DIETARY CHANGES ASSOCIATED WITH AN INTERVENTION TO REDUCE SEDENTARY BEHAVIOR IN WOMEN

by

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Abstract

Evidence from physical activity interventions suggests that women, in particular, may overcompensate for exercise energy expenditure by increasing caloric intake. Sedentary behavior and poor diet quality are independent risk factors for many major chronic diseases including cardiovascular disease (CVD). It is unknown whether insufficiently active women alter dietary quality or caloric intake when participating in an intervention to reduce sedentary behavior. Insufficiently active women (n=49) working full-time sedentary jobs were randomized into one of two 8-week sedentary interventions occurring during the work week [short breaks (SB) (1-2 min every half hour, n=24) or long breaks (LB) (15 min twice daily, n=25)]. Dietary information was collected through 3-day food records at baseline, week 4 and week 8. Dietary quality was assessed using the Alternative Healthy Eating Index 2010 (AHEI-2010). CVD risk factors (systolic and diastolic blood pressure (BP), fasting cholesterol, triglycerides, and blood glucose, and body mass index) were assessed at baseline and week 8. For all participants there were no changes in AHEI-2010 scores over time (baseline: M=53.4, 95% CI [49.2, 57.6], week 4: M=50.3, 95% CI [45.9, 54.7], week 8: M=48.4, 95% CI [44.1, 52.7], p>0.05). Average caloric intake in the SB group (baseline: M=1943.8 kcals/day, 95% CI [1716.2, 2171.5], week 4: M=1728.8 kcals/day, 95% CI [1462.4, 1995.2], week 8: M=1616.8 kcals/day, 95% CI [1450.2, 1783.4]) decreased significantly from baseline to week 4 (p=0.015) and baseline to week 8 (p=0.002). There were no significant changes in caloric intake in the LB group (p>0.05) at either time point. In all participants, absolute changes in LDL were positively correlated with absolute changes in caloric intake (r=0.473, p=0.005). There were no other significant associations between changes in dietary quality or caloric intake with changes in any other CVD risk factor (p>0.05). Following an 8-week sedentary intervention in the workplace, insufficiently active women did not alter their dietary quality, but decreased caloric intake. Future research should explore sedentary interventions compared to physical activity interventions in women as a means to create negative energy balance, as sedentary breaks throughout the day may be effective for improving health outcomes.

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Chapter 1 - Literature Review

Introduction

In the United States, chronic diseases are the leading causes of death, poor health, disability, and they impact the lives of approximately half of the population (Bauer, Briss, Goodman & Bowman, 2014). Of the ten leading causes of death in the US, six are related to lifestyle choices (e.g., diet and physical activity) and are potentially modifiable (National Center for Health Statistics, 2015). Poor diet quality is known to be a contributing factor to many major chronic diseases such as cancer, hypertension, cardiovascular disease (CVD), diabetes, and stroke, however nearly the entire US population fails to meet federal dietary recommendations (Wang et al., 2014). The typical American diet is high in food components such as total fat, saturated fat, added sugar, and sodium that are associated with increased risk for many major chronic diseases. Additionally, the American diet is typically low in fruits, and vegetables which are associated with risk reduction (Leenders et al., 2014).

Heart disease in particular is the leading cause of death among both males and females in the US (Murphy, Xu, Kochanek, & Bastian, 2016). Along with several other contributing risk factors, diet strongly affects risk of CVD. For example, red meat consumption has been shown to increase risk of dying from coronary heart disease (Kushi, Lenart, Willett, 1995), and higher intake of fiber, antioxidants, and polyunsaturated fatty acids (PUFAs), as well as moderate intake of alcohol are associated with lower CVD risk (Kushi et al., 1995; Getz & Reardon, 2007). High amounts of sodium and solid fat typically found in the American diet can lead to hypertension and plaque buildup in the arteries, which are both associated with poor heart health (Getz & Reardon, 2007). In a 13-year prospective cohort study of European adults (n=451,151), self-reported dietary intake showed that participants in the highest intake of fruit and vegetables had a lower risk of death from circulatory system diseases as compared to those with the lowest intake (Leenders et al., 2014).

One cross-sectional study of young adults (*n*=223) aged 18-22y found that 84% of participants with normal blood pressure adhered to a balanced diet of fresh fruits and vegetables, along with occasional consumption of sugar sweetened beverages (SSBs) and fast food. Conversely, 92% of participants who were hypertensive reported eating fast food 1-2 times daily. Consumption of plant-based dietary components such as fiber, calcium, magnesium, iron, antioxidants, and vitamins were all associated with a decreased risk of cardiovascular disease as well (Mishra et al., 2013).

Foods such as fast foods and SSBs are not only associated with increased risk of CVD, but are also typically calorically dense. Excessive caloric intake can lead to obesity, which is an independent risk factor for CVD due to adverse effects on low-density lipoprotein (LDL) cholesterol levels, triglyceride levels, blood pressure (BP), blood glucose levels, and high-density lipoprotein (HDL) cholesterol levels (Lichtenstein et al., 2006). For example, Wilson and colleagues in 2002 found that obese individuals had a higher relative risk of CVD, as compared to individuals of a healthy weight. Changes in energy balance resulting in modest weight reduction (about 10% of body weight) in obese patients with hypertension or hyperlipidemia, have been shown to reduce blood pressure, and to reduce cholesterol levels respectively (Goldstein, 1992). Healthy weight can be maintained when energy consumed is equal to energy expended, and for individuals who need to lose weight, energy expenditure must exceed energy intake in order to reduce risk of obesity (Klein et al., 2004).

Based on findings such as these, the Dietary Guidelines for Americans have been established with the two major goals of attaining energy balance to achieve a healthy weight, and consuming nutrient-dense foods and beverages. The Dietary Guidelines suggest controlling total caloric intake, consuming alcohol in moderation if at all, reducing consumption of cholesterol, sodium, trans fat, saturated fat, added sugar, and at the same time consuming a variety of fruits and vegetables, lean proteins and plant based protein, and whole grains (US Department of Health and Human Services, 2010).

Dietary Quality

Dietary quality is often assessed based on adherence to the Dietary Guidelines. One common method for evaluating overall dietary quality is the Healthy Eating Index (HEI) that was developed by Kennedy and colleagues (1995) in order to assess dietary quality as it related to the Dietary Guidelines. The original HEI comprised ten components, each of which were scored zero to ten. The first five components measured how well a diet followed the USDA Food Guide Pyramid (grains, vegetables, fruits, milk, and meat) with a score of ten being given when recommended servings per day were met based on age and gender, and a score of zero given if no foods from that food group were eaten. Proportional scores between zero and ten were given for any values in between. The second half of the components (total fat, saturated fat, cholesterol, sodium, and overall variety in diet) also received a score of zero to ten but were inversely scored, with a score of ten given to the lowest amount of consumption and a score of zero given to the highest.

While HEI was intended to evaluate dietary quality as it related to the Dietary Guidelines, studies showed that the HEI may not be useful with regard to prediction of chronic disease. A preliminary study of 67,272 healthy adult females who were part of the Nurses’ Health Study showed that HEI scores were reflective of adherence to US Dietary Guidelines, however they were only modestly associated with reduction in risk of CVD, and not associated with lower cancer risk (McCullough et al., 2000). Because of these preliminary results for HEI related to prediction of chronic disease, in 2002 McCullough and colleagues developed the Alternative Healthy Eating Index (AHEI) in an attempt to improve the HEI's chronic disease predictive ability. The first eight components (vegetables, fruit, nuts and soy protein, ratio of white to red meat, cereal fiber, trans fat, polyunsaturated to saturated fat ratio, and alcohol) received a score of zero to ten, much like the HEI. The ninth and final component, duration of multivitamin use, either received a score of two and a half for nonuse, or seven and a half for use of at least five years. In a cohort study of 38,615 men and 67,271 females from 1986-1994 the AHEI was nearly two times better at predicting chronic disease as compared to the HEI. Women in particular had a 28% lower risk of CVD when scoring highest on the AHEI as compared to those who had the lowest scores (McCullough & Willett, 2006).

Several previous studies have shown that lower AHEI scores are strongly associated with major chronic disease, CVD risk, diabetes, heart failure, colorectal and breast cancer, and total cardiovascular mortality, yet improvements began to be made on the AHEI in 2010 (Chiuve et al., 2012). In the time that had passed since the AHEI was developed, a large body of research had begun to indicate importance of other dietary factors related to major chronic disease risk, such as SSBs and omega-3 (ω-3) fatty acid consumption. The result of this revision was the AHEI-2010, an eleven-component dietary index comprising vegetables, fruit, whole grains, SSBs/fruit juice, nuts and legumes, red/processed meat, trans fat, ω-3 fatty acid, PUFA, sodium, and alcohol. Using the same dietary data from the original AHEI study, the AHEI-2010 was shown to be associated with lower risk of chronic disease much like the original AHEI, but also captured metabolic disease risk (Wang et al., 2014).

