Acute Affects of a Walking Workstation on Ambulatory Blood Pressure in Prehypertensive Adults

by

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ABSTRACT

INTRODUCTION**:** Exercise performed at moderate to vigorous intensities has been shown to generate a post exercise hypotensive response. Whether this response is observed with very low exercise intensities is unclear. PURPOSE: To compare post physical activity ambulatory blood pressure (ABP) response to a single worksite walking day and a normal sedentary work day in pre-hypertensive adults. METHODS: Participants were 7 pre-hypertensive (127 $\pm$ 8 mmHg / 83 $\pm$ 8 mmHg) adults (3 male, 4 female, age = 42 $\pm$ 12 yr) who participated in a randomized, cross-over study that included a control and a walking treatment. Only those who indicated regularly sitting at least 8 hours/day and no structured physical activity were enrolled. Treatment days were randomly assigned and were performed one week apart. Walking treatment consisted of periodically increasing walk time up to 2.5 hours over the course of an 8 hour work day on a walking workstation (Steelcase Company, Grand Rapids, MI). Walk speed was set at 1 mph. Participants wore an ambulatory blood pressure cuff (*Oscar 2*, SunTech Medical, Morrisville, NC) for 24-hours on both treatment days. Participants maintained normal daily activities on the control day. ABP data collected from 9:00 am until 10:00 pm of the same day were included in statistical analyses. Linear mixed models were used to detect differences in systolic (SBP) and diastolic blood pressure (DBP) by treatment condition over the whole day and post workday for the time periods between 4 -10 pm when participants were no longer at work. RESULTS:BP was significantly lower in

response to the walking treatment compared to the control day (Mean SBP 126 ±7 mmHg vs.124 ±7 mmHg, p=.043; DBP 80 ± 3 mmHg vs. 77 ± 3 mmHg, p = 0.001 respectively). Post workday (4:00 to 10:00 pm) SBP decreased 3 mmHg (p=.017) and DBP decreased 4 mmHg (p<.001) following walking. CONCLUSION: Even low intensity exercise such as walking on a walking workstation is effective for significantly reducing acute BP when compared to a normal work day.

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Chapter 1

INTRODUCTION

Overview:

In 2003 it was estimated that 52.4% of the U.S. workforce spent their occupational day stationary, in front of a computer (1). This is an alarming statistic when considering that prolonged sitting is associated with significantly higher risk of all-cause mortality and coronary heart disease (42,66). Physical inactivity also increases the risk for developing hypertension (68) and lifetime risk for developing hypertension is about 90% (9). Even those with prehypertension, defined as lightly elevated resting blood pressure values (systolic 120-139 mm Hg or diastolic 80-89 mm Hg), are at higher risk for cardiovascular morbidity and mortality (9). Currently the only recommended treatment for prehypertension is to modify lifestyle (9,89). Thus, reducing sitting time is an area of increased public concern to improve blood pressure and reduce coronary heart disease risk.

Attempts have been made to reduce immobility at the workplace; most recently the walking workstation has garnered much attention. The walking workstation was presented about 25 years ago by Edelson to decrease sedentary behavior in the workplace (15). The workstation allows a worker to move back and forth between a seated and ambulatory position throughout the work day while simultaneously still engaging in their work. More recently, Levine has hypothesized that the walking workstation can be used

to increase Non-Exercise Activity Thermogenesis (NEAT) (51). NEAT is a measure of all leisure time activity excluding planned exercise: standing, walking, sitting, shopping, gardening, fidgeting, etc. Levine observed that obese (BMI >30) individuals engage in >2 ½ more hours a day of sedentary time than their leaner counterparts, suggesting that the workstation could close this gap and sub-sequentially lead to weight loss and improved health(50). Debate within the literature exists as to whether levels of NEAT are biologically set (72), and if so, behavioral interventions that focus on increasing one's physical activity may be futile. Studies have shown that often when one increases physical activity at one time point compensation occurs at other time points resulting in a homeostatic physical activity state (21,85,92,93)This possible biological mechanism in the brain is referred to as the "ActivityStat" (72).

Experiments have been performed that have measured the effects of the walking workstation on typing speed, cognition, attention, motor skill, and speech quality (10,37,59). The results indicate that depending on the nature of the office work, the walking workstation could be a feasible possibility within the workplace without adversely affecting job function (81).

The biggest deficiency within the research literature is that there appears to be no published studies that have examined the acute or long term health benefits of the walking workstation. While increasing NEAT may potentially help with weight loss, the effects of using a walking workstation on health outcomes such as blood pressure has not

been examined. The level of exercise intensity typically recommended for the walking workstation, about 1 mph, is lower than what has previously been shown to elicit a reduction blood pressure (52). However, most studies also use shorter exercise bouts. Levine recommends that to get increases in NEAT the walking workstation needs to be used 2-4 hours a day over the course of an eight hour day in an office-type setting (50).

It is well documented that an acute exercise bout of moderate to vigorous intensity can result in post exercise hypotension (PEH) (23,43,67,73), with many bouts leading to chronic favorable adaptations (24,86) in those with elevated blood pressure. A small number of studies have shown reductions in 24-hour blood pressure with an overall increase in daily physical activity (61,64). It is not well documented however, what role acute or chronic low intensity NEAT activities have on blood pressure in hypertensive or prehypertensive individuals (9,68,91). No previous studies have been conducted that used supervised low intensity walking on blood pressure changes. Since the walking workstation is known to increase NEAT and overall physical activity, it is possible that this low intensity modality can also reduce blood pressure.

Extensive evidence exists that show mean 24 h ambulatory blood pressure (ABP) being superior to casual blood pressure when predicting cardiovascular morbidity and mortality (17). 24 h ambulatory blood pressure also allows for measurements of blood pressure load (% of readings above a given threshold, usually 140/90 for day time BP).

Blood Pressure load could be even better than 24 h mean blood pressure when determining adverse affects on the cardiovascular system (93).

Prehypertensive individuals are at increased risk for cardiovascular morbidity and mortality (9,89). Lifestyle modifications, such as increased physical activity, are the singular treatment recommended for prehypertensive individuals (9,89). It is estimated that people spend half their waking hours at work (76) and that the workplace is becoming increasing sedentary. Incorporating the walking workstation could pose to be a valuable tool to reduce sedentary behavior, improve blood pressure, and reduce risk for coronary heart disease.

The study purpose: The primary objective of this randomized cross over experimental study was to examine the acute effect of a walking workstation on 24-hour ambulatory blood pressure. The secondary aim was to analyze the acceptability of the walking workstation over an eight hour workday. Lastly, the acute effects of the waking workstation on total levels of physical activity throughout the day and days following the intervention was examined.

Specific questions to be answered are:

1) What is the mean difference of the post exercise systolic and diastolic blood pressure following 2.5 hours of walking at 1 mph over an 8 hour day compared to a non-walking 8 hour day in adult men and women with prehypertension?

2) What is the acceptability of walking 2.5 hours at 1 mph over an 8 hour day compared to a non-walking 8 hour day in adult men and women?

3.) What effect does walking at 1mph for 2.5 have on total activity levels the day of the intervention and days following?

Hypothesis: It is hypothesized that the physical activity accumulated from the walking workstation day will result in a lower reduction in systolic and diastolic blood pressure when compared to the non-activity day.

It is predicted that the walking workstation will be regarded as acceptable to the participants and that they will judge that their daily activities were not negatively impacted.

It is also hypothesized that walking on the walking workstation will result in down regulation of physical activity immediately following the walking intervention for the remainder of the day.

Definition of terms:

- Activity-Stat: A distinct physiological entity in the brain that controls physical activity levels.
- Ambulatory blood pressure: Mobile blood pressure cuff worn throughout the day and designated to activate at given intervals. Data can be downloaded to computer to view blood pressure throughout the day.

- Blood Pressure Load (BP Load): percentage of blood pressure readings above 140/90 during the day and 120/90 at night (93).
- Non-Exercise Activity Thermogenesis (NEAT): Every activity that is performed throughout the day besides planned exercise. This could be shopping, house work, playing with your children, etc.
- Obese: BMI>30kg/m^2
- Physical Activity Compensation: When physical activity is increased in one segment of an individual's day, it is reduced in another.
- Prehypertensive: defined as systolic blood pressure of 120-139mmHg and/or diastolic blood pressure of 80-89mmHg (9).

Delimitations and limitations: The population to be studied will be delimited to those with resting blood pressure within the values considered "prehypertensive" (i.e., systolic: 120-139mm Hg or diastolic: 70-89 mmHg). The decrease in blood pressure from exercise in normotensives is traditionally milder than that seen in prehypertensives. It has been shown that hypertensive individuals typically experience greater reductions in exercise blood pressure than prehypertensives, implying that if this study is effective at lowering blood pressure in the prehypertensives, it might be favorable for those with hypertension as well.

Possible limitations of the study include the fact that subjects were allowed limited time to acclimatize to the walking workstation and the subjects were inactive sedentary individuals. Results may have differed if a longer acclimation period were to be granted. The biggest limitation is that the study was a measure of only an acute response to 2.5 hours of walking. Clearly, chronic exercise with longer interventions are warranted to elicit sustained physiological responses. Only one intensity (1 mph) will be utilized for this study which limits extrapolation to other intensity levels.

Chapter 2

LITERATURE REVIEW

Health Effects of Physical Inactivity/Sitting Time

With the advent of certain electronics and time saving devices there has been a steady decrease in physical activity. Researchers have examined the possible health consequences of increasing sedentary behavior. Research has also addressed the question of the amount of exercise or activity that is necessary to ameliorate adverse health outcomes; and to examine the current exercise guidelines to determine if that is enough to combat an increasingly sedentary lifestyle.

Katzmarzyk, Church, Craig, and Bouchard (42) assessed 7278 men and 9735 woman aged 18-19 yr in the 1981 Canada Fitness Survey. Questionnaires were administered that quantified the amount of sitting the participants engaged in most days of the week. Participants could have answered as 1) almost none of the time, 2) approximately one fourth of the time, 3) approximately half of the time, 4) approximately three fourths of the time, or 5) almost all of the time. Leisure time physical activity questionnaire was also given that assessed 20 leisure time physical activities, 19 of them with MET values of 3.0 or greater. Activity was assessed as MET-hours per week by adding the products of the metabolic costs of each activity, the durations, and the average occurrence per week across a 12-month recall period. Smoking status and alcohol consumption was accounted for. After the 12.9 yr follow up it was found that there was a

positive association between amount of sitting time and mortality rates from all causes including cardiovascular disease and other causes excluding cancer. Figure 1 has been adapted from the article (42) and shows this association.

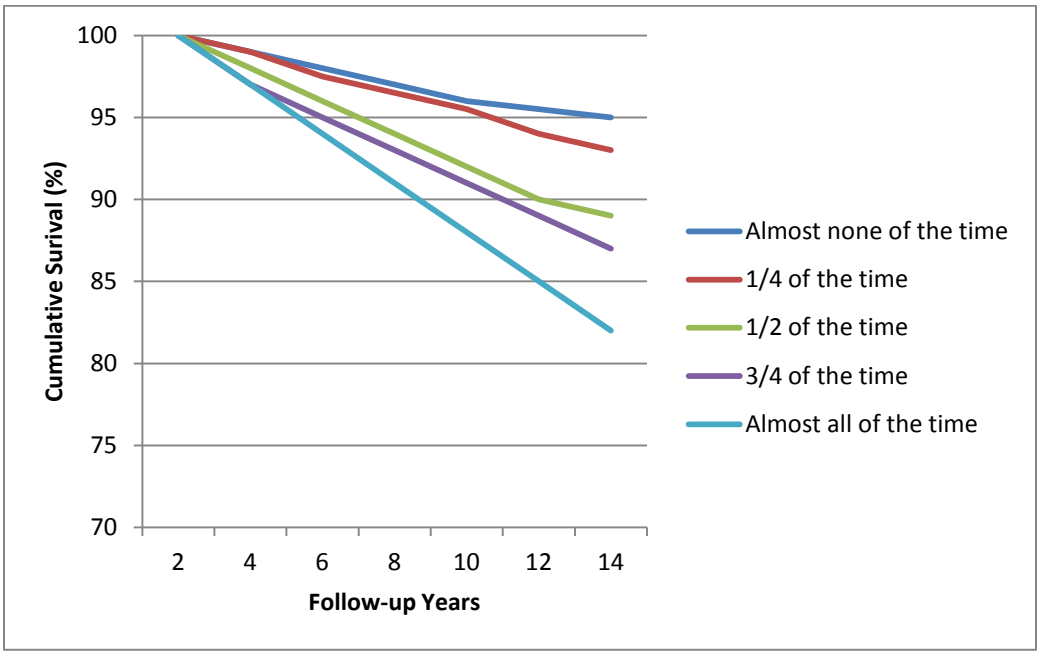
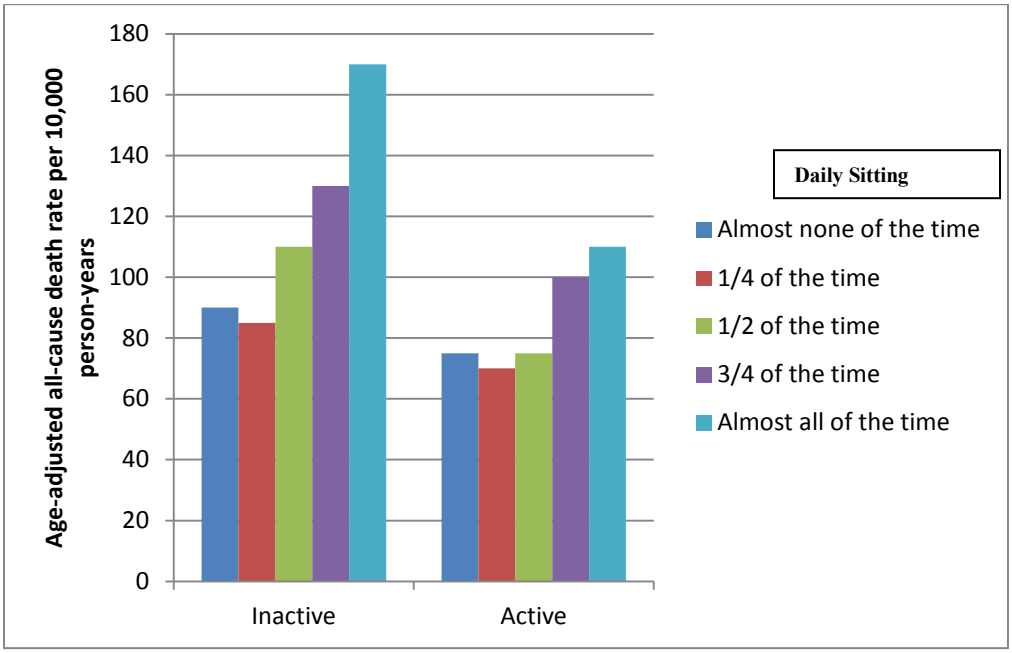


FIGURE 1- Survival curve for all-cause mortality across categories of daily sitting in 17,013 men and women 18-90 yr of age, in the Canada Fitness Survey, 1981-1993. Categories represent the amount of sitting time throughout the day.

These results remain significant even when correcting for confounders such as age, sex, smoking status, alcohol consumption, leisure time physical activity levels, and the PAR-Q. Interestingly, Figure 2 indicates that sitting time in and of itself is associated with adverse health outcomes independent of leisure time physical activity and BMI.

One limitation of this study is the subjective nature of physical activity questionnaires. However, because of the large population and the long time course, it very likely that these trends are true.



