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Relationship Between Dietary Choices Made during a Low-Calorie, Low-fat Diet and Changes in Caloric Intake, Caloric Intake from Fat, and Weight Loss

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To the Graduate Council:

I am submitting herewith a thesis written by Vaishali Deepak Keshani entitled "Relationship Between Dietary Choices Made during a Low-Calorie, Low-fat Diet and Changes in Caloric Intake, Caloric Intake from Fat, and Weight Loss." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Nutrition.

Hollie A. Raynor, Major Professor

We have read this thesis and recommend its acceptance:

Melissa Hansen-Petrik, Lauren Gellar

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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Relationship Between Dietary Choices Made during a Low-Calorie, Low-fat Diet and Changes in Caloric Intake, Caloric Intake from Fat, and Weight Loss

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Vaishali Deepak Keshani
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ABSTRACT

Background: To better understand what dietary changes enhance consumption of a low-Calorie, low-fat diet and improve weight loss, this secondary data analysis examined relationships between changes from 0 to 6 and 6 to 18 months in food group intake and reductions in energy and energy from fat intake and weight during a lifestyle intervention in 162 participants.

Methods: Participants were aged 52.5 ± 8.4 years, predominantly white (92%), female (57.4%), with some college education (88.9%), married (76.5%), and not Hispanic (97.5%), with a body mass index (BMI) of 34.9 $\pm$ 4.5 kg/m^2. Anthropometric and physical activity measurements and three, telephone, 24-hour dietary recalls were collected at 0, 6, and 18 months. Food group servings consumed were determined from NDSR Food Guide Pyramid food group codings. Hierarchical regressions examined relationships between changes in food group intake and changes in energy and percent energy from fat intake and weight from 0 to 6 months (weight loss) and 6 to 18 months (weight loss maintenance).

Results: Food group intake changes with significant positive ($p < 0.05$) associations to energy and percent energy from fat intake changes from 0 to 6 months were: Higher Fat Oils, Higher Fat Meat, Higher Fat Fats, and Modified Regular Fat Dairy. Food group intake changes with significant ($p < 0.05$) associations to weight changes from 0 to 6 months were: Sugar Sweetened Sweets and Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (positive relationship), and Lower Fat Artificially Sweetened Beverages and Lower Fat Unsweetened Beverages (negative relationship). Food group intake changes with significant ($p < 0.05$) positive associations to energy and percent energy from fat intake changes from 6 to 18 months were Higher Fat Nuts, Higher Fat Fats, and Modified Regular Fat Dairy.

Conclusion: Changes in food group intake associated with reducing energy, percent energy from fat, and weight were decreases in servings consumed from higher fat and sugar sweetened food groups and increases in artificially sweetened and unsweetened beverages. Future research should examine if providing goals for these food groups within the context of a low-Calorie, low-fat dietary prescription enhances outcomes.

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INTRODUCTION

Since 1980, the prevalence of obesity has doubled in the United States.[1] Obesity increases the risk for the development of several diseases and mortality, and is believed to be a large factor for driving up healthcare costs.[2–4] Obesity is caused by positive energy balance, when energy intake is greater than energy output.[4] Several environmental factors, such as convenience foods, serving sizes at restaurants, increased sedentary lifestyle, and insufficient physical activity have contributed to the epidemic.[4–6,9] A low-Calorie diet has been recommended for weight loss for obesity treatment.[10,11]

While a hypocaloric, low-fat diet has been widely used in trials to produce a 5-10% weight loss,[11] no study has examined the changes in food group intake that occur when this diet is prescribed and how these changes are related to weight loss and weight loss maintenance. There are several different changes in food group intake that may occur during a hypocaloric, low-fat diet that may be associated with reductions in energy and percent energy from fat intake, along with weight loss. One change may be a reduction in the number of servings consumed from many different foods, thus reductions in energy and fat intake occur predominantly by implementing portion control. Another method is by increasing naturally low-Calorie, low-fat foods while decreasing naturally high-Calorie foods, high-fat foods.[19–21] An example of this is to choose foods that are naturally lower in energy and fat, such as fruits and vegetables, instead of foods that are higher in energy, such as cakes, cookies and chips. Lastly, modified foods (foods that are modified in fat or sugar content) could be used to replace foods naturally high in fat and sugar to decrease overall energy intake.[22–24] An example of this is when full fat foods, such as whole milk, are replaced with fat-modified foods, such as 2% or 1% milk. By replacing full fat

or sugar sweetened foods with lower fat or artificially sweetened foods, overall energy and fat intake can be decreased, which can aid with weight loss.

As limited research has been conducted that examines overall changes that occur in the diet when a low-Calorie, low-fat diet is prescribed,[13–16] the objective of this project was to investigate dietary choices participants made during a lifestyle intervention when prescribed a low-Calorie, low-fat diet, and examine the relationship between changes in dietary choices and reductions in energy and fat intake and weight loss.

CHAPTER I

LITERATURE REVIEW

BACKGROUND & SIGNIFICANCE

Introduction

Since 1980, the prevalence of obesity, classified as a body mass index (BMI) $\geq$ 30 kg/m^2, doubled in adults, rising from 15% in 1980 to 34% in 2008.[1] Although the increase in obesity prevalence has been slowing,[2] as of 2009-2010 over 72 million adults were estimated to be obese in the United States.[2] Obesity increases the risk for cardiovascular disease, hypertension, stroke, type 2 diabetes, high cholesterol, liver and gallbladder disease, sleep apnea and respiratory problems, degeneration of cartilage, infertility, mental health conditions, and certain types of cancer (such as breast and colon cancer).[3] Furthermore, obesity increases the risk of mortality, with a BMI exceeding 30 kg/m^2 associated with an increased risk factor of mortality of 1.5 and increases the longer one is obese.[4]

The increased risks of morbidity and mortality associated with obesity contribute to healthcare costs.[2] In 2008, it was estimated that 147 billion dollars were spent in medical costs related to obesity.[2] Obesity has also been linked to decreased productivity at work (including absence and efficiency) and leads to increases in indirect healthcare costs.[2] Absenteeism and disability additionally contribute substantially to indirect costs.[5] Obesity may also impact transportation costs, due to the greater need of larger vehicles and increased gasoline usage for sufficient transportation.[5] The economic burden of obesity increases the need for prevention and treatment of this chronic disease.

Due to the relationship between obesity, health, and healthcare and workforce costs, obesity has become a public health priority.[6] For example, Healthy People 2020 addresses the top 26 leading health indicators under 12 topics, and one of these areas is nutrition, physical activity, and obesity.[7] The goals of Healthy People 2020 related to weight status are to decrease

the amount of overweight and obese adults and children, increase the number of healthy weight adults in the US, and prevent inappropriate weight gain in adults and children.[7] The Surgeon General also calls for the need to make changes to treat and prevent obesity due to its impact on the public's health.[8]

Causes of Obesity

Obesity is caused by positive energy balance, which is when energy intake is greater than energy output.[4] Positive energy balance can be caused by an increase in energy consumed through food without compensating with increased physical activity or by reducing the amount of physical activity one engages in without compensating by reducing energy intake. There are many environmental factors that are currently believed to contribute to positive energy balance.[6] Convenience foods that are high in energy density are easier to consume in today's hectic lifestyle and can contribute to excessive energy intake.[6] In addition to this, environmental factors such as increased number of fast food businesses, larger portion sizes served at restaurants, and vending machines with packaged foods have become more accessible and affordable than foods lower in energy density, such as fruits and vegetables.[3] These factors are believed to have contributed to increased consumption of high-sugar, high-fat, low-nutrient foods, thus contributing to positive energy balance.[5]

As previously stated, decreases in energy expenditure also contribute to positive energy balance. Today's society has many luxuries and conveniences that promote a sedentary lifestyle, rather than a physically active one. Automobile transportation, desk jobs, drive-through fast food restaurants, remote controls, videogames, and television are just a few examples of convenience that encouraged Americans to engage in sedentary behavior.[9] In regards to physical activity, 10,000 steps per day are recommended, however, in the United States, adults are taking only a

little over 5,000 steps per day.[6] The lack of sidewalks, necessity of vehicles, and lack of safe parks and neighborhoods are believed to play a large role in the low amounts of physical activity in Americans.[9]

Recommendations for Obesity Treatment in Adults

A task force from the American College of Cardiology (ACC) and the American Heart Association (AHA) in collaboration with the National Heart, Lung, and Blood Institute (NHLBI) revised evidence-based clinical guidelines previously released for obesity treatment in overweight and obese adults based on a systematic review of the most recent published scientific research.[10] In 2013, the task force recommended comprehensive lifestyle interventions, which are a combination of diet and physical activity goals, in addition to behavioral therapy, for adult overweight and obesity treatment. The dietary goals to reach this initial weight loss should be individualized and should include a 500 to 750 Calories/day deficit, which commonly translates to a 1,200 to 1,500 Calories/day diet for women and a 1,500 to 1,800 Calories/day diet for men.[10] The recommended physical activity goals are to gradually increase the amount of physical activity to equal at least 30 minutes of moderate- to vigorous-intensity physical activity on as many days as possible.[10] Behavior therapy provides the foundation from which behavior modification strategies are implemented to change dietary intake and physical activity. Behavior modification strategies that are recommended to be used for assisting in changing diet and physical activity include self-monitoring, stress management, stimulus control, problem solving, cognitive restructuring, social support, and time management.[10]

