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IMPACT OF A 16-WEEK BEHAVIORAL WEIGHT-LOSS PROGRAM ON DIETARY AND PHYSICAL ACTIVITY CHANGES

Eunkyung Lee
University of Kentucky, eunkyung.lee@uky.edu

ABSTRACT OF THESIS

IMPACT OF A 16-WEEK BEHAVIORAL WEIGHT-LOSS PROGRAM ON DIETARY AND PHYSICAL ACTIVITY CHANGES

Behavioral weight loss programs have been shown to be effective for short-term weight loss, however the impact of these programs on dietary changes is unclear. This study examined the changes in participant's diet and physical activity over the course of a 16-week Internet behavioral weight-loss program. A single-center randomized controlled trial was conducted from August 2008 to December 2008 in Lexington, KY, and sixty-six women whose mean (SD) age was 48.6 (10.8) years and body mass index was 31.8 (3.7) kg/m^2 completed all dietary and physical measures. Participants received two face-to-face group sessions with a dietitian, at baseline and 4-weeks, in addition to 16 weekly behavioral weight loss lessons delivered via an Internet website. Participants showed a significant reduction in energy intake (1879.2±771.7 vs. 1372.9±423.7; $p<0.001$), dietary energy density (2.1±0.5 vs. 1.9±0.5; $p=0.002$) and a significant increase in diet quality score as measured by the HEI-2005 (53.9±9.9 vs. 57.4±10.6; $p =0.002$). Participants did not show significant differences in physical activity intensity, duration or energy expenditure. However, post hoc analysis revealed that those who adopted a healthy life style, such as eating more fruits and vegetables and being physically active, achieved greater weight loss than those who did not adopt a healthy lifestyle. Participation in this Internet behavioral weight loss program significantly improved dietary intake in adult women and did not significantly improve daily physical activity levels.

KEY WORDS: Internet Behavioral Weight-Loss Program, Diet Quality, Dietary Energy-Density, Physical Activity, Healthy Eating Index-2005

Eunkyung Lee

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By

Eunkyung Lee

Kelly H. Webber, PhD, MPH, RD, LD

Director of Thesis

Hazel Forsythe, PhD, RD, LD

Director of Graduate Studies

August 27, 2010

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THESIS

Eunkyung Lee

The Graduate School

University of Kentucky

2010

IMPACT OF A 16-WEEK BEHAVIORAL WEIGHT-LOSS PROGRAM ON DIETARY AND PHYSICAL ACTIVITY CHANGES

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
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at the University of Kentucky

By

Eunkyung Lee

Lexington, Kentucky

Director: Dr. Kelly H. Webber, Assistant Professor of

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Chapter 1: Introduction

Today the obesity epidemic is a major health concern worldwide. During the past few decades there has been a dramatic increase in obesity in the United States; now two-thirds of adult Americans are reported to be overweight or obese (Body Mass Index $\geq 25 kg/m^2$) [1-3]. Obesity is associated with the increased risk of many preventable chronic diseases including coronary heart disease, Type 2 diabetes and some cancers [4, 5]. As a consequence, medical costs associated with obesity have been increasing [6-9].

Although overweight and obesity are caused by many factors such as diet, genetic predisposition, culture and environment, energy imbalance is a main cause for weight gain. Dietary changes in the past decades may be one explanation for energy imbalance. According to the U.S. Food Supply Data from ERS/USDA, energy consumption has increased from 2172 kcal per day per capita in 1970 to 2742 kcal per day in 2002. Increased energy from foods high in added fat and sugar played an important role in increasing energy consumption. Fat consumption has increased from 45.7 g per day per capita in 1970 to 72.7 g per day in 2002, and the consumption of sugar-sweetened beverages in US adults increased by 46 kcal per day based on data from NHANES III 1988-1994, and NHANES 1999-2004 [10]. Increases in the serving sizes at restaurants also contributed to this increase in energy consumption [11-14].

Physical inactivity or sedentary life style may be another explanation for the obesity epidemic. A sedentary lifestyle is defined as engaging in no leisure-time physical activity (exercise, sports, and physically active hobbies) in a two-week period. Data from the National Health Interview Survey (NHIS) showed that in 1997-98 nearly four in 10 (38.3 %) adults reported no participation in leisure-time physical activity, and the

percentage of adults who are physically inactive did not change through 2007 (39.1%) despite the well-known benefits of physical activity and the Surgeon General's call to increase a physical activity for general health improvement [15-17]. Based on the NHIS 2007 statistics, U.S. adults become more physically inactive with aging and women are generally more physically inactive than men [15]. It is important for health care providers to incorporate physical activity when they plan health or weight loss interventions for women.

Therefore behavioral weight loss interventions that focus on dietary change and exercise are considered the most effective in achieving a significant (10%) weight loss among many interventions used to decrease obesity [18]. These behavioral weight loss interventions encourage participants to self-monitor their eating and exercise and lead them to reconstruct their environment and cognitions steadily during the intervention period. But this face-to-face format burdens consumers as well as health care providers in the aspect of time and money. For example, one study reported that most adults preferred to lose weight without having to participate in a structured face-to-face treatment program [19]. So, researchers and clinicians began to seek alternative ways to deliver weight loss programs. To keep pace with the rapid changes in the era, researchers have used the Internet as an alternative delivery channel of behavioral weight loss interventions since the 1990s. Although researchers could conveniently reach a large audience through the Internet, they did not show as much weight loss as traditional behavioral weight loss interventions [20, 21]. So many researchers have investigated the possibilities of incorporating other strategies such as ongoing counseling using e-mail and chat, technical devices to monitor physical activity and motivational interviewing techniques [22-24] in

enhancing program adherence and increasing weight loss. Using these strategies increased weight loss in some studies, however, these studies did not show the expected quantitative relationship between energy balance and weight loss. In addition, most Internet weight loss programs report the relationship between behavioral parameters such as social support or login frequency and weight and BMI changes with negative energy balance [20, 25].

Recently, researchers showed that obesity is related to poor diet. When they assessed the diet quality of US adults who participated in the Third National Health and Nutrition Examination Survey, they found that poor diet quality was associated with overweight and obesity after adjusting for age, gender, ethnicity, physical activity, smoking, alcohol use, income and education [26]. There is a lack of literature concerning the effect of the participation in a weight loss program on the change in dietary quality. There is a need to expand the investigation of the possible effects of participation in the weight loss intervention on dietary and physical activity changes such as diet quality, dietary energy density and exercise patterns. Since this intervention encouraged participants to decrease their energy intake to 1200-1500 kcal per day with a low-fat diet and to expend a minimum of 1000 kcal per week through moderate physical activity to produce energy deficit of 500-1000 calories per day for 16 weeks, it is necessary to investigate the nutrient adequacy, especially for calcium, iron, zinc, and vitamin B12 to ensure the safety of the weight loss program. Since poor diet quality is related to obesity, improved diet quality may help participants maintain their decreased weight in the long-term. Also, these dietary and exercise changes were chosen by the participants themselves, therefore these behavioral changes may be sustained longer than the

behavioral changes which were forced by the study design. Understanding dietary and exercise changes in detail may increase weight loss through more sustainable dietary and exercise guidelines, and also this research will contribute to the literature on the relationship between diet quality and a weight loss program.

Chapter 2: Research Purpose

The purpose of this study was to investigate the effect of a 16-week Internet-based behavioral weight-loss program, incorporating motivational interviewing, on the dietary intake and physical activity changes in overweight and obese women. Secondarily, this study will compare the differences in changes in dietary intake and physical activity between those participants who achieved a 5 percent or greater weight loss and those participants who did not achieve a 5 percent weight loss [27].

Hypotheses

H1: Participants will decrease total daily caloric intake between baseline and 16-weeks of the weight loss program.

H2: Participants will increase the total amount of calories burned weekly in physical activity between baseline and 16-weeks of the weight loss program.

H3: Participants will decrease the energy density in their diets between baseline and 16-weeks.

H4: Participants will improve their diet quality score, as measured by the HEI-2005, between baseline and 16-weeks.

H5: Participants who achieved a 5 percent or greater weight loss will have a greater decrease in caloric intake and energy density, and a greater increase in diet quality than participants who did not achieve at least 5 percent weight loss.

H6: Participants who achieved a 5 percent or greater weight loss will have a greater increase in exercise intensity, duration, and weekly calories burned than participants who did not achieve at least 5 percent weight loss.

Chapter 3: Literature Review

Prevalence of Obesity

According to the National Institutes of Health Clinical Guidelines, overweight in adults is defined as a BMI between 25 and 29.9, and obesity in adults is defined as a BMI of 30 or greater. Body Mass Index (BMI) is calculated as body weight in kilogram divided by square of height in meter (kg/m^2). Overweight and obesity are increasing in both genders and among all population groups. In NHANES 2005-06, an estimated 67.3 percent of adults, age 20-74 years in the U.S. were overweight or obese; this contrasts with the NHANES(1) 1971-1974, when an estimated 46.8 percent of adults were overweight or obese. The 2007 Behavioral Risk Factor Surveillance System Survey Data showed that 69% of Men and 52% of Women in America were considered overweight or obese. In Kentucky where obesity prevalence is higher than the US average, 72 % of men and 55% of women were considered overweight or obese. The prevalence of obesity increased as they age in both men and women.

Obesity epidemic shows disparities across gender, age, racial/ethnic groups, socioeconomic status, and geographic regions in the United States based on national data. Prevalence of obesity is higher in some ethnic groups. Data from NHANES, BRFSS, and the Add Health study show large racial/ethnic differences, especially for women. Non-Hispanic Blacks had the highest prevalence. Non-Hispanic Blacks and Mexican Americans had a higher prevalence than non-Hispanic Whites while Asian Americans had much lower prevalence than the national average [28]. It is widely accepted that low-socio-economic status (SES) groups in the United States are at increased risk of obesity, but the association between SES and obesity varies by ethnicity. For instance, on the

basis of NHANES 1999–2000 data, overall, less educated persons in the United States (those with less than a high school education) have a higher prevalence of obesity than their counterparts, with the exception of Black women. Black women with less than a high school education had the lowest prevalence compared with those who had higher educational levels [29].

According to the report by Centers for Disease Control and Prevention (CDC), in 2008, only one state, Colorado, had a prevalence of obesity (BMI ≥ 30) less than 20%. Thirty-two states had prevalence equal to or greater than 25% and six of these states having a prevalence of obesity equal to or greater than 30% are located in the mid-southeast regions (Alabama, Mississippi, Oklahoma, South Carolina, Tennessee, and West Virginia).

Obesity and Chronic Diseases

Overweight and obesity are known for the primary causes for many preventable chronic diseases (U.S. Department of Health and Human Services, 2001). Many studies revealed the direct association between obesity and the increased risk of chronic diseases such as coronary heart disease, Type 2 diabetes, hypertension, and some cancers [30, 31] and the incidence of disabilities [32]. Recent study conducted in Japan indicated that increased BMI is associated with Chronic Kidney Disease (CKD) independently of blood pressure, serum lipid and glucose levels in the general population [33].