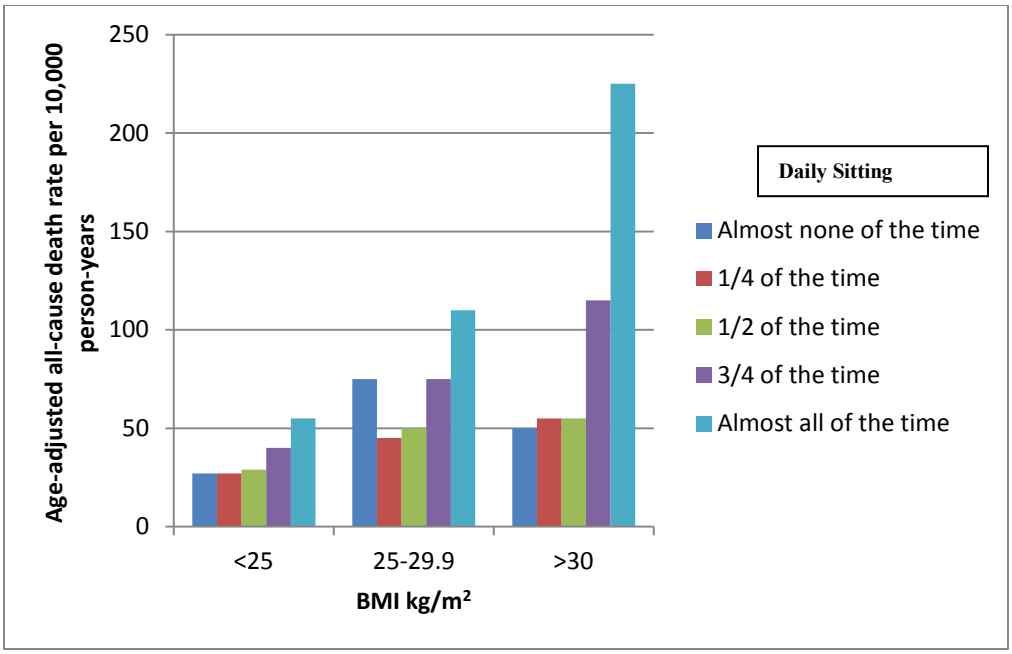


FIGURE 2- Age adjusted all-cause death rates across categories of daily sitting time in subgroups defined by leisure time physical activity (defined as ≥ 7.5 MET h/wk) and body mass index in 17,013 men and woman from the Canada Fitness survey, 1981-1993. The heights of the bars indicate mortality rates.Adapted from Article (31).

Initiativ

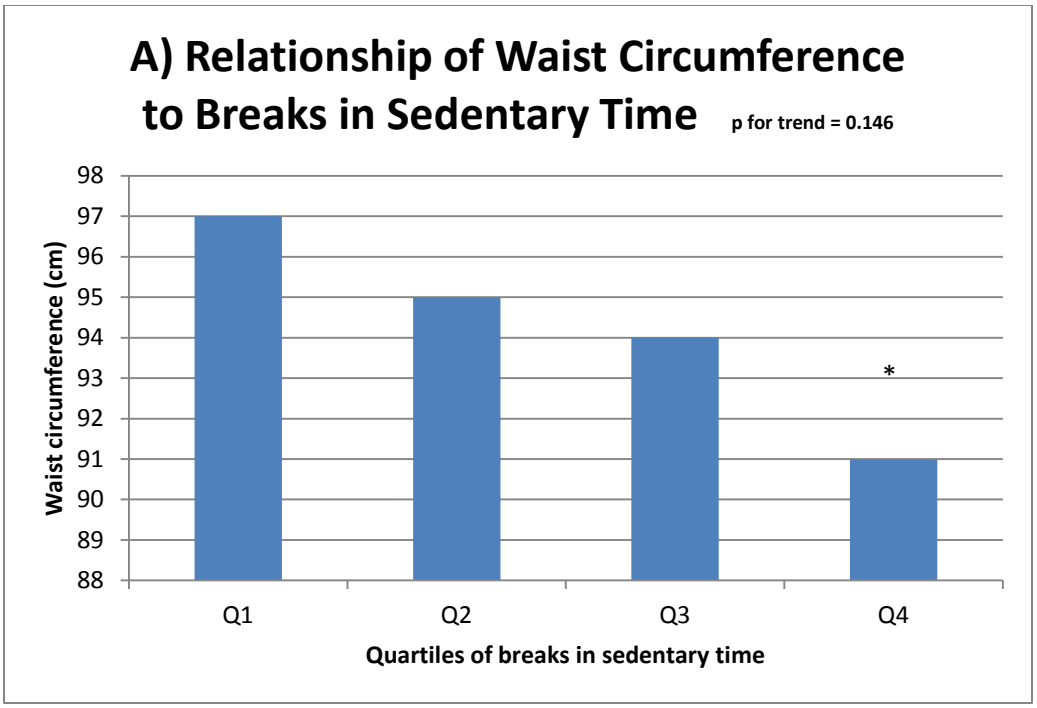
or more per day sitting had increased risk for CVD (RR 1.68) over the course of a 6 yr follow up compared to those who spent less than 4 hr a day sitting. Several other studies have shown that excessive television viewing time was associated with adverse metabolic risk independent of overall physical activity levels (23,13,36). A meta-analysis conducted by Thorp, Owen, Neuhaus, and Dunstan (82) examined sedentary behaviors and subsequent health outcomes of several longitudinal studies. The researchers found convincing evidence that adverse long term health outcomes such as CVD, gallstone

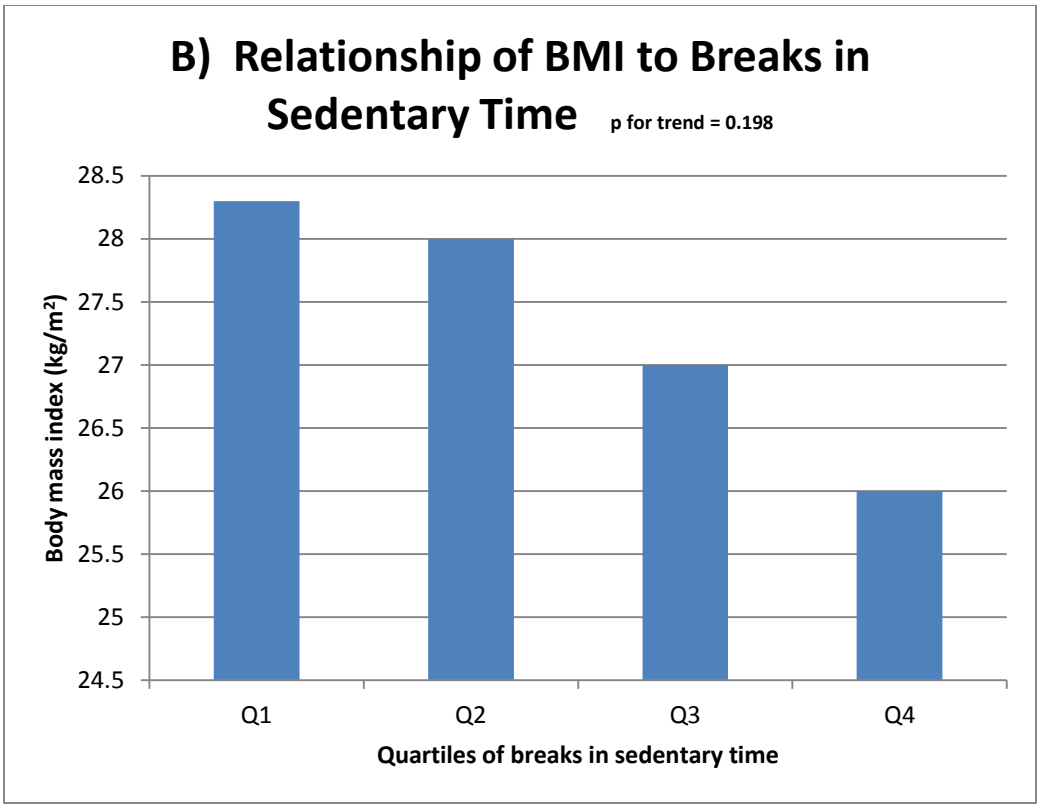
disease, and mental disorders are positively associated with sedentary behavior. This association was largely independent of physical activity time, leading to the suggestion that it is not sedentary behavior per se, but possibly uninterrupted prolonged sitting that is the instigator (60).

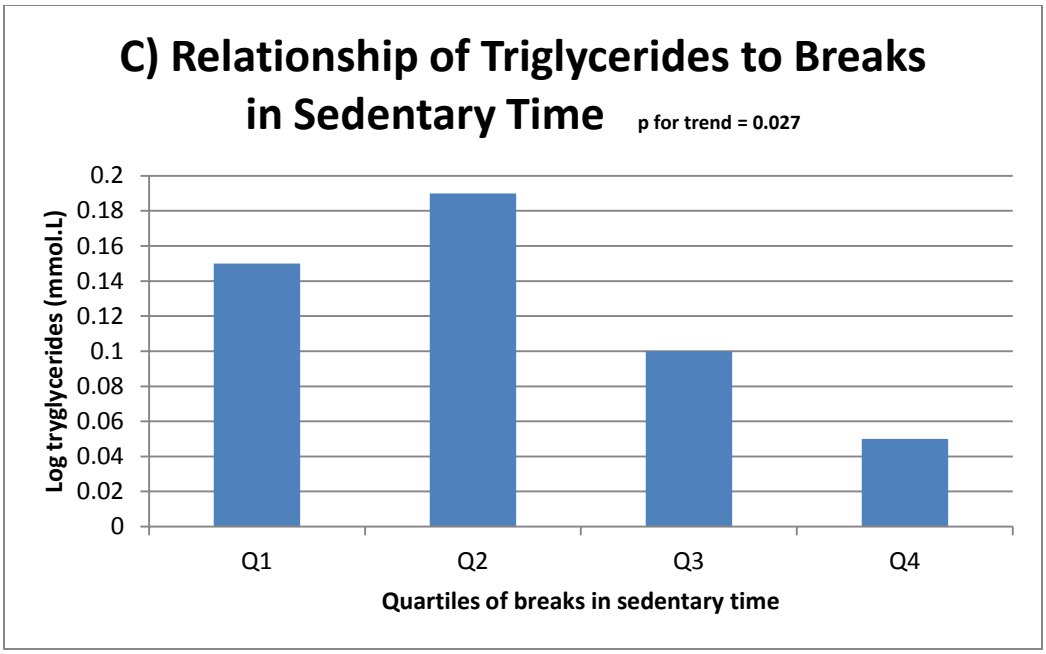
Bed rest studies have been used as the extreme test of the detrimental metabolic abnormalities associated with prolonged sitting and inactivity. Alibegovic et al. (2) found that only nine days of bed rest led to reduced insulin sensitivity and altered expressions of more than 4500 genes, including mRNA changes in the vastus lateralis. incredible is the find that 17% of the changed mRNA did not recover after 4 weeks of exercise. This suggests that the deleterious effects of inactivity may be long lasting or possible irreversible. Other activity restriction studies have shown adverse changes to heart dynamics such as stroke volume and output (75). Hamilton and colleagues (27) have found that long periods of muscular unloading may suppress lipoprotein lipase (necessary for HDL production and triglyceride uptake), and reduce glucose uptake.

It has been suggested that in addition to total sedentary time, the way that sitting is accumulated or the amount of breaks to sitting may be just as important. Healy et al. (31) analyzed data from the Australian Diabetes, Obesity and Lifestyle Study (14). The purpose of the research was to examine how breaks in muscular unloading may affect health outcomes. 168 healthy adults aged 30-87 yr were given uniaxial accelerometers that were worn seven days straight during all waking hours. Data from accelerometers

were recorded in 1-minute epochs. A cutoff of <100 counts/minute was chosen to designate sedentary time. Examples of these types of activities could be quietly sitting, reading, typing, etc. A break was counted when an interruption of sedentary time (>100 counts/minute) of at least 1 minute occurred. Counts of ≥100-1951 were classified as light intensity activity and counts ≥1952 were classified as moderate-to-vigorous intensity activity. Analysis at the end of the study showed that about 57% of the participants waking hours were spent sedentary, 39% in light intensity activities, and 4% in moderate-to-vigorous-intensity activities. Researchers saw that independent of total sedentary time, the number of breaks throughout the day was associated with lower BMI, triglycerides, waist circumference, and 2-h plasma glucose (Figure 3). The authors concluded that incorporating frequent breaks throughout the day may provide many metabolic health benefits. Additionally it was suggested that individuals should try to engage in more moderate to vigorous intensity exercise. It must be understood that this was a cross-sectional study so it cannot be determined if these relationships are causal.


A) Relationship of Waist Circumference to Breaks in Sedentary Time
p for trend = 0.146
Waist circumference (cm)
98
97
96
95
94
93
92
91
90
89
88
*
Q1
Q2
Q3
Q4
Quartiles of breaks in sedentary time


B) Relationship of BMI to Breaks in Sedentary Time
p for trend = 0.198
28.5
28
27.5
27
26.5
26
25.5
25
24.5
Body mass index (kg/m²)
Q1
Q2
Q3
Q4
Quartiles of breaks in sedentary time



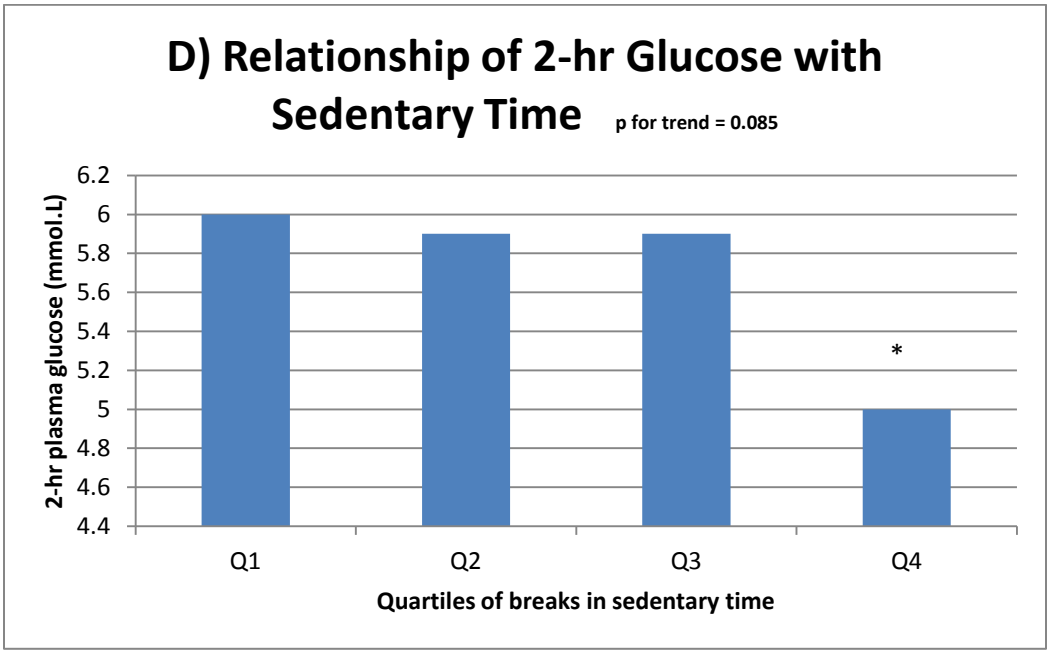


FIGURE 3- Quartiles of breaks in sedentary time with metabolic risk variables: waist circumference (A), BMI (B), triglycerides (C), and 2-h plasma glucose (D). Cut points for quartiles were 506, 612, and 673 breaks. *P<0.05 compared to quartile 1. Adapted from REF (31). N=168.