The Diabetes Prevention Program (DPP) has demonstrated how a lifestyle intervention can produce an amount of weight loss that enhances health.[11] This randomized controlled trial of 3,234 persons with elevated fasting and post-load plasma glucose concentrations, who did not

have diabetes, showed that a lifestyle intervention produced the greatest weight loss and lowered the incidence of diabetes more so than medication, metformin, and placebo.[11] All participants received standard care, which was a 20- to 30-minute individual session with the case manager in which the importance of a healthy lifestyle for the prevention of diabetes was reviewed, and participants were given instructions to follow the USDA Food Pyramid[12] for a cholesterol step 1 diet, to increase physical activity, and to lose weight.[11] Participants randomized to the lifestyle intervention were prescribed a low-Calorie, low-fat diet (1200, 1500, 1800, or 2000 Calories/day based on starting body weight and 25% Calories from fat) and given a moderate-intensity physical activity goal of at least 150 minutes per week[11] to assist with losing 7% body weight. Participants in the lifestyle intervention were provided behavior modification strategies and support throughout 16 sessions to assist with behavior change.[11] The lifestyle intervention group lost 5.6 kg, the metformin group lost 2.1 kg, and the placebo group lost 0.1 kg.[11] In this trial, weight loss was shown to be an important factor for the reduction of the incidence of diabetes, with one kg of weight loss reducing diabetes incidence risk by 16%.[11]

Changes in Dietary Intake During Consumption of a Hypocaloric, Low-fat Diet

Dietary changes that occur during a low-Calorie, low-fat diet intervention may impact macronutrient and micronutrient intake, as well as food group consumption, as routine habits of consumption are altered. While a low-Calorie diet is currently recommended to assist with weight loss,[10,11] limited research has been conducted that examines overall changes that occur in the diet when this type of diet is consumed.[13–16] For example, Ashley et al[13] randomized 96 overweight or obese women to a traditional food group or a meal replacement group and examined macronutrient and micronutrient intakes of the two groups over the course of 12 months. Both groups were prescribed a 1200 Calorie/day diet, with guidelines based on the

USDA Food Pyramid[12] in combination with instruction from a Registered Dietitian that were provided over the course of 18 sessions.[13] The traditional food group selected their own diet based on the USDA Food Pyramid[12] and they were encouraged to incorporate all food groups into the diet. They also received compensation for groceries equal to the compensation that was provided to the other meal replacement group.[13] The meal replacement group used commercial meal replacements for two of three meals, for which the study provided one of 3 choices to them,[13] while the third meal was chosen by the participant using the USDA Food Pyramid.[12] Each meal replacement had 220 Calories, with the drink meal replacement providing 1.5 to 3 grams of fat and 15-100% of daily vitamins, and the bar meal replacement provided 5 grams of fat and 25-35% daily vitamins.[13] Weight loss was similar between the two groups. Dietary changes included decreased sodium intake, increased fruit and vegetable intake, and decreased cholesterol and saturated fat intake between both groups.[13] Both groups also decreased saturated fat intake and increased fiber intake, though not to optimum ranges designated in the study (7% saturated fat and 25 g of fiber).[13] Micronutrient intake was significantly higher in the meal replacement group than the traditional food group at 6 and 12 months.[13]

In another study conducted by Benezera and colleagues,[14] 219 overweight and obese post-menopausal women were recruited to participate in a community-based wellness program. One hundred and fifteen women completed every part of the study, which was designed to examine nutrient intakes when prescribed a reduced-Calorie diet from the food exchange system that was 30% Calories from fat, 55% Calories from carbohydrate, and 15% Calories from protein.[14] For the Calorie prescription, each individual's resting metabolic rate (RMR) was calculated using the Harris-Benedict equation, 0.8 of the RMR was used for weeks 1 through 12, 1.0 of the RMR was used for weeks 13 through 20, and 1.2 of the RMR was used for weeks 21

through 32.[14] All participants were assigned the same diet and kept 3-day food records and were told to increase physical activity over the course of 32 weeks.[14] A pedometer was used to measure steps taken every day for 32 weeks.[14] Results showed participants lost an average of 6 pounds by 12 weeks and 7.8 pounds by 32 weeks, walking increased by 22.5 km/week by the end of 32 weeks, energy intake decreased by 36% in the first 12 weeks and remained 23% less than at the beginning of the study by week 32, and energy intake of fat was significantly lower, while carbohydrate and protein intake increased significantly throughout the study.[14] An average of 67% of RDA/DRI guidelines were met for nutrient intakes during the study, despite the 23% to 36% reduction in energy intake and fat intake.[14] Vitamin E, calcium, iron, and zinc intakes significantly decreased, and folate and magnesium marginally decreased as energy and fat intake decreased during this study.[14]

Turner-McGrievy and colleagues[15] examined the nutrient intakes of 99 men and women with type 2 diabetes who were randomly assigned to a low-fat vegan diet or a standard diet for type 2 diabetes from the 2003 American Diabetes Association Guidelines. Participants in the vegan group were only told to consume a vegan diet and avoid high-fat foods, without any emphasis on portion size or energy intake and the standard diet group was prescribed an individualized diet based on recommendations with a 500 to 1,000 Calorie deficient dietary prescription, with emphasis on glycemic control.[15] Participants in both groups met for 1 hour each week for 22 weeks for group sessions about meal preparation, meal planning, and discussions about any issues related to changing their diet. Both groups were asked to maintain baseline levels of physical activity.[15] Both groups significantly decreased energy and fat intake, as well as protein, cholesterol, vitamin D, selenium, and sodium.[15] The vegan group had decreased intake of B-vitamins, but increased intake of carbohydrate, fiber, vitamin A activity,

vitamins C and K, folate, magnesium, and potassium compared to the standard group.[15] The standard diet group had decreased levels of iron, but no other increases in intake, compared to the vegan group.[15]

Akers and colleagues[16] examined consumption of water, fruits and vegetables and physical activity in older adults during a weight loss intervention and followed participants for 3 years to see how these behaviors were related to weight maintenance. Both the control and intervention groups were prescribed a 1,200 to 1,500 low-Calorie diet, while the intervention group was also told to consume 16 oz of water before each meal.[16] Body weight, 4-day food records, blood pressure and surveys were taken during the trial.[16] Results showed both groups significantly decreased dietary fat consumption and lost weight, while the intervention group had higher intakes of fruits and vegetables and higher step count compared to the control group.[16]

Research shows when a reduced-Calorie, low-fat diet is prescribed, several nutrient intakes levels decrease, such as, dietary fat, vitamin E, calcium, iron, zinc, folate and magnesium,[14] as well as B-vitamins,[15] Other nutrients were found to increase in consumption, such as carbohydrate, fiber, vitamin A activity, vitamins C and K, folate, magnesium, and potassium.[15] In addition, other dietary changes, such as fruit and vegetable intake, can impact nutrient intake if they are targeted in the prescription.[16]

Ways to Reduce Energy and Fat Intake

There are several ways to alter the diet to reduce energy and fat intake to meet dietary goals prescribed in lifestyle interventions. One method is to reduce the amount of food consumed, with no other changes in the diet. Common strategies in reducing amount of food consumed focus on portion control. For example, Pedersen and colleagues[17] randomized 130 participants with type 2 diabetes to an intervention and control group to observe effects of

reducing portion size on weight loss and glycemic control. The intervention group received a calibrated dinner plate and cereal bowl, a 10-15 minute counseling session, and a booklet of instructions on how to use the plate and bowl.[17] The male plate was for 800 Calories and the female plate was for 650 Calories, with food groups divided throughout the plate.[17] The bowl was calibrated for 200 Calories.[17] The control group did not receive the counseling session or tools, but maintained usual care with dietitians. Although energy intake and dietary fat intake were not measured, the intervention group had significantly greater weight loss and decrease in dosage of medication for glycemic control, as well as a greater decrease in blood pressure and cholesterol levels.[17]

Besides using portion-controlled plates and bowls to reduce intake, consuming foods that are packed in single serving sizes can also assist with reducing intake. Raynor et al[18] conducted an 8-week intervention to observe the effects of single-serving packages compared to standard packages of foods on energy intake among the 19 randomized participants for this study. The foods provided were identical for both groups, except for portion size, and consisted of typical breakfast foods such as cereal, applesauce, canned peaches, and cheese.[18] Participants were asked to only consume the provided foods for breakfast only and not to consume these foods for the rest of the day.[18] Both groups received identical treatment during intervention sessions, which included a cognitive behavioral intervention delivered in 60-minute weekly group sessions, a low-Calorie (1,200 to 1,500 Calories/day), low-fat ($\leq$ 30% Calories from fat), diet prescription, and a physical activity goal of 30 minutes of physical activity 5 days per week.[18] Results showed participants in the single-serving package size condition consumed less energy from cereal and applesauce compared to the standard package condition, though this was not seen with the other combinations (peaches and cheese).[18] These results again suggest that

decreasing the portion consumed can assist with reducing intake when consuming a low-Calorie, low-fat diet.