Especially in women, obesity is the best-established predictor of gallbladder disease, osteoarthritis, breast cancer, and endometrial cancer [34, 35]. Also obesity is associated with infertility, birth defects, gynecological complications, and urinary

incontinence after childbirth in women [36, 37]. In addition, women with obesity report to have much more prejudice and discrimination directed against them than men with obesity [38, 39].

The Health Effects of Weight Loss

On the other hand, many researchers reported the benefits of modest weight loss [27, 37, 40, 41]. Five to ten percent weight loss can reduce the incidence of type 2 diabetes, cardiovascular disease, hypertension and urinary incontinence and produce significant health improvement.

Behavioral Weight-Loss Program

Behavioral weight-loss interventions that focus on diet and exercise are considered the most effective treatments for obesity. These programs typically consist of 16-24 treatment sessions delivered over a 6 month period. A group treatment format is typically used and a multidisciplinary team of therapist is involved (nutritionists, behavior therapists, and exercise physiologists). Participants are given calorie goals of approximately 1200-1500 calories per day depending on their baseline weight. These calorie goals are selected to produce an energy deficit of 500-1000 calories per day and consequently a 1-2 pound-per-week of weight loss. Fat gram goals are typically equal to a 20-25 percent fat diet. Also participants are encouraged to expend a minimum of 1000 calories per week through moderate physical activity (e.g., brisk walking for 30 minutes, 5 days per week). Behavioral weight-loss programs emphasize nutrition education to help participants eat a balanced diet as well as meet the calorie goal.

The Diabetes Prevention Program is an excellent example of the implementation and efficacy of behavioral modification of lifestyle. The Diabetes Prevention Program enrolled 3,234 overweight and obese patients with elevated fasting and postprandial plasma glucose who were randomized to receive placebo, metformin, or intensive lifestyle modification [42, 43]. The lifestyle modification group resulted in a weight loss of 6.7 kg at 1-year follow-up, compared with weight losses of 2.7 and 0.4 kg in the metformin and placebo groups, respectively. At the 4-year follow-up, lifestyle, metformin, and placebo groups maintained weight losses of 3.5, 1.3, and 0.2 kg, respectively. Behavioral modification of lifestyle reduced the incidence of type 2 diabetes by 58% and metformin by 31%, as compared with placebo.

Behavioral weight-loss programs encourage participants to self-monitor their food intake and physical activity. Participants record daily the time, type, amount of food eaten and exercise. Participants learn behavioral technique to modify their eating and exercise habits, and also they learn how to manipulate their environment at home and at work to limit cues associated with eating and to increase cues associated with exercise. Self monitoring is considered the major predictor of weigh loss [44, 45].

Outcomes of Behavioral Weight-Loss Interventions

Behavioral weight loss programs involving weekly face-to-face contact typically produce 9.1-kg or 10% weight loss in 20 to 24 weeks [44]. The Internet weight loss programs produce 4.1-4.4 kg weight loss over 6 months and it is still one-half of the level of weight loss expected in a traditional face-to-face intervention [20, 21, 44]. The

adherence to the program such as the number of logins [25], and continued diary submission [44] is considered another important predictor of weight loss.

Dietary Energy-Density

When it comes to the dietary guidelines for weight loss, there have been many studies about the relationship between the macronutrient composition and weight loss. From these studies, it was concluded that weight loss on calorie restricted diets was related with energy intake level, not with macronutrient composition [46, 47]. Recently, Rolls et al., reported that a low energy-density diet was effective in achieving negative energy balance and greater weight loss [48]. Energy density refers to the amount of energy in a given weight of food. Foods with a low energy density provide less energy per gram than do foods with a high energy density. Studies indicate that people tend to consume a fairly consistent weight of food over the course of a few days; therefore, the consumption of low-energy-density foods that contain less energy per gram may decrease overall energy intakes [49].

Ledikwe et al. reported mean daily diet-energy density values vary by age, gender and race/ethnicity. Men reported diets with a higher energy density than women and there was an inverse linear trend for age. Non-Hispanic Blacks reported diets higher in energy density than non-Hispanic Whites. Hispanic respondents reported diets lower in energy density than non-Hispanic Whites. Asian and Pacific Islander respondents reported diets the lowest in energy density among populations [50].

According to the data from CSFII 1994-1996, diet energy density consumed by adult women was 1.79kcal/g. Women with a low-energy-dense diet had lower mean

BMI values and body weights than did women with a high-energy-dense diet [51]. Persons with a high fruit and vegetable intake had the lowest energy density regardless of fat content of their diet. Ledikwe et al. examined the possible eight calculation methods for diet-energy density. In this report they suggested that investigators who examining diet energy density should use several calculation methods and at a minimum, methods should include a calculation based on food only because energy density values differ by calculation methods which deal beverages differently [50].

Dietary energy density can be lowered by adding water-rich fruits, vegetables, cooked grains, and soups to the diet, or by reducing the fat content. Low energy density diets are effective strategy for weight management since they help participants achieve negative energy balance without both reducing food volume and suffering hunger [52].

Ledikwe et al. also investigated the relationship between changes in diet energy density and changes in diet quality. They reported reduction in energy density were associated with improved diet quality as well as greater weight loss. They showed that the reduction in energy density was associated with increased intakes of fruits, vegetables, fiber, vitamins and minerals [53].

Development of Index for Diet Quality

Since the association between diets and the risk of many chronic diseases were revealed through epidemiologic studies, many researchers tried to assess the characteristics of healthy diets. Until the seventies, the diet met nutrient adequacy was considered a good quality diet. After eighties, researchers became interested in specific dietary pattern such as Mediterranean diet, and they tried to define healthy dietary pattern

through cluster analysis method. In 1994, some researchers developed the index which was connected with dietary guidelines to measure diet quality [54]. After that USDA developed Healthy Eating Index which had 10 components to evaluate the nutrient adequacy, moderation and variety of diets [55]. In 2005, Dietary Guidelines for American were modified extensively to reflect current information about the diet and health. Consistent with this modification, USDA revised Healthy Eating Index to the HEI-2005. HEI-2005 adapted energy density standard concept, added new components such as Oils, Calories from Solid Fat and Added Sugar, and specified dietary variety with whole fruit, whole grain, and dark orange green vegetables [56, 57].

Diet Quality and Weight Status

In cross sectional studies, obesity is reported to be associated with poor diet quality [26, 58]. Another recent study examining the relationship between the Healthy Eating Index and waist circumference suggested that dietary consumption that follows the HEI is associated with a lower risk for abdominal obesity. Especially in women, for each point increase for fruit score, abdominal obesity risk was decreased by 2.6% [59]. Wolongevicz et al. reported that women with lower diet quality, as measured by the Framingham Nutritional Risk Score, were significantly more likely to become overweight or obese compared with those higher diet quality in the Framingham Offspring and Spouse Study which followed participants over 16 years [60]. Other researchers reported that the consumption of fast food more than once per week increased the risk of overall low diet quality as well as being obese [61, 62].

Diet Quality and Socio-demographic Characteristics

Reports from the Center for Nutrition Policy and Promotion (CNPP) show that there is substantial room for improvement in the diet quality of most Americans. The CNPP reports that only 10% of the population has a good diet (HEI > 80); conversely, 16% has a poor diet (HEI < 51). Almost three-quarters of Americans have an HEI between 51 and 80, an indication that diet quality needs to be improved. The CNPP reports females have higher average HEI scores than do males and there are important differences in average HEI across age, race/ethnic groups, income, and education. According to Basiotis et al, non-Hispanic Blacks, low-income groups, and those with a high school diploma or less also had lower quality diets [63]. Forshee and Storey's investigation is consistent with previous results. Young adults (20-29 years), male, persons with low household income and African-Americans had lower HEI scores [63]. They found that family income had a positive association with consumption of total fruits and vegetables other than fried potatoes. Drewnowski explained that family income may be related to diet quality in part because healthier foods, such as fruits and vegetables are expensive on an energy–cost basis compared with palatable, energy-dense foods, such as fats and sugars [64, 65]. The different preference in food choice may explain the difference in diet quality score by race/ethnic groups [63].

Physical Activity Recommendations

Regular physical activity has been found to be associated with long-term weight loss maintenance; however, it is less clear how much exercise is adequate, or what type of exercise is more effective than others for weight loss or weight loss maintenance. So, it

is difficult to develop a single recommendation for physical activity. For the purpose of the chronic disease risk reduction and fitness enhancement effects, recommendation of a 30 minutes of moderate intensity activity on most days of the week (~700kcal/week), which was developed by the Centers for Disease Control and Prevention and the Surgeon General, has been widely accepted by the public [66]. More recently, exercise guidelines have been revised to recommend more physical activity for weight loss maintenance. In 2002 the Institute of Medicine recommended a minimum of 60 minutes a day of moderate intensity exercise (~2000kcal/week) to control body weight [67].

Studies on the effect of exercise on weight loss suggest that it is the total energy expenditure of the activity that appears to be important for weight loss rather than the intensity of activity [68]. On the other hand, resistance training has been highlighted by the fact that strength training may be beneficial for prevention of weight gain after weight loss since resistance exercise may increase total energy expenditure by promoting an increase in muscle mass which can lead to an increase in metabolic rate [69]. This was reflected in recent guidelines. According to the 2008 Physical Activity Guidelines for Americans, US adults need to do two types of physical activity each week to improve health–aerobic and muscle-strengthening. 2 hours and 30 minutes (150 minutes) of moderate-intensity aerobic activity (i.e., brisk walking) every week and muscle-strengthening activities on 2 or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders, and arms).

Characteristics of Weight-Loss Maintainers

The National Weight Control Registry (NWCR) was established in 1994 to investigate the characteristics and behaviors of individuals who have succeeded at long-term weight loss. To qualify for NWCR entry, individuals must have lost a minimum of 13.6 kg (30lb) and have maintained that amount of weight loss for at least 1 year. Even though the fact that majority of the NWCR entrants are female (71.3%), White (95.5%), married and highly educated may limit the generalization of the results, understanding of their dietary and physical activity patterns may lead to some insight regarding the common strategies used by individuals who are successful at weight loss and weight loss maintenance. For example, approximately 90 % of the NWCR entrants reported they used a combination of diet plus exercise to lose weight and maintain weight loss and weigh themselves frequently [70, 71].