The relationship shown in Figure 3 (A-D) remains constant even among those who engage in the public health recommendations of 150 min/wk of moderate to vigorous intensity exercise (30). Thus regardless of meeting activity guidelines, the amount of sitting time was associated with adverse health outcomes. In fact, Healy et. al. reported significant ($p < 0.05$) dose-response relationship between TV watching time with waist circumference, systolic blood pressure, and 2-h plasma glucose among men and woman. There were also adverse outcomes in fasting plasma glucose, triglycerides, and HDL cholesterol in woman only (32). Hence while people reported that they met the minimum activity levels they also compensated and tended to spend the remainder of their time sedentary. This was termed the "*active couch potato phenomenon"* (60). In other words these are people who exercise for the recommended allotment of time but the remainder of the day is spent in sedentary behaviors.

To summarize; many detrimental health outcomes are associated with being sedentary. The recommendations of engaging in 150min/wk of moderate exercise may need to be reevaluated to account for potential compensatory sitting behavior. There is compelling evidence supporting the importance of incorporating interruptions in sedentary time throughout the day to negate the harmful effects of chronic muscular unloading. The total time spent being physically active, while important, may not be as effective at minimizing health risk as limiting total sedentary behavior and breaking up

sitting time. It simply is not enough to be an "active coach potato". Reducing post activity compensatory sitting may be the most effective health behavior goal.

Hypertension/Post exercise hypotension mechanisms

Hypertension is defined as a blood pressure of >140/90 mmHg (91). It has been estimated that worldwide prevalence of hypertension is at 1 billion individuals with about 7.1 million deaths worldwide being attributed to hypertension (91). Cardiovascular disease risk is doubled for each 20/10 mmHg incremental increase in blood pressure with this suboptimal blood pressure being the number one attributable risk for death throughout the world (91). Although awareness of the debilitating consequences of hypertension has risen, more must be done. The two areas of focus for treatment are pharmacological interventions and lifestyle modifications coming in the form of diet alterations and increasing physical activity.

It is well documented that after an acute bout of exercise there is a significant post-exercise hypotension period (PEH) (23,43,67,73). PEH response is most clearly evident in hypertensive and prehypertensive individuals as the hypotensive response to exercise in normotensive individuals is inconsistent (52).

Mean arterial pressure is the product of cardiac output and total peripheral resistance. In the majority of cases, indices of systemic and regional resistance are reduced below pre exercise values during the hypotensive period (52), signifying that decreased peripheral resistance is occurring. Studies have shown lessened peripheral

resistance at sites other than the functioning musculature suggesting that there could be a whole body effect (8,69). It is known that immediately following exercise there is a brief period of hypotension due to a pooling of blood in the vasodilator muscle beds (52). The mechanisms for PEH may be different from this immediate response witnessed post exercise. Other possible mechanisms could be changes in thermoregulation, blood volume, afferent nerve activity, and circulating hormones expressed from an exercise bout. A recent paper by Halliwill et al. (25) indicated that much of the PEH can be explained by histaminergic vasodilation, primarily due to the H_1 and H_2 receptors. It was shown that blockade of these receptors but not removal of the sympathetic component reduced PEH. Halliwill(25) also showed that combined H_1 and H_2 receptor antagonism reduces post exercise vasodilation by roughly 80% and reduced PEH by 65%. The precise mechanisms of PEH are not completely understood but it is most likely not one factor but many that play a role.

Blood pressure response to exercise

Taylor et al. (80) recruited 11 sedentary obese (32 $\pm$ 4% body fat) hypertensive subjects to examine the duration of blood pressure reduction after an acute bout of aerobic exercise. The study was a crossover design in which all subjects performed a control day and an exercise day. Exercise consisted of 45 minutes of aerobic exercise at 70% VO_2 peak. Ambulatory blood pressure was recorded for 24 hours after exercise and on a separate day for the control. It was found that SBP was lower by 6 to 13 mm Hg for

the first 16 h after exercise when compared to the control day. As can be seen from Figure 4, both day and night average SBP was significantly lower when compared to the non-exercise day (80). Significant reductions were also seen in diastolic blood pressure at 16 hours and over the course of the 24 hours after exercise. It was concluded that a single bout of moderate intensity aerobic exercise significantly lowered blood pressure in obese sedentary hypertensive men over a 24 hour period.

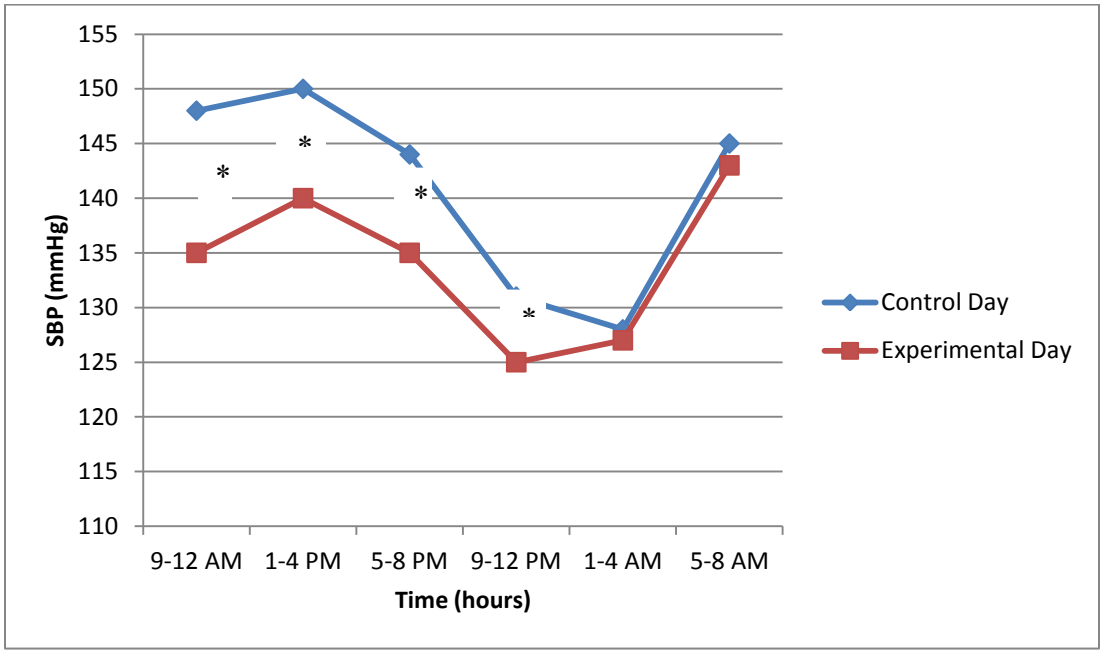


FIGURE 4- Systolic blood pressure for the 24-h ambulatory BP recording preceded by and not preceded by 45 minute of acute aerobic exercise at 70% $V0_2$ max. Values are expressed as $\pm$ SE. *P<0.05 for the between group readings.Adapted from REF (80).

To fully understand the impact that exercise has on PEH, it is necessary to examine the effects of intermittent verses continuous exercise on blood pressure responses. Weltman et al. (86) examined the blood pressure response to fractionalized (three bouts separated by time) exercise compared to a single session. 29 sedentary normotensive to prehypertensive adults aged 26.9 $\pm$ 7.0 y with systolic blood pressure at 125 $\pm$ 10mm Hg and diastolic blood pressure at 74 $\pm$ 10 mm Hg were enrolled in the study. Participants were randomly assigned to either a 1 x 30-minute session or 3 x 10-minute session at a VO_2 peak of 60-70%. The 1 x 30-minute exercise session was performed from 0900-0930; the 3 x 10-minute sessions were initiated at 0920, 1320, and 1720 hours. All subjects performed both sessions in addition to a control day. Blood pressure was taken hourly from 0900 to 2100 hours by an automated cuff. Between readings the subjects were at bed rest. It was found that when compared to the control and the 1 x 30 day, the fractionalized exercise had consistently lower SBP in the afternoon and early evenings. Authors concluded that repeated exercise bouts may be superior to one exercise bout to reduce SBP in those with slightly elevated blood pressure. PEH was not observed in the 1x 30 group. This is thought to be due to inconsistent findings of PEH within the normotensive population and the timing of the exercise (57,84). Exercise in the afternoon has been found to have a stronger effect on PEH than exercise in the morning (40).

Park, Rink, and Wallace (65) conducted a similar study utilizing prehypertensive individuals. 21 prehypertensive adults engaged in a randomized crossover study to assess if the accumulation of physical activity leads to a greater reduction in blood pressure than a single continuous session. Ambulatory blood pressure was monitored for 12 hours after the accumulated physical activity, the continuous session, and the control day. The physical activity group consisted of four 10-minute sessions over a four hour period at an intensity of 50% of VO_2 peak. Exercise was performed at 0900 h, 1000 h, 1100 h, and 1200 h. The single continuous group performed 40 minutes of physical activity at 1100 h at 50% of VO_2 peak. For the control treatment the participants arrived at the laboratory at 1200 h and began to collect data for the same 12 hour time period as the two other treatment groups. It was found that SBP was reduced for 11 hours after the accumulated physical activity compared to only 7 hours after the continuous activity($p<.05$). DBP was reduced 10 hours after the accumulated physical activity compared to 7 hours after the continuous ($p< .05$). These results show that accumulating low intensity physical activity can lead to superior blood pressure reductions than one continuous session of exercise.

The same authors performed a sub study (64) to the previously examined one focusing on the blood pressure reductions between the 10-minute walking bouts. They found that there was only a significant reduction in blood pressure after the third exercise

bout. Diastolic blood pressure did not decline. The researchers suggested that it was the accumulation of physical activity that caused the decline after the third session.

In a similar manner, Padilla, Wallace, and Park (61) investigated PEH using self-selected lifestyle activities. It was also hypothesized that the reduction in blood pressure would correlate with energy expenditure. Using a pre-post repeated measures design, 8 normotensive, 10 prehypertensive, and 10 hypertensive individuals were randomized to one of two treatments for a 24-h study period. One treatment was the accumulation of physical activity through incorporating lifestyle activities such as gardening, digging, raking, or brisk walking. The second group represented the control and was asked to resume their normal activities while abstaining from any exercise. Measurements began at 0700 hours in both groups and took place for the next 24-hours. The physical activity group was asked to accumulate 150Kcals of physical activity over an 8 to 12 h period. A three-dimensional accelerometer along with an activity log was used to quantify the physical activity. An ambulatory blood pressure cuff was utilized. The cuff was programmed to take measurements at 15 minute intervals in the day and 30 minute intervals at night. At the end of the measurement period it was found that blood pressure reduction was only witnessed in the prehypertensive and hypertensive groups. The magnitude of the reduction was significant ($p=0.024$ for prehypertensive, $p=0.023$ for hypertensive) in both groups when compared to the control. A 6 hour SBP reduction of 6.6 ± 2.3 mm Hg within the prehypertensive group and 8 hour reduction of 12.9 ± 4.3 mm

Hg in the hypertensive group were reported. There was no correlation between blood pressure reduction and energy expenditure. These results are very promising when considering that a person who has elevated blood pressure would only need to incorporate modest levels of physical activity to reduce blood pressure. A major limitation was that physical activity was not supervised or standardized for the treatment group.

It is important to note that chronic exercise training at low to moderate intensities can induce favorable adaptations in blood pressure. Moreau et al. (57) recruited 24 post-menopausal women with borderline to stage 1 hypertension to undergo a 24 week walking intervention. 15 women were randomly assigned to the exercise group while 9 were assigned to the control. The women were asked to wear a pedometer for 1 week prior to the trial to gage baseline walking measurements. They were then instructed to add enough steps into their day do increase walking by 3-km/day (recommended by ACSM and CDC) and to walk at a self-selected pace. The control group was asked to maintain normal daily habits. Measurements were taken at baseline, 12 wk, and 24 wk. At 12 wk it was found that the exercise group reduced systolic blood pressure by 6 mm Hg and after 24 weeks systolic blood pressure further reduced by 5 mm Hg. No reductions were seen in regards to diastolic blood pressure reductions. Researchers also stated that these reductions were not correlated with medication, body mass, adiposity, diet, or fasting insulin levels. Staffileno, Minnick, Coke, and Hollenberg (77) similarly

found significant blood pressure reductions with an incorporation of active lifestyle modifications among young African American woman.

To summarize, both acute and chronic low intensity physical activity can induce favorable changes in blood pressure. It has been shown that fractionalized exercise may be able to induce greater reductions in blood pressure over the course of the day than a single bout and that blood pressure is decreased between these exercise sessions. Diastolic blood pressure typically does not respond as much as systolic blood pressure to exercise. Lifestyle activities at an intensity level classified as low to moderate intensity are enough to elicit PEH for the majority of a 24-hour period.

Physical Activity Intensity and Disease Risk

Wen et al. (87) conducted a prospective cohort study to quantify the minimum amount of physical activity needed to reduce mortality and extend life expectancy. 416,175 Taiwanese men and woman (age >20 y) were recruited to undertake the 13 year study. The participants were asked to report to the National Health Institute in Taiwan. During this visit they were given a questionnaire to quantify the amount of physical activity that was undertaken during the previous month. Participants were asked to classify the type and intensity of weekly leisure time physical activity that was engaged in; many examples were given to aid in classification. They were also asked the duration per week of exercise that was spent on different leisure time physical activities. After transferring the questioner data into met/hours per week, participants were classified into

one of five categories: inactive, low active, medium active, high active or very high active. Hazard ratios and life expectancy for each group was calculated and compared with the inactive group. It was found that just 15 minutes of moderate intensity physical activity a day resulted in a significant 17% reduction of all-cause mortality risk when compared to the inactive group. There was a dose response exhibited, the more active the person was the greater reduced risk they expressed. There are inherent flaws with this type of study, the biggest one coming in the form of the questionnaires. Physical activity was not monitored and was recalled from memory. Some misclassification between the groups could have taken place. Nevertheless, the results imply that a very little amount of physical activity may be all that is needed to experience health benefits.

Further interventional studies have been conducted to show a cause and affect relationship between low intensity physical activity and health outcomes. Hansen et al. (29) recruited fifty obese male subjects with type 2 diabetes (age 59 $\pm$ 8 y, BMI 32 $\pm$ 4 kg/m^2) to see if continuous low to moderate intensity exercise is as effective as moderate to high intensity exercise on health markers. Participants were randomly assigned to either a low to moderate intensity (55 minutes at 50% VO_2 peak) or moderate to high intensity (40 minutes at 75% VO_2 peak) exercise intervention. Exercise intervention lasted 6 months with exercise being performed 3 times a week. Oral glucose tolerance, blood glycosylated hemoglobin, and a lipid profile were completed at the beginning and end of the study. At the completion of the study it was found that HbA_{1c} content

decreased from 7.2 $\pm$ .2% to 6.9 $\pm$ .2% along with plasma LDL-cholesterol reduction in both groups. No differences were found between exercise intensity groups. In addition, body composition and whole body and skeletal muscle oxidative capacity improved significantly with no between group differences. Researchers concluded that when matched for energy cost, low to moderate intensity exercise is just as effective as moderate to high intensity exercise in lowering HbA_{1c} and increasing muscle oxidative capacity.