Another way to reduce energy and fat intake can be to change the types of foods regularly consumed. For example, increasing intake of naturally lower-Calorie and lower-fat foods, such as low-energy-dense fruits and vegetables, and reducing intake of higher-Calorie, higher-fat foods, such as cakes, chips, and cookies, should assist with reducing energy and fat intake. In another trial, 441 overweight and obese participants were enrolled in an online web-based intervention for changing diet and physical activity to promote weight loss or enrolled in a control comparison.[19] The intervention group was given 5 goals to promote weight loss: increase fruits and vegetables to 5 to 9 servings each day, consume at least 3 servings of whole grain products each day, consume less than 20 g of saturated fat a day, taking at least 10,000 steps 5 days each week, and engaging in strength training at least twice a week.[19] The control group was a wait-list control, where participants were given the option to cross-over into the intervention group at the 12-month time point.[19] The results found the intervention group decreased overall fat and saturated fat intake, increased fruit and vegetable serving and fiber intake, and walked 16 minutes more per day.[19] Although it cannot be differentiated whether increasing fruits and vegetables alone affected overall energy intake or weight loss, the combined dietary and physical activity goals produced weight loss in participants with high adherence.

In addition, Tanumihardjo and colleagues[20] conducted a randomized trial with 60 obese individuals to observe the difference in weight loss when prescribed a high vegetable, moderate fruit diet compared to the traditional low-Calorie, low-fat diet. Participants in the high vegetable, moderate fruit group had a goal to consume 8 servings of vegetables and 2 to 3 servings of fruit per day, while the reduction group was told to reduce daily intake by 500 Calories and consume

< 25% Calories from fat per day.[20] Phase 1 of the trial, from weeks 1 to 3, consisted of transitioning to the prescribed diet and attending small group sessions twice a week, with food being provided for participants to consume 5 days per week.[20] Phase 2, weeks 4 to 12, was similar to Phase 1, with greater enforcement of adhering to dietary goals.[20] Phase 3, month 4, encouraged participants to adhere to dietary goals without aid, with food provided only twice per week, no group sessions, but access to individual consultation was provided.[20] Phase 4, months 5 to 12, was an extension of Phase 3, but no food was provided. The coordinator called participants once a month for months 5 to 12, and then called once a week for months 12 to 18.[20] At 3, 12, and 18 months, both groups significantly decreased energy intake compared to baseline, however no difference was seen in energy intake reduction between the two groups.[20] The high vegetable (HIVEG) group significantly decreased fat intake at 3 months compared to baseline, but was not less than the reduction group (was still > 25%), while the reduction group successfully met the <25% g fat goal at each time point.[20] At the 3-month follow-up, the reduction group consumed significantly less energy and fat grams and percent energy from fat than the HIVEG group, though the HIVEG group consumed more vegetables (but never met the goal of 8 servings a day).[20] Both groups lost weight after 3 months, and the reduction group resulted in lower weight over time.[20] The reduction group maintained weight loss at 12 and 18 months, which the HIVEG group did not.[20]

Lastly, Raynor and colleagues[21] examined the effect of energy density on weight loss and diet quality in 44 adult participants during a 3 month long intervention. Participants were randomized either to a low-energy-density group (with emphasis on increasing fruits and vegetables), a low-Calorie, low-fat group, or a low-energy-density and low-Calorie, low-fat group.[21] Participants were stratified by sex and the interventions consisted of 12, 60-minute

sessions about diet prescription and achieving 10,000 steps a day of physical activity in a controlled laboratory setting.[21] Results showed each of the groups reduced energy density of the diet, decreased energy intake, increased physical activity, and lost weight.[21] The low-energy-density group lost the most weight, and both the low-energy-density group and the low-energy-density, low-Calorie, low-fat group increased fruit intake.[21] The low-energy-density group had the most reduction in energy intake and percentage of fat intake compared to the other 2 groups over time.[21]

A third method for reducing energy and fat intake can be to increase use of modified foods, foods that are reduced in fat or sugar content, to assist with meeting energy and fat goals. Gatenby and colleagues[22] conducted a randomized control trial to see the effects of fat-modified food consumption on macronutrient composition of the diet. Twenty-nine participants were randomized to a control or intervention group, with the control group receiving standard care and the intervention group instructed to replace full-fat foods in their diet with reduced-, low-, or fat-free versions, (i.e., replace whole milk with skim milk). A list of appropriate products was given to participants to assist with understanding which foods to replace in the diet. This condition was also instructed to make no other changes in the diet.[22] Results found the intervention group decreased intake of dietary fat, both percent energy from fat and grams of fat, increased percent energy from protein and carbohydrate intake, with no change in gram protein and carbohydrate gram intake, and a had a weight loss of 1.1 kg.[22] Implications from this study are the use of fat-modified foods may be helpful for reducing fat and energy intake.[22]

In another study, Raben and colleagues[23] conducted a trial to examine the use of artificial sweeteners in 42 overweight men and women, randomized to a sucrose or artificial sweetener group. All participants were provided with the drinks and foods for their group and instructed to

consume at least a minimum amount of foods and beverages within their condition.[23] In the sucrose condition, participants were prescribed 2 g sucrose per kg of body weight, with approximately 70% of the prescribed sucrose consumed from drinks and 30% of the prescribed sucrose consumed from solid foods. Participants in the artificially sweetened group consumed an equal amount, by weight, of artificially sweetened drinks and foods as the sucrose group.[23]

A 7-day food record was kept to examine any variations in the diet. Participants were instructed not to make any other changes to the diet they consumed.[23] Results showed the sucrose group had increases in total energy, sucrose, and decreases in fat and protein intake, while the artificial sweetener group had decreases in sucrose intake and energy density.[23] In addition, the sucrose group had increased body weight and fat mass, while the artificial sweetener group had decreased body weight and fat mass.[23] These results show the possible role of artificial sweeteners in reducing energy intake and body weight.

Similarly, Blackburn and colleagues[24] examined the effects of aspartame on weight loss and weight maintenance in 163 obese women. There were two groups in the investigation: non-aspartame group and the aspartame group. Both groups were instructed to consume a diet based on the American Dietetic Association exchange list.[24,25] The non-aspartame group was given seltzer water, products sweetened with sugar or honey, and milk, while the aspartame group was given diet sodas, products sweetened with aspartame, and dairy products sweetened with aspartame to consume based on the exchange list for the 16 week intervention.[24] Both groups received highly structured personalized sample menus, attended weekly group sessions, were instructed to exercise 200 minutes each week, and attended 16 weekly group intervention sessions.[24] A 12-month maintenance phase followed, that provided monthly 1-hour group sessions, an adjustment in diet for maintenance, and an individualized prescription of physical

activity.[24] Finally, a 2-year follow-up was conducted to examine uses and habits of aspartame, weight, health events, exercise level, and eating control.[24] Overall energy intake decreased for both groups without any significant differences between the two at the end of the intervention phase.[24] Both groups lost 10% of their body weight, however during maintenance (1 year) and follow-up (2 years), the aspartame group regained less weight (2.6 kg and 4.6 kg) compared to the non-aspartame group (5.4 kg and 9.4 kg).[24]

While these investigations have examined how reducing portion sizes, increasing intake of foods that are naturally lower in fat and energy, and increasing intake of modified foods can impact on energy and fat intake, little research has investigated the choices individuals make when prescribed a low-Calorie, low-fat diet during weight loss intervention to actually assist with reducing energy and fat intake.

Dietary Choices and Weight Loss Maintenance

To investigate factors related to successful weight loss maintenance, the National Weight Control Registry (NWCR), the largest prospective study for successful long-term weight loss maintenance, was developed.[26] In 1997, 629 women and 155 men were enrolled into the NWCR.[27] The registry now tracks over 10,000 individuals, who have lost anywhere between 30 to 300 lbs and have maintained their weight loss for 1 to 66 years.[26] The average weight loss for participants is 66 lb and the average weight loss maintenance is 5.5 years.[26] Criteria for enrollment includes being at least 18 years of age, and having a weight loss of $\geq$ 30 lb and weight maintenance of the weight loss for at least 1 year.[27] In the NWCR, questionnaires and annual follow-up surveys are used to assess dietary, leisure-time behaviors, and behavioral and psychological characteristics of successful weight loss maintainers.[26] These questionnaires assess

weight loss methods, weight maintenance methods, previous weight-loss attempts, difficulties of weight loss maintenance, and effects of weight loss on other areas of life.[27]

When dietary aspects of participants in the NWCR are examined, research reports consumption of a low-Calorie, low-fat diet.[28] While specific dietary choices of participants in the NWCR have not been examined, other aspects of the diet that have been reported by registry participants for weight loss include limiting intakes of certain foods (87%), limiting quantities of foods eaten (44%), counting Calories (43%), and using a liquid formula (20%).[27] As far as dietary strategies for weight loss maintenance, the NWCR found participants report limiting consumption of particular foods (92%), limiting quantity of food eaten (49%), limiting percentage of fat intake each day (38%), counting Calories (35%), and counting fat grams (30%).[27] Participants also report eating five small meals a day.[27] Raynor and colleagues[29] also reported that NWCR participants consume a limited amount of food group variety. While not conducted with participants in the NWCR, one investigation examined the use of modified foods by successful weight loss maintainers and found that weight loss maintainers reported consuming less fat, more fat-modified foods, and using more low-fat strategies than normal weight individuals.[30] As a whole, and particularly from research regarding the NWCR, dietary strategies that limit amounts of energy and fat, such as controlling portions of high-fat foods and using fat-modified foods, may assist with overall weight loss maintenance success.

