropometric and intervention data, and the sample size was even less for the diet data (N=20). The power for the paired-T test statistical analysis was 74%, which is close to the level of adequate sample power (>75%) (www.statpages.org, Iowa, USA). However, the power for the repeated measures ANOVA was far from the level of acceptable sample power at 49% (www.statpages.org, Iowa, USA). The third limitation is the lack of a control in this study for pedometer use. A control group that does not wear pedometers is necessary in order to support that the use of pedometers is responsible for the observed outcomes in the study. Therefore, it cannot be concluded with certainty that pedometer-metered walking was responsible for the results in this study. A control group was not incorporated into this study because participants joined the study in order to receive a free pedometer and would not have tracked their daily steps without a pedometer.

Future studies using the present study as their background can perform the same study using overweight and obese participants and compare the results between pedometer-metered walking for the two populations. Research comparing the effects of pedometer-metered walking on healthy and overweight/obese participants is necessary to determine the effectiveness of using pedometers for increasing the number of steps walked per day for the general population. Additional research could perform a similar
study and analyze gender differences to see if gender affects pedometer usage. Only two out of the thirty-two participants who finished the current study were male, therefore gender differences could not be analyzed. In conclusion, the results of the current study support the use of pedometers as a method of increasing daily walking and decreasing WHR over time in individuals of healthy weight (18.5 < BMI < 25.0). Any PA tool that has the potential to motivate individuals to increase their PA level will aid in decreasing the rising obesity rates within the US.

ACKNOWLEDGEMENTS

Gratitude is expressed to Dr. Bonny Burns-Whitmore for creating the idea for the project and for helping supply the materials for the study. Andy Reynaga collected the FBG samples, Corinne Worland collected the waist and hip measurements, Laura Bradfield collected BP measurements, and Shanna Miller helped with participant recruitment. Special thanks is expressed to Fernando Garcia and the Wellness Center Staff for allowing us to use their facility for part of the data collection. Gratitude is expressed to the participants for their time and effort, and to Dr. David Still for editing this project. This study was funded by Cal Poly Pomona through the California Wellness Grant (SEES Scholar) and the Research, Scholarship and Creative Activities (RSCA) program.

CONFLICT OF INTEREST

To the author’s knowledge, there was no conflict of interest in this study. This study was not used or supported by the American College of Sports Medicine (ACSM).

REFERENCES

1. Aadland E, Jepsen R, Andersen JR, Anderssen SA. Differences in Fat Loss in


18. Lassale C, Castetbon K, Laporte F et al. Correlations between Fruit, Vegetables, Fish,


27. Skelton JA, Cook SR, Auinger P, Klein JD, Barlow SE. Prevalence and Trends of


31. Tieland M, Van de Rest O, Dirks ML et al. Protein Supplementation Improves
Physical Performance in Frail Elderly People: A Randomized, Double-Blind, Placebo-Controlled Trial. *J Am Med Dir Assoc* [Internet]. 2012 [cited 2015 Dec 1];13(8). Available from


**FIGURE(S):**

![FIGURE](image.png)

**FIGURE CAPTION(S)**

Figure 1. Comparison of mean waist and hip circumference (N = 29) over time.

Significant decreases were observed for both (waist circumference decreased from 77.1cm ± 2.23cm to 74.5cm ± 2.03cm, *p = 0.002; hip circumference decreased from 99.8 ± 1.74cm to 99.0 ± 1.78, *p = 0.030).

**TABLE(S):**

<table>
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<tr>
<th>Diet Record</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Effect Size</th>
<th>P value 1-2</th>
<th>P value 1-3</th>
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<tbody>
<tr>
<td>Total Calories (kcals)</td>
<td>1794 (498)</td>
<td>1774 (607)</td>
<td>1640 (580)</td>
<td>0.061</td>
<td>1.000</td>
<td>0.842</td>
</tr>
<tr>
<td>Simple Sugars (g)</td>
<td>10.2 (20.1)</td>
<td>3.41 (5.06)</td>
<td>7.55 (15.7)</td>
<td>0.010</td>
<td>0.519</td>
<td>1.000</td>
</tr>
<tr>
<td>Fruits (cup)</td>
<td>3.08 (1.03)</td>
<td>2.20 (0.96)</td>
<td>2.40 (1.00)</td>
<td>0.318</td>
<td><strong>0.007</strong>*</td>
<td><strong>0.023</strong>*</td>
</tr>
<tr>
<td>Vegetables (cup)</td>
<td>2.18 (0.84)</td>
<td>2.10 (1.05)</td>
<td>1.82 (0.79)</td>
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<td>0.137</td>
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<tr>
<td>Sodium (mg)</td>
<td>3028 (1781)</td>
<td>3180 (2556)</td>
<td>3006 (1564)</td>
<td>0.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>1241 (600)</td>
<td>1233 (681)</td>
<td>1320 (879)</td>
<td>0.007</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>632 (229)</td>
<td>639 (298)</td>
<td>687 (325)</td>
<td>0.019</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>74.5 (27.3)</td>
<td>78.4 (26.6)</td>
<td>73.7 (24.5)</td>
<td>0.001</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Fats (g)</td>
<td>62.1 (28.2)</td>
<td>64.2 (32.6)</td>
<td>58.9 (23.0)</td>
<td>0.013</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>228 (57.9)</td>
<td>258 (156)</td>
<td>209 (64.3)</td>
<td>0.056</td>
<td>1.000</td>
<td>0.903</td>
</tr>
</tbody>
</table>
TABLE CAPTION(S):

Table 1. Comparison of mean dietary intake records (N=20) at three random time points within the four-week period. Significant decrease in fruit intake was observed between the first diet record compared to both the second (p=0.007) and third (p=0.023) diet records using the repeated measures ANOVA test. No significant changes were observed for the other dietary variables (p>0.05).