Dietary Characteristics*:* The NWCR entrants are eating a low-calorie (1379 kcal/day), low-fat (26.6% energy from fat) diets with slightly high protein (18.6%). Even though the percent energy from fat showed an increase from 23.8 % in 1995 to 29.4 % in 2003, more than 75% of entrants are consuming a diet within the recommended range of fat intake (i.e., 20% to 35 % kcal from fat). Their eating habits of eating breakfast every day, self-monitoring their weight frequently, eating fast foods occasionally (less than once per week), and maintaining a consistent eating pattern across weekdays and weekends remained overtime, and they showed increase in vegetable intake and recent entrants consume nearly four servings a day [72, 73]. Shick et al report that intakes of the selected nutrients (calcium and vitamins A, C, and E) of the NWCR entrants are higher than the national sample and meet RDA except iron [72]. This can be translated they are

consuming a nutrient-dense diet by including a large number of fruits and vegetables while consuming low-calorie and low-fat diets. Another study comparing the eating pattern of weight-loss maintainers with that of weight gainers reported that maintainers had a lower energy-density intake and limited portion sizes of food groups high in energy density [74].

Raynor et al. reported that decreases in variety of high-energy-dense food groups were associated with reductions in energy and percent dietary fat intake, and weight loss during treatment and maintenance, and increases in variety of low-energy-dense foods were related to decreases in percent fat intake and weight loss during maintenance [75].

Physical Activity Characteristics*:* The NWCR also collects data on the physical activity habits of those participants in the Registry. Those who are successful at weight loss and weight maintenance are highly physically active. On average they expend 2621 ± 2252 kcal per week in physical activity (Men 2903 ± 2509 kcal/week and women 2532 ± 2156 kcal/week) which can be translated into 60-75 minute of moderate intensity activity per day. They expend most of their energy in heavy intensity activity and walking, followed by medium intensity activity, increased number of flights of stairs climbed and light intensity activity. Twenty seven percent of the entrants report they expend more than 3500 kcal per week in physical activity. Those who reporting very high levels of activity (> 3500 kcal/day) tend to be male, lower age, unmarried or never married [71]. Other study report that the use of physical activity as a strategy for weight loss seems inversely related to participants' age and BMI and directly related to the level of education [76].

For the most preferred types of activity, walking was the most commonly reported activity (52.2%), and resistance training was the second most commonly reported activity (29.2%). There were no significant differences between the percentages of men and women reporting resistance training, while the number of women reporting walking was slightly higher than the number of men (53.4% vs. 48.6%; p=0.13). In women, aerobic (19.2%), cycling (16.6%), cardiovascular exercise machine (15.2%) rounded out the top five physical activities. From these results, the entrants were using at least one type of physical activity to expend their kilocalories. One important change over time between 1993 entrants and 2001 entrants was observed: outdoor walking was decreased and indoor walking using treadmill was more preferred by women. Another change in the type of physical activities preferred was an increase in resistance training in both men and women [71].

Obesity is a growing problem in the US and developed countries, and can be treated with behavioral weight loss interventions. Much research has been conducted showing the relationship between dietary and exercise habits and weight loss and weight-loss maintenance. The impact of behavioral weight loss programs on the changes in dietary energy density, dietary quality, and exercise habits have not been fully researched. This research seeks to explore and explain the changes in dietary and exercise habits in a group of overweight and obese women enrolled in a 16-week behavioral weight loss program.

Chapter 4: Methodology

Study Design

This study utilized data from a randomized controlled trial, which tested the efficacy of two different Internet behavioral weight loss programs. The trial was conducted from August 2008 through December 2008 at the University of Kentucky. Each study group received two face-to-face group sessions, which were held at the beginning of the program and at four weeks. Except for these two sessions all weight loss lessons were delivered through the study website (www.HealthEhabitII.com) during this 16 week study. Daily structured meal plans were not provided; rather participants were taught how to incorporate various strategies for reducing their calorie and fat intake and increasing fiber and protein intake into their diets.

Participants

Our goal was to recruit 80 overweight and obese women who have home access to a computer with Internet service. To be eligible for the study, participants had to be 20 to 65 years of age and have a body-mass index of 25 to 40. Participants were excluded if they met any of the following criteria: the presence of diabetes or unstable cardiovascular disease, taking medications that would affect body weight, a medical diagnosis of orthopedic or joint problems that may prohibit regular exercise, being hospitalized for a psychiatric disorder within the last year, a history of anorexia or bulimia nervosa, intention to move out of the immediate area within the study period, being pregnant, nursing, or planning to become pregnant within the study period, being less than nine months post-partum, medical diagnosis of HIV, diagnosis with a major psychiatric

disorder, cancer diagnosis within five years with the exception of skin cancer, and recent weight loss of ≥10 pounds.

A local newspaper advertisement was the primary means of recruitment. All recruited participants were screened for eligibility via telephone and the eligible participants were then invited to a study orientation session. At this session, they were informed that the study would be assessing the effects of participating in an Internet weight-loss program on their dietary intake and exercise and they would be assigned to a group at random. Participants completed study questionnaires prior to entry into this study and provided permission from their physician indicating that the proposed intervention was not contraindicated. All participants provided written informed consent. Random assignment to one of two groups was generated by the data manager after eligibility of all participants was confirmed. The study was approved by the University of Kentucky Institutional Review Board.

Dietary Intervention

The participants' goals were to eat a low-calorie and low-fat diet with not more than 25% of calories from fat and not more than 1200 kcal per day for participants weighing less than 200 pounds and a diet of 1500 kcal per day for participants weighing 200 or more pounds. Each participant's caloric goal represented a deficit of 500~1000 kcal per day from baseline based on their baseline weight and weight-loss goal. This calorie deficit can cause 1 ~ 2 lb weight loss per week.

Low energy-density diets were recommended through increasing water-rich foods such as fruits and vegetables. Also an increase in fiber intake was emphasized through

more vegetables and more whole grain consumption to enhance satiety. Maintaining protein intake or increasing protein percentage intake was emphasized. Participants were instructed to record their daily food intake in a log and the online self-monitoring tool.

Physical Activity Intervention

The goal for physical activity was 60 minutes of moderate to vigorous exercise per day. Participants were instructed to exercise at least five days per week with walking encouraged as the primary mode of exercise. The exercise was to occur in bouts of at least 10 minutes. They were also instructed on the importance of lifestyle activity. Participants were instructed to record their daily exercise in a log and the online self-monitoring tool.

Internet Weight-Loss Program Website

At the end of the initial face-to-face session, participants were given password protected access to the study website (www.HealthEhabitII.com). The website contained a weekly weight-loss lesson, a message board feature, and links to self-help diet, exercise, and behavioral modification resources available on the web. The site also provided a personal online diary and progress page which participants were asked to use to report daily caloric intake and expenditure.

Online weight-loss lessons were delivered for 16 weeks (August 2008 to December 2008). Topics were similar to the core of the Diabetes Prevention Program (DPP), which was developed for use in a face-to-face individual setting. These lessons were modified for use in this study to be more self-directed and suitable for posting to the website. Examples of weekly topics were goal setting, energy balance, becoming more

active, eating out, low-fat diet (25% of total calories), incorporating physical activity into everyday life, creating healthy environments for eating and physical activity, and body image.

Participants were instructed to record their food and beverage intake in a daily food diary and in a web-based self-monitoring tool. Participants were encouraged to get to know each other at the face-to-face sessions and get together for exercise or other weight loss support through the program.

Anthropometric Measurement

All participants visited the University of Kentucky campus at baseline, four weeks, and four months for measurement of body composition and completion of study questionnaires and received $30 for attending the follow-up appointment. Trained research assistants measured participant's body composition and weight at baseline and at 16-week using a BOD POD (Life Measurement, Inc., CA). Participant's height was measured at baseline only using a calibrated, wall-mounted stadiometer (Perspective Enterprises, Inc., Portage, MI).

Dietary Intake Assessment

Dietary intake data were collected at baseline and 16-week follow-up with the use of the 2005 version of the Block Food Frequency Questionnaire (FFQ) in order to assess the impact of the program on dietary intake. The Block Food Frequency Questionnaire (FFQ) 2005 is composed of 110 food items and was designed to estimate the usual and customary intake of a wide array of nutrients and food groups. FFQ validity has been reported as being moderate to high when it was compared with multiple diet records or

with plasma nutrient markers. Recently researchers confirmed its validity (r=0.59) and reliability (r=0.75) among a sample of Canadian women [77]. The analysis of the questionnaires was conducted at NutritionQuest, Berkeley, CA. The intake of the three major macronutrients, micronutrients, and USDA MyPyramid food group servings were obtained from the analysis. The intake from supplements was not included in the dietary data. Energy density and the dietary quality score were calculated from the results of the food frequency questionnaire.

Dietary Energy-Density

Dietary energy density refers to the amount of energy in a given weight of food. It was calculated as daily energy intake divided by the weight of food consumed in a day (kcal/g) using foods only excluding all beverages, because they have a lower energy density than most foods and may disproportionately influence dietary energy density values [50].

The HEI-2005

The diet quality score was calculated using the Healthy Eating Index-2005 with dietary data from the food frequency questionnaire at baseline and follow-up. The HEI-2005 is a composite measure of diet quality as described by the key diet-related recommendations of the 2005 Dietary Guidelines. As shown in Table 4.1, diets that meet the least restrictive of the food-group recommendations, expressed on a per 1,000 calorie basis, receive maximum scores for the nine adequacy components of the index: Total

Table 4.1: Components of the Healthy Eating Index- 2005[a]

Component	Scoring range[b]	Criteria for maximum score	Criteria for minimum score of 0
Total Fruit	0-5	≥ 0.8 cup eq/1000kcal	0 cup eq/1000kcal
Whole Fruit	0-5	≥ 0.4 cup eq/1000kcal	0 cup eq/1000kcal
Total Vegetables	0-5	≥ 1.1 cup eq/1000kcal	0 cup eq/1000kcal
Dark green and orange vegetables and Legumes	0-5	≥ 0.4 cup eq/1000kcal	0 cup eq/1000kcal
Total Grains	0-5	≥ 3.0 oz eq/1000kcal	0 oz/1000kcal
Whole Grains	0-5	≥ 1.5 oz eq/1000kcal	0 oz/1000kcal
Milk	10	≥ 1.3 cup eq/1000kcal	0 cup eq/1000kcal
Meat and Beans	10	≥ 2.5 oz eq/1000kcal	0 oz/1000kcal
Oils	10	≥ 12 g/1000kcal	0 g/1000kcal
Saturated Fat[c]	10	≤ 7% of energy	≥ 15 % of energy
Sodium[d]	10	≤ 0.7 g/1000kcal	≥ 2.0 g/1000kcal
Calories from SoFAAS (solid Fat, Alcohol, and Added Sugar)	20	≤ 20% of energy	≥ 50 % of energy

[a] Adapted from Guender et al., 2008
[b] Individuals with intake between the minimum and maximum ranges were assigned scores proportionately
[c] 8 for 10% of energy from saturated fat
[d] 8 for 1.1 g /1000kcal

Fruit (5 points), Whole Fruit (5 points), Total Vegetables (5 points), Dark Green and Orange Vegetables and Legumes (5 points), Total Grains (5 points), Whole Grains (5 points), Milk (10 points), Meat and Beans (10 points), and Oils (10 points). Lesser amounts are prorated linearly. The following three components measure moderation and population probability densities were examined when setting the standards for minimum and maximum scores for these components: Saturated Fat (10 points), Sodium (10 points), and Calories from Solid Fats, Alcoholic beverages and Added Sugars (SoFFAS, 20 points). Calories from solid fats, alcoholic beverages, and added sugars are a proxy for the discretionary calorie allowance [57]. The HEI measure has been shown valid for assessing diet quality [56]. The HEI score is highly associated with plasma biomarkers which represent a good diet: Vitamin C(r=0.41), a-carotene(r=0.28), b-carotene (r=0.28), b-cryptoxanthin (r=0.41), lutein (r=0.23), and vitamin C (r=0.26) [78].