In the US, average AHEI-2010 scores are low, but AHEI scores in general, have been increasing over time. Mean AHEI-2010 scores for US women from 2009-2010 were 39.0 (95% CI 38.3-39.8) and have been steadily increasing since 1999 when the average score was 36.5 (95% CI 35.5-37.5). Slight increases occurred in fruit, whole grain, PUFA, and nut scores over the twelve-year period, and sodium scores have decreased. The largest change in scoring from 1999-2010 came from the trans-fat category, due to the steady removal of trans-fats from processed foods in the US, leading to improvements in overall AHEI scores. AHEI-2010 scores are not only associated with dietary trends in the US, but also with socioeconomic status, education level, and gender. Those with higher socioeconomic status and education have higher AHEI-2010 scores and women tend to have higher scores than men (Wang et al., 2014).

Sedentary Behavior

Prolonged sitting is also a risk factor for CVD (Katzmarzyk, Church, Craig, & Bouchard, 2009; Wilmot et al., 2012). Until recently, sedentary behavior has been categorized as lack of physical activity. For example, the American College of Sports Medicine (ACSM) guidelines for CVD risk factors include sedentary lifestyle which is described as not regularly participating in moderate physical activity (American College of Sports Medicine, 2013). New research, however, suggests that time spent engaging in sedentary behavior impacts health regardless of physical activity practices (Owen, Healy, Matthews, & Dunstan, 2010). Despite emerging evidence, sedentary behavior is becoming more common in the workplace. Over the past 50 years, jobs that require moderate physical activity have declined significantly (Church, et al., 2011). Over 80% of adults now have sedentary jobs and 70-80% of a typical workday is spent sitting, primarily for 20 minutes or more at a time (Clemes, O'Connell, & Edwardson, 2014; Parry, & Straker, 2013). As technology continues to advance and replace physical labor in the workplace, it is likely that these sedentary trends will continue.

Along with the negative health impacts associated with sedentary behavior, prolonged sitting is also thought to be harmful in part due to the opportunity to consume food during this time (Williams, Raynor, & Ciccolo, 2008). Sedentary time often takes place when watching TV or engaging in screen time, which may include viewing of advertisements for unhealthy foods (Scully, Dixon, & Wakefield, 2009). Eating food while watching TV may also be distracting and inhibit the body's ability to signal satiety (Temple, Giacomelli, & Kent, 2007). For example, one systematic review of 15 cross-sectional studies found that screen time/television viewing was positively associated with sugar-sweetened beverage intake, and inversely associated with fruit and vegetable intake in adolescents (Hobbs, Pearson, Foster, Biddle, 2014). Another cross-sectional study of 2,908 adolescents in India from 2009-2010 found a significant positive correlation between screen time and consumption of French fries, potato chips, cakes and donuts, SSBs, candy and chocolate, and energy drinks (Al-Hazzaa, Abahussain, Al-Sobayel, Qahwaji, Musaiger, 2011). Although studies have indicated that there are correlations between TV viewing and unhealthy food intake in adolescents, research in adult sedentary behavior and diet is less conclusive.

Three studies were reviewed in Hobbs and colleague's meta-analysis that found that television viewing was marginally positively associated with total energy intake and marginally inversely associated with HEI scores in adults. All of these studies used self-reported television viewing as the sedentary behavior studied, and it is unknown whether participants multitasked (e.g. doing chores) while watching TV. When comparing sedentary individuals to their more active counterparts, there seems to be a distinction between the two, with more active individuals consuming more healthful foods (Matthews, Hebert, Ockene, Saperia, Merriam, 1997).

One recent cross-sectional study by Gillman and colleagues (2001) examined the diet and exercise patterns of 1,322 adult men and women and found that participants who were more sedentary had higher intake of red and processed meats, saturated fats, dietary cholesterol, and lower intake of fruits, vegetables, and dietary fiber as compared to those who engaged in at least 150 minutes of moderate activity or 60 minutes of vigorous activity per week. This study by Gilman and colleagues classified individuals as sedentary if they reported not engaging in moderate to vigorous physical activity regularly. With current research suggesting that sedentary behavior is separate from physical activity, the study by Gilman and colleagues may not have resulted in a clear depiction of diets of sedentary individuals.

When using accelerometry to compare inactive individuals to more active individuals, actual time spent sitting or lying can be compared to time spent up and moving. Shuval and colleagues (2015) used accelerometry to determine sedentary behavior. Accelerometers were worn at the hip for 7 consecutive days and tracked acceleration as activity. Cut-points for quartiles were: meeting physical activity guidelines (≥150 minutes of moderate to vigorous physical activity/week), 6.8 hours/day sedentary (<100 counts/min), 8.1 hours/day sedentary, and 9.5 hours/day sedentary. Participants who met physical activity guidelines had higher HEI fruit scores and consume fewer empty calories compared to those who engaged in excessive sedentary behavior (≥9.5 hours per day) (Shuval, K., Nguyen, B., Yaroch, A., Drope, J., & Gabriel, P., 2015). More research needs to be done to see whether there is an association between sedentary behavior and dietary patterns, using a standardized definition of sedentary.

Multiple Lifestyle Factors Changing Together

Due to the associations between physical activity and dietary behaviors, previous studies have investigated these behaviors changing together. Lifestyle behaviors have previously been shown to cluster together, and in general, as people attempt to change behavior to either achieve weight loss or health improvement benefits, they tend to alter more than one lifestyle behavior at a time (Spring, B., King, C., Pagoto, L., Van Horn, L., & Fisher, D., 2015). For example, in adults attempting to lose weight, there is often an increase in physical activity coinciding with a increase in fruit and vegetable consumption (Dutton, G., Napolitano, M., Whiteley, J., & Marcus, B., 2008).

The relationship between physical activity changes and changes in dietary habits is still somewhat unclear. Wilcox et al. (2000) found that participants randomized into varying levels of physical activity conditions did not show a covarying relationship between level of physical activity and dietary changes. Dietary changes such as reduced total fat and cholesterol intake were seen in all participants, even those randomized into the control group. In contrast to the previous study, Dunn et al. (1999) found that physical activity changed following a physical activity intervention, but diet did not. These opposing findings suggest the possibility that participating in a clinical trial targeting physical activity may increase attention to overall diet quality, regardless of actual increased physical activity. Current research has not looked at changes in sedentary time related to dietary changes. It would be worth examining such changes, particularly since sedentary behavior has been shown to be associated with poor diet quality.

Previous weight loss interventions aimed to target physical activity in both men and women indicate that some individuals may be more prone to compensation (not producing predicted weight loss) than others (King et al., 2008). Women, in particular, participating in weight loss studies tend to have lower success rates than their male counterparts, possibly due to caloric overcompensation. Women participating in physical activity interventions without caloric restriction tend to maintain weight whereas men in the same interventions tend to lose weight (Donnelly et al., 2003; Donnelly & Smith, 2005). In a six-month randomized exercise trial of inactive, postmenopausal women (n=411), high doses of exercise (12 kcal/kg/week) resulted in caloric compensation, while those moderate doses of exercise (4 kcal/kg/week and 8 kcal/kg/week) did not compensate calorically (Church et al., 2009).

An interest in lifestyle factors clustering together has resulted in new research that suggests small changes may be effective in improving overall health. For example, small behavior changes, such as taking an extra taking the stairs instead of escalator, may stop weight gain in most adults (Hill, 2009). Smaller changes may result in more pleasant experiences, and the willingness to repeat an activity depends partially on previous experiences (Hills, Byrne, Lindstrom, & Hill, 2013). Positive experiences with physical activity increases the chance of engaging in physical activity again in the future (Pollock M., Wilmore J., Fox S., 1978). Likewise, uncomfortable or painful exercise experiences may reduce likelihood of engaging in physical activity in the future (King et al., 2007). Possible small changes such as reducing time spent in sedentary behavior may allow for individuals to impact lifestyle patterns through positive experiences. For example, participating in a study intended to reduce sedentary time is not likely to cause discomfort or pain for participants, and it simultaneously allows them to make positive changes to their health. Whether intentionally or not, an intervention on sedentary behavior could be paired with attention to dietary intake, potentially moving away from a less healthful diet toward a more healthful dietary pattern as part of a healthier overall lifestyle.