Coding Dietary Data

When examining changes in food consumption choices that occur during a dietary intervention, it is important to code and analyze dietary data in a manner that aids with understanding choices made that assist with achieving the dietary intervention targets. One dietary software program commonly used to analyze dietary data is the Nutrition Data System

for Research (NDSR).[31] NDSR is designed to analyze dietary data from 24-hour recalls, food records, menus, and recipes.[32] NDSR provides standardized dietary assessment methods, contains interactive interview modules through a multiple pass approach, calculates nutrients, contains quality assurance features, and provides a variety of output files.[32] NDSR links to the Nutrition Coordinating Center (NCC) Food and Nutrient Database, developed and maintained by the University of Minnesota.[32] NDSR contains 18,000 foods and over 7,000 brand name products, and the database is continually updated each year.[31] NDSR automatically codes the number of servings for 168 subgroups of foods associated with 9 larger groups[32] that are based off the Food Guide Pyramid,[33] which allows measurements of food consumption from recommended food groups, as well as commonly eaten foods that may not fit in these groups. These groups are fruits, vegetables, grains, dairy/nondairy, meat/fish/poultry/eggs/nuts/seeds, fats, sweets, beverages, and miscellaneous foods. Coding can create variability when multiple coders are involved in the process; however, using a computer software, such as NDSR, to code dietary data can eliminate the issue of inter-coder reliability.[34] NDSR also has a time related feature that allows dietary data to be compared over time and enhances validity of data being input into the software.[32] NDSR provides information about the diet consumed, including energy, and macro- and micronutrients amounts, at the ingredient, food, eating bout, or daily totals level.[32] All output files have the capability to be imported into several statistical programs.[32]

As mentioned previously, there are three main ways in which dietary intake can be altered to assist with reducing energy and fat intake. The first way in which the diet can be changed is to reduce the overall amount of food consumed, with no other change in the diet. Analyses from NDSR that would demonstrate this change would indicate reductions in energy

and fat and the number of daily servings consumed from food groups also high in these nutrients (i.e., higher fat meats, higher fat grains), with no increases in daily servings consumed from other food groups. A second method of altering the diet is to increase consumption foods that are naturally lower in energy and fat, such as fruits and vegetables, and reduce consumption of foods that are higher in energy and fat. The final method of altering the diet to assist with reducing energy and fat intake is to replace consumption of regular fat and sugar sweetened foods with lower fat and artificially sweetened foods, which are often called modified foods.

To determine changes in servings consumed from food groups, the 168 subgroups of foods in NDSR can be combined so that changes in food group consumption representing specific dietary qualifications can be examined.[32] A common foundation from which to start combining food groups is the use of nationally recognized food groupings, such as those found in United States Department of Agriculture's Food Guide Pyramid (FGP)[33] and ChooseMyPlate.[35] Previous studies have used this method, which is also accessible to the general public.[18,36,37] These guidelines can be further defined to group foods within the each food group that are lower and higher in fat and added sugar, which includes modified foods. Table 1 in Appendix A outlines these combined food groupings based upon the FGP[33] and MyPlate[35] using the NDSR food subgroups without including modified foods. NDSR food subgroups not included in Appendix A, Table 1 include those focused on infant/baby food, flour, and powder milk.

Using this foundation, grains are defined as any food made from wheat, rice, oats, cornmeal, barely, or cereal.[35] Within the FGP scheme, grains are subdivided into higher and lower fat whole grains, refined grains, and some whole grains (Appendix A, Table 1). Within the MyPlate food grouping scheme, grains higher in fat are part of Saturated Fats and Added Sugars (SoFAS).

Vegetables are defined as 100% vegetable juice, raw vegetables, cooked vegetables, fresh, frozen, canned, dried, whole, cut, or mashed.[35] Vegetables are further categorized into five groups, based on nutrient contents of foods: dark green vegetables, starchy vegetables, red and orange vegetables, beans and peas, and other vegetables.[35] These five subgroups can help ensure diet quality from a variety of nutrients provided by a variety of vegetables. Fruits are defined as 100% fruit juice, fresh, canned, frozen, dried, whole, cut, or pureed.[35] Under MyPlate, fried vegetables, vegetable-based savory snacks, fried fruits, and fruit-based savory snacks are classified as SoFAS since they do not fall into any other vegetable or fruit category. Under the FGP, these are coded as higher fat vegetables and higher fat fruits, respectively.

MyPlate has a group called Oils, which is defined as fats that are liquid at room temperature.[35] Other types of fats, including sauces/dressings/condiments are SoFAS based on the MyPlate food groups. Other foods that fall into the SoFAS category are butter, margarine, chocolate, candy, and desserts. In FGP, all of these foods fall into one category: the Fats, Oils, and Sweets group.

Dairy is defined as all fluid milk products and many products that are made mostly of milk.[35] Since both the FGP and MyPlate says dairy should be low-fat or fat-free,[35] food groups can be coded based on whether the dairy product was whole or fat-modified (i.e., reduced-fat, low-fat, fat-free) in both coding schemes.

Proteins are defined as foods that are meat, poultry, seafood, beans and peas, eggs, processed soy products, nuts, and seeds.[35] Within the FGP, meats, poultry, and seafood are each sub-categorized into regular or lean groups. MyPlate does not differentiate regular and lean meat; therefore the protein group of MyPlate is meat, poultry, and seafood in one category.

For modified foods, foods are generally coded as fat- or sugar-modified if they do not occur naturally (i.e., lower in fat and/or sugar) in this form. For example Phelan and colleagues[30] analyzed consumption of sugar- and fat-modified foods in successful weight loss maintainers. For the sugar-modified categories, they compared full sugar products (sweetened soft drinks, sweetened drinks other than soft drinks) to sugar-modified products (artificially sweetened soft drinks, artificially sweetened drinks other than soft drinks, and unsweetened water). For the fat-modified categories, they compared full-fat products (energy- dense snack foods, full-fat dairy foods, and full-fat salad dressings) to fat-modified products (fat-modified or artificially sweetened dairy foods, and fat-modified or artificially sweetened dressings).[30] These categories were based off the Nutrition Data System Software (NDS) developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, with some groups combined for categorization.[30]

Modified foods can be classified based on fat and sugar modification, with full-fat and sweetened products considered regular, while reduced-fat, low-fat, fat-free, artificially sweetened and unsweetened foods that do not naturally occur in the environment (they have been processed to be fat- or sugar- modified) are considered modified foods. Foods can be categorized by food groups in FGP and MyPlate and then subdivided into fat-modified or sugar-modified or both. Since NDSR groups low-fat and fat-free together, it is effective to group all reduced-fat, low-fat, and fat-free foods together as a fat-modified category. See Appendix A, Table 2 for modified food groupings. NDSR food subgroups not included in Appendix A, Table 2 include those focused on infant/baby food, flour, and powder milk.

Beverages are coded in Appendix A, Table 3. Beverages are coded into the same sub-groups used for all other foods: higher fat or lower fat, sugar sweetened, artificially sweetened,

or unsweetened. The FGP classifies beverages in the Fats, Oils, and Sweets group, which includes items such as soft drinks, fruit drinks, and coffee. FGP has a separate group for Alcohol, which includes non-alcoholic beer, beers, liquor, and wine. MyPlate classifies the same beverages in the SoFAS group, including alcohol.

CONCLUSION

In summary, since 1980, the prevalence of obesity, classified as a BMI $\geq$ 30 kg/m^2, doubled in adults, rising from 15% in 1980 to 34% in 2008.[1] Obesity increases the risk for several diseases and mortality, and can also increase healthcare costs.[2,3,5] Obesity is caused by positive energy balance, when energy intake is greater than energy output.[4] Several environmental factors, such as convenience foods, serving sizes at restaurants, increased sedentary lifestyle, and insufficient physical activity have contributed to the epidemic.[4–6,9] A low-Calorie diet, as part of a lifestyle intervention, has been recommended for obesity treatment.[10,11] There are several ways to decrease energy and fat intake during a lifestyle intervention, such as decrease portion size,[17,18] increase consumption of naturally lower-fat and lower-energy foods while decreasing intake of higher-fat foods,[19–21] or increase the use of modified foods, foods that are reduced in fat or sugar content.[22–24] While a low-Calorie diet is currently recommended to assist with weight loss,[10,11] limited research has been conducted that examines overall changes that occur in the diet when this type of diet is prescribed.[13–16] Additionally, it is not clear which changes are more related to reductions in energy and fat intake, and weight loss.