Physical Activity Assessment

Participants' physical activity was assessed with the Women's Health Initiative (WHI) questionnaire at baseline and 16 weeks. Exercise duration, intensity and energy expenditure were calculated from the questionnaire.

Statistical Analysis

This study was designed to have at least 80% power to detect a difference of 2.5kg between groups with a pooled standard deviation of 4.5kg and alpha = 0.05 on the primary outcome of weight loss. The Statistical Package for the Social Sciences (SPSS, version 16.0, 2007, SPSS Inc, Chicago, IL) was used for data analyses. The primary purpose of this analysis was to access the change in the dietary variables and the

secondary purpose was to access the change in physical activity over a period of 16 weeks. Data were pooled from the two groups since the body weight, physical activity, and dietary changes were not statistically different between the two groups. Comparisons of baseline data for those who completed all dietary data and those randomized were performed using an independent-samples *t* test for continuous variables and χ^2 test for categorical variables. The description of the effects of the Internet weight-loss program on the changes in dietary intake and physical activity over time was examined with the use of paired t-tests and frequency distributions. Diet quality was compared by socio-demographic groups; differences among groups were examined using ANOVA. Associations among dietary variables were explored with the application of correlation analysis. Correlation coefficients were used to determine the association among the HEI score, dietary energy density and dietary variables; Pearson's R coefficient was used when data were normally distributed and continuous, while Spearman's rho was used when data were non-normally distributed or ordinal.

For post hoc analysis, the entire sample was split into two groups, one that achieved a 5% or greater weight loss and one that did not achieve a 5% or greater weight loss, and dietary and exercise variables were compared with independent samples *t* test. A significance level of α=0.05 using a two-tailed test was set.

Chapter 5: Results

Participants

Of 140 women who were assessed for eligibility, 80 were allowed to attend the study and randomized into two groups; Motivation-enhanced Intervention Vs Standard Intervention. At 16 weeks, complete nutrient data were available for 66 participants (Figure 5.1). Since no significant difference in weight change and dietary changes between these two groups was detected during the study period, data were pooled. Baseline demographic information is reported in Table 5.1. Comparison of baseline characteristics between those who were randomized (n=80) and those who completed the dietary data (n=66) revealed no significant differences in the two groups. Data presented is for completers only.

Half of participants were 51 to 65 years of age with a mean age of 48.6±10.8 years. Thirty six percent of participants were defined as overweight, while 64 percent as obese. Participants' mean Body Mass Index (BMI) was 31.8±3.7 kg/m^2. The majority of participants were White (92.4 %), while others were African-American (6.0%) and Asian (1.5%). Participant's education level showed a strong leaning toward a higher education. Eighty eight percent of participants reported they had higher than "some college" (50% some college and 37.8% graduate) level education. Their marital status was diverse: most participants (78.8%) were married or living with partner, 7.6% were single, 7.6% were divorced, and 6% were widowed. The average number of children in the household was 0.76±0.99.

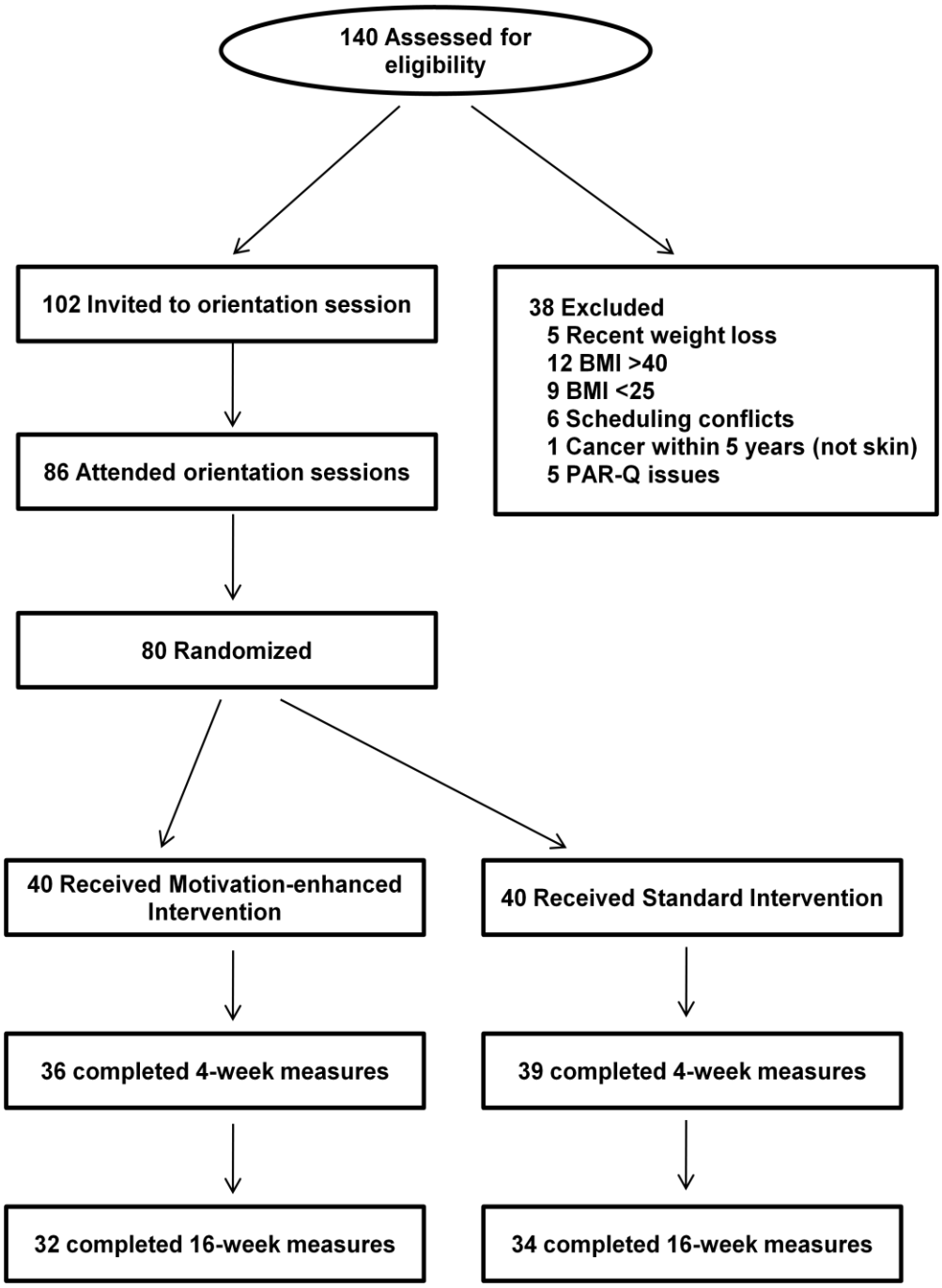

Figure 5.1 - Diagram for Participant's Flow

Table 5.1: Participant Characteristics at Baseline

Characteristics	Total (n=80)	Completers (n=66)	p-value
	mean ± s.d		
Age (y)	48.7±10.6	48.6±10.8	P=0.818
Weight (kg)	84.2±12.1	83.7±12.3	P=0.372
Body Mass Index (BMI)	32.0±3.7	31.8±3.7	P=0.365
Energy Intake	1843±739	1854.2±771.7	P=0.772
PA Energy burned weekly	989.7±956.6	955.3±978.1	P=0.969
	N (%)		
Race/Ethnicity			
White	73 (91.2)	61 (92.4)	P=0.469
Black-American	6 (7.5)	4 (6.0)	
Asian	1 (1.2)	1 (1.5)	
Education level			
High school graduate	8 (10.0)	8 (12.1)	P=0.326
Some college	11 (13.8)	8 (12.1)	
College graduate	29 (36.2)	25 (37.9)	
Some graduate school	4 (5.0)	4 (6.0)	
Graduate or professional degree	28 (35.0)	21 (31.8)	
Marital status			
Single	6 (7.5)	5 (7.6)	P=0.322
Married or living with partner	62 (77.5)	52 (78.8)	
Divorced	8 (10.0)	5 (7.6)	
Widowed	4 (5.0)	4 (6.0)	
Number of children in household			
0	43 (53.8)	36 (54.5)	P=0.105
1	17 (21.2)	16 (24.2)	
2	13 (16.2)	8 (2.1)	
3	7 (8.8)	6 (9.1)	

Nutrient Intakes at Baseline and 16 weeks

Baseline Characteristics*:* Table 5.2 shows energy and dietary intake characteristics of participants at baseline. Most participants were consuming high calorie (Mean 1879.2 kcal/day and Median 1694.5 kcal/day) and moderate energy-density (2.1±0.5 kcal/g) diets. An average macronutrient composition of Protein: Carbohydrate: Fat (15.4: 48.7: 36.1) showed that they were consuming a high-fat and moderate-protein diet. Energy from Sweets (15.1 ± 10.3%) was a great portion of their daily calorie intake. They were consuming less fiber (20.4g/day, or 11.0 g/1000kcal), less fruit (1.05servings/day), less whole grain (0.9serving/day) and less dairy products (1.1 serving/day) than the recommendations of the Dietary Guidelines for Americans 2005. Their mean diet quality score accessed by Healthy Eating Index-2005 was 53.9±9.9.