Dunn, Marcus, Kampert, Garcia, Kohl, and Blair (12) compared a lifestyle intervention to a structured cardiorespiratory program and its effects on plasma lipid and lipoprotein cholesterol concentrations, and blood pressure. 116 sedentary men and 119 sedentary women were recruited to undergo this 24-month study. The structured exercise group was prescribed 5 supervised aerobic exercise sessions per week at 50-85% intensity (VO_2 peak). The lifestyle intervention groups was asked to accumulate at least 30 minutes of moderate intensity physical activity on most, preferable all, days of the week in a manner uniquely adapted to the individual. At the end of the study it was found that cardiorespiratory fitness increased significantly in both groups from baseline, along with similar significant between group reductions in blood pressure, and an increase ratio of total cholesterol to HDL. The results from this study support the notion that health markers may be expressed from a lifestyle physical activity intervention. One

major limitation to the study was that exercise was not monitored or standardized for the group.

Further research has been conducted to substantiate the health benefits of low intensity physical activity. Data from the STRRIDE (Studies of a Targeted Risk Reduction Intervention through Defined Exercise) trials (38) suggest that duration of exercise rather than intensity was more important for improving insulin sensitivity, blood lipid profile and the metabolic syndrome. These results suggest that exercise "time" is more important than intensity for improving health outcomes.

Walking Workstation

Over the past two decades a shift has taken place in developed/high income societies that has increasingly placed the employee in front of a computer (76). It has been observed that the rise of computer based work has resulted in many people spending the majority of their day in sedentary behavior (33,34). In conjuncture is the fact that individuals spend at least half their waking hours at work (66). It has also been postulated that obese individuals engage in 2-4 hours less of non-exercise activity thermogenesis (NEAT) than their leaner counterparts (50). As people become increasingly more sedentary as a society, interventions must be examined to combat the debilitating diseases associated with inactivity.

The walking workstation is a low speed treadmill attached to a computer

and desk (figure 5). The idea was first proposed 22 years ago by Edelson to reduce physical inactivity (15). Edelson pushed the workstation to try to ameliorate the postural hazards (aches, pains, other stresses) of prolonged sitting (15). After receiving little responsiveness from his day, Levine and colleagues brought renewed attention to the idea of the walking workstation as a means to increase ambulatory activity in the workplace (50). Levine has suggested that the workstation could increase energy expenditure and hopefully reduce obesity and disease (50).

Feasibility and Metabolic Cost of Walking Workstation

Regardless of whether the walking workstation can increase NEAT, if they are not feasible or acceptable to the workers they would not be used. Several investigations have been conducted to address the concerns expressed as to the feasibility of the workstation in an office type environment.



FIGURE 5- Image retrieved from cdc.gov

Thompson, Foster, Eide, and Levine (81) recruited 25 participants who were employees in the Executive Health Program at the Mayo Clinic. The employees were given access to the walking workstations along with instructions to participate in as much walking as they desired, no quota or reminders were given. They were also equipped with the Step Watch Activity Monitor System (shown to be superior to pedometers) to gage number of steps taken. A survey of 10 questions regarding feasibility and productivity was also administered. Trial lasted for 6 weeks total; 2 weeks performing normal job function, 2 weeks for acclimation, and 2 weeks using the walking workstation. At the conclusion of the trial it was found that most subjects increased their steps between 1.5 and 2 times with the availability of the treadmill. All of the subjects

walked an additional 30 minutes a day with two participants walking an additional 2 hours a day. The majority response from the questionnaire was that the workstation could be used in the clinical environment and that they would be used if available. Some of the participants reported feeling "more tired" at the end of the day while some felt more "energized", average response to this question was neutral. Importantly, the employees did not feel that the walking workstation negatively affected their work productivity. The weakness of this study was the subjective nature of the surveys and that walking 30 minutes extra a day is far less than the 2-4 hours that Levine has suggested (52) for increased NEAT. It could be hypothesized that with longer duration on the treadmill a decrease in work productivity would be seen. Strength of this study is that results showed significant increase in steps taken without any coaching or reminders.

Fidler et al. (16) conducted an objective evaluation of work competence utilizing two male radiologists. Each radiologist was given 100 cases to interpret while on the walking workstation. The cases were originally interpreted by the identical radiologist at least one year prior. Each radiologist was given a familiarization period that consisted of interpreting 2-3 cases on the workstation prior to the study. Results showed that for both interpreters there was a significant ($p=0.0003$) improvement in reinterpreting the cases when using the walking workstation (detection rate of $99.0 \pm 5.3\%$ compared to $88.9 \pm 25.3\%$ in the traditional technique). The researchers concluded that the walking workstation may actually improve cognitive ability when evaluating radiology cases as

compared to sitting at a typical computer station. The mechanisms for this improvement were speculated to be an increase in alertness and blood flow to the brain. However, the authors did not measure other variables that may have accounted for this change. Interpreting these findings, considering the small number of subjects, must be done with caution. Nevertheless, this study does suggest that the walking workstation did not negatively impact work function during CT image interpretation in these two radiologists.

Many skills are necessary to be productive in the workplace. Ohlinger, Horn, Berg, and Cox (59) recently assessed the feasibility of the walking workstation by measuring cognition, attention, and motor skill while walking. 50 employees of Miami University volunteered for this study. Participants were asked to complete various cognitive and motor skill tasks under 3 conditions: walking on workstation (1.6km/h), standing, and seated. All tasks have been previously found reliable and valid under non-walking conditions. Data were collected in one 75-minute laboratory session. The results indicated that there was no significant difference in the cognitive tests. There was a small, yet statistically significant, reduction in motor skill between the seated and walking condition. The authors concluded that tasks that are cognitive in nature are not negatively impacted by the walking workstation but that motor skill oriented tasks may be negatively impacted while walking. A limitation of this study was that the tasks did not simulate actual office type work. It is unknown what impact the walking workstation has on "real life" office work productivity and accuracy. A summary of research that

has been conducted using the walking workstation on various office type skills is provided (table 1).

Research Outcomes Using the Walking Workstation

Study	N	Outcome Variable	Results	Recommendations
Thompson, Foster, Eide, Levine, (2007)	25	# of steps, Feasibility questionnaire	Increased steps by 1.5 to 2 times. Generally favorable survey outcomes.	Walking workstation has the potential to be used as a tool to reduce low activity behavior.
Fidler (2008)	2	CT image interpretation	An increased number of findings were detected while walking compared to traditional.	Walking workstation does not inhibit work function in CT image interpretation.
John, Bassett, Thompson, Fairbrother, and Baldwin, (2009)	20	Attention and process speed, typing speed, mouse clicking accuracy, and GRE math and reading questions.	Walking workstation adversely affected mouse accuracy, typing speed, and math scores. No difference between selective attention, processing speed, or reading comprehension.	Walking workstation caused a 6-11% decrease in fine motor skills and math problems when compared to seated conditions. Type of task may be important for prescribing the workstation.
Straker, Levine, and Campbell (2010)	30	Keyboard and mouse performance.	Computer task performance was lower when walking.	Although computer task performance decreased while walking, the magnitude of this detriment needs to be studied further. Workstation may be a feasible option to increase physical activity.
Ohinger, Horn, Berg, Cox, (2011)	50	Cognition, Attention, Motor skill	Decrease in motor skill performance but not cognition or attention was seen while walking.	Results show the potential of the walking workstation without adversely affecting cognitive capacities.
Cox, Guth, Seikemeyer, Kellems, Brehm, Ohlinger, (2011)	31	Speech quality	No statistical difference in speech quality when walking.	Study supports the feasibility of walking workstation without effecting speech quality.

Table 1. Note- average walking speeds for all studies were 1.1mph.

It is important to note that in relation to decreased motor skill and computer type performances; research has shown that acclimation to duel task performances can reduce or even eliminate the interference (74). As individuals practice and acclimate to completing the duel tasks they are more likely to increase performance. In addition, the magnitude of the decline in these functions must be recognized in context with the actual job responsibility. When viewed in this context the impact on work performance may be negligible. For Example, when doctor's time answering e-mails was evaluated while walking, the decrease in typing speed was 17.5 seconds which accounted for only an additional 4.9 seconds per correspondence (37). A major limitation to all of these studies was the short measurement time that was involved. The long term impact of using a walking workstation on work performance is unknown.

In addition to the feasibility and effects of the walking workstation on office tasks, the metabolic cost has also been analyzed. Levine and Miller (51) recruited 15 healthy sedentary obese (BMI 30-35 kg/m^2) men and woman (14 woman, 1 male). Energy expenditure was then measured using indirect calorimetry under 5 conditions: lying motionless, office chair sitting, standing motionless, walking at 1, 2, and 3 mph, and walking at a self-selected speed. It was found that 65 kcal/h were expended at rest, 72 kcal/h while sitting, 82 kcals/h while standing, 198 kcals/h while walking 1 mph, 254 kcals/h walking 2 mph, and 307 kcals/h were expended walking at 3 mph. When subjects self-selected their speed, an average of 191 kcals was expended. The authors speculated

that if obese individuals could replace 2-3 hours of sedentary time with the walking workstation, while controlling other components of energy balance, a weight loss of 20 kg/year could occur. Similar values for the metabolic cost of using the walking workstation have been reported in other studies (10). One limitation to these studies is that the duration does not extend over the course of the whole workday. It is unknown what total energy cost for a 24 hour day using a walking workstation would be.

Activity-Stat and physical activity compensation

A primary goal of many exercise interventions is weight control or weight loss. This requires a negative energy balance meaning, in regards to exercise, the subject must displace sedentary/inactive behavior with increased levels of physical activity. Roughly 20-45% of total daily energy expenditure is due to physical activity (50). However, more often than not individuals will compensate for increased physical activity levels by decreasing activity elsewhere in the day. Evidence shows that increases in total daily energy expenditure (TDEE) during prescribed exercise prescriptions are less than what is expected based on the prescribed exercise session (11,21,55,58). This holds especially true for certain age groups i.e. elderly individuals and children.

Debate exists as to whether physical activity (PA) interventions targeted at children have any efficacy to them. Wilkin et al. (93) reported similar activity levels between children of different socio-economic status, location, and amount of PE time in school. These results are ambiguous in that not all studies have come to the same

conclusions. Goodman and colleagues examined activity levels of 194 8-13 yr. old British children utilizing accelerometers and found no evidence for compensation (19). Meanwhile debates continue to rage on the topic with varying opinions (4,70,92,93). Much of the discrepancy may be attributed to different methods of data analysis. Some author's analyzed proportion of time spent in classifications of activity levels; some evaluated 'average counts per minute' and some analyzed 'sum of all counts'. These methodological differences could possibly explain the incongruity. The question at hand would best determine the ideal way to analyze the data. If a researcher is focusing on the ActivityStat hypothesis, total physical activity counts would be the ideal way to analyze the data.

The evidence appears inherently stronger that when elderly individuals engage in an exercise program there is a compensatory decline in spontaneous activity. Goran(21) had 11 elderly (56-78 yr.) persons engage in a short term endurance training program. They examined total energy expenditure (TEE) using doubly labeled water. They found that there were no significant changes in TEE (2,408 +/- 478 to 2,479 +/- 497 kcal/day) before and during the last 10 days of the endurance training program mainly due to a 62% reduction in energy expenditure of physical activity. Similar results have been replicated by Morio(58) and Meijer (55), both showing that elderly individuals do not increase their total daily physical activity by engaging in an exercise program. The driving force behind this is a decline in spontaneous physical activity.

Comparable results can be found using other sub-groups of the population. Keytel et al. (44) set out to determine the effects of 8 weeks of moderate intensity exercise on weight loss and total daily energy expenditure (TDEE) in 9 post-menopausal women. 10 subjects were recruited as the control. The exercise group was asked to walk 3-6 km at an intensity of 70-75% MHR. TDEE was predicted using heart rate energy expenditure regression equations and 24-h heart rate monitoring. At the end of 8-weeks it was found that there were no differences in TDEE between the two groups.

Limited research exists as to the effects of acute exercise on total daily physical activity. Wang (85) recruited 36 overweight or obese postmenopausal women to undertake 5 months of either moderate or vigorous intensity exercise (18 were randomly assigned to the moderate group while 18 were assigned to the vigorous). Subjects wore RT3 accelerometers before and each month during the intervention for 5-7 days. Moderate exercise was prescribed at 45-50% VO_2 max, vigorous was prescribed at 70-75% VO_2 max, and exercise sessions were supervised. Data was analyzed on a daily basis to assess the acute effects of the exercise bouts. During the last month of the intervention it was found that in the moderate intensity group, the average PAEE on days with exercise was higher than on days without exercise (577.7 $\pm$ 219.7 kcal/d vs. 450.7 $\pm$ 140 kcal/d P=.011). However, the difference was much smaller than the energy expended during the exercise bout (325 $\pm$ 80 kcal), suggesting that women expended less energy on activities outside of the exercise session when exercise occurred during the

day. Conversely, in the vigorous exercise group the average PAEE on days with exercise was lower than on days without exercise (450 $\pm$ 153 kcal/d vs. 519 $\pm$ 127 kcal/d P=0.47), energy expenditure during exercise (296.9 $\pm$ 93 kcal/d) was included into PAEE totals. These results suggest that both moderate and vigorous exercise induces a compensatory decline in PAEE. Vigorous exercise induced such a decline that PA on the days *without* exercise was greater than days *with* exercise. The impact of longer duration exercise or low intensity exercise on PA compensation is unknown.

Possible mechanisms for compensation

Rowland first coined the term 'ActivityStat' meaning an activity control center in the brain that regulates one's daily energy expenditure through motor activity (72). The concept of the ActivityStat suggests that there is a biological basis of physical activity. Claude Bernard in 1865 wrote that, "The human body must be so perfect that it continually compensates for and counterbalances external variations". The evidence in favor for this concept is increasing. In addition to the studies cited above, research on play in children provides further evidence. While it is not fully understood, it seems that play activity and behavior may be reflective of biologically driven physical activity(72). Play is greater in the young than in the old. A reduction in play has been documented in several species, including humans, as a period of food deprivation (72). It has been suggested that children diagnosed with ADHD may have frontal lobe dysfunction (72), proposing that physical activity is determined within the brain. Panksepp et al. (63)

found that experimental CNS lesions drastically effected activity levels of rats. Large lesions in the amygdala have shown to diminish spontaneous physical activity while septal lesions make rats more physically active.

Levine (49) has shown that when adults are overfed by an extra 1000 kcal/day for 8 weeks subjects displayed huge heterogeneity on compensatory physical activity levels ranging from -98 to +692 kcals/day. Suggesting that the body may be attempting to maintain homeostasis and when a perturbation presents itself biological feedback may occur. Levine (50) observed that obese individuals were seated for 164 minutes/day more than leaner subjects and lean subjects were upright for 152 minutes/day longer than obese subjects. Levine then had the obese subjects lose 8kg and the lean subjects gain 4 kg. Following the weight change both obese and lean subjects maintained their same allotment of postural allocation. This suggests that obese persons are not inactive due to their fat but that their activity levels are biologically set.

A genetic basis for physical activity supports the concept of an ActivityStat. Kaprio et al. (41) compared levels of physical activity in 1537 monozygotic and 3507 dizygotic adult male twins. Correlations for activity reached 0.57 in 1,537 pairs of monozygotic twins and 0.26 in 3,507 pairs of dizygotic twins. This signifies a significant heritability score of 0.62 for general physical activity.

Compensation could also be a result of increased skeletal muscle work efficiency opposed to decreased amount of motion per se (71). Research has shown an approximate 20% increase in skeletal muscle work efficiency at low levels of exercise (71).