Specific Aims

Therefore, the objective of this project was to investigate dietary choices participants made during a lifestyle intervention when prescribed a low-Calorie, low-fat diet, and examine

the relationship between changes in dietary choices and reductions in energy and fat intake and weight loss. A secondary data analysis that included complete dietary data from 162 participants of a previously conducted randomized control trial was conducted to examine these changes. Food groups were created based on the Food Guide Pyramid to examine food group changes over time and how changes in food group intake were related to changes in energy intake, percent energy from fat intake, and weight. Analyses examined the following aims:

1. Changes in food group intake made by participants during an 18-month lifestyle intervention, in which a low-Calorie, low-fat diet was prescribed.
2. Relationship between changes in food group intake and reductions in energy intake and percent energy from fat intake, within the context of a low-Calorie, low-fat diet prescribed during an 18-month lifestyle intervention.
3. Relationship between changes in food group intake and weight loss, within the context of a low-Calorie, low-fat diet prescribed during an 18-month lifestyle intervention.

CHAPTER II

MANUSCRIPT

INTRODUCTION

Since 1980, the prevalence of obesity has doubled in the United States.[1] Obesity increases the risk for the development of several diseases and mortality, and is believed to be a large factor for driving up healthcare costs.[2–4] Obesity is caused by positive energy balance, when energy intake is greater than energy output.[4] Several environmental factors, such as convenience foods, serving sizes at restaurants, increased sedentary lifestyle, and insufficient physical activity have contributed to the epidemic.[4–6,9] A low-Calorie diet has been recommended for weight loss for obesity treatment.[10,11]

While a hypocaloric, low-fat diet has been widely used in trials to produce a 5-10% weight loss,[11] no study has examined the changes in food group intake that occur when this diet is prescribed and how these changes are related to weight loss and weight loss maintenance. There are several different changes in food group intake that may occur during a hypocaloric, low-fat diet that may be associated with reductions in energy and percent energy from fat intake, along with weight loss. One change may be a reduction in the number of servings consumed from many different foods, thus reductions in energy and fat intake occur predominantly by implementing portion control. Another method is by increasing naturally low-Calorie, low-fat foods while decreasing naturally high-Calorie foods, high-fat foods.[19–21] An example of this is to choose foods that are naturally lower in energy and fat, such as fruits and vegetables, instead of foods that are higher in energy, such as cakes, cookies and chips. Lastly, modified foods (foods that are modified in fat or sugar content) could be used to replace foods naturally high in fat and sugar to decrease overall energy intake.[22–24] An example of this is when full fat foods, such as whole milk, are replaced with fat-modified foods, such as 2% or 1% milk. By replacing full fat

or sugar sweetened foods with lower fat or artificially sweetened foods, overall energy and fat intake can be decreased, which can aid with weight loss.

As limited research has been conducted that examines overall changes that occur in the diet when a low-Calorie, low-fat diet is prescribed,[13–16] the objective of this project was to investigate dietary choices participants made during a lifestyle intervention when prescribed a low-Calorie, low-fat diet, and examine the relationship between changes in dietary choices and reductions in energy and fat intake and weight loss.

METHODOLOGY

Study Design

This secondary data analysis was conducted using data collected from a previous published lifestyle intervention trial examining a reduced variety dietary prescription.[38] In brief, 202 overweight and obese participants were randomly assigned to 1 of 2 conditions: Limited Variety (LV) and Lifestyle. Both conditions were given a standard low-Calorie, low-fat diet prescription (1200 Calories/day prescribed for an entry weight < 200 lb and 1500 Calories/day prescribed for an entry weight > 200 lb, and a 30% Calorie from fat restriction), a physical activity prescription (200 minutes of moderate-intensity physical activity per week and 10,000 steps per day) and a cognitive behavioral intervention to assist with changing dietary and physical activity behaviors. The LV condition was also provided with a limited variety prescription, which was designed to decrease the number of non-nutrient-dense, high-energy-dense foods (NND-EDFs) (i.e., cookies, chips, candy) consumed to only 2 types, which were selected by the participants.[38] NND-EDFs also included modified versions, such as reduced-fat or low-fat cookies.[38] The Lifestyle condition did not receive the limited variety prescription.

The intervention lasted 18 months, and provided 48, 60-minute group sessions. Sessions covered lessons on behavioral and cognitive skills (self-monitoring, stimulus control, goal setting) to help with changing dietary and physical activity behaviors,[38] all of which were modeled after lessons used in the Diabetes Prevention Program.[11]

In the first 6 months, which was the weight loss phase, participants attended weekly intervention sessions. In months 7 to 18, which was the weight maintenance phase, participants attended two intervention sessions per month. Measures were taken at 0, 6, 12, and 18 months. Results of the study found that the LV group consumed less variety of NND-EDFs and less overall energy intake daily from these foods than the Lifestyle group at 6, 12, and 18 months.[38] The LV group consumed less total energy daily at 6 months than the Lifestyle group, but no significant differences were seen between the groups in energy intake at 12 and 18 months.[38] Percentage of weight loss was significantly lower at 6 months and 12 months compared to 18 months, with no differences occurring between the groups.[38] At 18-months both groups lost approximately 9% of body weight, with no differences occurring between the groups.[38]

The current study is a longitudinal secondary data analysis. The primary dependent variables of this investigation were intake from food groups, energy, and percent energy from fat; and pounds of weight lost. Time points examined were 0, 6, and 18 months, with 0- to 6-months considered the weight loss phase, and 6-to 18-months considered the weight loss maintenance phase.

Participants

Participants for the initial study were recruited from Providence, RI and Knoxville, TN.[38] Eligibility criteria required participants to be 21- to 65-years-old with a BMI (kg/m^2) between 27 and 45 kg/m^2.[38] Participants were excluded if they were not able to walk at least two blocks

without stopping; reported a heart condition, chest pain, or loss of consciousness; were taking weight loss medication or participating in another weight loss program; had undergone bariatric surgery; were pregnant or lactating, less than 6 months post-partum, or planning to become pregnant during the study; were allergic to foods being used in taste-test measures conducted during the study; or were consuming less than 5 different types of NND-EDFs.[38] For the secondary data analysis conducted, only participants with complete dietary and physical activity data and weight measurements at 0, 6, and 18 months were included in the analyses. One-hundred and sixty-two of the 202 total participants had complete data based on these criteria.

Measures

Measures were collected in a research setting by trained research staff blinded to the randomization assignment at 0, 6, and 18 months.[38]

Demographics

Demographic measures, such as sex and age, were collected at baseline by self-report surveys.[38]

Anthropometrics

A height measurement was taken at 0 months and weight measures were taken at 0, 6, and 18 months to calculate BMI.[38] Height measures were recorded to the nearest millimeter at baseline using a stadiometer.[38] Weight was measured using a calibrated scale, with participants wearing light street clothes, and recorded to the nearest 0.05 kg.[38] For this investigation, weight loss in pounds was used to assess weight loss and weight loss maintenance. Weight loss was calculated as amount of weight loss from 0 to 6 months (weight at 6 months – weight at 0 months), with a negative number indicating weight loss from 0 to 6 months. For weight loss maintenance, pounds of weight loss maintained was calculated by subtracting weight at 6 months

from weight at 18 months (weight at 18 months – weight at 6 months), with a negative number indicating weight loss from 6 to 18 months.

Dietary intake

Three random 24-hour recalls were collected by phone during a 1 week period at 0, 6, and 18 months.[38] Interviewers from the Cincinnati Center for Nutritional Research and Analysis conducted the recalls were trained and blinded to intervention and intervention assignment.[38] The Nutrition Data System Software for Research developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN was used to collect and analyze 3-day food records.[38] The multiple-pass method was used to collect the data. This method for recall of dietary data consists of 5 distinct phases.[32] The first phase occurs when the participant tells the reviewer all the foods and beverages that were consumed.[32] The second phase occurs when the reviewer reviews the list with the participant.[32] The third phase consists of the interviewer receiving detailed information about the foods and beverages that were consumed.[32] The fourth phase was that participants were all given 2-dimensional models of food portion sizes to assist with accurate reporting. The fifth phase is when the reviewer reviews the entered information with the participant to ensure completeness.[32]

Variables of dietary intake were calculated as means of three days. Variables included energy and percent energy from fat. Additionally, servings consumed per day from food groups were examined. For food group coding, groups were created based on the Food Guide Pyramid (FGP) (see Appendix A, Tables 1-3).[33] Using the FGP classification system allowed for comparisons of higher fat and lower fat items within each food group. Additionally, NDSR uses the FGP to code foods into generalized food groups for nutrient printouts and information. Changes in dietary intake during the weight loss phase were calculated as dietary variable at 6

months – dietary variable at 0 months. Changes in dietary intake during the weight loss maintenance phase were calculated as dietary variable at 18 months – dietary variable at 6 months. A negative value represented a decrease in consumption.