While more research is needed on physical activity interventions and dietary patterns changing together, there are currently no studies examining changes in sedentary time associated with changes in dietary intake. The aim of the current study was to determine whether insufficiently active women who participate in an intervention aimed at reducing sedentary time in the workplace would also make dietary changes without a particular intervention focus on making dietary changes. In particular, would participants also make reductions in caloric intake or improve dietary quality? These questions are especially relevant for women, as there is some evidence that women often fail to attain weight loss results to the extent that men do following weight loss or physical activity interventions, with some sort of compensatory effect as the logical rationale for the sex difference. We hypothesized that participants would decrease caloric intake and improve dietary quality.

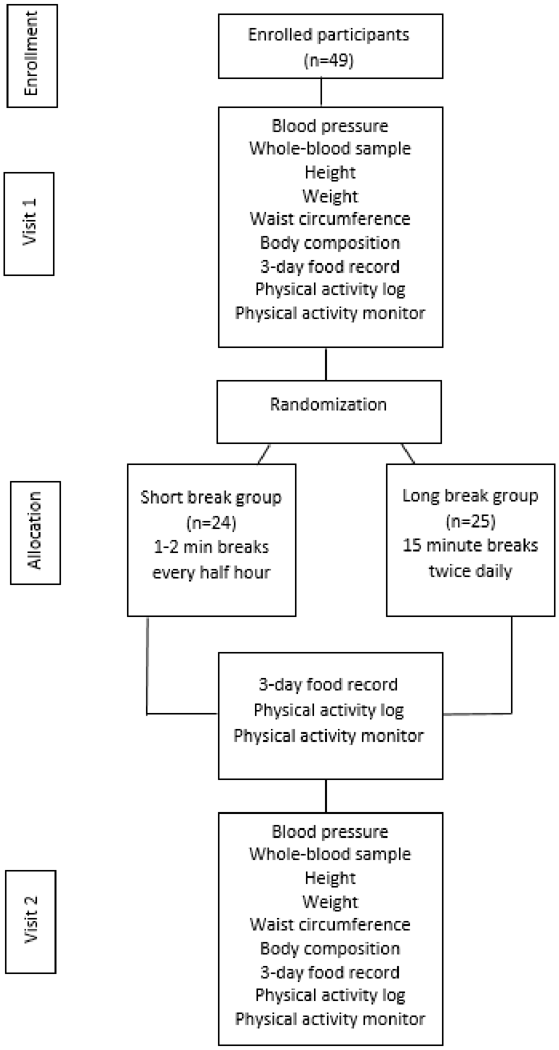
Chapter 2 - Methods

Participants

Participants were 50 healthy women (aged 25-50 years) who worked 35 or more hours per week in a job where at least 80% of the work day was spent seated. All participants were insufficiently active, accumulating less than 60 minutes per week of moderate to vigorous physical activity, not pregnant, and not currently trying to change physical activity or dietary behaviors. Written informed consent was obtained from all those who participated. The experimental protocol was approved by the Institutional Review Board at Kansas State University in Manhattan, KS (IRB #7031) and conforms to the Declaration of Helsinki.

Experimental Design

Figure 1
Study Design



The current study was part of a larger sedentary intervention which will be outlined briefly below. Participants were screened though an online survey which determined eligibility to participate in the study. Once eligibility was determined, packets were mailed to participants containing an informed consent document, an accelerometer, an accelerometer log, a 3-day food record, a link to the online questionnaires, and instructions for wearing the accelerometer and completing the food records. After wearing the accelerometer for seven days, participants came to the Physical Activity and Nutrition Clinical Research Consortium (PAN-CRC) for their baseline visit. At baseline, data were collected regarding participants' anthropometrics and cardiovascular disease risk factors. Anthropometric measurements included height, weight, waist circumference, and body fat composition. Cardiovascular disease risk factor assessments included total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, and fasting glucose. Dietary intake was collected through a 3-day food record and as part of the larger study, physical activity was measured objectively through accelerometry, as the participants wore an accelerometer on their waist for seven consecutive days at each of the assessment periods. Once baseline date collection was complete, participants were randomly assigned to one of two groups, the short-break (SB) group or the long-break (LB) group. The SB group was instructed to take a break from sedentary behavior for one to two minutes every half hour throughout their work day. The LB group was instructed to take a break for 15 minutes, twice during their workday.

Tests and Measurements

Anthropometrics

At the baseline and 8-week assessment periods, the following tests were performed. Participants were asked to remove their shoes and any heavy outer garments. Height was measured to the nearest 0.1 cm with a portable stadiometer (Invicta Plastics, Leicester, England) and weight was measured to the nearest 0.1 kg with a digital scale (Pelstar LLC, Alsip, IL, USA). Waist circumference was measured with a spring-loaded MyoTape tape measure horizontally, at the top of the iliac crest to the nearest 0.5 cm. Participants were asked to cross their arms across their chest and breathe normally. The measurement was made at the end of a normal exhalation. All measurements were taken twice, and a third measurement was taken if the values differed by more than 0.5 cm or 0.5 kg. The two values that were within the acceptable difference range were then averaged and used in the analyses. Body composition was measured with total body dual-energy x-ray absorptiometry (DEXA) scan (GE Lunar Prodigy, Madison, WI, USA). Due to state environmental regulation, for a period of time, DEXA scans could not be performed, in which case bioelectrical impedance analysis (BIA) (RJL Systems, Quantum II, Clinton Twp, MI, USA) was used to determine body composition of participants. Electrode tabs were placed on the following locations on the same side of the body: around the proximal portion of the middle finger, across the top of the wrist, across the top of the ankle, on the joint between the metatarsals phalanges on the top of the foot. The BIA wires were connected to the electrode tabs and readings were recorded for both resistance and reactance. These values were entered into the prediction equation using RJL software to calculate body composition. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared.

Cardiovascular Disease Risk Factor Assessment

At the baseline and 8-week assessment periods, the following tests were conducted and measurements were taken by a trained research assistant. Blood pressure was measured using an automated blood pressure cuff (Omron, Hoofddorp, Netherlands) after participants had been seated for 5 minutes. Participants were instructed to sit with their feet flat on the floor and refrain from talking while the measurement was being taken. Systolic and diastolic blood pressure measurements were taken twice one minute apart, and a third measurement was taken one minute after the second if the values differed by more than 5 mmHg. The two values that were within the acceptable difference range were then averaged and used in the analyses. Following a 10-12 hour fast, a whole-blood sample was taken using a finger puncture to measure total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, and glucose using a Cholestech LDX analyzer (Alere, Orlando, FL, USA).

Physical Activity and Sedentary Behavior

As part of the larger sedentary intervention trial, physical activity was measured objectively by using Actigraph GT3x physical activity monitors. These are devices that the participants wore on their waist at the right hip for seven days at each assessment period. A valid day was considered to be any day where the accelerometer was worn for more than 10 hours. For the current study, physical activity was not considered for analyses.

Dietary Intake

Dietary intake was measured through 3-day food records completed by participants at each of the three time points. Participants recorded their diet on two week days and one weekend day, which has been previously validated by Yang and colleagues. The participants were given written instruction on how complete the log, and reviewed their logs with a trained research assistant at each assessment for any unclear entries. Dietary intake was analyzed using Nutritionist Pro nutrition analysis software (version 6.1.0, Axxya Systems, Stafford, TX) by a trained research assistant.

Dietary quality was assessed using the Alternative Healthy Eating Index 2010 (AHEI-2010) that evaluates 11 components of diet: total fruit, total vegetable, whole grains, sugar-sweetened beverages (SSBs) and fruit juice, nuts and legumes, red and/or processed meat, trans fat, ω-3 fatty acids, polyunsaturated fatty acids (PUFAs), alcohol, and sodium consumption. Each component receives a score of 0-10 based proportionally on the intake as compared to guidelines, with a possible total AHEI-2010 score of 110 (Wang et al., 2014). Higher scores are earned for higher consumption of fruits, vegetables, whole grains, nuts, ω-3 fatty acids, and

PUFAs. Conversely, lower scores are earned for higher consumption of SSBs and fruit juices, red and/or processed meat, trans fats, and sodium. The alcohol score is based on moderate drinking, with a maximum score given for moderate alcohol intake (0.5-1.5 drinks/day), the lowest score given to those who drank in excess (>1.5 drinks/day), and a score of 2.5 given to non-drinkers. Scores were determined using data retrieved from 3-day food records, reports generated from Nutritionist Pro (detailed below), and additionally, individual food composition data were obtained directly from Nutritionist Pro. Data collected for all components were averaged over 3 days and used the following guidelines for scoring. Table 1 shows locations of AHEI-2010 components within Nutritionist Pro.