Exercise induced fatigue is another possible mechanism for physical activity compensation. Stubbs et al (79) proposed that fatigue was a significant contributor to the compensatory decline of spontaneous physical activity. Westerterp (88) also support this idea showing that vigorous exercise had the greatest impact on physical activity compensation.

Profile of Mood State

One's mood may be defined as a host of transient, fluctuating affective states (54) that reveal how the individual feels at that specific time or altogether. Mood and physical health have been shown to be bi-directly related. Specific links between mood and health include influences on the immune system, health habits, and the onset and time-course of specific disease (56). Due to the pervasiveness of mood, the ability to self-regulate may be vital to establishing healthy habits and gaining personal happiness. A strong agreement exists between researchers that mood enhancement is a primary benefit of physical activity (5).

The Profile of Mood State (POMS) has been widely used as a measure of mood and how it relates to exercise. The original version of the POMS was developed in 1971 and contained 65 items; many shorter versions exist today. On all versions the

responders are asked to reply by rating each item on a 5-point Likert scale with end points ranging between “Not at all” to “Extremely”. The items form six distinct subscales: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment. Each subsection may be analyzed individually and a collective score is given to determine the total mood disturbance (TMD). There are four mode requirements that must be met to necessitate conducive mood alterations: 1) abdominal and rhythmical breathing, 2) relative absence of interpersonal competition, 3) predictable activities, and 4) repetitive movements (5).

Hansen, Stevens, and Coast (28) recruited 21 college female students to determine the duration of exercise needed to alter mood state. The female participants were given a PAR-Q to screen for any contraindications to exercise. Participants were asked to complete the POMS before each of the four testing criteria. Each participant was randomly assigned to either sitting quietly for 30 minutes facing a window, a 10 minute cycle ergometer ride at 60% of max, a 20 minute cycle ergometer ride at 60% max, or a 30 minute cycle ergometer ride at 60% max. Each subject engaged in every activity. Following a ten minute cool down the POMS was re-administered. Researchers found that there was no significant improvement across all treatments within the categories of tension, depression, or anger. There was however a significant decrease in fatigue and confusion along with a significant improvement in vigor across all treatments. The Total Mood Disturbance score was significant ($p=.003$). There was not a dose-response

relationship found with regards to mood. The researchers concluded that as little as ten minutes of exercise may provide some measure of psychological benefits within the given population.

Other modes of exercise have been shown to necessitate a mood response. Lane, Crone, and Lane (46) recruited 26 females (mean age 34 yr) and had them perform two resistance training sessions separated by one week. The POMS was administered following each exercise session. Following the first session fatigue was statistically increased ($p<.01$); interestingly fatigue was statistically lowered after the second session. Depression was statistically lowered after both sessions of exercise ($p<0.5$). Researchers concluded that exercise does indeed influencemood.

Moderate exercise intensity has been shown to be superior to either high or low intensity to elicit a favorable response in mood (6), little data exists as to the impact that low-intensity exercise may have on mood. Also the possible mechanisms of the mood altering response of exercise are only speculative. It is likely that the response is a result of intertwining physiological and psychological mechanisms.

The POMS has been utilized extensively in research involving exercise and mood. Between 1991 and 1996 there were more than 80 studies involving the use of the POMS (6). The POMS has been found to be valid and reliable (46).

Conclusion

The act of being physically inactive has many deleterious effects on normal human physiology. CVD is one of these areas that have been associated with increased risk as higher levels of sedentary behavior occur. One modifiable risk factor for CVD is elevated blood pressure. It has been shown that blood pressure reduction may be expressed through incorporating lifestyle interventions such as walking. The walking workstation could be an invaluable tool utilized within the workforce to lower blood pressure in prehypertensive or hypertensive populations.

Chapter 3

METHODS

Participants and Study Design

25 male/female volunteers between the ages of 25 and 55 y were screened for resting blood pressure, sedentary behaviors, and physical activity levels. Prehypertensive individuals were recruited for this study. Prehypertension is defined as 1) having a mean systolic blood pressure $\geq$120 mm Hg and <140 mm Hg, or 2) having a mean diastolic blood pressure $\geq$80 mm Hg and <90 mm Hg measured by auscultation (9). Subjects were not meeting the physical activity guidelines and had to have a sedentary job that required them to sit for the majority of the day. Participants were recruited through word of mouth and fliers posted at ASU campuses (Appendix A). All procedures were evaluated and approved by the ASU Institutional Review Board and written consent was obtained from subjects prior to participation (Appendix B).

A randomized cross-over experimental design with two treatments, 7 days apart, was administered to prehypertensive, sedentary, inactive individuals. A familiarization day took place before the treatments to acquire health history and baseline measurements (see Appendix A for flow chart of randomization). 24-hour blood pressure was monitored using an ambulatory blood pressure cuff (*Oscar 2* SunTech Medical, Morrisville, NC).

The control treatment consisted of subjects residing at their customary office from 0800h-1600h. Each was asked to perform his/her normal daily office activities. At the end of the work day a questionnaire to measure mood (POMS) was given. Blood pressure was taken automatically every 15 minutes throughout the day and at 1 hour intervals during the night. The following day the investigator collected the blood pressure cuff. Subjects were asked to wear accelerometers for a two week period, one week following the walking treatment and one week following the control.

The exercise treatment was identical to the control day except that subjects were asked to walk at a simulated office using the walking workstation at progressive intervals throughout the 8 hour day. Walking time began with 10 minutes and progressed to 30 minutes per hour for a total of 2.5 hours of walking over an 8-hour day. Walking speed was 1 mph for all participants. Participants were asked to not engage in any planned exercise. A food recall was administered to ensure that the same food was eaten on both treatments. Subjects were asked to wear an accelerometer.

Procedures

The procedures of the study consist of 1) Recruitment and screening blood pressure, sedentary behavior, and physical activity levels 2) Completing a Par-Q health questionnaire, 3) recording medications 4) Measuring height (cm), weight (kg), and body fat (BIA using Tanita; TBF-300WA, Tanita corporation of America, Inc., Arlington Heights, Il) 5) Familiarization of walking on treadmill, 6) Familiarization of 24 h

ambulatory blood pressure, 7) 8 hours of either control day or walking treatment day/wearing the accelerometer for 2 weeks. 8) Administering POMS and acceptability questionnaire. All procedures were conducted in the walking workstation laboratory and cubicles in the Nursing and Healthcare Innovation 2 building at Arizona State University downtown campus.

Sample size

Prior work on physical activity and 24-h ambulatory blood pressure reduction provided data for sample size calculations (27,29). The estimated sample size was 10 people to provide a 6 mm Hg reduction in systolic blood pressure over the 24 hour period in the walking workstation group. The alpha error for the primary end point was set at 0.05 and the beta error level at 0.2 (i.e., a power of 80% to detect a difference as large as 10%).

Blood Pressure Screening

For all participants, three blood pressure measurements were taken on two separate days; 3 d apart with an automated BP monitor (Dinamap® PRO 100 Vital Signs Monitor, GE Healthcare) according to the protocol described by the World Health Organization (90). On the first day blood pressure was taken in both arms. The arm with the highest blood pressure was used for screening on the second day. Six total measurements were averaged together. Exclusion criteria included: 1) known coronary

artery disease, 2) orthopedic limitations for performing physical activity, 3)obesity to the extent that the ambulatory monitor could not fit the subject properly.

A brief physical activity questionnaire was also administered to ensure that subjects were inactive (<150 min of moderate exercise/week) and sedentary for most of the day (Appendix C).

Treatment Groups

Participants were randomly assigned to the non-activity day or the walking day. 7 days later the participants underwent the other treatment. The control day was conducted at the participant's office from 0800 h – 1600 h. The ambulatory blood pressure cuff was worn from 0800 h- 0800 h the next day. The POMS was administered at the end of the day. Subjects were asked to wear the accelerometer for a 2 week period to measure total physical activity.

The activity treatment day was identical to the control day except that subjects were asked to walk at the simulated office using the walking workstation at progressive intervals throughout the 8 hour day. Subjects walked on the walking workstation each hour (8 times) throughout the day for a total of 2.5 hours in the 8 hour period. Walking time progressively increased from 10 minutes to 30 minutes throughout the day. Walking speed was 1 mph for all participants. When subjects were not walking they were asked to be seated. Table 2 outlines the walking time progression over the 8 hour day. Subjects wore accelerometers during this period.

Table 2:

	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 5	Hour 6	Hour 7	Hour 8	Total
Clock Time:	850 -900	950 - 1000	1045 1100	1145 – 1200	1200 - 1230	1240- 1300	1320- 1340	1400 - 1430	1530 - 1600	8:00am to 4:00pm
Walking Time	10 min	10 min	15 min	15 min	LUNCH	20 min	20 min	30 min	30 min	150 min or 2.5 hr

Ambulatory Blood Pressure Monitoring

The *Oscar 2* ABP System (SunTech Medical, Morrisville, NC) was used in this study. The Oscar 2 has been validated in accordance to the standards of British Hypertension Society, European Society of Hypertension International Protocol and the Association for Advancement of Medical Instrumentation (20). The intra-class correlation coefficient for 24 h ABP monitoring is estimated at 0.95 for SBP and 0.90 for DBP (47). The non-dominant arm was used in all participants. The *Oscar 2* was programmed to take measurements every 15 minutes throughout the day (0600 to 2200 h), and every 60 minutes throughout the night (2200-0600 h). One repeat measurement was taken if the first measurement was unsuccessful during the daytime and two repeat measurements were taken if needed during the night time. The inflation of the cuff for each measurement was 30 mm Hg greater than the previous reading. The cuff deflation rate was set at 3 mm Hg per second. The participants were instructed to 1) abstain from

exercise (outside of what was prescribed), 2) not to take a shower while wearing the machine, 3) to relax and straighten out the arm during the blood pressure measurement, and 4) remove device and turn off the ambulatory blood pressure monitor at 800 am and 5) Meet with investigator and return cuff by 900 am.

Ambulatory Blood Pressure Data

All data were manually reviewed for missing and erroneous readings. Data were purged if: 1.) Data was missing, 2.) Systolic blood pressure was lower than diastolic blood pressure, 3.) Systolic blood pressure was >240 mm Hg or <50 mm Hg, 4.) Diastolic blood pressure was >140 mm Hg or <40 mm Hg, 5.) Heart rate was >150 beats·min, or <40 beats·min, 6.) Systolic and diastolic blood pressure deviated $\pm$ 50 and $\pm$ 20 mm Hg, respectively, from surrounding values, and 7.) Heart rate deviated $\pm$ 30 beats·min from surrounding values.

Accelerometer

All subjects wore the GT3X plus activity monitor (Pensacola FL, USA) for a period of 2 weeks, one week following the control day and one week following the walking day. The device is approximately the size of a pager that is worn over the right hip. The subjects were instructed not to remove the device except when sleeping, bathing or showering. Activity counts were accumulated over 60-s epochs during the 14 days. Data were collected in units of acceleration. Data were only included when there were valid data from the control day and the walking day. Minimum wear time was set at 600

minutes for a day. Non-wear time was excluded from the analysis. Freedson cut-off points were utilized to analyze time in a physical activity category (<100 counts/minute is classified as sedentary, 100-1952 is classified as light, and >1952 is classified as moderate to vigorous physical activity) (19). Total counts were divided by the time worn to compare within person between treatments. Time periods that were analyzed comprised of: work time (9-4 pm), post work time (4-10 pm), full day (9-10pm), and whole week.

Walking Workstation Apparatus

The walking workstation (Details, A Steelcase Company, Grand Rapids, MI) that was utilized is a commercially available product that consists of a height-adjustable desk with an integrated treadmill. The height of the desk is adjustable from 56-116 cm above the treadmill and the desktop is 99 cm wide by 69 cm deep. The treadmill speed is adjustable from .48 to 3.20 km/h. There was a phone and laptop on the workstation desk.

Subjective Measures

The Profile of Mood State (POMS) was administered at the end of each treatment to measure distinct psychological mood states. The POMS is comprised of a 65-item questionnaire that assesses a person's mood–e.g., anger, anxiety, confusion, depression, fatigue, vigor, (see Appendix C). The POMS has been found reliable and valid (46).

An online questionnaire assessing acceptability of workstation was given to all participants at the end of the walking day (Appendix D).

Statistical Analysis

All statistical analyses were done using SPSS software version 19 (SPSS 19.0 IBM Corporation, Armonk, New York, USA). Data are expressed as means $\pm$ the standard deviation (SD). Data was analyzed for normality and values with skewed distribution were transformed to achieve normality ($p>.05$). Descriptive statistics was used for the demographics of the subjects. All *P* values were calculated assuming two-tailed hypothesis; $P<0.05$ was considered statistically significant. Statistical analysis included ABP data collected from 9:00 am until 10:00 pm of the same day (nocturnal blood pressure was not analyzed because of too many missed readings). Time periods of *during work* (9:00 am until 4:00 pm) and *post work* (4:00 pm until 10:00 pm) were analyzed separately. Linear mixed models were used to detect differences in systolic and diastolic BP by treatment condition over the entire measurement period. The analysis was conducted in a hierarchical fashion using Restricted Maximum Likelihood model and 'variance components' covariance error structure. Both fixed and random effects were explored in the model. Treatment condition and time were used as fixed effects and time was also used as a random effect during daytime and all day analysis, not the post work analyses, to account for both interindividual and diurnal variations in ABP. Addition of age, gender, Body fat, and body mass index did not improve the model fit and were therefore not used as covariates. One way ANOVA was used to test for baseline BP differences. Post hoc analyses were performed using the Bonferroni

adjustment for multiple comparisons. Chi-Square tests were used to compare frequency differences in BP load between the two trials. Pairwise comparisons in frequency differences were made using the z-test and Bonferroni correction was applied in the statistical software to appropriately adjust for the P-value. Paired t-tests were used to compare differences in POMS scores. Paired t-tests were also used to compare average counts and time spent in activity classifications within person by treatment for the different measurement points: work day (9-4 pm), post work day (4-10 pm), full day (9-10 pm), and full week.

Chapter 4

RESULTS

Twenty-five subjects were screened for this study and 9 met the prehypertension and physical activity criteria. Seven of the 9 subjects completed the study. Two were dropped from the analysis due to equipment failure. Subject characteristics are summarized in table 3.

TABLE 3. Demographic information of subjects (mean ± SD).

Sex (men/woman)	3/4
Age (years)	42± 12.0
Height (cm)	170± 11.6
Weight (kg)	72± 18.8
BMI (kg/m^2)	24± 5.6
Body fat (%)	25± 11.0
Resting SBP (mmHg)[a]	127± 8.0
Resting DBP (mmHg)[a]	83+ 8.4

[a]Average of 6 screening blood pressures. (n=7).

There were no significant differences in baseline systolic (p=.073) or diastolic (p=.704) BP. Mean (± SE) systolic and diastolic BP were significantly lower during the walking treatment compared to the control day (126 ±7mmHg vs. 124 ±7mmHg, p=.043; 80±3mmHg vs. 77±3mmHg p<.001, respectively), (See Figure 6A and 6B). There were no significant differences in SBP (p=0.090) during the work day (9am-4pm) on the walking treatment when compared to the control. DBP was significantly (p=0.01) reduced during the work day (9am-4pm) on the walking treatment compared to the control. Post workday (4pm- 10pm) SBP significantly decreased 3 mmHg (p=.017) and

DBP decreased 4 mmHg ($p<.001$) following walking. Nocturnal BP was not analyzed because of too many missed readings. BP load (defined as wake time BP>140/90 mmHg) was not significantly different for SBP. There was however 13.6% of the control readings above 140 mmHg compared to 11.3% of the treatment readings above 140 mmHg. DBP load was significantly different ($p=.05$). There were 11.3% of the control readings >90 mmHg versus 6.6% of the treatment readings >90 mmHg. See figure 7A & 7B.