Changes in Energy and Macronutrient Composition: After participation in the 16-week Internet behavioral weight loss program, participants showed significant reduction in intake of energy by 506.3±557.7 kcal per day (from 1879.2 kcal/day to 1372.9kcal/day; $p<0.001$). Their macronutrient composition was kept similar to baseline with a slight, but significant increase in the percentage of energy from protein (from 15.4 % to 16.6 %; $p=0.003$). Participants reduced their average fat intake from 75.6 g to 53.1g per day, but this did not help reduce their percent of energy from fat. Participants decreased both saturated fat percent (from 10.8±1.9% to 10.2±2.4; $p=0.039$) and trans-fat percent from energy (from 1.2±0.5% to 1.1±0.5; $p=0.041$) significantly at 16-week follow-up. The percent of energy from sweets was significantly decreased (from 15.1 ±10.3% to 12.6±8.2 %; $p=0.012$). Fiber intake was also decreased in accordance with the

Table 5.2: Dietary Intake

Dietary Intakes	**Baseline**	**16 weeks**	Difference	p-value
Energy(Kcal/d)	1879.2±771.7	1372.9±423.7	506.3±557.7	p<0.001
Protein (% of energy)	15.4±3.2	16.6±2.8	1.13±3.01	p=0.003
Carbohydrate (% of energy)	48.7±6.9	48.5±7.0	-0.18±5.46	P=0.792
Total fat (% of Energy)	36.1±4.5	34.9±5.9	-1.15±5.07	P=0.069
Sweets (% of energy)	15.1±10.3	12.6±8.2	-2.49±7.81	P=0.012
Saturated fat (% of energy)	10.8±1.9	10.2±2.4	-0.57±2.2	P=0.039
Monounsaturated fat (g)	30.1±12.2	21.7±8.1	-8.3±9.6	P<0.001
Polyunsaturated fat (g)	17.2±7.6	12.2±4.7	-4.9±5.5	P<0.001
Trans fat (% of energy)	1.2±0.5	1.1±0.5	-0.14±0.53	P=0.041
Cholesterol (mg)	192.3±88.6	150.0±71.3	-42.3±70.0	P<0.001
Total fiber (g/day)	20.4±8.1	15.7±6.1	-4.73±6.30	p<0.001
Energy Density	2.1±0.5	1.9±0.5	-0.18±0.46	p=0.002
Healthy Eating Index-2005 total score	53.9±9.9	57.4±10.6	3.5±8.8	p=0.002

P-values are for t-tests of comparisons of baseline and 16 weeks.
Dietary data was reported from Food Frequency Questionnaire.

reduction in overall energy intake, from 20.4g to 15.7g and both were below the daily recommended intake.

Micronutrient Intake: In accordance with the reduction of energy intake, almost all micronutrient intakes were decreased (Table 5.3). Among these micronutrients, intake of calcium, potassium, iron, and folic acid were below the Dietary Reference Intakes (DRIs) for adult women (DRI tables, www.usda.gov) both at baseline and at follow-up. The mean intake of magnesium was decreased below the DRIs with reduction of energy intake. Sodium intake was also significantly reduced at 16 weeks, however, it was still greater than the DRIs (2438.3 mg at 16 weeks Vs 1300mg).

Changes in Intakes by Food Groups

To help understanding participants' dietary intake and food choices, My Pyramid Food Group Servings were examined and presented in Table 5.4. At baseline, participants showed a wide range of consumption of each food group. From the mean intake of each food group, fruits, whole gains, and milk groups were less than the recommendation. After the study, participants showed a significant decrease in intake of some food groups which are important sources of energy intake, i.e. meat, fat and grain groups, to achieve the energy reduction goal while keeping their intake of fruit, vegetable and dairy groups the same as baseline. Intake of whole grains showed a significant decrease from 6.05±2.54 to 4.26±1.54 ($p<0.001$) in accordance with the reduction of intake of total grains. Participants decreased starchy vegetable intakes (from 0.41±0.30 to 0.24±0.18; $p<0.001$) and maintained dark green and orange vegetable intakes.

Table 5.3: Micronutrient Intake

Nutrients	Baseline	16 weeks	Difference	p-value	DRIs for women (19y-70y)
Sodium (mg)	3131.0±1224.9	2438.3±833.8	-692.7±1020.1	P<0.001	1300-1500
Potassium (mg)	2731.6±961.4	2269.2±791.8	-462.4±811.6	P<0.001	4700
Calcium (mg)	814.3±298.0	682.6±267.9	-131.8±256.9	P<0.001	1000-1200
Iron (mg)	14.7±5.2	11.5±3.8	-3.3±4.4	P<0.001	8-18
Zinc (mg)	10.9±3.9	8.5±2.9	-2.4±3.4	P<0.001	8
Vit. C (mg)	93.1±53.5	81.2±45.8	-11.9±44.2	P=0.032	75
Vit. B12 (mcg)	4.5±2.5	3.8±1.9	-0.77±2.7	P=0.022	2.4
Magnesium (mg)	337.9±146.8	264.7±98.1	-73.3±126.9	P<0.001	310-320
Folic acid (mcg)	153.2±86.6	115.5±69.5	-37.7±79.9	P<0.001	400
Copper (mg)	1.49±0.72	1.14±0.44	-0.34±0.65	P<0.001	0.9
Selenium (mcg)	92.2±34.7	72.1±24.1	20.0±30.8	P<0.001	55

P values are for t-tests of comparisons of baseline and 16 weeks.
Dietary data was reported from Food Frequency Questionnaire.

Table 5.4: MyPyramid Food Group Servings

	Baseline	16 weeks	P-value	Recommendation for women > 19y
Total Fruit (cups)	0.77±0.57	0.68±0.48	P=0.132	1 ½ - 2
Vegetable –not legumes/potatoes (cups)	1.77±0.99	1.54±0.89	P=0.049	Total Vegetables: 2-2 ½
Vegetable-dark green (cups)	0.53±0.36	0.49±0.39	P=0.299	-
Vegetables-orange (cups)	0.13±0.16	0.12±0.11	P=0.526	-
Vegetables-legumes, soy (cup equiv)	0.21±0.41	0.14±0.20	P=0.062	-
Vegetables-potatoes (cups)	0.41±0.30	0.24±0.18	P<0.001	-
Vegetables-other (cups)	1.09±0.65	0.92±0.57	P<0.03	-
Total Grain (oz. equiv)	6.05±2.54	4.26±1.54	P<0.001	5-6 (Minimum 3)
Whole Grain (oz. equiv)	1.71±0.91	1.19±0.55	P<0.001	2 ½ - 3
Meat (oz)	3.20±1.91	2.79±1.44	P=0.053	5- 5 ½
Nuts & seeds (oz. equiv)	0.72±0.64	0.44±0.30	P<0.001	-
Dairy (cup equiv)	1.22±0.63	1.08±0.63	P=0.046	3
Oils (tsp)	2.73±1.59	1.95±1.09	P<0.001	< 5

P-values are for t-tests of comparisons of baseline and 16 weeks.
Dietary data was reported from Food Frequency Questionnaire.

Dietary Energy-Density

Dietary energy density was significantly reduced from 2.1±0.5 kcal/g to 1.9±0.5 kcal/g ($p=0.002$). This reduction was associated with a decrease in percent energy from sweets ($r=0.740$, $p<0.001$) and fat serving ($r= 0.558$, $p<0.001$). Also the change in dietary energy density was negatively correlated with a change in percent of energy from protein ($r=-0.395$, $p=0.001$) and fruit and vegetable intake ($r=-0.443$, $r=-0.634$, $p<0.001$). The higher intakes of protein, fruits and vegetables contributed to lowering dietary energy density.

Diet Quality

HEI-2005 Score: At baseline assessment, the mean Healthy Eating Index (HEI) - 2005 score for the total sample was 53.9 and the scores were below the maximum possible score for all food components (Table 5.5). The following components had the lowest scores: Total Fruit; Milk; Sodium; and Calories from Solid Fat, Alcohol, and Added Sugar. The score for the other food components were also substantially below their maximums. The total HEI-2005 score was significantly increased at the 16-week follow-up (from 53.9 to 57.4; $p=0.0016$). The scores for Total Fruit ($p<0.05$), Milk, Meat and Beans ($p<0.001$), and Calories from Solid Fat, Alcohol, and Added Sugar ($p<0.01$) showed a statistically significant increase, while each score for Total Grain ($p<0.05$) and Sodium ($p<0.01$) was significantly decreased at the follow-up. The score for Sodium marked one of the lowest score of possible maximum both at baseline and the follow-up. Improvement in the diet quality was highly correlated with the decrease in the percent energy from sweets ($r=-0.509$, $p<0.001$) and the lowered energy-density of diets

Table 5.5: Healthy Eating Index-2005 Score by Food Components

Component (maximum score)	Baseline		16 weeks		Americans from NHANES 2001-2002
	Intake per 1000kcal	score	Intake per 1000kcal	score	
Total Fruit (5)	0.42	2.50	0.49	2.85*	3.1
Whole Fruit (5)	0.36	3.38	0.41	3.66	3.4
Total Vegetables (5)	2.17	4.89	2.49	4.91	3.2
Dark green and orange vegetables and Legumes(5)	0.48	4.06	0.57	4.23	1.4
Total Grains (5)	3.27	4.72	3.17	4.56*	5.0
Whole Grains (5)	0.95	3.07	0.92	2.93	1.0
Milk (10)	0.67	4.99	0.78	5.64**	6.3
Meat and Beans (10)	2.14	7.69	2.43	8.52***	10.0
Oils (10)	7.36	5.92	7.22	5.79	6.8
Saturated Fat (10)	10.78	6.33	10.2	6.96	6.4
Sodium (10)	1680	2.95	1780	2.26**	4.1
Calories from solid Fat, Alcohol, and Added Sugar (20)	47.75	3.46	44.1	4.85*	7.5
Total HEI-2005 score (100)		53.9		57.4**	58.2

The study participants' mean HEI-2005 score was calculated from Food Frequency Questionnaire, and the national mean score was calculated using 1 day dietary intake data from NHANES 2001-02.

* Significantly different from baseline at $p<0.05$

** Significantly different from baseline at $p<0.01$

*** Significantly different from baseline at $p<0.001$

(r= - 0.50, p<0.001). Also HEI-2005 improvements were correlated with the increase in servings of fruits (r= 0.442, p<0.001) and vegetables (r= 0.357, p=0.003).

HEI-2005 Scores and Socio-demographic Status: The mean HEI-2005 score, stratified by socio-demographic groups, is presented in Table 5.6. As shown in Table 5.6, at baseline, the average HEI-2005 score varied across socio-demographic groups, trend being lower in the young age group, African-American, single or widowed, individuals with lower education or higher BMI, and individuals living with children at home. The HEI-2005 total score was significantly increased after participating in the Internet weight loss program, but the effects on the diet quality score varied by the socio-demographic characteristics (Figure 5.2). The biggest increase was observed in the following groups that had the lowest score at baseline: those who had a high school education only, lower physical activity at baseline, and higher BMI at baseline. On the contrary, the groups that had the highest HEI-2005 score at baseline -some graduate school and the divorced- showed little or no improvements.

Physical Activity Changes

At baseline, most participants were engaged in a significant amount of physical activity. Their average exercise duration was 159.4 minutes per week and energy expenditure was 966.0 kcal per week at baseline. This corresponded to 30 minutes per day for 5 day a week and this met the recommendation of physical activity for healthy life [66], but did not meet the recommendation for weight control [67].