Table 1
Nutritionist Pro Reports for AHEI-2010 Scoring

Component	Nutrition Summary Report	MyPlate Summary Report	Food Analysis	Food Record
Whole Fruit		**X**		
Total Vegetables		**X**		
Whole Grains			**X**	**X**
SSBs and Fruit Juice				**X**
Nuts and Legumes				**X**
Red and/or Processed Meat				**X**
Trans Fat	**X**			
ω-3 Fats	**X**			
PUFAs	**X**			
Alcohol	**X**			**X**
Sodium	**X**			

Nutritionist Pro's Nutrition Summary report was used to obtain data on average 3-day macronutrient composition and total caloric intake. The Nutrient Analysis report was used to obtain data on the individual AHEI-2010 components: trans fats, PUFAs, ω-3 fatty acids, sodium, and alcohol intake. Research assistants calculated the percent of overall calories from trans fats and PUFAs using the grams per day provided by Nutritionist Pro in order to score these two categories. The direct output in milligrams per day provided from Nutritionist Pro was used for scoring ω-3 fats.

Fruit and vegetable data were obtained through the MyPlate Summary report. In this report, research assistants were able to view each individual food component consumed, that component's MyPlate category, and the amount that was consumed. A serving of whole or dried fruit was equivalent to 0.5 cups, and fruits mixed with non-fruit foods were considered by weighting by half. Vegetable intake was scored by cups/day of whole vegetables, excluding potatoes, starchy vegetables, vegetable juices and vegetable sauces. Half weight was given to mixed vegetable foods such as soups as well as vegetables with sauces.

Nuts and legumes, SSBs and fruit juices, and red and/or processed meat data were obtained from the 3-day food records. Amounts of each component consumed was averaged over the three-day period at each time point. Nuts, legumes, and seeds along with nut butters and tofu were all considered for the nut and legume category. Half weight was assigned for nut butter sandwiches, soy milk, tofu soups, and mixed dishes containing nuts/legumes. One serving of SSBs or fruit juices was defined as 8 fl oz. Red and/or processed meat included any beef, pork or processed meat, with 3.5 oz considered as one serving. Half weight was given to mixed foods such as sandwiches, broths, or dishes containing meat and vegetables.

Whole-grain consumption data were obtained through several steps. Foods in the 3-day food record that met the AHEI-2010 guidelines such as brown rice and popcorn were recorded in grams. All other grain products were individually evaluated for their carbohydrate to fiber ratio. Grams of carbohydrates and grams of fiber were obtained through the analysis feature for each food consumed. Foods that had a carbohydrate to fiber ratio less than or equal to 10:1 were considered whole grains (Mozaffarian et al., 2013). Serving size was determined based on the type of grain, 1 slice of bread, 0.5 cups pasta, and 1 cup of cereal were all considered one serving.

Overall sodium intake in milligrams was divided into deciles for each time point and these deciles were used for scoring. The lowest decile was given the highest score of 10, the highest decile was given the lowest score of 0, and all other deciles were given scores 1-9 accordingly. When the Nutrient Analysis report indicated that the participant had consumed alcohol, the research assistant went through the 3 days of food journals and calculated the per day average consumption, with serving sizes defined as 141.75 g of wine, 340.20 g of beer, or 42.53 g of liquor, and half weight assigned to cocktails.

Table 2

Scoring of AHEI-2010 Components

Component	Maximum Score (10)	Minimum Score (0)
Whole Fruit	≥4 servings/day	0 servings/day
Total Vegetables	≥2.5 cups/day	0 cups/day
Whole Grains	75 g/day	0 g/day
SSBs and Fruit Juice	0 oz/day	≥8 oz/day
Nuts and Legumes	≥1 oz/day	0 oz/day
Red and/or Processed Meat	0 servings/day	≥1.5 servings/day
Trans Fat	≤0.5% of energy/day	≥4% of energy/day
ω-3 Fats	250 mg/day	0 mg/day
PUFAs	≥10% of energy/day	≤2% of energy/day
Alcohol	0.5-1.5 drinks/day	≥2.5 drinks/day
Sodium	Lowest decile	Highest decile

Adherence

Adherence was measured using the activity logs that participants kept daily. For the SB group, full adherence was defined as taking 12 or more breaks during the workday, and for the LB group full adherence was taking 2 or more breaks totaling 25 minutes or more during the workday. Partial adherence for the SB group was taking at least 6 breaks during the workday, and for the LB group either one break of ten minutes or more, or two breaks less than 25 minutes. Any days that participants did not meet these break guidelines were considered days of no adherence. More detail on adherence is provided in Comparative Effectiveness of Two Intervention Approaches for Reducing Sitting Time at Work: A randomized Trial (currently under review in Preventive Medicine Reports).

Statistical Analyses

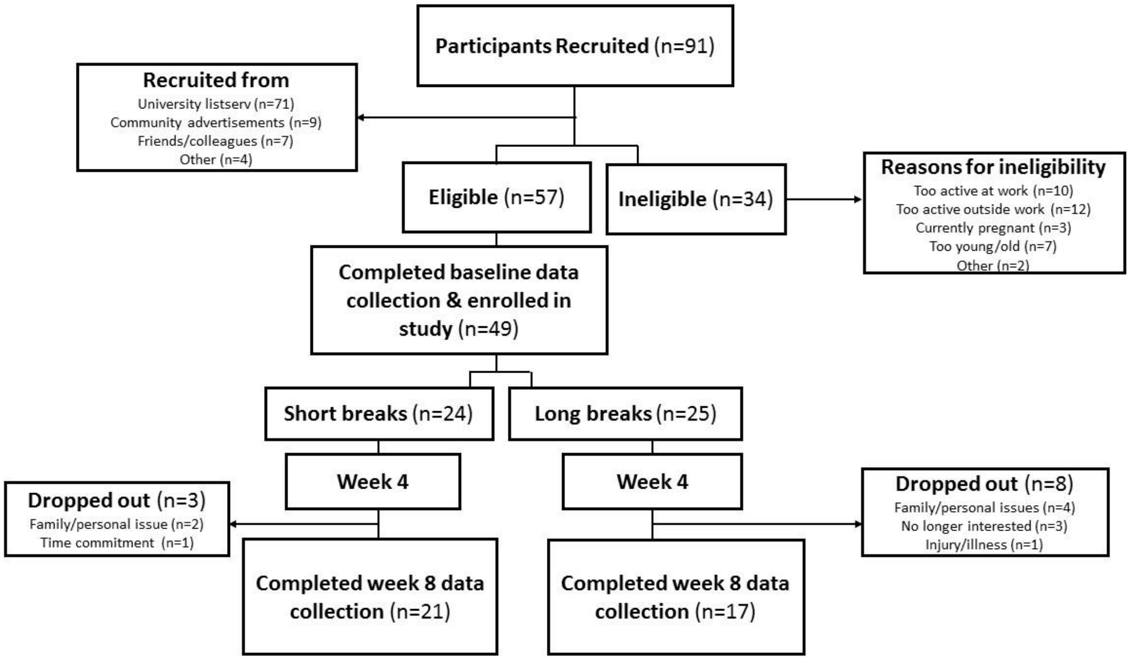
Statistical analyses were performed using SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp). Parametric assumptions were tested for all independent and dependent variables, and if assumptions were not met data were transformed (Lg10). In order to test for changes in caloric intake and dietary quality, t-tests were used to determine differences between SB and LB groups, as well as differences from baseline to week 4 and week 8. In order to test for associations between changes in dietary intake and changes in CVD risk factors Pearson’s correlations were performed. For data that did not meet parametric assumptions after transformation (glucose, vitamin K, MUFA, total fat %, vitamin D, saturated fat, trans fat AHEI-2010 score, and alcohol AHEI-2010 score) Friedman’s tests were used to determine within and between group differences, and Wilcoxon signed rank tests were used to determine changes in dietary intake and CVD risk over time. Spearman’s Rho was used to determine associations between changes in dietary intake and changes in CVD risk factors. Caloric intake and macronutrient distribution were analyzed using values that represented the average intake across the three days included for each assessment time-point. Percent adherence was calculated by dividing days of full adherence, partial adherence, or no adherence by total days worked. Data are shown as the mean ± standard deviation. For all tests, statistical significance was set at $p<0.05$. Where multiple tests were performed, Bonferroni corrections were used to account for the increased chance for type I error.

Chapter 3 - Results

Recruitment and Retention

Figure 2 shows the flow diagram for recruitment and retention of participants in the current study. Of the 91 participants originally recruited, 49 were enrolled in the study, and 38 completed the final data collection.