Physical Activity

Self-reported physical activity was assessed by using the Paffenbarger Activity Questionnaire[39] at 0, 6, and 18 months. This questionnaire provides estimates of total energy expended in all self-reported physical activity per week based on flights of stairs climbed per day, city blocks walked per day (for both structured walking and lifestyle walking), and hours of structured activity acquired within a typical week. It has been shown to be significantly correlated with an objective measure of physical activity[40]. During the weight loss phase, physical activity was calculated as a change in kcal/week from 0 to 6 months (kcal/week at 6 months – kcal/week at 0 months). A positive value for change in kcal/week represents an increase in physical activity. During the weight loss maintenance phase, physical activity was calculated as a change in kcal/week from 6 to 18 months (kcal/week at 18 months – kcal/week at 6 months). A positive value for change in kcal/week represents an increase in physical activity.

Statistical Analyses

Independent t-tests and chi-squared tests were conducted to compare demographics and anthropometrics measures between participants included in the secondary data analyses and those not included. A significant difference was found between those included and those not included in the analyses for age, which was entered as a covariate in the remaining analyses.

For participants included in this secondary analysis, independent t-tests and chi-squared tests were used to compare demographics and baseline anthropometrics, dietary intake, and physical activity between LV and Lifestyle. Significant group differences ($p < 0.05$) were found

in baseline intake of Higher Fat Fruit, Higher Fat Eggs, and Higher Fat Nuts, as well as self-reported energy expenditure from physical activity. Due to these baseline differences, changes across time in dietary intake and self-reported energy expenditure from physical activity were examined with repeated measures analyses of covariance (ANCOVA), with intervention group as a covariate.

Thus, for Specific Aim 1, a repeated measures ANCOVA, with group assignment and age as covariates, was conducted to assess food group, energy, and percent energy from fat intake; weight; and self-reported energy expenditure from physical activity at 0, 6, and 18 months. Greenhouse-Geisser probability levels were used to adjust for sphericity where appropriate.

For Specific Aim 2, hierarchical regression analyses were used to assess the relationship between changes in food group intake and changes in energy and percent energy from fat from 0 to 6 months (weight loss phase) and 6 to 18 months (weight loss maintenance phase). First, change scores for all variables were calculated. For weight loss, change scores were calculated as (6 months – baseline), and for weight loss maintenance, change scores were calculated as (18 months – 6 months). Next, residualized change scores of all variables were calculated to control for variance in change that may be due to the initial score of the measurement period. To calculate these scores, a linear regression, with the independent variable being the variable of interest at baseline and the dependent variable being change score 0 to 6 months was conducted for the weight loss phase. A linear regression, with the independent variable being the variable of interest at 6 months and the dependent variable being change score 6 to 18 months was conducted for the maintenance phase.

Next, for the hierarchical regressions, sex and age were force entered into the first block. Treatment group was also force entered into the second block. The residualized physical activity

change score was force entered into the third block. To determine which food groups should be entered into the fourth block, linear regression analyses, controlling for sex, age, and group assignment were conducted, with change in each food group as the independent variable and change in energy intake (or percent energy from fat intake) as the dependent variable, with each food group run separately. The food groups with a significant association to energy intake (or percent energy from fat intake) were included in the hierarchal regression. These food groups were then entered stepwise, by stepwise selection, into the fourth block of the hierarchical regression analyses. The standard probability levels set by SPSS, at 95% confidence, were used in the analyses. The dependent variable was change in energy intake (or percent energy from fat intake). A separate regression analyses was conducted for these variables for the weight loss phase (0 to 6 months) and the weight loss maintenance phase (6 to 18 months). For the weight loss and weight loss maintenance phases, food groups were further separated into regular food groups and modified food groups. Since several foods were grouped into regular and modified food groups, separate regression analyses were conducted for regular food groups and modified food groups in each phase to prevent overlap of foods classified in both groups.

For Specific Aim 3, hierarchal regression analyses were used to assess the relationship between food group intake and weight loss and weight loss maintenance, from 0 to 6 months (weight loss phase) and 6 to 18 months (weight loss maintenance phase). First, change scores of all dietary variables were calculated. For weight loss, change scores were calculated as (6 months – baseline), and for weight loss maintenance, change scores were calculated as (18 months – 6 months). Next, residualized change scores of all dietary variables were calculated to control for variance in change that may be due to the initial score of the measurement period. To calculate these scores, a linear regression, with the independent variable being the variable of interest at

baseline and the dependent variable being change score at 0 to 6 months was conducted for the weight loss phase. A linear regression, with the independent variable being the variable of interest at 6 months and the dependent variable being change score 6 to 18 months was conducted for the maintenance phase.

Next, for the hierarchical regressions, sex and age were forced entered into the first block. Treatment group was also force entered into the second block. The residualized physical activity change score was force entered into the third block. To determine which food groups should be entered into the fourth block, linear regression analyses, controlling for sex, age, and group assignment were conducted, with change in each food group as the independent variable and pounds weight loss (or pounds weight loss maintained) as the dependent variable, with each food group run separately. The food groups that had a significant association to pounds of weight loss (pounds of weight loss maintained) were included in the hierarchal regression. These food groups were then entered stepwise, by stepwise selection, into the fourth block of the hierarchical regression analyses. The dependent variable was pounds of weight loss (or pounds of weight loss maintained). Separate regression analyses were conducted for these variables for the weight loss phase (0 to 6 months) and the weight loss maintenance phase (6 to 18 months). The standard probability levels that SPSS sets, at 95% confidence, was used in the analyses. Since several foods were grouped into regular and modified food groups, separate regression analyses were conducted for regular food groups and modified food groups in each phase to prevent overlap of foods classified in both groups.

All analyses were conducted using SPSS Statistics 21.0[41], with alpha level set at 0.05.

RESULTS

Baseline Participant Characteristics

Baseline characteristics for those included in the analyses (n = 162) compared to those that were excluded from the analyses (n = 38) are shown in Appendix A, Table 4. No significant difference was found in weight, BMI, gender, race, ethnicity, education, marital status, or group assignment. A significant difference was found between these groups for age, with those included in the analyses being older than those not included in the analyses (52.5 ± 8.4 years vs. 48.0 ± 10.2, $p < 0.05$) Therefore, age was entered as a covariate in all subsequent analyses.

Baseline characteristics for the Lifestyle and LV groups are shown in Appendix A, Table 5. Participants were middle-aged (52.5 ± 8.4 years); predominantly white (92%), female (57.4%), with at least some college education (88.9%), married (76.5%), and not Hispanic (97.5%); and were obese (BMI = 34.9 ± 4.5 kg/m^2). For daily servings consumed from food groups at baseline, there were no significant differences in the majority of the food groups (see Appendix A, Table 5). There were significant differences between LV and Lifestyle in daily servings consumed for the following food groups: Higher Fat Fruit (LV: 0.03 ± 0.13 servings/day vs. Lifestyle: 0.00 ± 0.00 servings/day, $p < 0.05$), Higher Fat Eggs (LV: 0.54 ± 0.58 servings/day vs. Lifestyle: 0.35 ± 0.40 servings/day, $p < 0.05$), and Higher Fat Nuts (LV: 0.35 ± 0.64 servings/day vs. Lifestyle: 0.85 ± 1.16 servings/day, $p < 0.05$). There were no significant differences between the conditions in energy intake and percent energy from fat intake. Self-reported energy expended per week for physical activity was significantly different between the groups (LV: 766.9 ± 1023.4 Calories/week vs. Lifestyle: 1348.9 ± 1587.7 Calories/week, $p < 0.05$).

Changes in Self-reported Dietary Intake, Self-reported Physical Activity, and Weight Over Time

There were no significant differences in intake at 0, 6, and 18 months for most dietary variables (see Appendix A, Table 6). Energy intake decreased, though not significantly, from 1982.8 ± 568.7 kcal/day at baseline, to 1372.9 ± 413.0 kcal/day at 6 months, and 1549.9 ± 502.5 kcal/day at 18 months. In addition, percent energy from fat intake decreased, though not significantly, from 35.2 ± 6.4% at baseline, to 25.1 ± 6.6% at 6 months, and 28.6 ± 6.9% at 18 months. Also, weight decreased, though not significantly, from 222.7 ± 42.0 lbs. at baseline, to 196.2 ± 37.6 lbs. at 6 months, and 198.8 ± 42.0 lbs. at 18 months. No significant differences across time were found for the majority of food groups. However, a significant effect of time was seen for Lower Fat Unsweetened Beverages, F (2) = 5.184, $p < 0.05$, with significant ($p < 0.05$) differences from 0 to 6 months and 0 to 18 months (0 mo: 3.43 ± 2.40 servings/day, 6 mo: 4.67 ± 3.21 servings/day, 18 mo: 4.65 ± 2.70 servings/day), and physical activity, F (2) = 5.263, $p < 0.05$, with significant ($p < 0.05$) differences from 0 to 6 months and 0 to 18 months (0 mo: 1072.25 ± 1376.41 Calories/week, 6 mo: 2150.89 ± 2005.16 Calories/week, 18 mo: 1922.36 ± 1834.94 Calories/week), shown in Appendix A, Table 6.