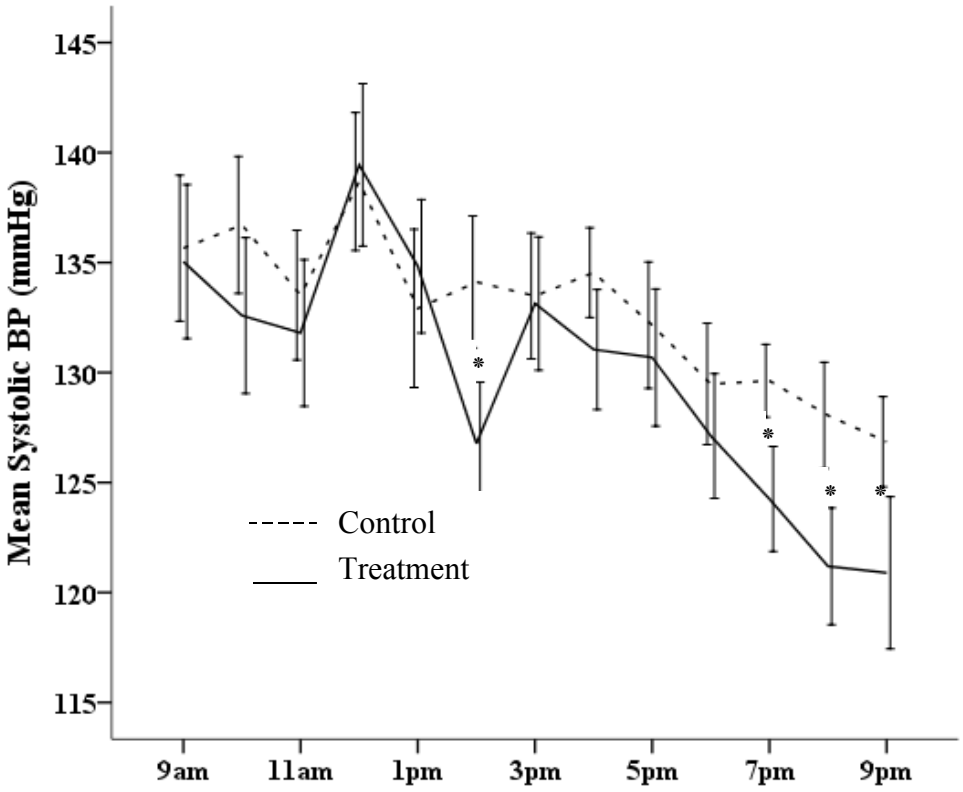


Figure 6A- Pattern of SBP across 12 h comparing the control day and the exercise treatment.Error bars represent $\pm$1SD.*Symbolizes $p<0.05$.

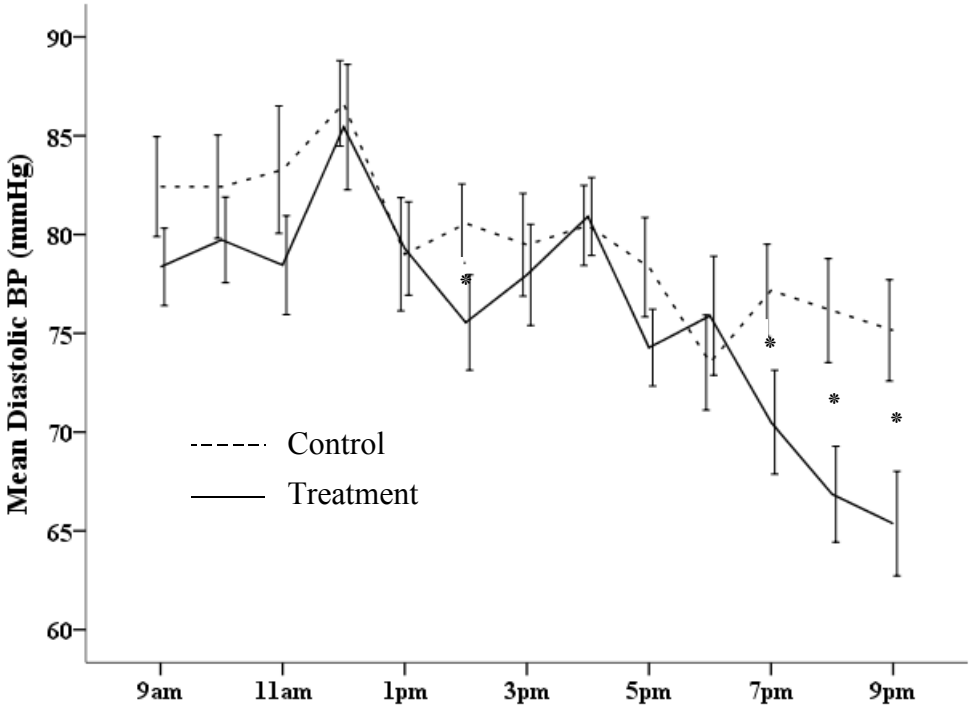


Figure 6B- Pattern of DBP across 12 h comparing the control day and the exercise treatment.Error bars represent ±1SD.*Symbolizes $p<0.05$.

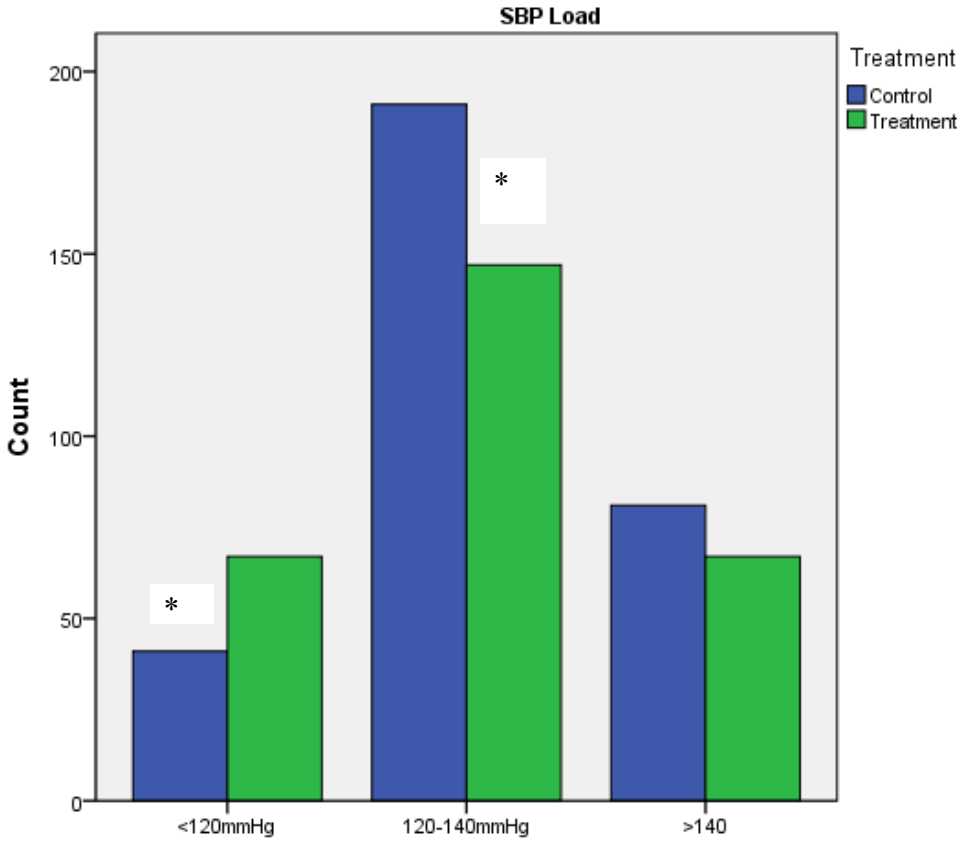


Figure 7A-SBP load, number of SBP<120 mmHg and >140 mmHg from the time period of 0900-1000. * $p<0.05$.

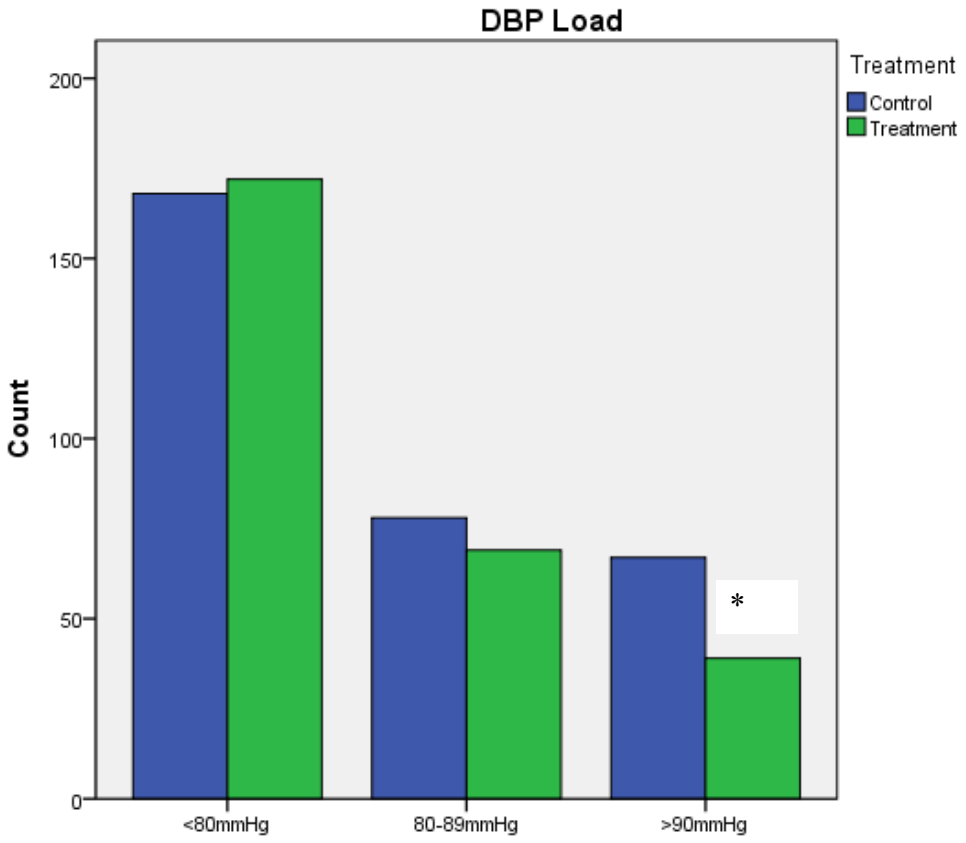


Figure 7B-DBP load, number of DBP<80 mmHg and >90 mmHg from the time period of 0900-1000.*p<0.05

There was significant difference between total activity counts (p=0.041) and steps (p=0.001) during the work day (9am-4pm) in favor of the treatment condition. However, average wear time during the treatment day was 37 minutes longer (p=0.027) when compared to the control day. Therefore, when averaging the counts and steps (counts and steps/time worn) statistical significance is lost for total counts (p=0.126) but maintained

for steps (p=0.001). There were no statistical difference between the condition on any other factor. One outlier was removed from the analysis. See table 4 for specifics. There was no significant difference in sedentary behavior between interventions during the post work time period (4pm-9pm, 80.9% vs. 80.6% p=.937). There was a significant correlation between the intervention week and the control week (r= .870, p=.05).

The amount of time in each activity level during the treatment day is shown in table 5. All 7 subjects were used for this analysis. There is a discrepancy between actual monitored activity and what was recorded on the activity monitoring devices. Total time in light activity, the activity that 1mph walking would be classified as, was 80.8 minutes, the actual monitored activity was for 150 minutes.

Table 4. Accelerometer data. Comparisons between control and treatment. (N =5).

Time period	Mean Control	Mean Treatment	Difference (SD)	Sig (2-tailed)
Total counts whole day	15386	187541	33674 (± 61046)	.285
Total time worn	812.2	861.4	49.20 (±96.8)	.319
Total daily steps	4074.2	6213.6	2139.70 (±1247.7)	.019*
Work day sedentary time	407.6	400.0	7.7 (±37.7)	.673
Work day light activity	40.0	78.4	38.4 (±45.0)	.129
Work day lifestyle activity	17.5	17.9	.47 (±3.2)	.759
Work day moderate	13.1	19.5	6.4 (±10.9)	.258
Work day total counts	82467.0	11365.0	31183 (±23521.8)	.041*
Work day steps	2229.0	4118.8	1889.8 (±514.9)	.001*
Work day time	478.7	516.0	37.3 (±24.6)	.027*
Avg. work day counts	170.9	219.5	48.6 (±56.4)	.126
	4.7	8.0	3.3	.004*

Avg. work day steps			(±1.2)	

Time period	Mean Control	Mean Treatment	Difference (SD)	Sig (2-tailed)
Post work day light activity	32.9	34.8	1.9 (±11.7)	.729
Post work day moderate	11.63	10.0	1.6 (±8.81)	.699
Post work day total counts	66002.8	61111.4	4891.4 (±40174.5)	.799
Post work day steps	1670.4	1678.6	8.20 (±925.32)	.985

During work Treatment day Descriptive		
Activity	Mean	SD
Sedentary time	397.21	52.18
Light activity time	80.80	52.18
Lifestyle activity time	18.33	8.02
Moderate activity time	15.9	6.7
Counts	103156.43	37631.22
Steps	3666.71	1206.96

Table 5. Time in activity categories during the working treatment day. (n=7).

There were no significant differences between any of the 6 indices of mood. See Table 6.

Profile of Mood State				
	Control score	Treatment score	Mean difference (SD)	P value
Tension	5.2	6.4	1.2 (± 4.32)	.569
Vigor	12.8	12.4	.4 (±6.27)	.893
Confusion	7.8	7.0	.8 (± 2.39)	.495
Depression	4.6	1.8	2.8 (± 5.36)	.285
Anger	2.4	2.4	0 (± 2.55)	.99
Fatigue	2.6	1.0	1.6 (± 12.6)	.180

Table 6.Profile of Mood State, comparison between 2 treatments. (N=6).

Qualitative data

100% of participants stated that they would recommend the walking workstation to a friend. 90% stated that the workstation had a neutral impact or a positive impact on work productivity and quality. 100% of the participants stated that the workstation increased their desire to improve their health. 75% thought that the workstation increased their ability to improve their health.

Chapter 5

DISCUSSION

The main finding of this study was that 2.5 hours of fractionalized walking at 1mph on a walking workstation throughout an eight hour work day significantly decreased SBP and DPB when compared to a control non-walking day in prehypertensive men and women. This significant BP lowering effect was seen when examining both total day (9am-10pm) BP and post work day (4pm-10pm) BP. During the actual work day (9am-4pm) ambulatory SBP was not significantly lower during the intervention whereas DBP was statistically lower during the intervention day compared to the control condition. While the subjects did wear the ABP cuffs during sleep, there were too few acceptable readings to conduct comparisons between treatments. Not having sleeping BP measurements may have contributed to an underestimation of the overall effect. In fact, the reductions in SBP and DBP appeared to continue and perhaps increase beyond 10 pm. Bhammar et al. (7) compared a 3 x 10 protocol (3 separate sessions of 10 minutes each) to a 1 x 30 protocol (1 continuous 30 minute exercise session) and its effects on ABP. They found that the greatest decrease in response to the 3 x 10 protocol was exhibited at night. However, it is unknown from this study if the intervention actually lowered sleeping BP measures.