Figure 2
Recruitment and Retention of Participants



Participant Characteristics

Baseline characteristics (anthropometrics, CVD risk factors, and dietary intake) are shown in Table 3. There were no significant differences when comparing SB and LB groups at baseline for age, anthropometrics and cardiovascular risk factors, with the exception of LDL and total cholesterol ($p>0.05$). Participants in the LB group had higher LDL ($p=0.047$) and total cholesterol ($p=0.021$) at baseline as compared to the SB group. There were no significant dietary intake differences between the SB and LB group at baseline for total AHEI-2010 scores, kilocalories, or macronutrient distribution ($p>0.05$).

Table 3

Baseline Participant Characteristics of SB and LB Groups

	SB Group (n=24)		LB Group (n=25)		
	Mean±SD	Range	Mean±SD	Range	*p*-value
Age (yr)	38.5±8.7	22.0-50.0	38.9±7.9	24.0-53.0	0.860
Weight (kg)	85.8±25.5	48.2-167.6	86.1±27.5	50.3-142.7	0.964
Height (cm)	163.2±5.0	153.1-174.1	162.4±5.5	148.9-170.4	0.608
BMI (kg/m^2)	32.4±10.1	18.9-65.9	32.4±9.3	20.3-50.5	0.981
Waist Circumference (cm)	102.4±17.9	75.3-146.5	101.2±21.9	45.9-136.8	0.832
Systolic BP (mmHg)	112.4±11.9	93.3-134.5	113.6±12.9	89.7-141.0	0.738

Diastolic BP (mmHg)	74.2±8.5	62.7-89.5	74.7±10.5	51.0-93.0	0.870
Triglycerides (mg/dL)	127.5±54.6	45.0-219.0	153.9±78.2	47.0-313.0	0.182
Total cholesterol (mg/dL)	172.6±28.8	120.0-223.0	190.9±24.8*	145.0-234.0	0.021
HDL (mg/dL)	51.3±15.4	24.0-83.0	48.8±16.3	15.0-80.0	0.579
LDL (mg/dL)	94.9±26.0	42.0-147.0	109.6±24.1*	62.0-150.0	0.047
Glucose (mg/dL)	98.0±14.4	81.0-135.0	100.8±32.8	72.0-243.0	0.603
Kilocalories (per day)	1,944±539	873-3,034	1,725±386	999-2,543	0.118
% Carbs	44.5±7.6	30.5-58.5	44.9±8.9	24.6-66.6	0.844

% Protein	16.8±4.2	10.8-28.2	17.3±4.3	10.7-29.9	0.717
% Fat	37.1±6.6	21.7-46.4	36.8±6.8	22.7-45.9	0.907
AHEI-2010	52.4±16.3	29.5-90.5	54.5±12.0	29.5-76.0	0.611

BMI, body mass index

Systolic BP, systolic blood pressure

Diastolic BP, diastolic blood pressure

HDL, high density lipoprotein

LDL, low density lipoprotein

% Carbs, percent of total calories from carbohydrate

% Protein, percent of total calories from protein

% Fat, percent of total calories from fat

* Statistically significant difference between SB and LB groups, $p < 0.05$

Cardiovascular Disease Risk Factors

Table 3 shows CVD risk factors at baseline. Cut-points for positive cardiovascular risk factors were determined using ACSM guidelines (American College of Sports Medicine, 2013). These risk factors include: blood pressure (BP) ≥140/90 mmHg, low density lipoprotein (LDL) ≥130 mg/dL, high density lipoprotein (HDL) <40 mg/dL, BMI ≥30 kg/m^2, or fasting blood glucose ≥100 mg/dL. For all participants, BMI (mean±SD) was in the obese range at 32.4±9.6 kg/m^2 and fasting blood glucose was considered to be borderline risk at 99.4±25.3 mg/dL. Elevated BMI was a risk factor for both groups, SB group BMI was 32.4±10.1 kg/m^2 and the LB group BMI was 32.4±9.3 kg/m^2. There were several participants who had risk factors including elevated systolic BP (n=2), diastolic BP (n=3), TC (n=15), fasting glucose (n=17), and BMI (n=29). Along with these risk factors, accumulating less than 30 minutes of physical activity three days per week also increases risk, which adds another risk factor for all participants. The presence of two or more of these risk factors increases overall risk for CVD. Of the 49 participants, 34 had two or more risk factors (LB: n=19, SB: n=15).

For all participants, from baseline to week 8, total cholesterol (mean±SD) significantly decreased (baseline: 182.1±30.8, week 8: 174.4±32.8 *p*=0.054). There were no other significant changes for other CVD risk factors when examining all participants together. The SB group had a significant reduction in fasting blood glucose from baseline to week 8 (baseline: 98.8±15.2, week 8: 94.6±13.8 *p*=0.009), while the LB group showed no significant change in any of the CVD risk factors. Of the 34 participants who had two or more risk factors at baseline, two participants, both from the LB group, moved to having fewer than two risk factors at week eight.

Dietary Intake

The mean ± SD total AHEI-2010 score for all participants at baseline was 53.4±14.2 out of a possible score of 110 which is above the national average for women (39.0, 95% CI [38.3,39.8]). At week 4, AHEI-2010 scores for all participants was 50.3±13.0, for the SB group it was 51.2±14.8, and for the LB group 49.3±11.0. At week 8, AHEI-2010 scores remained above the national average for women (all participants: 48.4±12.5, SB: 47.2±13.1, LB: 50.0±11.8). There were no significant changes in total AHEI-2010 scores or in any of the individual AHEI-2010 component scores over time for all participants, SB, or LB group ($p>0.05$).

Table 4 Average
AHEI-2010 Scores During Three Assessment Periods for SB, LB, and All Participants

	SB Group (n=18)			LB Group (n=14)			All Participants (n=32)		
	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8
Whole Fruit	3.0±3.0	1.7±2.0†	2.3±2.3	2.6±2.4	3.4±3.2	3.5±2.9	2.8±2.7	2.5±2.8	2.8±2.6
Total Vegetable	3.2±2.2	4.0±2.6	4.1±2.8	3.4±2.3	2.5±1.8	3.0±1.9	3.3±2.2	3.3±2.4	3.6±2.5
Whole Grains	4.5±3.6	5.4±3.9	3.3±3.4	5.0±4.2	4.7±4.1	4.1±3.9	4.7±3.9	5.1±3.9	3.6±3.6
SSBs and Fruit Juices	5.4±4.4	6.4±4.6	6.1±4.2	6.4±4.4	4.3±4.2	6.2±4.4	5.9±4.3	5.4±4.5	6.1±4.2

Nuts and Legumes	5.3±4.3	6.1±4.4	4.4±4.4	4.6±4.4	4.9±4.1	4.7±4.8	4.9±4.3	5.5±4.3	4.5±4.5
Red and/or Processed Meat	4.2±3.4	3.6±2.9	4.1±2.9	5.0±2.8	5.5±3.4	4.2±2.4	4.6±3.1	4.5±3.2	4.1±2.7
Trans Fat	9.9±0.3	9.3±1.1†	9.3±1.3*	9.7±0.7	9.5±0.9	9.1±2.6	9.8±0.5	9.4±1.0	9.2±1.9
ω-3 Fats	3.2±3.3	1.9±2.2	2.7±3.3	3.1±3.5	2.3 ± 3.2	2.1±2.6	3.1±3.3	2.1±2.7	2.4±3.0
PUFA	4.9±2.4	4.2±2.6	3.5±2.7	5.0±2.7	2.7±2.2	4.1±2.5	4.9±2.5	3.5±2.5	3.8±2.6
Alcohol	4.1±3.1	3.7±2.8	2.4±0.6	3.8±2.9	3.7 ± 3.1	3.5±2.6	3.9±3.0	3.7±2.9	2.9±1.8
Sodium	4.8±3.4	4.9±3.5	5.3±3.4	6.0±2.4	5.8 ±2.5	5.5±2.5	5.4±3.0	5.4±3.0	5.4±3.0
Total Score	52.4±16.3	51.2±14.8	47.2±13.1	54.5±12.0	49.3±11.0	50.0±11.8	53.4±14.2	50.3±13.0	48.4±12.5

Maximum possible score for individual components: 10, maximum total score possible: 110

† Statistically significant decrease from baseline to week 4 ($p<0.05$)