Food Group Changes and Changes in Energy Intake, Percent Energy from Fat Intake, and Weight during Weight Loss

Simple Regressions

Significant food group intake changes in relation to change in energy intake were seen with the following food groups when age, sex, and group were controlled in the linear regressions: Lower Fat Refined Grains (β=0.408, $p < 0.00$), Lower Fat Red/Orange Vegetables (β=0.145, $p < 0.05$), Higher Fat Dairy (β=0.317, $p < 0.00$), Higher Fat Meat (β=0.232, $p < 0.001$), Higher Fat Nuts (β=0.298, $p < 0.00$), Higher Fat Oils (β=0.371, $p < 0.00$), Sugar

Sweetened Sweets (β=0.346, p < 0.00), Modified Regular Fat Dairy (β=0.323, p < 0.00), Modified Lower Fat Dairy (β=0.200, p < 0.01), Modified Higher Fat Fats Oils and Sweets (β=0.239, p < 0.001), Modified Higher Fat Sugar Sweetened Fats Oils and Sweets (β=0.179, p < 0.05), Modified Lower Fat Fats Oils and Sweets (β=0.225, p < 0.01), Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (β=0.286, p < 0.00), Lower Fat Sugar Sweetened Beverages (β=0.254, p < 0.001), and Lower Fat Sugar Sweetened Alcohol (β=0.148, p < 0.05), as shown in Appendix A, Table 7.

Significant associations for change in percent energy from fat intake were seen for changes in consumption of Lower Fat Fruit (β= -0.282, p < 0.00), Higher Fat Meat (β=0.328, p < 0.00), Higher Fat Fats (β=0.392, p < 0.00), Higher Fat Oils (β=0.285, p < 0.00), Modified Regular Fat Dairy (β=0.261, p < 0.001), and Modified Higher Fat Fats Oils and Sweets (0.446, p < 0.00), as shown in Appendix A, Table 7.

Significant associations were seen for change in weight and change in intake for Lower Fat Refined Grains (β=0.164, p < 0.05), Higher Fat Meats (β=0.178, p < 0.05), Sugar Sweetened Sweets (β=0.187, p < 0.05), Modified Regular Fat Sugar Sweetened Dairy, Modified Regular Fat Artificially Sweetened Dairy, Modified Lower Fat Artificially Sweetened Dairy (β= -0.159, p < 0.05), Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (β=0.186, p < 0.05), Lower Fat Artificially Sweetened Beverages (β= -0.215, p < 0.01), and Lower Fat Unsweetened Beverages (β= -0.157, p < 0.05), as shown in Appendix A, Table 7.

Hierarchical Regressions

Hierarchical regressions, with sex and age force entered into the first block, treatment group force entered into the second block, and the residualized change score of physical activity

force entered into the third block, found that the food group intake changes that had a significant association to change in energy intake during weight loss (0 to 6 months) were: Lower Fat Refined Grains (β=0.213, $p < 0.01$), Higher Fat Oils (β=0.272, $p < 0.01$), Higher Fat Nuts (β=0.295, $p < 0.01$), Higher Fat Dairy (β=0.221, $p < 0.01$), Higher Fat Meat (β=0.207, $p < 0.01$), and Higher Fat Fats (β=0.190, $p < 0.01$), as shown in Appendix A, Table 8. All of these food group intake changes had positive relationships with change in energy intake, indicating that changes in these variables were associated with the same direction of change as energy intake.

Food group intake changes that had a significant association to change in percent energy from fat intake during weight loss were Higher Fat Fats (β=0.388, $p < 0.01$), Higher Fat Meat (β=0.280, $p < 0.01$), Higher Fat Oils (β=0.275, $p < 0.01$), and Lower Fat Fruit (β= -0.215, $p < 0.01$), as shown in Appendix A, Table 8. Changes in intake of these food groups had positive relationships with change in percent energy from fat intake, except Lower Fat Fruit, which had a negative relationship with change in percent energy from fat. Thus, except for Lower Fat Fruit, changes in these food groups were associated with the same direction of change as percent energy in fat intake.

Food group intake changes that had a significant association to change in weight during weight loss was Sugar Sweetened Sweets (β=0.160, $p < 0.05$), shown in Appendix A, Table 8. This food group changed in the same direction as change in weight.

Changes in intake of modified food groups that had a significant association to change in energy intake during weight loss were: Modified Regular Fat Dairy (β=0.264, $p < 0.05$), Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (β=0.260, $p < 0.05$), Lower Fat Sugar Sweetened Beverages (β=0.179, $p < 0.05$), Modified Lower Fat Dairy (β=0.185, $p < 0.05$), Modified Lower Fat Fats Oils and Sweets (β=0.172, $p < 0.05$), and Modified Lower Fat Sugar

Sweetened Dairy (β=0.155, $p < 0.05$), as shown in Appendix A, Table 9. All of these food groups had positive relationships with change in energy intake, indicating that changes in these variables were associated with the same direction of change as energy intake.

Changes in intake of modified food groups that had a significant association to change in percent energy from fat intake during weight loss were: Modified Higher Fat Fats Oils and Sweets (β=0.409, $p <0.05$) and Modified Regular Fat Dairy (β=0.156, $p < 0.05$), as shown in Appendix A, Table 9. Both of these food groups had positive relationships with change in percent energy from fat, indicating that changes in these variables were associated with the same direction of change as percent energy from fat.

Changes in intake of modified food groups that had a significant association to change in weight during weight loss were: Lower Fat Artificially Sweetened Beverages (β= -0.250, $p < 0.05$), Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (β=0.190, $p < 0.05$), and Lower Fat Unsweetened Beverages (β= -0.184, $p < 0.05$), as shown in Appendix A, Table 9. Most of these food groups had negative relationships with change in weight, indicating that changes in these variables were associated with the opposite direction of change as weight. However, Modified Lower Fat Sugar Sweetened Fats Oils and Sweets had a positive relationship with change in weight. Thus, an increase in artificially sweetened beverages and unsweetened beverages and a decrease in sugar sweetened fats oils and sweets were associated with a decrease in weight.

Food Group Changes and Changes in Energy Intake, Percent Energy from Fat Intake, and Weight during Weight Loss Maintenance

Simple Regressions

Significant food group intake changes in relation to change in energy intake were seen for the following groups when age, sex, and group were controlled in the linear regressions: Lower Fat Refined Grains (β=0.492, $p < 0.00$), Higher Fat Dairy (β=0.236, $p < 0.01$), Higher Fat Meat (β=0.381, $p < 0.00$), Higher Fat Nuts (β=0.353, $p < 0.00$), Higher Fat Oils (β=0.443, $p < 0.00$), Sugar Sweetened Sweets (β=0.253, $p < 0.001$), Modified Regular Fat Dairy (β=0.232, $p < 0.01$), Modified Lower Fat Fats Oils and Sweets (β=0.295, $p < 0.00$), and Lower Fat Sugar Sweetened Alcohol (β=0.261, $p < 0.001$) as shown in Appendix A, Table 10.

Significant associations were found for change in percent energy from fat intake and for changes in intake of Higher Fat Dairy (β=0.267, $p < 0.001$), Higher Fat Meat (β=0.412, $p < 0.00$), Higher Fat Poultry (β=0.259, $p < 0.001$), Higher Fat Nuts (β=0.369, $p < 0.00$), Higher Fat Fats (β=0.388, $p < 0.00$), Modified Regular Fat Dairy (β=0.271, $p < 0.001$), and Modified Higher Fat Fats Oils and Sweets (β=0.393, $p < 0.00$), as shown in Appendix A, Table 10.

No significant associations were seen for change in weight and food group intake changes during weight loss maintenance.

Hierarchical Regressions

Hierarchical regressions, with sex and age force entered into the first block, treatment group force entered into the second block, and the residualized change score of physical activity force entered into the third block, found that food group intake changes that had a significant association to change in energy intake during weight loss maintenance (6 to 18 months) were Lower Fat Refined Grains (β=0.389, $p < 0.01$), Higher Fat Oils (β=0.367, $p < 0.01$), Higher Fat

Nuts (β=0.280, $p < 0.01$), and Higher Fat Fats (β=0.178, $p < 0.01$), as shown in Appendix A, Table 11. All of these food groups had positive relationships to change in energy intake during weight loss maintenance, indicating that changes in these variables were associated with the same direction of change as energy intake, which slightly increased.

Food group intake changes that had a significant association to change in percent energy from fat intake for weight loss maintenance were Higher Fat Meat (β=0.368, $p < 0.00$), Higher Fat Fats (β=0.381, $p < 0.00$), Higher Fat Nuts (β=0.303, $p < 0.00$), and Higher Fat Poultry (β=0.231, $p < 0.00$), as shown in Appendix A, Table 11. All of these foods groups had positive relationships to change in percent energy from fat intake during weight loss maintenance, indicating that changes in these variables were associated with the same direction of change as percent energy from fat intake, which slightly increased during the weight loss maintenance phase.

Changes in intake of modified food groups that had a significant association to change in energy intake during weight loss maintenance were: Modified Lower Fat Fats Oils and Sweets (β=0.282, $p < 0.01$), Lower Fat Sugar Sweetened Alcohol (β=0.215, $p < 0.01$), and Modified Regular Fat Dairy (β=0.209, $p < 0.01$), as shown in Appendix A, Table 12**.** All of these food groups had positive relationships to change in energy intake during weight loss maintenance, indicating that changes in these variables were associated with the same direction of change as energy intake, which slightly increased during the weight loss maintenance phase.