Angadi et al (3) and Bhammar et al. (7) both recently showed fractionalized exercise to be superior to a single bout in eliciting a lowered SBP response. It has also

been shown that an accumulation of physical activity over the course of a day (4 10 minutes exercise sessions at 50% V02 peak) caused a longer duration of PEH compared to a single exercise session (40 minutes at 50% $V0_2$ peak) (65), suggesting that this accumulation per se could be beneficial. In the current study subjects were asked to walk every hour throughout their work-day, thereby receiving fractionalized physical activity bouts. The length of BP reduction is vitally important and could be the most important factor clinically for subjects with elevated BP (52). Our study showed a significant decrease for SBP for 6 h and for DBP the decrease was seen over the whole day. It is important to note that we were not able to analyze nocturnal BP do to missed readings during this time period. The trend of reduction however appears that we may have underestimated our finding. The graph lines show a widening as the time after the last walking period increases. Bhammar et al. (7) saw the greatest reductions during this nocturnal period.

In addition, this study also enforces the importance of duration opposed to intensity on PEH. Our subjects walked a total of 150 minutes at 1mph over the course of a day. This finding would agree with previous literature on the subject (18).

Furthermore, Jones et al (39) showed that the acute hypotension effects of exercise performed in the morning is not as favorable as exercised performed later in the day. This was accounted for by back loading the amount of walking performed so that two times the amount of walking was completed after 12pm. This is possibly why the BP

analyzed later in the day tends to have greater reductions than the BP examined earlier in the day.

An interesting finding from our study was the significant decrease in DBP. DBP reductions were greater than SBP reductions during all time periods that were analyzed. Typically DBP reductions are minimal following exercise or not seen at all. Guidry et al (22) found a slight advantage of longer duration exercise bouts (30 minutes compared to 15 minutes) on DBP. It could be that the long duration of some of the walking session had a greater impact on DBP versus SBP.

Blood pressure load has been associated with adverse cardiovascular risk and target organ damage independent of average systolic ABP values (94). There was a non significant 3% difference between the two conditions of the SBP readings that were below 140 mmHg. There was however a significant 4.5% difference between conditions of the DBP. Zachariah and Summer (94) showed that DBP load was the only ambulatory blood pressure measure that significantly correlated with left ventricular mass index. The significant reduction that the current study showed in DBP load could be clinically important.

The current study showed a significant increase in steps during the work hours (9am-4pm) but failed to show an increase in physical activity counts. Such low intensity as 1mph walking could be consequently counted as sedentary time, thus accounting for the lack of difference when comparing times in each activity category. The activity was

monitored and totaled 150 min of low intensity walking. Average time spent in low intensity activity for the treatment day was 80.8 minutes. There is a discrepancy from the devices and what was actually done. Thus, the subjects in the walking day walked for 150 minutes compared to the subjects at their office got only 40 minutes in this activity category, accounting for an increase of 110 minutes on the treatment day. Behavior patterns from the subjects following the walking (4pm-10pm) were not statistically different, suggesting that compensation did not occur following the walking treatment. A strength of the study was that an objective measure of physical activity behaviors between the two days was examined by accelerometery. Most studies of this nature utilize PA questionnaires to assess physical activity behavior. It could be postulated that when the participants went home after walking they could have increased their time spent in sedentary behavior due to fatigue or compensation. If that were the case than the mechanism for the effect may not be due to the walking but the change physical activity behavior following the walking. Taking into account the accelerometer data, this is very unlikely. Time spent in sedentary behavior following walking (4pm-10pm) was virtually identical between the two treatments (80.9% vs. 80.6%).

It is interesting however that when examining the data over the course of two weeks (one week following the control and one week following walking) there is a significant correlation of R=.870 (p=0.05). Suggesting that individuals remain relatively constant in the amount of physical activity they engage in regardless of an acute

perturbation being placed in their week. This also suggests that activity outside of the intervention on the treatment and control day were more than likely similar.

Mood changes may prove to be important if this type of intervention were to be used chronically. Even with improved health parameters, if mood is adversely affected individuals may not utilize walking workstations at work. Having said this, mood was not different in any of the six mood categories between treatments. Again this may be due to the small sample size. However, this suggests that walking on the workstation over the course of a work day did not adversely affect one's mood while at the same time decreasing their BP. Further studies will have to be done to study the effects that the walking workstation may have on mood markers while at work.

Overall the subjects gave positive subjective data in response from using the workstation. Following are some statements and phrases from the subjects: "I do feel that physical activity stimulated my mind throughout the day", "by the end of the day I felt comfortable typing and using the mouse and felt that walking did not affect my ability to work or concentrate. As I worked…I nearly forgot I was doing anything physical", "I would like to have one in my office" and "great method to improve focus and avoid sitting all day". Clearly they reported that the workstation was *not a nuisance* and that they thought that they would increase their health by using it. While mood was not enhanced by the intervention, it is also clear that the intervention did not seem to adversely affect one's mood throughout the day.

There are some weaknesses of the study. The original sample size needed to adequately power the study was calculated to be 10 subjects. However because of issues with scheduling of the machinery the study was completed with seven. Regardless, the intervention did result in a statistically significant reduction in BP with 7 participants. This can be interpreted to mean that there was a strong intervention effect. Additionally, subjects were not prompted to record their posture every time the cuff inflated. However, this failing was overcome as the subjects all wore accelerometers for 2 weeks during the study. This allowed for assessments of "usual" or normal daily activity to be compared with the control and intervention condition. Lastly, the subjects completed the two intervention at different sites. It could be that the subjects were more relaxed away from their work area thus accounting for some blood pressure reductions. This is unlikely, the subjects reported no difference on the POMS survey and most of the reduction was seen after work when the subjects would be at home. Diet was asked to be similar between the two interventions and a diet recall survey was given so the subjects could record what they ate plan accordingly for the next condition. After analyzing the subjects diet recall surveys, there was no difference on caffeine, alcohol, or salt intake, all of which could affect BP. There were several strengths of the study. First, the cross-over design limited between subject errors in interpreting the blood pressure responses. Also, using accelerometers clearly allowed for objective estimates of physical activity behavior

instead of subjective questionnaires. Lastly, all of the walking during the intervention was supervised which eliminated errors in determining the exercise dose.

In conclusion, walking at 1mph for an accumulated 2.5h over the course of an eight hour day significantly reduced systolic and diastolic blood pressure when compared to a control non-walking day. This type of program was seen as acceptable to the participants and they stated that they would utilize the walking workstation. Taking into account that perceived lack of time is a leading cause of physical inactivity, physical activity performed at work may be a viable option and should be further investigated.

It must be noted that a blood pressure reduction of 3-4 mm Hg (compared to control) could possibly reduce stroke mortality by up to 8%, reduce cardiovascular mortality by up to 5% and all-cause mortality by up to 4%. If this type of protocol could be shown to be effective long term and if it could be adopted population wide, then it would have clear public health benefit.

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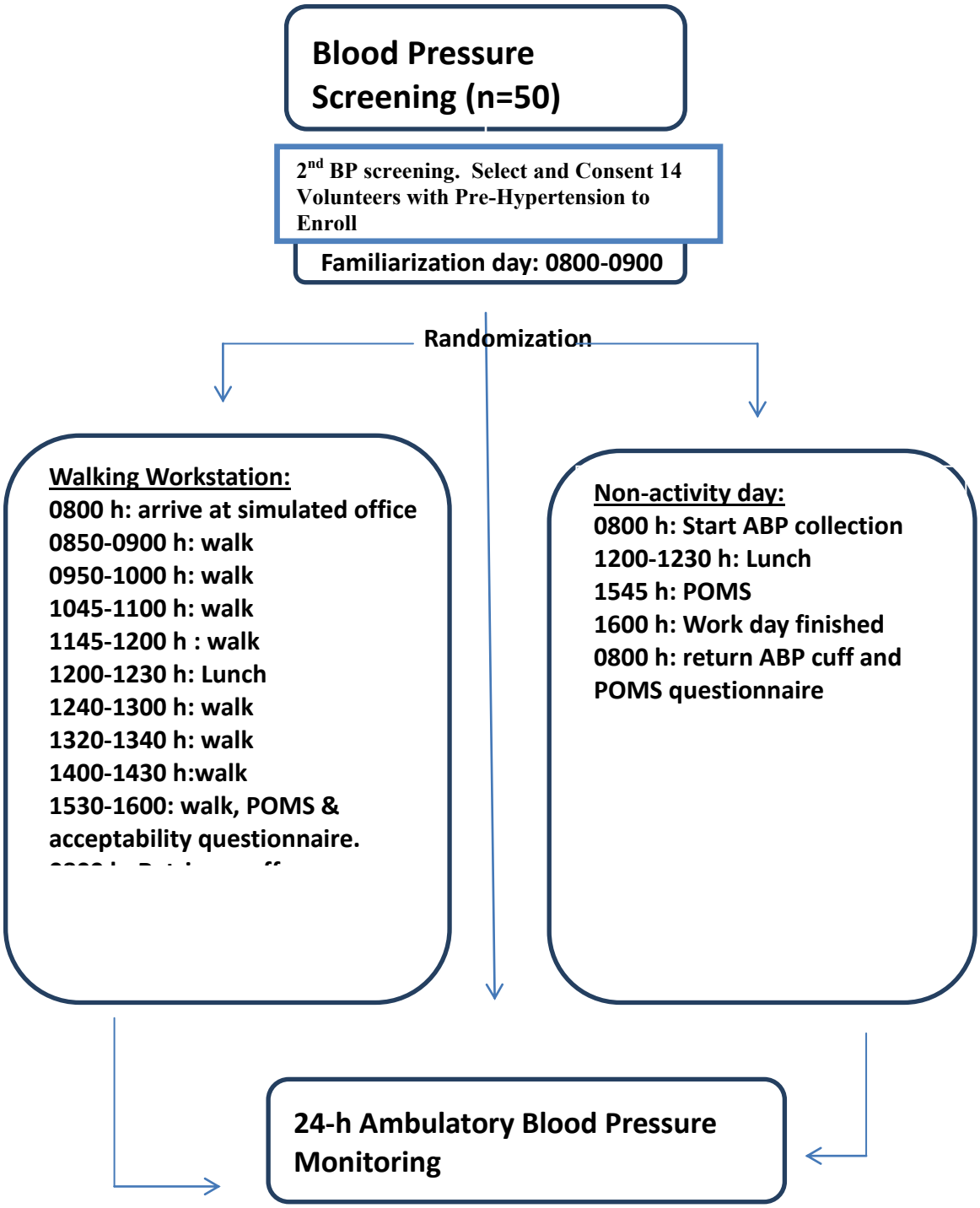
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APPENDIX A

TIMELINE AND RANDOMIZATION


Blood Pressure Screening (n=50)
2nd BP screening. Select and Consent 14 Volunteers with Pre-Hypertension to Enroll
Familiarization day: 0800-0900
Randomization
Walking Workstation:
0800 h: arrive at simulated office
0850-0900 h: walk
0950-1000 h: walk
1045-1100 h: walk
1145-1200 h : walk
1200-1230 h: Lunch
1240-1300 h: walk
1320-1340 h: walk
1400-1430 h:walk
1530-1600: walk, POMS & acceptability questionnaire.
Non-activity day:
0800 h: Start ABP collection
1200-1230 h: Lunch
1545 h: POMS
1600 h: Work day finished
0800 h: return ABP cuff and POMS questionnaire
24-h Ambulatory Blood Pressure Monitoring

APPENDIX B

INFORMED CONSENT

CONSENT FORM
Acute Affects of Walking Workstation on Ambulatory Blood Pressure in the Pre-hypertensive Population

INTRODUCTION
The purposes of this form are to provide you (as a prospective research study participant) information that may affect your decision as to whether or not to participate in this research and to record the consent of those who agree to be involved in the study.

RESEARCHERS
Zachary S. Zeigler, a Master's Degree student, and Pamela Swan PhD an Associate Professor in the School of Nutrition and Health Promotion at Arizona State University, have invited your participation in a research study.

STUDY PURPOSE
The primary objective of this study is to examine the affect of using a walking workstation over the course of an 8 hour day in a simulated office setting on 24-hour ambulatory blood pressure in men and women with pre-hypertension. A secondary aim is to evaluate how acceptable the walking workstation is to you.

DESCRIPTION OF RESEARCH STUDY
Following the first blood pressure screening your resting blood pressure value will be given to you. If the value is in the range considered pre-hypertensive (i.e., systolic greater than 120 but less than 140 or diastolic greater than 80 but less than 90) measure you will be eligible to participate. If you are eligible and decide to participate, then as a study participant you will join a study that will evaluate the effects of using a walking work station in the workplace on your 24 hour blood pressure changes. A walking workstation is a treadmill attached to a computer desk. The treadmill moves very slowly and allows you to use the computer as you walk. If you choose to participate you will be asked to complete three sessions: the first would only last one hour and will consist of a familiarization session to introduce you to the workstation and measurement procedures. The second two meetings will be eight hour office days, one at your personal office and one at the simulated office, that consist of either walking or not walking. The order of these two meetings will be randomly chosen and will be separated by 1 week.

The 'non-walking' day consists of a normal office day. You will be asked to be seated doing computer work for eight hours in your office setting. The 'walking' day consists of a normal office day but you will be asked to do some of your work while walking at 1 mph at the walking computer workstation. Each hour you will be asked to walk for

progressively longer intervals starting at 10 minutes and ending at 30 minutes for a total of 2 hours and 30 minutes over the course of the eight hour day. The Table below provides an example of the walking progression.

	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 5	Hour 6	Hour 7	Hour 8	Total
Clock Time:	850 - 900	950 - 1000	1045 - 1100	1145 – 1200	1200 - 1230	1240- 1300	1320- 1340	1400 - 1430	1530 - 1600	8 hours
Walking Time	10 min	10 min	15 min	15 min	LUNCH	20 min	20 min	30 min	30 min	150 min or 2.5 hr

Lunch will be provided each day. Over the course of the work day sessions you will be asked to complete questionnaires regarding your mood state and how you rate the walking workstation. You will also have a blood pressure cuff attached to your arm that will allow you to go through your day as normally as possible. You would be asked to wear the cuff for 24-hours from the time the session starts. The cuff will be programmed to activate every 15 minutes throughout the day, and every hour at night time. You will also be asked to wear an accelerometer for a two week period starting after the first eight hour day. An accelerometer is a tiny non-invasive device that attaches to the hip and measures bodily movement.

If you say YES, then your participation will last for three sessions. Session 1 is a 1 hour familiarization session to acquaint you with the walking workstation and to get baseline measurements before we start. Sessions 2 will be at your personal office, and session 3 will consist of coming to the NHI2 building on the downtown Phoenix ASU campus for eight hours (8:00 am – 4:00 pm). Approximately 14 subjects will be participating in this study.

RISKS

As with any research involving increased physical activity, there is some possibility that you may be subject to minimal risks. If you decide to participate in this study, then you may face a risk of increased fatigue or mild discomfort. You should wear shoes that are appropriate for walking to minimize the risk of foot discomfort from standing and walking.

BENEFITS

Although there may be no direct benefits to you, the possible benefit of your participation in the research is the possibility to change the sedentary nature of the workplace and increase overall health and wellbeing of office workers.

NEW INFORMATION

If the researchers find new information during the study that would reasonably change your decision about participating, then they will provide this information to you.