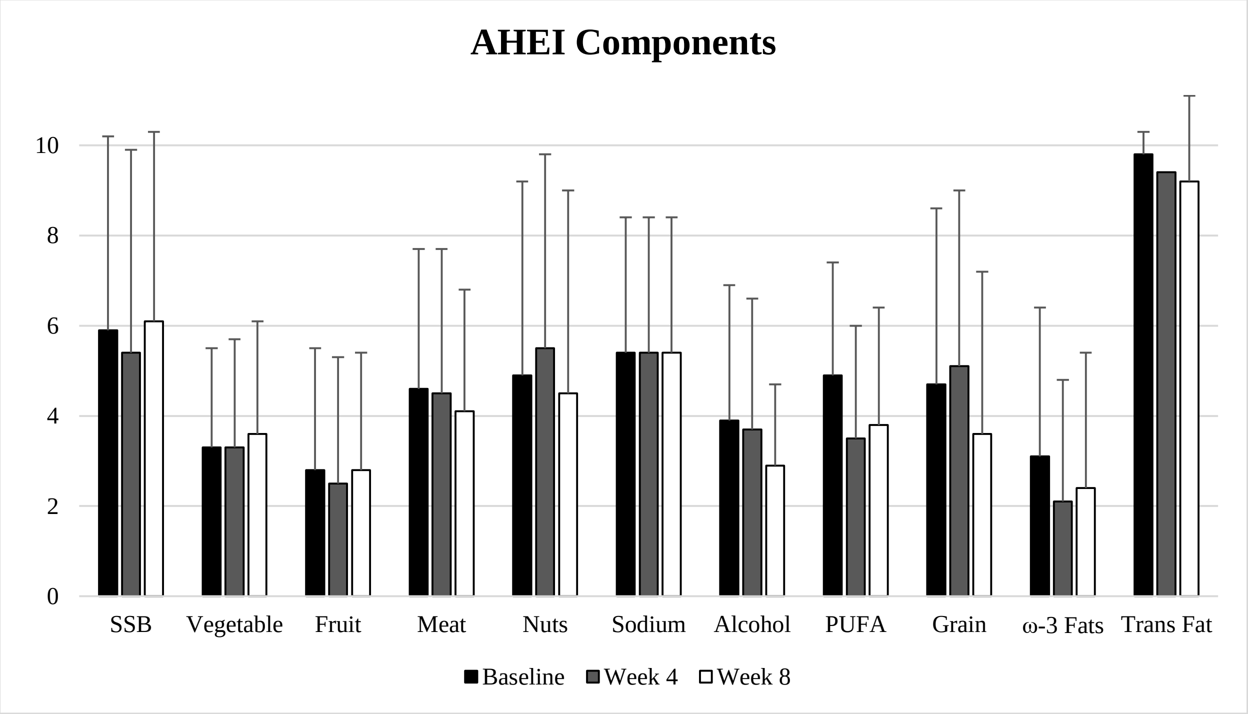
* Statistically significant decrease from baseline to week 8 ($p<0.05$)

There were no significant differences between groups at any time points for AHEI-2010 components ($p>0.05$).

There were no significant differences between week 4 and week 8 ($p>0.05$).

Figure 3

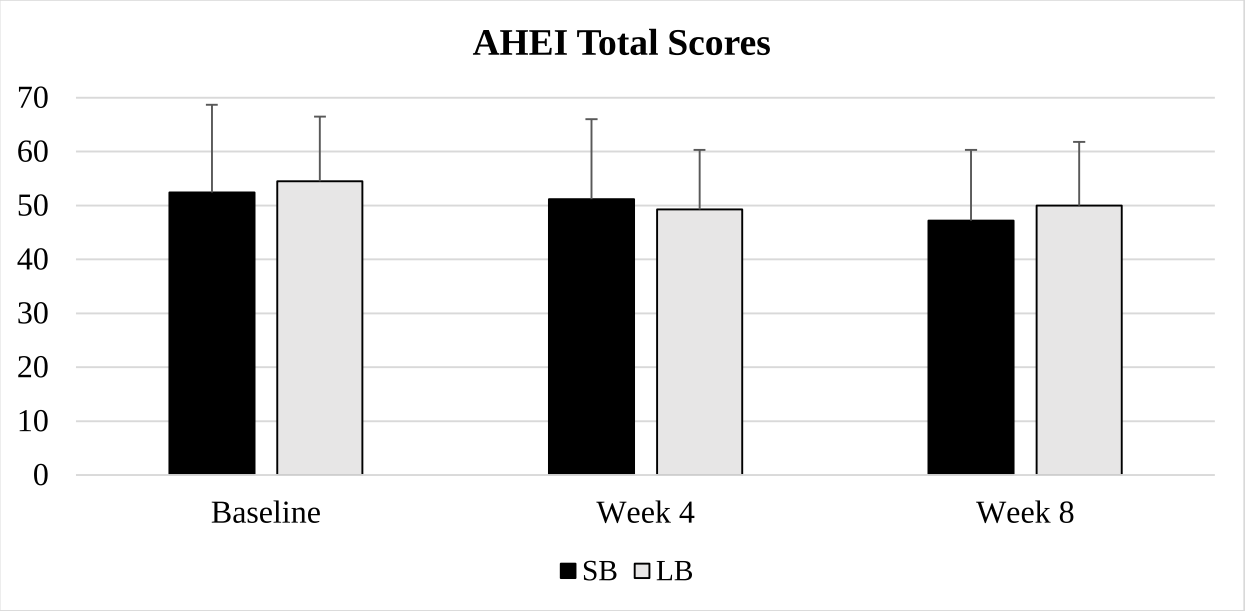
AHEI-2010 Individual Component Scores over Three Assessment Periods for All Participants



Baseline shown in black. Week 4 shown in gray. Week 8 shown in white. Error bars indicate SD.

There were no significant changes in individual components of AHEI-2010 scores for all participants across time using Bonferroni corrections to correct for multiple comparisons (*p*>0.0045).

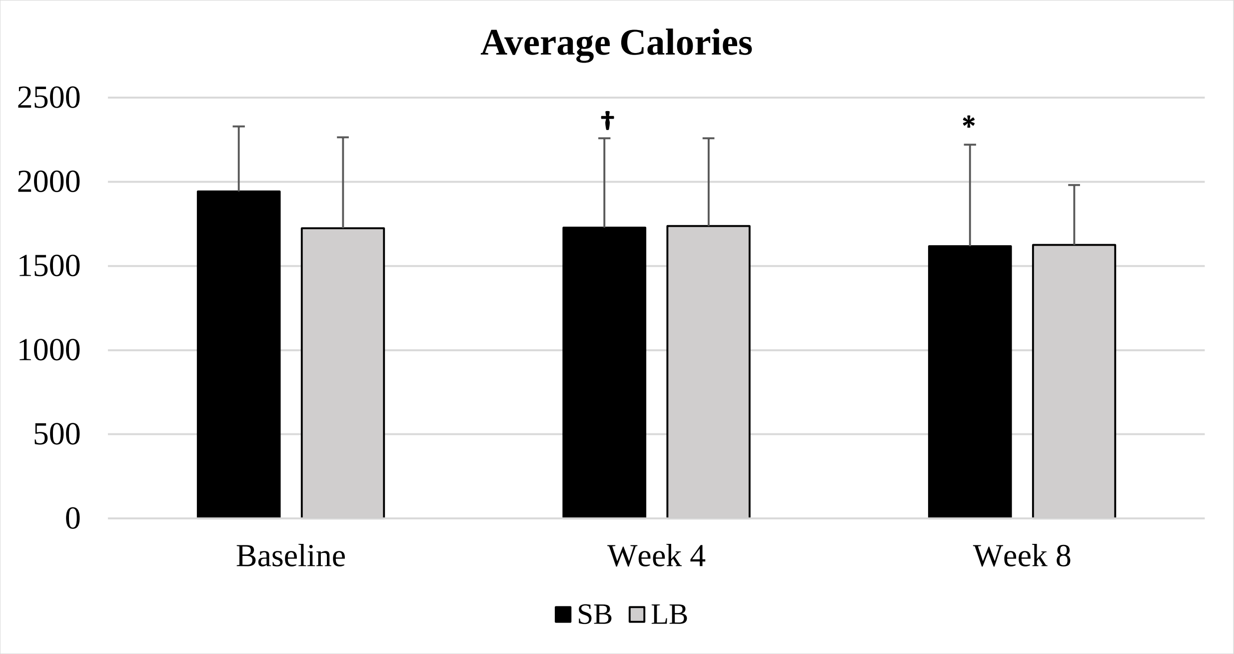
Figure 4
SB and LB Total AHEI-2010 Scores Over Three Assessment Periods



SB group shown in black. LB group shown in gray. Error bars indicate SD. There were no differences between or within groups at any of the time points (p>0.05).