Changes in physical activity which are calculated based on the Women's Health Initiative (WHI) questionnaire over 16 weeks are presented in Table5.7. There were

Table 5.6: Mean Healthy Eating Index-2005 Score by Socio-demographic Characteristics

Participant characteristics		HEI score		
		Baseline Mean ±S.D.	**Follow-up Mean ±S.D.**	**Difference**
Age (y)	< 49	50.3	53.2	+2.9
	≥ 49	56.7	60.6	+3.9
		P=0.009	P=0.004	P=0.663
Ethnicity	Caucasian	53.7	57.4	+3.6
	African-American	52.2	54.1	+1.9
		P=0.756	P=0.545	P=0.715
Education level	High school graduate	47.0	52.3	+5.2
	Some college	52.3	54.2	+1.8
	College graduate	53.5	57.7	+4.3
	Some graduate school	60.2	60.7	+0.5
	Graduate or professional degree	56.6	59.7	+3.2
		P=0.122	P=0.404	P=0.870
Marital status	Single	49.6	52.5	+2.9
	Married or living with partner	54.5	58.4	+3.9
	Divorced	60.3	60.3	+0
	Widowed	43.7	47.5	+3.8
		P=0.054	P=0.142	P=0.825
Living with children	No	56.6	59.8	+3.2
	Yes	50.7	54.6	+3.9
		P=0.015	P=0.043	P=0.768
Weight status	25 < BMI < 30	56.1	58.3	+2.2
	BMI > 30	52.7	56.9	+4.2
		P=0.186	P=0.611	P=0.380
Physical activity	<1000 kcal/week	52.7	57.6	+4.9
	>1000 kcal/week	56.7	57.1	+0.31
		P=0.132	P=0.844	P=0.05

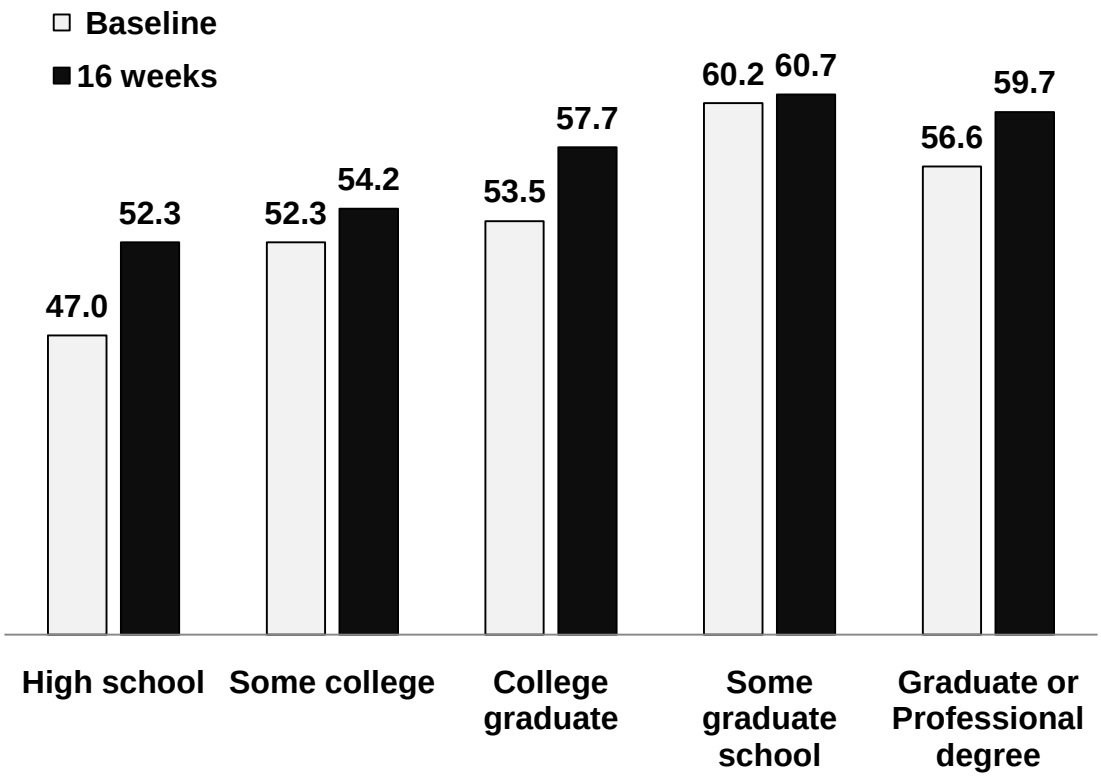

Figure 5.2 - The HEI-2005 Score Change by Education Level

Table 5.7: Physical Activity Changes

		Baseline	Final	Difference	p-value
Duration, min/wk	**mean**	**159.4±149.4**	**179.6±132.0**	**+ 20.23±140.2**	**P=0.246**
	median	**135.0**	**165**	**+ 30**	**P=0.189**
Intensity, kcal/min	**mean**	**6.18±1.2**	**6.26±1.1**	**+ 0.18±1.4**	**P=0.346**
	median	**5.75**	**5.91**	**+ 0.16**	**P=0.277**
Energy Expenditure, kcal/wk	**mean**	**966.0±981.8**	**1130.8±869.3**	**164.8±889.2**	**P=0.140**
	median	**750**	**1081.25**	**+ 331.25**	**P=0.075**

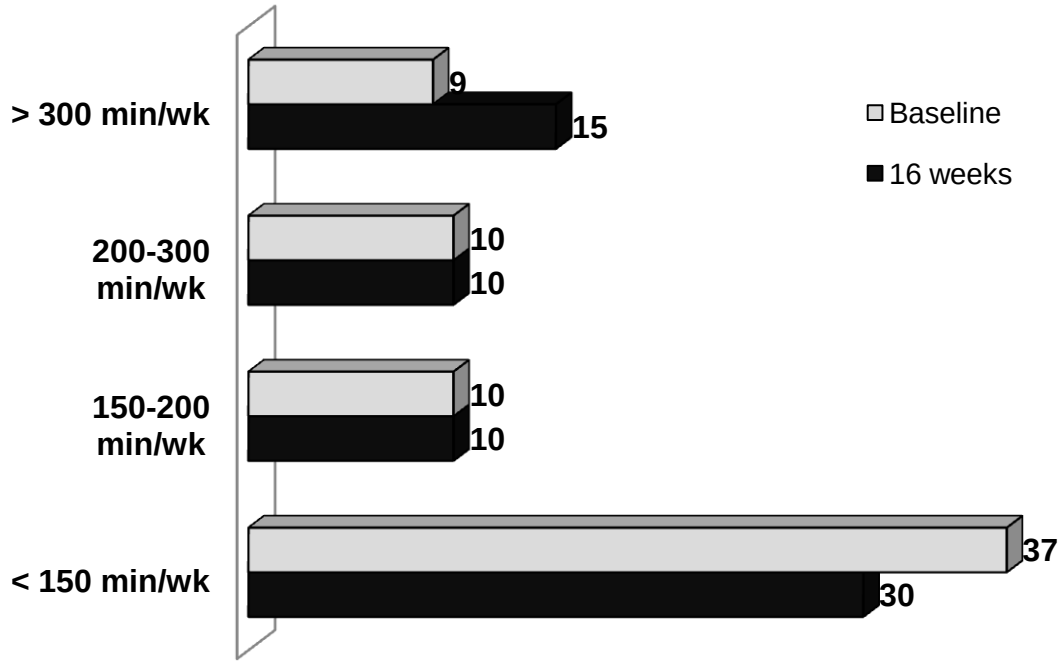

Figure 5.3 - Frequency Distribution of Participant's Exercise Duration

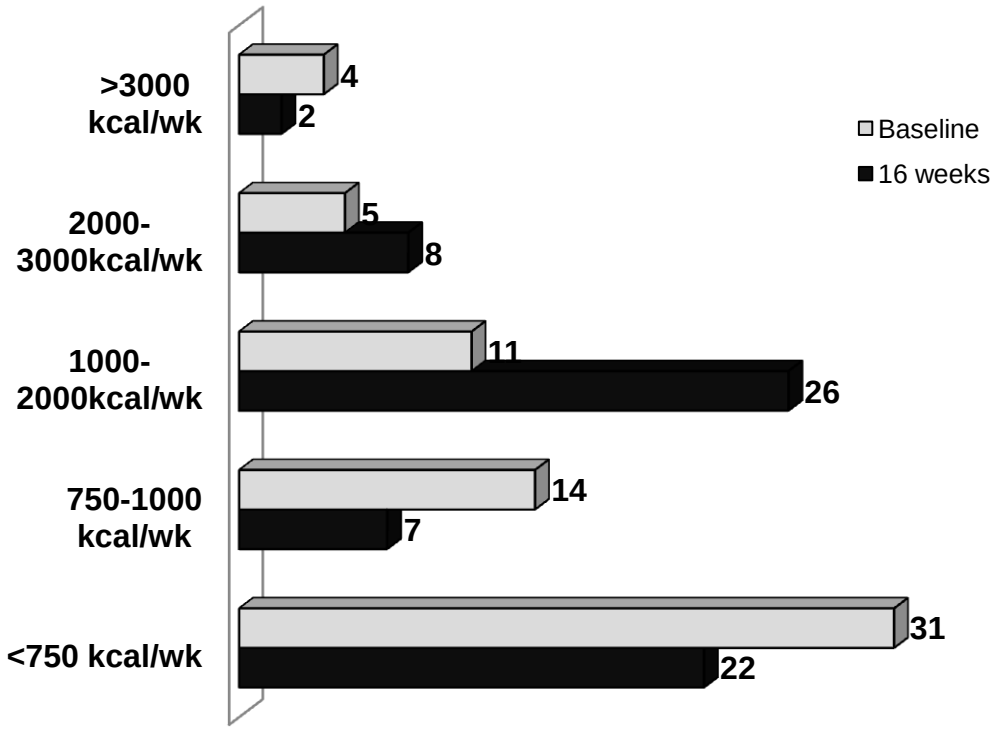

Figure 5.4 - Frequency Distribution of Participant's Exercise Energy Expenditure

trends in increase in exercise duration, intensity and energy expenditure, but they were not statistically significant. While their average exercise duration did not reach the recommended excise duration for weight loss, 60 min/day or 300 min/week, more than half of the participants showed increases or maintenances of their exercise duration and energy expenditure according to the study instruction (Figure 5.3, 5.4).

Comparison of Diet and Physical Activity Strategies by Weight Loss

In post hoc analysis, participants were divided into the following groups based on the amount of weight loss: Group A- those who achieved 5 percent or greater weight loss (n=23); Group B- those who did not achieve 5% weight loss (n=43). Comparison of characteristics between the two groups is presented in Table 5.8. At baseline, there were no significant differences in mean age, BMI and the diet quality score between the two groups, but there was a significant difference in diet- energy density (2.3 Vs 2.0; p=0.012). Greater weight loss was observed in those who had lower quality diets in terms of baseline diet energy density.