CONFIDENTIALITY

All information obtained in this study is strictly confidential unless disclosure is required by law. The results of this research study may be used in reports, presentations, and publications, but the researchers will not identify you. In order to maintain confidentiality of your records, Zachary S. Zeigler will assign a number to be used in place of your name. Once the study is completed your names' connection to this study will be destroyed.

WITHDRAWAL PRIVILEGE

It is ok for you to say no. Even if you say yes now, you are free to say no later, and withdraw from the study at any time. Your decision will not affect your relationship with Arizona State University or otherwise cause a loss of benefits to which you might otherwise be entitled.

COSTS AND PAYMENTS

There is no payment for your participation in the study. You will be provided parking if you need it for the days that you participate and you will be provided lunch.

COMPENSATION FOR ILLNESS AND INJURY

If you agree to participate in the study, then your consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury.

VOLUNTARY CONSENT

Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by Zachary Zeigler, (480)200-2416 or Pamela Swan, (602)827-2281.

If you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at 480-965 6788.This form explains the nature, demands, benefits and any risk of the project. By signing this form you agree

knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In signing this consent form, you are not waiving any legal claims, rights, or remedies. A copy of this consent form will be given (offered) to you.

Your signature below indicates that you consent to participate in the above study.

_____ _____
Subject's Signature Printed Name
Date

_____ _____
Other Signature Printed Name
Date
(if appropriate)

INVESTIGATOR'S STATEMENT

"I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided (offered) the subject/participant a copy of this signed consent document."

Signature of Investigator_____
Date____

APPENDIX C

PROFILE OF MOOD STATE

PROFILE OF MOOD STATES

Subject #_____ Date _____

Directions:
Describe **HOW YOU FELT TODAY** by circling the number after each of the words listed below:

FEELING	Not at all	A little	Mod.	Quite a bit	Extremely
Friendly	1	2	3	4	5
Tense	1	2	3	4	5
Angry	1	2	3	4	5
Worn Out	1	2	3	4	5
Unhappy	1	2	3	4	5
Clear-headed	1	2	3	4	5
Lively	1	2	3	4	5
Confused	1	2	3	4	5
Sorry for things done	1	2	3	4	5
Shaky	1	2	3	4	5
Listless	1	2	3	4	5
Peeved	1	2	3	4	5
Considerate	1	2	3	4	5
Sad	1	2	3	4	5
Active	1	2	3	4	5
On edge	1	2	3	4	5
Grouchy	1	2	3	4	5
Blue	1	2	3	4	5
Energetic	1	2	3	4	5
Panicky	1	2	3	4	5
Hopeless	1	2	3	4	5
Relaxed	1	2	3	4	5
Unworthy	1	2	3	4	5
Spiteful	1	2	3	4	5
Sympathetic	1	2	3	4	5
Uneasy	1	2	3	4	5

Restless	1	2	3	4	5
Unable to concentrate	1	2	3	4	5
Fatigued	1	2	3	4	5
Helpful	1	2	3	4	5
Annoyed	1	2	3	4	5
Discouraged	1	2	3	4	5
FEELING	**Not at all**	**A little**	**Mod.**	**Quite a bit**	**Extremely**
Resentful	1	2	3	4	5
Nervous	1	2	3	4	5
Lonely	1	2	3	4	5
Miserable	1	2	3	4	5
Muddled	1	2	3	4	5
Cheerful	1	2	3	4	5
Bitter	1	2	3	4	5
Exhausted	1	2	3	4	5
Anxious	1	2	3	4	5
Ready to fight	1	2	3	4	5
Good-natured	1	2	3	4	5
Gloomy	1	2	3	4	5
Desperate	1	2	3	4	5
Sluggish	1	2	3	4	5
Rebellious	1	2	3	4	5
Helpless	1	2	3	4	5
Weary	1	2	3	4	5
Bewildered	1	2	3	4	5
Alert	1	2	3	4	5
Deceived	1	2	3	4	5
Furious	1	2	3	4	5
Effacious	1	2	3	4	5
Trusting	1	2	3	4	5
Full of pep	1	2	3	4	5
Bad-tempered	1	2	3	4	5
Worthless	1	2	3	4	5

Forgetful	1	2	3	4	5
Carefree	1	2	3	4	5
Terrified	1	2	3	4	5
Guilty	1	2	3	4	5
Vigorous	1	2	3	4	5
Uncertain about things	1	2	3	4	5
Bushed	1	2	3	4	5

APPENDIX D

PRODUCTIVITY SURVEY

Productivity Assessment

***1. Please Insert your study participation number (e.g. 001)**

2. What is your gender?

- ◯ Male
- ◯ Female

3. Which of the following age categories best describes your age?

◯ 18 - 29 ◯ 30 - 39 ◯ 40 - 49 ◯ 50 - 59 ◯ 60 - 69 ◯ >70

***4. What is your ethnicity**

- ◯ Hispanic or Latino
- ◯ Not Hispanic or Latino
- ◯ Prefer not to answer

5. What is your race?

- ◯ American Indian or Alaskan Native
- ◯ Asian
- ◯ Black or African American
- ◯ Native Hawaiian or Other Pacific Islander
- ◯ White or Caucasian
- ◯ Other

6. What was your highest education level completed?

- ◯ Less than 7th grade
- ◯ Junior high/ middle school
- ◯ Some high school
- ◯ Completed high school
- ◯ Some college or vocational training
- ◯ Completed college or university

7. How would you describe your overall health?

◯ Excellent ◯ Good ◯ Average ◯ Fair ◯ Poor ◯ Unknown

10. Please indicate all tasks, if any, that you engage in during the session

- [ ] Process E-mail
- [ ] Create/ Review documents, spreadsheets, and/or presentations
- [ ] Enter data or database management
- [ ] Read or research on the internet or other online source
- [ ] Review class materials or studying for class
- [ ] Phone calls, conference calls

Other (please specify)

11. What percent of time do you spend doing each of the above marked tasks? (Your answer should add up to 100%)

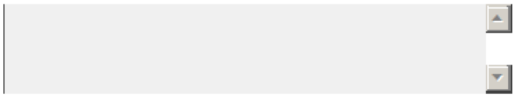
12. Please select the response that most closely reflects your feedback.

	Highly Decreases	Decreases	No impact/ Neutral	Increases	Highly Increases	Not Applicable
Overall my use of the Walk Station impacts my WORK QUALITY	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my WORK PRODUCTIVITY.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my ABILITY TO FOCUS ON MY WORK.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my SATISFACTION WITH MY WORKPLACE.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my KNOWLEDGE OF HEALTH.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my DESIRE TO IMPROVE MY HEALTH.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my ABILITY TO MAINTAIN MY HEALTH.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my ABILITY TO CONTROL MY WEIGHT.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my STRESS LEVEL.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my RISK FOR GETTING INJURED.	◯	◯	◯	◯	◯	◯
Overall my use of the Walk Station impacts my PAIN AND DISCOMFORT WHEN PERFORMING WORK TASKS. Note: Please select "Not Applicable" if you do not experience pain and discomfort. Possible causes of discomfort are overuse or existing injuries.	◯	◯	◯	◯	◯	◯

13. I would recommend use of the Walk Station to a friend or colleague who is interesed in increasing his or her physical activity level.

◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly Agree ◯ N/A

14. Please share any general comments you would like to make about the Walk Station.



APPENDIX E

RECRUITMENT FLYER

Working Adults…

Problem:

Do You sit at a desk all day?

HAVE No time to exercise during your work day?

Solution:

WALK AT WORK!

Recruiting Now for a Research Study

Effects of Light Intensity Walking On Ambulatory Blood Pressure

Who: **Healthy non-smoking Men and Women aged 25-50**

Eligibility: **Slightly elevated resting blood pressure (we will screen)**

- Systolic 120-139 mmHg or diastolic 80-90 mmHg
- Not on blood pressure control medication
- No restrictions for participating in physical activity

What: Requires 3 visits – Downtown Phoenix ASU Campus-NHI2 building

- Visit 1: Orientation session
- Visits 2 & 3 8 hours (1 work day) each
  - You will be asked to perform your normal office desk tasks (computer, telephone) while walking on a treadmill walking-workstation at very slow speeds for 10 – 30 minutes each hour (total = 2.5 hours per 8 hour day)
  - You will be asked to wear a blood pressure monitor for 24 hours for visit 2 &3.

Benefits: **Will be given a health assessment & personalized exercise program**

Contact: **Zachary Zeigler** zzeigler@asu.edu **480-200-2416**

APPENDIX F

PHYSICAL ACTIVITY SCREENER

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do aspart of their everyday lives. The questions will ask you about the time you spent beingphysically active in the **last 7 days**. Please answer each question even if you do notconsider yourself to be an active person. Please think about the activities you do atwork, as part of your house and yard work, to get from place to place, and in your sparetime for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous**physical activities refer to activities that take hard physical effort and make you breathemuch harder than normal. Think *only* about those physical activities that you did for atleast 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ days per week
   No vigorous physical activities ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ hours per day
   _____ minutes per day
   __ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate**activities refer to activities that take moderate physical effort and make you breathesomewhat harder than normal. Think only about those physical activities that you didfor at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis?Do not include walking.

   _____ days per week
   No moderate physical activities ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

   _____ hours per day

_____ **minutes per day**
__ Don't know/Not sure

Questionnaire continued on next page…

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002

Think about the time you spent **walking** in the **last 7 days**. This includes at work and athome, walking to travel from place to place, and any other walking that you might dosolely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutesat a time?

   _____ **days per week**
   No walking ***Skip to question 7***
6. How much time did you usually spend **walking** on one of those days?

   _____ **hours per day**
   _____ **minutes per day**
   __ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7days**. Include time spent at work, at home, while doing course work and during leisuretime. This may include time spent sitting at a desk, visiting friends, reading, or sitting orlying down to watch television.

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

   _____ **hours per day**
   _____ **minutes per day**
   __ Don't know/Not sure

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

APPENDIX G

SEDENTARY BEHAVIOR QUESTIONNAIRE

91

SEDENTARY BEHAVIOR QUESTIONNAIRE
CARDIA VIII—Year 25 Exam

H91EXDAT ***H91SDATE***
Exam Date: ___ ___/___ ___/___ ___ ___ ___ **OR** Same Date Blood Pressure Taken ❑

On a typical <u>WEEKDAY</u>, how much time do you spend (from when you wake up until you go to bed) doing the following? Please check one answer per question.

SEDENTARY BEHAVIOR: Weekday

	None	15 min. or less	30 min.	1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.	6 hrs. or more
1. Sitting while watching television (including videos on VCR/DVD). ***H91WKTV***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
2. Sitting while using the computer for non-work activities or playing video games. ***H91WKCP***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
3. Sitting while doing non-computer office work or paperwork not related to your job (paying bills, etc). ***H91WKPAP***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
4. Sitting listening to music, reading a book or magazine, or doing arts and crafts. ***H91WKMUS***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
5. Sitting and talking on the phone or texting. ***H91WKPH***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
6. Sitting in a car, bus, train or other mode of transportation ***H91WKCAR***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐

___ ___ ___ INTERVIEWER ID ***H91IVID***

On a typical WEEKEND DAY, how much time do you spend (from when you wake up until you go to bed) doing the following? Please check one answer per question.

SEDENTARY BEHAVIOR: Weekend Day

	None	15 min. or less	30 min.	1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.	6 hrs. or more
7. Sitting while watching television (including videos on VCR/DVD). ***H91WNTV***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
8. Sitting while using the computer for non-work activities or playing video games. ***H91WNCP***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
9. Sitting while doing non-computer office work or paperwork not related to your job (paying bills, etc). ***H91WNPAP***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
10. Sitting listening to music, reading a book or magazine, or doing arts and crafts. ***H91WNMUS***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
11. Sitting and talking on the phone or texting. ***H91WNPH***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐
12. Sitting in a car, bus, train or other mode of transportation ***H91WNCAR***	1☐	2☐	3☐	4☐	5☐	6☐	7☐	10☐	11☐

APPENDIX H

DIETARY RECALL

Dietary Recall

Breakfast: Time:

Snack: Time:

Lunch: Time:

Snack: Time:

Dinner: Time:

APPENDIX I

ACCELEROMETER INFORMATION AND TRACKING

General Information about the accelerometer

The accelerometer is used to measure your level of physical activity.

Please wear the accelerometer ALL the hours you are **awake** for the next **seven** days in a row starting from midnight tonight.

Today's date is: _____

- Put the monitor on first thing **tomorrow morning** when you wake up, and take it off at night for bed. Put the sensor somewhere safe, where you will see it in the morning and put it on again right away when you awake.
- The sensor needs to stay dry, so take it off to shower, take a bath or swim. Make sure to put the sensor back on when you are done. If you take the sensor off for more than 20 minutes for any reason during the day, write down what time you took it off and back on and why you did so in your booklet (e.g. swim).
- Please log in your booklet the time you put the sensor on in the morning, any times where you take the unit off for more than 20 minutes, and the time you take the sensor off at night.
- Be careful when changing clothes, going to the bathroom or other types of activities where you could drop the sensor. Please remember when changing your clothes to move the sensor to your new set of clothes.

- It is very important that you go about your normal, everyday activities this week, and you do not make changes to your routines. You should do your daily activities just as you would without the sensor.
- The sensor may or may not have a blinking light; this light does not indicate whether it is or is not functioning properly and you may ignore it.

Instructions for Wearing the Accelerometer



The sensor should be worn around the body at about hip level on the right side using this elastic belt. To best position the sensor, draw an imaginary line from the center of your right knee cap up the front of your leg to your right hipbone. The sensor should be worn over your right hip at this spot. Once you put the belt on, slide the sensor to this spot. The belt should be snug enough to hold the sensor in place, and you can use the safety pin to secure the pouch to your clothing to help it stay put. Make sure to always wear the belt and use the pin as extra if you want.

At the end of the seven days

At the end of the seven days, we will come back to get this sensor back from you. It cannot be used by itself, and it has no monetary value if it is lost, stolen or sold.

We will return to pick up your sensor at: _____

Questions?

If you have any questions, please call Zachary Ziegler: _____.

Today's Motion Sensor Record (Circle AM of PM where indicated) DATE: _____/_____/_____ _____	**Today's Motion Sensor Record** (Circle AM of PM where indicated) DATE: _____/_____/_____ _____
TIME ON: _____ (AM PM) WORK ARRIVAL TIME: _____ (AM PM) TIME(s) OFF: _____ (AM PM) Did you take the sensor off for more than 20 minutes during the day? (YES NO) WHY:	TIME ON: _____ (AM PM) WORK ARRIVAL TIME: _____ (AM PM) TIME(s) OFF: _____ (AM PM) Did you take the sensor off for more than 20 minutes during the day? (YES NO) WHY:
Did you exercise today? (YES NO) START TIME: _____ (AM PM) STOP TIME: _____ (AM PM) TYPE:	Did you exercise today? (YES NO) START TIME: _____ (AM PM) STOP TIME: _____ (AM PM) TYPE:
WORK DEPARTURE TIME:	

_____ (AM PM) TIME OFF: _____ (AM PM)	WORK DEPARTURE TIME: _____ (AM PM) TIME OFF: _____ (AM PM) (AM PM)

APPENDIX J

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Physical Activity Readiness Questionnaire (PAR-Q) and You

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly:

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2.	Do you feel pain in your chest when you do physical activity?
☐	☐	3.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6.	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7.	Do you know of any other reason why you should not do physical activity?

If you answered:

YES to one or more questions

Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

Delay becoming much more active:

- If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed use of the PAR-Q: Reprinted from ACSM's Health/Fitness Facility Standards and Guidelines, 1997 by American College of Sports Medicine

Signature: _____ Date: _____