Average caloric intake (mean±SD) decreased significantly for all participants from baseline to week 4 (*p*=0.020) and baseline to week 8 (*p*=0.001) (baseline: 1836.7±478.2kcals, week 4: 1732.6±534.4kcals, week 8: 1620.7±470.0kcals). Average caloric intake decreased significantly in the SB group from baseline to week 4 (*p*=0.015) and baseline to week 8 (*p*=0.002) (baseline: 1943.8±539.1kcals, week 4: 1728.8±522.7kcals, week 8: 1616.8±355.9kcals). No significant changes (*p*>0.05) in caloric consumption occurred in the LB group at any of the time points (baseline: 1724.9±385.6kcals, week 4: 1736.9±530.1kcals, week 8: 1625.9±603.8kcals). There were no significant differences (p>0.05) between groups at any of the time points. Average caloric intakes for each group at each time point are shown in figure 5.

Figure 5
Caloric Intake over Three Assessment Periods for All Participants

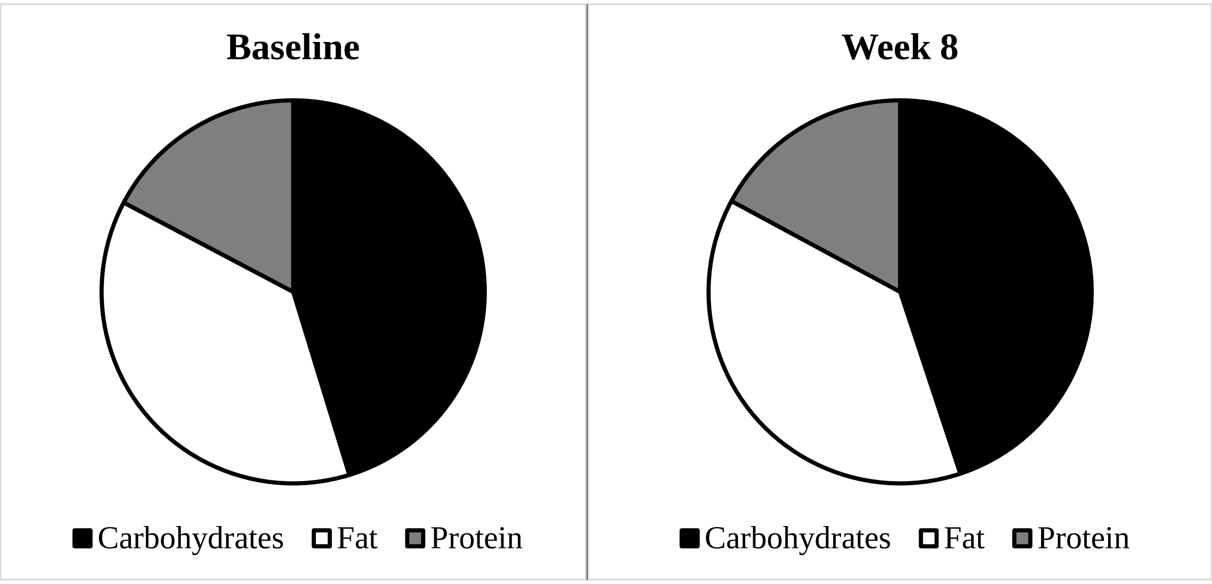


SB group shown in black. LB group shown in gray. Error bars indicate SD.
† Statistically significant decrease from baseline to week 4 ($p<0.05$)
* Statistically significant decrease from baseline to week 8 ($p<0.05$)

The acceptable macronutrient distribution range (AMDR) is 10-35% of total calories from protein, 20-35% of total calories from fat, and 45-65% of total calories from carbohydrates ("Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids," 2005). At baseline, the macronutrient distribution (mean±SD) for all participants was 17.1±4.2% protein, 37.0±6.7% fat, and 44.7±8.2% carbohydrates. The group mean fell within the AMDR for protein, but exceeded the AMDR for fat and fell slightly below recommendations for carbohydrates. At baseline, the SB and LB groups both had the same macronutrient distribution, meeting AMDR guidelines for protein (SB: 16.8±4.2%, LB: 17.3±4.3%), exceeding AMDR guidelines for fat consumption (SB: 37.1±6.6%, LB: 36.8±6.8%), and falling below AMDR guidelines for carbohydrate consumption (SB:

44.4±7.6%, LB: 44.9±8.9%). Macronutrient distributions at baseline and week 8 are shown in Figure 6. There were no significant changes in macronutrient distribution either for all participants across time, or within or between groups at any time point.

Figure 6
Percent Macronutrient Distribution at Baseline and Week 8



Percent carbohydrates shown in black. Percent fat shown in white. Percent protein shown in gray. There were no differences between or within groups at any of the time points (p>0.05).

Other dietary components that are often targeted as nutrients of concern for Americans ("Dietary guidelines for Americans,” 2015) that were not included in the AHEI-2010 were also examined. These dietary factors of concern included: sugar, vitamin C, vitamin D, folate, and iron. For all participants, mean vitamin D (p=0.027) and iron (p=0.010) intake decreased from baseline to week 4, and sugar (p=0.003), vitamin D (p=0.011), and iron (p=0.020) intake decreased from baseline to week 8. In the SB group, mean intake of sugar (p=0.001), vitamin D (p=0.020), folate (p=0.042), and iron (p=0.047) decreased from baseline to week 4, and sugar (p=0.012), vitamin C (p=0.033), vitamin D (p=0.019), and folate (p=0.045) intake decreased from baseline to week 8. In the LB group no significant changes (p>0.05) occurred in the nutrients of concern at any of the time points. Mean values of these dietary components are shown in table 5.

Table 5

Additional Dietary Factors of Concern for All Participants, SB, and LB Over Three Assessment Periods

	SB Group (n=18)			LB Group (n=14)			All participants (n=32)		
	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8
Sugars (g)	86.8±46.9	67.3±40.0†	67.8±31.4*	83.7±28.0	84.6±42.0	63.9±36.3	85.4±38.9	75.2±41.2	66.2±33.0*
Vitamin C (mg)	73.4±60.4	72.6±52.8	45.8±42.8*	64.5±4.7	57.6±45.4	143.4±283.6	69.3±53.2	65.7±49.4	86.0±187.4
Vitamin D (mg)	5.6±5.9	2.8±2.8†	2.5±2.4*	3.8±3.9	2.4±1.8	2.8±2.3	4.7±5.1	2.7±2.4†	2.6±2.3*
Folate (µg)	365.3±207.5	269.2±160.4†	237.0±147.5*	251.3±118.4	258.4±168.7	284.9±143.0	313.2±179.7	264.3±161.9	256.7±145.5
Iron (mg)	16.0±7.3	12.6±5.4†	10.9±5.2	10.9±4.5	12.1±7.5	12.6±6.9	13.7±6.6	12.3±6.4†	11.6±5.9*

†Statistically significant decrease from baseline to week 4 ($p<0.05$)

*Statistically significant decrease from baseline to week 8 ($p<0.05$)

There were no significant differences between week 4 and week 8 ($p>0.05$)

Dropout and Adherence

Thirty-two percent of participants randomized into the LB group dropped out by the end of the study, whereas only 13% of SB group participants dropped out. We also examined whether or not adherence to the intervention was associated with dietary quality, caloric intake, or CVD outcomes. For SB group participants, percent of full adherence was negatively correlated with percent change in caloric intake with a moderate effect size (r=0.467), and percent non-adherence was positively correlated with percent change in caloric intake with a large effect size (r=0.505). There were no associations between adherence and dietary quality or CVD outcomes. For LB group participants, there were no correlations between adherence and dietary quality, caloric intake, or CVD outcomes.

Associations between dietary changes and CVD risk factors

Absolute change in AHEI-2010 red/processed meat scores were positively correlated with absolute changes in HDL cholesterol (*r*=0.377, *p*=0.028) and diastolic BP (*r*=0.376, *p*=0.031) for all participants, noting that higher AHEI-2010 scores for red/processed meat indicate lower consumption. Also, absolute change in ω-3 scores were positively correlated with HDL cholesterol (*r*=0.342, *p*=0.047). For SB and LB groups individually, there were no significant associations between absolute changes in AHEI-2010 scores and absolute changes in CVD risk factors.

In all participants, absolute changes in LDL cholesterol were positively correlated with absolute changes in total fat intake (*r*=0.478, *p*=0.005), saturated fat intake (*r*=0.561, *p*=0.001), and total caloric intake (*r*=0.473, *p*=0.005). Changes in total blood cholesterol were positively correlated with absolute change in saturated fat intake (*r*=0.630, *p*=0.036). In the SB group only, absolute changes in HDL cholesterol were negatively correlated with absolute changes in total fat intake (*r*=-0.447, *p*=0.048). In the LB group only, absolute changes in LDL were positively correlated with absolute changes in caloric intake (*r*=0.600, *p*=0.023), total fat intake (*r*=0.612, *p*=0.020), and saturated fat intake (*r*=0.660, *p*=0.010).