Energy and Macronutrient Intake: At baseline both groups consumed over 1500 kcal per day, but they reduced energy intake to less than 1500 kcal per day at 16-week follow-up. Even though dietary total energy reduction did not show a significant difference between the two groups, the changes in macronutrient composition showed differences; participants who achieved 5 percent or greater weight loss showed a greater decrease in fat gram intake (-33.5g Vs -14.9g; p=0.002) and percent energy from fat (-3.3% Vs -0.2%; p=0.016) than those who did not achieve 5 percent of weight loss. Change in percent energy from carbohydrate showed a different direction. Group A

Table 5.8: Comparison of Characteristics between Those Who Achieved 5 % or Greater Weight Loss (Group A) and Those Who Did Not (Group B)

Characteristics	Group B: 5% or less (n=43)	Group A: 5% or greater (n=23)	p-value
	mean ± s.d		
Age (y)	47.1±11.3	51.4±9.5	P=0.126
Baseline Weight (kg)	83.4±11.9	84.3±13.3	P=0.769
Baseline BMI (kg/m^2)	32.0±3.5	31.5±3.9	P=0.600
Baseline Energy Intake	1755.2±749.1	2039.3±114.23	P=0.156
Final Energy Intake	1394.9±446.6	1331.5±383.2	P=0.566
Baseline PA Energy consumed weekly	901.8±879.7	1055.4±1154.6	P=0.547
Final PA Energy consumed weekly	868.0±800.5	1572.8±883.1	P=0.001
Baseline HEI-2005 Score	53.5±9.5	50.7±11.6	P=0.305
Baseline Energy Density	2.0±0.4	2.3±0.6	P=0.012
Change in diet calorie (kcal)	-825.9±1067.9	-466.5±1199.3	P=0.219
Change in diet fat (g)	-14.9±17.8	-33.5±28.4	P=0.002
Change in diet fat (%)	-0.2±4.5	-3.3±5.4	P=0.016
Change in diet carb (%)	-1.4±4.9	1.7±6.0	P=0.024
Change in diet prot (%)	0.9±2.8	1.4±3.5	P=0.563
Change in Veg (serv)	-0.79±1.8	0.23±1.9	P=0.031
Change in Fruit (serv)	-2.1±0.6	0.17±0.7	P=0.022
Change in Fat (sev)	0.60±1.3	-1.6±1.9	P=0.016
Change in energy density	-0.007±0.4	-0.47±0.41	P<0.001
Change in HEI Score	1.2±8.2	8.3±9.1	P=0.0016
Change in PA duration	-5.8±131.8	68.9±145.3	P=0.038
Change in PA intensity	-0.070±1.5	0.62±1.4	P=0.086
Change in PA calorie	-68.0±861.4	517.4±929.6	P=0.013

showed an increase in the percent energy from carbohydrate while group B showed a decrease (1.7% Vs -1.4%; p=0.024).

Micronutrient Intake: There were no significant differences in intake of calcium, iron, zinc, magnesium, vitamin C, and vitamin B12 between the two groups either at baseline or at follow-up.

Dietary Energy-Density: Dietary energy-density reduction at 16 weeks was significantly greater in the participants who achieved 5 percent or greater weight loss compared with those who did not (-0.47±0.41 Vs -0.007±0.4, p<0.001).

Diet Quality: Increase in diet quality score was significantly greater in the group with 5 percent or more of weight loss compared with the group with less than 5 percent of weight loss. (8.32±9.03 Vs 1.20±8.21; p=0.0016)

Food Groups*:* Participants who achieved weight loss of 5 percent or greater showed an increase in vegetable and fruit intakes assessed by food group servings while those who did not achieve 5 percent weight loss showed a decrease (Vegetable: 0.23 servings Vs -0.79servings; p=0.031, Fruits: 0.17servings Vs -2.1servings; p=0.022). Participants who lost more than 5 percent weight decreased their fat servings more than that of those who had less than 5 percent weight loss (-1.58 ±1.94 servings Vs 0.60±1.26 servings; p=0.016).

Physical Activity: The changes in physical activity duration, intensity and energy expenditure are presented in Figure 5.5. Change in physical activity showed a different direction. Participants who achieved weight loss of 5 percent or greater increased their exercise duration, exercise intensity and energy expenditure while participant who did not reach 5 percent of weight loss showed decreases in exercise duration, exercise intensity

and energy expenditure (Duration: 68.9 min Vs -5.8 min; p=0.038, Intensity: 0.62 Vs -0.007; p=0.086, Energy expenditure: 517.4kcal Vs -75.9kcal; p=0.013).

In summary, the two groups showed patterns of lifestyle change consistent with the weight loss literature. Group A adopted a healthy lifestyle with consumption of more fruits and vegetables, a diet lower in energy density, and an increase in physical activity. Group B did not adopt these healthy lifestyle behaviors and in fact decreased their intake of fruits and vegetables and energy expended in physical activity.

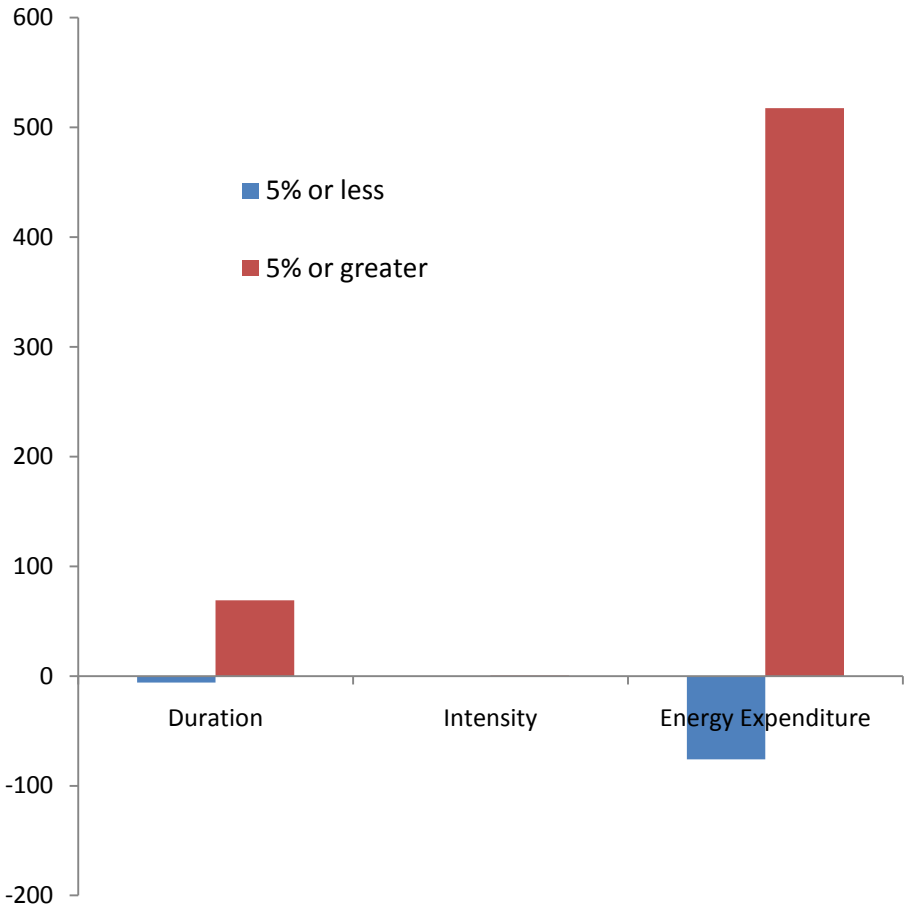

Figure 5.5 - Comparisons of Exercise Pattern Changes during a 16-week Weight Loss Program between Those Who Achieved 5 % or Greater Weight Loss and Those Who Did Not

Chapter 6: Discussion

Energy Intake

Baseline data of the current study revealed that the women who were obese or overweight and seeking a weight loss program were consuming an average 1879.2 kcal per day. Their average dietary energy-density was 2.1 and fat intake was 36.1 percent of total energy. These dietary characteristics implied that study participants needed improvement in eating habits as well as a reduction in energy intake. According to the study results, after 16 weeks, participants reduced their energy intake by 506.3±557.6 kcal per day. A previous internet weight loss study, which used motivational interviewing, has reported a decrease in caloric intake at 16 weeks of 368±814 kcal/day [24]. Similar dietary calorie reduction was found in studies reporting the efficacy of a structured Internet behavioral weight loss program [20, 44, 79] and a face-to-face weight loss intervention [80]. The current weight loss program resulted in far more decrease in caloric intake than previous studies.

Macronutrient Composition

Even though participants were instructed to reduce the percent energy from fat and to maintain their protein intake as usual, they kept their macronutrient composition similar to baseline during the study period, except for protein. Percent energy from protein was slightly but significantly increased at follow-up (15.4±3.2 Vs 16.6±2.8; p=0.003). This 1.2 percent increase may not be sufficient to expect the benefits of high-protein diets, 20 to 30 percent of total energy, during a weight loss period, however, high protein diets are considered to be effective in weight loss and weight-loss maintenance through enhancing satiety and maintaining lean body mass [81-83]. Decreasing fat

percent from energy may need more intensive interventions over time. High fat foods are more palatable and addictive than low fat foods. One recent study reported that fat intake was reduced from 34.5% to 28.4% when study participants were instructed through the intensive individual and group face-to-face weight loss interventions over 1 year [80]. In the short-term, reducing the size of portions seems an easier way to achieve a reduction of calorie intake than decreasing energy derived from fat percent. This statement was supported from the analysis of food frequency questionnaires which showed participants marked small or medium portions more often ($p<0.001$ and $p=0.013$ respectively) and they marked large or extra large portions less often ($p<0.001$ both) at 16 weeks than at baseline.

Even though percent energy from fat was not significantly decreased, participants showed significant decreases in energy in both saturated fat percent and trans-fat percent at 16-week follow-up. This result suggests that participating in a weight-loss program can lead participants to choose more healthy foods in addition to weight loss. However, the fact that their fat intake levels did not meet the recommendation for cardiovascular health at both baseline and 16 weeks also suggests that weight-loss program needs to incorporate more lessons on the importance of the restriction of saturated fats and trans-fats in order to decrease the cardiac complications of obesity.

We emphasized increasing fiber intake with whole grain, fruit, and vegetables for satiety, because hunger is a barrier when trying to decrease energy intake. However, participants showed a decrease in total fiber intake. When we examined the data in detail, participants decreased fiber intake significantly from grains (9.3g to 6.4 g; $p<0.001$), not from vegetables (7.8g to 7.1g; $p=0.09$). Therefore when following an energy reduction

diet, replacing grain intake with whole grain is essential to ensure that daily fiber needs are met. One important finding was that participants maintained their total fruit and total vegetable intake as usual when they were required to decrease their total energy intake. Another important finding was that participants decreased starchy vegetables and maintained dark green and orange vegetable intakes. Maintaining fruit and vegetable intake as usual or increasing fruit and vegetable intake has beneficial effects on micronutrient profiles as well as preventing chronic diseases such as hypertension, cardiovascular disease and colon cancer. To our knowledge, no other studies have reported on changes in fruit, vegetables, and grain intakes during a weight loss study. In addition, the fact that the greatest source of dietary fiber of the NWCR (National Weight Control Registry) entrants is from vegetables, not grains [73] indicates that high consumption of vegetables is an important strategy to be successful at weight loss as well as weight-loss maintenance.

Micronutrients

This study showed that most micronutrient intakes were decreased probably a result of a reduction of calorie intake. Therefore nutrient adequacy becomes a concern during weight loss. Regarding intakes of calcium, potassium, magnesium, folic acid, and iron, our findings suggest that people following an energy-restricted diet for weight loss need to consume nutrient-dense foods to ensure that these nutrients needs are met. Similar nutrient inadequacy was found in other studies comparing traditional diets with a meal replacement during weight loss [84] and the authors suggested that supplementation of these nutrients is necessary. Therefore, researchers and clinical health practitioners need to address this issue when they plan weight-loss programs. Future study could

investigate whether more nutrient-dense and lower-energy-density diets are effective in preventing nutrition inadequacy during weight loss and weight-loss maintenance.

Dietary Energy-Density

We found that participants' dietary energy density at baseline was quite high compared with that of nationally representative sample of women from CSFII 1994-1996 (2.1 kcal/g Vs 1.79 kcal/g) when dietary energy density was assessed using only foods excluding beverages [50]. At 16-week follow-up, energy density was decreased by 10% from the baseline value. This reduction was achieved by a decrease in intake of sweets and desserts and maintenance of fruit and vegetable intake. Other studies have found incorporating water-rich foods such as fruits and vegetables into the diet was effective in reducing dietary energy density as well as decreasing calorie intake [46, 85]. When participants need to decrease their caloric intake to achieve weight loss, the present study showed that there is a possibility that participants replace high-energy density foods, which contain added sugar or fat, with fruit because fruit is naturally palatable as a snack.

Diet Quality

This study showed that participating in a structured Internet-based behavioral weight loss program featuring self monitoring, social support, e-mail contact, chat and bulletin board as well as weekly lessons was effective in improving participants' diet quality as well as in achieving a significant weight loss goal. Sixteen weeks of participation in an Internet weight loss program improved the diet quality score by 3.5 points as measured by HEI-2005. Since the scoring system for HEI-2005 was based on a density standard (as amounts per 1000 kcal of energy intake) not on total amounts,

improvement in the score indicates that participants chose nutrient-dense foods when they needed to reduce energy intake. This statement is supported by improvement in the score in the following food components: total Fruits, Milk, Meat and Beans, and Calories from Solid Fat, Alcohol, and Added Sugar. Participants increased or maintained their fruits, milk, meat and beans while decreasing their intake of foods high in fat and added sugar. This corresponds with the results from another study that found people who succeed at weight loss limited portion sizes of food groups high in energy-density such as candy, ice-cream, and sweet desserts [74].

Improved diet quality was correlated with decreased dietary energy density and this corresponds with other studies [53]. Since the reduction in energy density is achieved by increasing fruits and vegetables, it implies that a lower-energy-density diet is a nutrient-dense high quality diet.

The Baseline HEI-2005 score was 53.9 and this was lower than the national average score of 58.2. There are several possible explanations. First, the national average score was calculated from the dietary data provided by 9,032 participants which included all ages excluding children under 2 years of age, all weight status, and all genders in the National Health and Nutrition Examination Survey, 2001-02 conducted by the National Center for Health Statistics [86], while our sample was composed of obese or overweight women who were seeking weight loss programs. These women might have a lower diet quality score because they have a tendency to prefer energy-dense foods high in fat and added sugar. Second, the national average score was calculated from the score of the population ratio which was reported to be higher compared with the mean of individual

scores [87]. Third, the national data was calculated using a 24-hour dietary record while our score was from a food frequency questionnaire.

Participants showed high intakes in sodium per 1000kcal both at baseline and at 16 weeks, and the sodium intake showed an increase at 16 weeks. This suggests that participants consumed more salty foods when they required restricting total calorie intakes. This might indicate that participants chose commercial foods more often when they were following an energy-restricted diet and they were required to record their calorie intakes, because commercial foods have easy to control portion sizes and are easy to record, since these foods already have nutrition facts such as calories and percent energy from fat.

When we compared the baseline HEI score by demographic characteristics, we found that our results confirmed other studies; older, White, married, educated people have a tendency to have higher diet quality [58, 63]. In addition, we examined the effects of having children at home and the physical activity level on diet quality. We assumed that the individual who has children in her household had a better diet quality, but the result was contrary to our assumption. Adult women who do not have children in their household could have more time to prepare their foods at home and showed higher scores while younger adult women who have children might be busier with child-rearing or after-school activity, so they use fast food or commercial foods more often. The frequent intake of fast food or high energy dense foods is observed in obese and overweight people and this high frequency was considered predictor of poor diet quality among these population [61] . At baseline, the participants who reported lower physical activity

(<1000 kcal/week) had lower diet quality scores, which is consistent with other studies [26, 88].

When we compared the change of the HEI-2005 score over the study period, we found very interesting facts. The group who had the lowest score at baseline showed the greatest improvement at 16 weeks. The group who had the highest score showed little or no improvement. For example, the HEI score for participants who had some graduate school showed no improvement at 16 weeks and the score for those who had only a high school education showed the greatest increase at 16 weeks. So, when researchers plan an Internet weight loss program, they need to deliver more intense nutrition and health knowledge to influence people who think they already have a good diet.

Physical Activity Change

We found that the average number of calories burned through physical activity was not affected by participating in an Internet behavioral weight-loss intervention. Participants reported they had a quite active lifestyle at baseline. They were expending 966.0±978.1 kcal per week at baseline and they increased their energy consumption by 164.8 ± 889.2 kcal over the 16 weeks of intervention, but this was not enough to show a significant difference. Other Internet weight loss studies have reported a larger increase in energy consumption at 3 months of 500 kcal/week [44], at 4 month of 1057 kcal/week [89] and of 372 kcal/week at 6 month [20] than that of our study. It could be a measurement error or lack of support for physical activity, although the program provided some lessons on physical activity via our study website. Another reason for the

unchanged physical activity is that Kentuckians are overall known for having lower physical activity levels [90, 91].

The current public health recommendations for physical activity from the Centers for Disease Control and Prevention and the Surgeon General of 30 minutes of moderate intensity activity per week was developed with a primary focus on the chronic disease risk reduction and fitness enhancement effects. More recently, exercise guidelines have been revised to recommend more physical activity for weight loss maintenance. In 2002 the Institute of Medicine recommended a minimum of 60 minutes a day of moderate intensity exercise to control body weight [67]. This corresponds to 2000 kcal energy expenditure per week through moderate-intensity exercise. Therefore, to enhance weight loss and weight-loss maintenance, more emphasis on increasing physical activity should be put for the whole study period via study websites. Posting an exercise program on a web site every week which participants can enjoy is one example. Our results did not show any significant relationship between the amount of weight loss and exercise pattern, however, other studies have shown that exercise combined with diet resulted in a greater weight reduction than diet alone and increasing exercise intensity increased the magnitude of weight loss [92].

Comparison of Diet and Physical Activity Strategies by Weight Loss

The post hoc analysis revealed that greater weight loss was associated with participants' behavioral differences. The group who achieved a 5 percent or greater weight loss showed a difference in their dietary and exercise behaviors compared with the group who did not achieve a 5 percent weight loss. Both groups decreased fat gram

intake and diet energy density, and increased the diet quality score at 16 weeks, but the greater change was observed in the participants who achieved a 5 percent or greater weight loss. The participants who achieved a 5 percent or greater weight loss increased their fruit and vegetable intake and percent energy from carbohydrate while the participants who did not achieve 5 percent decreased their fruit and vegetable intake and percent energy from carbohydrate. Participants who lost more than 5 percent body weight increased their exercise duration, intensity, and overall energy expenditure while their counter-parts decreased these things. These findings are consistent with the results from the National Weight Control Registry. They reported that the maintainers were consuming low-calorie (1400 kcal/day), low-fat diets (25% of total energy) with high intakes of fruits and vegetables, and they had a highly active lifestyle with energy expenditure through exercise of 2843kcal per week [73, 93].

Limitations and Strengths

There are several strengths and limitations of this study. A major strength of this study is that it is the first to analyze diet quality changes during a weight loss study using the HEI-2005, which is designed to assess adherence to the 2005 Dietary Guidelines for Americans. In addition, dietary variables that previous behavioral weight-loss studies have not measured, such as diet-energy density and food group intakes, were measured in the current study. The attrition rate was 12.5 % at 4 months. It was lower than other studies have reported; for example, Tate et al reported 15.4 % attrition at 3 months and 28.6% at 6 months [44], but, our attrition rate was higher than the result of the recent Internet weight-loss study which reported an attrition rate of 1.5% [24]. Since adherence

is a primary predictor of weight loss, the barriers or stimulators for retention should be investigated further and reflected in future studies.

This study still holds limitations. Diet was measured by a food frequency questionnaire, which is known to have a measurement error [94], and may not reflect the short-term changes in dietary intake, however this instrument has been used to estimate overall diet quality [95, 96], and may have advantages over diet records for less frequently or seasonally consumed foods. The study population does not reflect the general population and was highly educated, so these results may not be generalizable to other populations. Dietary changes shown in this study only reflect the short-term effect of participation in a weight loss program, so we cannot predict the long-term effects. Therefore future research is directed toward various groups of populations which would be generalized to the whole population, which can also examine the differences among groups.

Chapter 7: Conclusions

The results of this study demonstrate that participation in the Internet behavioral weight loss program improved participants' diet quality significantly over 16 weeks regardless of age, education level, and marital status. Since improved diet quality is correlated with reduced dietary energy-density, the dietary strategies which can decrease dietary energy density such as more fruits and vegetables, and eating soup prior to entrée, should be emphasized. Also the finding of that the greater improvement in diet quality and exercise patterns is observed in those who achieved 5 percent or greater weight loss than those who did not suggests that participating in a weight-loss program is effective in promoting healthy lifestyle as well as achieving a weight-loss goal. Future weight loss studies should emphasize improvement in diet quality along with calorie reduction and increased physical activity and also the barriers in improving diet quality need to be investigated.

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Vita:

Eunkyung Lee

Date and Place of Birth:
June 10, 1969
Pusan, South Korea

Education:

- Bachelor of Science in Food Science and Nutrition,
  Seoul National University, February 1992

- Master of Science in Food Science and Nutrition,
  Seoul National University, February 1994

Professional Positions:

- Clinical Dietitian, Seoul National University Hospital, 1994-2002

Scholastic Honors:

- Cum Laude, Seoul National University 1992