Chapter 4 - Discussion

Major Findings

Poor diet and elevated levels of sedentary behavior are risk factors for future development of CVD. The primary aim of this study was to determine whether insufficiently active women participating in an intervention to reduce sedentary time would alter their dietary intake. In partial agreement with our primary hypothesis, our results indicated that participants decreased caloric intake, but did not alter their dietary quality as measured by AHEI-2010 scores. Our results are similar to previous research that suggests that lifestyle behaviors such as diet and physical activity tend to cluster together, and that when individuals make a change in one lifestyle factor, they often will change another, whether or not that factor is the target of intervention.

Dietary Quality

While previous studies have indicated that more active individuals tend to eat diets higher in fruits and vegetables and lower in added sugars and solid fats (Matthews, Hebert, Ockene, Saperia, Merriam, 1997), there is currently limited information available about the diet quality of sedentary individuals. Typically, research examining this question categorizes those who do not meet physical activity guidelines as sedentary. Individuals not engaging in moderate to vigorous physical activity regularly have higher intake of saturated fats, dietary cholesterol, and lower intake of fruits, vegetables as compared to those who engaged in at least 150 minutes of moderate activity or 60 minutes of vigorous activity per week. (Gilman et al., 2001). The Sedentary Behaviour Research Network (SRBN) defines sedentary behavior as any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents of tasks (METs) while in a seated or reclining posture (Sedentary Behaviour Research Network, 2012). To our knowledge, there are no studies available on dietary quality and sedentary behavior that use this definition to categorize participants as sedentary. The current study included participants who were not meeting physical activity guidelines, but who also were employed in full time sedentary jobs based on the SBRN definition.

Since our participants were asked to decrease sedentary behavior rather than increase physical activity, it was unknown whether dietary quality as measured by AHEI-2010 scores would increase when sedentary behavior was targeted. Results indicated that there were no significant changes in overall dietary quality between or within groups throughout the study. It is important to remember that previous research has shown that caloric intake and AHEI-2010 scores are associated (McCullough et al., 2002) and that with reductions in caloric intake, it is possible that AHEI-2010 scores would decrease as a function of the way the scoring works. Although participants did not increase their dietary quality, the SB group was able to maintain their dietary quality, while also significantly decreasing caloric intake.

Even though participants in the SB group decreased their caloric intake without significantly negatively impacting their AHEI-2010 scores, there are other dietary concerns to keep in mind. Macronutrient distribution remained unchanged throughout the study. All participants were consuming higher than recommended total calories from fat and lower than recommended total calories from carbohydrates at baseline. Despite the caloric intake reduction in the SB group, macronutrient distributions did not shift toward acceptable ranges. There were also changes in specific nutrients within the SB group. As caloric intake decreased, so did intake of vitamin C, vitamin D, iron, and folate. At baseline, all participants were at lower than recommended levels of vitamin C, vitamin D, folate, and iron, so for the SB group to further decrease their intakes could potentially lead to deficiencies in the future.

Caloric Intake

With regard to overall caloric intake, there is much more known about diet and physical activity interventions than about diet and sedentary behavior interventions. Previous research examining dietary changes during physical activity interventions suggests that women may overcompensate for increased energy expenditure by increasing caloric intake (Donnelly et al., 2003; King et al., 2008). To our knowledge, no studies have looked at changes in caloric intake when participating in a study intended to reduce sedentary time, rather than one aiming to increase physical activity. In our study, participants in the LB group did not change caloric intake significantly, but participants in the SB group reduced their caloric intake by about at 215 calories at week 4, and by about 330 calories at week 8. Due to the nature of the LB group intervention (2 x 15 minutes breaks) it is possible that the women in the LB compensated for what they might have viewed as increased physical activity. Significant reduction in caloric intake for the SB group, but not the LB group may be supported by the idea that women tend to overcompensate calorically when increasing physical activity.

Dropout and Adherence

Both dropout during the study, and adherence to the randomized condition, likely played a role in outcomes. The higher dropout rate of LB participants may have been due in part to the demand of scheduling 15 minute breaks twice in every workday. We did not originally anticipate an advantage with regard to dietary quality or caloric composition for one intervention group or another, however, the SB seemed to have an advantage over the LB group for dietary outcomes as well as adherence to the assigned condition and dropout during the study. The SB condition may have been more reasonable in the context of the workday, resulting in better adherence to the intervention and retention for the duration of the study.

CVD Risk Factors

The current study included a sample of women who were insufficiently active and working in sedentary jobs, and 34 of them had two or more CVD risk factors at baseline, placing them at increased risk for future disease. One novel part of our study was that we assessed changes in CVD risk associated with dietary changes. For all participants, total cholesterol significantly decreased, and in the SB group participants had a significant decrease in fasting blood glucose. These decreases could reduce the risk of CVD in the future. For all participants, SB and LB groups, when participants increased their total and saturated fat intake and total caloric intake, these changes were associated with increases in LDL cholesterol. Increases in saturated fat intake were also associated with increases in total blood cholesterol. When examining SB participants only, increases in total fat intake were also associated with decreases in HDL cholesterol. Further, in the LB group only increases in total caloric intake, total fat, and saturated fat were associated with increases in LDL. Overall, these findings are consistent with previous research that suggests that higher intake of dietary cholesterol, total fat, saturated fat, and total calories are associated with increased number of CVD risk factors (Getz et al., 2007; Lichtenstein et al., 2006; Mishra et al., 2013).

Experimental Considerations

Strengths of Current Study

There are several strengths of the current study which add to the current body of literature. To our knowledge, this is the first study to examine the relationship between attempted reductions in sedentary time and dietary changes. Previous studies examining multiple lifestyle factors changing together have focused on dietary changes with physical activity or weight loss interventions. In contrast, our participants were not asked to increase physical activity, but to decrease sedentary time during their work day. Dietary intake was collected at the time of consumption for three days, and participants were not asked to recall their diet, so there is less chance of recall bias. Also, there was no dietary component to the intervention, so participants were not aware that the study was looking at changes in dietary patterns which may have minimized the demand characteristics of the study. Further, diet was evaluated, not only regarding calories and macronutrients, but also using an overall index of dietary quality. Finally, our study was strengthened due to the evaluation of cardiovascular disease risk factors to determine whether they were associated with dietary intake or changes in dietary quality.

Limitations of Current Study

There were some limitations in this study that should be considered when interpreting findings. Although the 3-day food record was a strength of the study, participants were not trained in keeping food records. Participants received the food record with instructions in the mail, and a trained research assistant reviewed the record with the participants for any unclear entries when they came in for assessments. With food records, there are also potential biases to consider as participants may change their eating patterns when they know they are being evaluated. However, this potential bias would apply to both the SB and LB groups equally. The study design required the participants to be actively engaged in the study every workday for eight weeks, which may have caused a large participant burden. Participants of the LB group did have higher dropout numbers which may have been due to the length requirements for the LB group breaks. Additionally, the quality of completion as well as the number of food records submitted throughout the study may have dropped due to participant fatigue. Lastly, data collection for some participants occurred during the winter holiday season. Eating habits as well as ability/willingness to comply with the intervention may have been affected by travel, days off from work, and other demands during this time.

Future Directions

Future research should investigate the dietary quality of sedentary individuals using the more accepted definition of sedentary behavior (Sedentary Behaviour Research Network, 2012). It would be valuable to compare dietary changes in physical activity interventions to dietary changes in sedentary interventions to determine whether women are less prone to caloric compensation in sedentary behavior interventions. Additionally, future interventions should focus on both decreases in sedentary behavior and improvements in dietary quality. Given that women in the current study did not seem to compensate for participating in the intervention with increased calories, actually targeting dietary quality in the intervention might result in not only improvements in sedentary behavior, but also improved dietary quality along with caloric reductions, perhaps improving CVD risk factors further.

Conclusion

This study is the first study that we are aware of, that examines the impact of a sedentary behavior intervention on dietary intake (quality and total calories). Our findings add important information to the existing body of literature investigating lifestyle changes occurring together. Insufficiently active women who took short breaks from sedentary behavior throughout their workday for eight weeks, significantly reduced caloric consumption without significantly negatively impacting dietary quality. Participants who took longer, 15 minute breaks twice per workday, however, did not change dietary quality or caloric consumption. The group that took shorter breaks also had better adherence to the intervention and more positive improvements in CVD risk factors following the intervention. If short, frequent breaks from sedentary behavior during the workday can lead to improvements in CVD risk factors, without compensation for caloric expenditure via dietary changes, this strategy may be a useful option for women who are not able or willing to adopt an exercise program and/or who tend to overcompensate for physical activity energy expenditure through increases in caloric intake.

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