Changes in intake of modified food groups that had a significant association to change in percent energy from fat intake during weight loss maintenance were: Modified Higher Fat Fats Oils and Sweets (β=0.348, $p < 0.05$) and Modified Regular Fat Dairy (β=0.172, $p < 0.05$), as shown in Appendix A, Table 12**.** Both of these food groups had positive relationships to change

in percent energy from fat intake during weight loss maintenance, indicating that changes in these variables were associated with the same direction of change as percent energy from fat intake, which slightly increased during the weight loss maintenance phase.

DISCUSSION

The purpose of this study was to investigate changes in food group intake during a lifestyle intervention, which provided a low-Calorie, low-fat dietary prescription. Additionally, this investigation examined the relationship between changes in food group intake and reductions in energy and fat intake and weight loss.

Results indicated that most food groups did not change significantly over time, except for unsweetened beverages, which increased over time. Physical activity also significantly changed across time. During weight loss, overall reductions in higher fat foods and foods sweetened with sugar, and increases in fruit were associated with decreases in energy intake and percent energy from fat intake. Reductions in sugar sweetened foods and increases in artificially sweetened beverages were associated with reductions in weight. During weight loss maintenance, reductions in higher fat foods were associated with decreases in energy intake and percent energy from fat intake. No changes in food groups were associated to changes in weight during weight loss maintenance.

The findings of this study indicate that decreasing consumption of foods higher in fat and sugar (i.e. meat, fats and oils, dairy products, and sugar sweetened foods) and increasing consumption of modified beverages and unsweetened beverages, rather than increasing consumption of foods that are naturally lower in energy and fat (i.e., fruits and vegetables), may be more helpful in significantly decreasing energy intake and percent energy from fat, and increasing weight loss. Artificially Sweetened Beverages was the only modified food that

significantly increased in relation to changes in energy, percent energy from fat, or weight. Thus overall, modified foods, such as lower fat and fat-free foods, were not used by this sample to assist with meeting the low-Calorie, low-fat dietary prescription.

While there has been limited research examining changes in diet intake during a low-Calorie, low-fat diet, several studies have proposed certain methods may be helpful for reducing energy and or fat intake. Portion control has been shown to be effective for reducing energy and fat intake[17,18]. Increasing lower-Calorie foods while reducing higher-Calorie foods is another method shown to be effective for reducing energy and fat intake[19,20]. Fat-modified (low-fat, non-fat) and sugar-modified (artificially sweetened) foods and beverages when used in place of their regular (full fat and/or sugar sweetened) forms, are also effective for reducing energy and fat intake[22–24]. As this investigation did not find large changes, or at least significant changes, in intake of servings from food groups, this suggests that portion control was not the main method for reducing intake. Nor were changes in most fruit and vegetable intake related to weight loss. In addition, for modified foods, only artificially sweetened beverages increased, showing increases in many different modified foods were not a strategy used by participants in this study to reduce energy and fat intake, which is contrary to other studies.[22,30] Instead, this study indicates that the food choices that participants made that were associated with a lower-Calorie, low-fat diet were to generally reduce intake of foods that are higher in fat and sugar. During weight loss, decreases in sugar sweetened foods and increases in artificially sweetened beverages and unsweetened beverages were associated with decreases in weight. However, during weight loss maintenance, there were no associations between food group changes and changes in weight.

While reductions in energy and percent energy from fat and weight were associated with consuming fewer servings from higher fat food groups and sugar sweetened foods and more servings of modified beverages, changes in energy, percent energy from fat, and weight were not associated with as many changes in food groups that are naturally lower in fat (i.e. fruits and vegetables). Thus, if additional dietary changes are desired during weight loss, specific goals, other than goals related to decreasing energy and fat, may need to be included in the dietary prescription. For example, to see an increase in fruits and vegetables during a low-Calorie, low-fat diet, it may be important to include a goal that specifically targets increasing fruits and vegetables within the low-Calorie, low-fat dietary prescription.

Limitations of the study include a sample that was fairly homogenous with regards to race and ethnicity and the use of self-reported dietary intake. Additionally, while the main study found changes in dietary intake and percent weight loss over time, in this investigation since differences at baseline between the intervention conditions were seen in several variables, analyses across time had to control for intervention condition, which may have limited ability to find changes across time. Moreover, the modified food groups were coded in such a way that there was some overlap in items in the food groups in the regular food groups and modified food groups. To control for this overlap, separate hierarchical regressions were conducted for regular food groups and modified food groups. It would be helpful to have food groups be in only regular or modified categories to prevent this overlap in the future and so that regular and modified food groups could be included in the same analyses to assist with ascertaining the relative weight of food group change on changes in energy, percent energy from fat, and weight over time. Also, since several analyses were conducted, it is possible that significant findings were due to chance, which is a result of an increased risk of type 1 error. The final limitation of

this study was the study design, a secondary data analysis, which limits ability to draw cause and effect conclusions.

Despite these limitations, this is the first study to examine changes in food group intake occurring when a low-Calorie, low-fat diet is prescribed and how these changes may be related to energy and percent energy from fat intake and weight loss during a lifestyle intervention. In addition, while dietary intake was self-reported, the use of unannounced 24-hr dietary recalls, collected using the multi-pass method with NDSR assist with minimizing bias.

Future research should examine the effect of a dietary prescription that includes goals to reduce servings from higher fat food groups, servings from sugar sweetened foods, and modified beverages (the groups that significantly decreased in this study in relation to energy, fat intake, and weight) compared to a prescription that did not encourage these changes to see if the additional guidance would improve outcomes.

CONCLUSION

The purpose of this study was to investigate changes in food group intake during a lifestyle intervention, which provided a low-Calorie, low-fat dietary prescription. Additionally, this investigation examined the relationship between changes in food group intake and reductions in energy and fat intake and weight loss.

While there has been limited research examining changes in diet intake during a low-Calorie, low-fat diet, several studies have proposed certain methods may be helpful for reducing energy and or fat intake. Portion control has been shown to be effective for reducing energy and fat intake[17,18]. Increasing lower-Calorie foods while reducing higher-Calorie foods is another method shown to be effective for reducing energy and fat intake[19,20]. Fat-modified (low-fat, non-fat) and sugar-modified (artificially sweetened) foods and beverages when used in place of their regular (full fat and/or sugar sweetened) forms, are also effective for reducing energy and fat intake[22–24]. As this investigation did not find large changes, or at least significant changes, in intake of servings from food groups, this suggests that portion control was not the main method for reducing intake. Nor were changes in most fruit and vegetable intake related to weight loss. In addition, for modified foods, only artificially sweetened beverages increased, showing increases in many different modified foods were not a strategy used by participants in this study to reduce energy and fat intake, which is contrary to other studies.[22,30] Instead, this study indicates that the food choices that participants made that were associated with a lower-Calorie, low-fat diet were to generally reduce intake of foods that are higher in fat and sugar.
Results indicated that most food groups did not change significantly over time, except for unsweetened beverages, which increased over time. Physical activity also significantly changed across time. During weight loss, overall reductions in higher fat foods and foods sweetened with

sugar, and increases in fruit were associated with decreases in energy intake and percent energy from fat intake. Reductions in sugar sweetened foods and increases in artificially sweetened beverages were associated with reductions in weight. During weight loss maintenance, reductions in higher fat foods were associated with decreases in energy intake and percent energy from fat intake. No changes in food groups were associated to changes in weight during weight loss maintenance.

Future research should examine the effect of a dietary prescription that includes goals to reduce servings from higher fat food groups, servings from sugar sweetened foods, and modified beverages (the groups that significantly decreased in this study in relation to energy, fat intake, and weight) compared to a prescription that did not encourage these changes to see if the additional guidance would improve outcomes.

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APPENDICES

APPENDIX A

TABLES

Table 1. Foods coded by Food Guide Pyramid and MyPlate

Food Group	Food Guide Pyramid	MyPlate
Grains *Whole Grains*	**Higher Fat** Cakes, cookies, pies (GRW0800) Snack Chips (GRW0900) Cakes, cookies, pies (GRS0800) Snack Chips (GRS0900) **Lower Fat** Loaf Bread or Rolls (GRW0200) Other Breads (GRW0300) Snack Bars (GRW1000) Crackers (GRW0400) Pasta (GRW0500) Cereal not pre-sweet (GRW0600) Cereal pre-sweet (GRW0700) Popcorn (GRW1100) Flavored popcorn (GRW1200) Loaf Bread (GRS0200) Other Breads (GRS0300) Snack Bars (GRS1000) Crackers (GRS0400) Pasta (GRS0500) Cereal not pre-sweet (GRS0600) Cereal pre-sweet (GRS0700)	Loaf Bread or Rolls (GRW0200) Other Breads (GRW0300) Snack Bars (GRW1000) Crackers (GRW040) Pasta (GRW05000) Cereal not pre-sweet (GRW0600) Cereal pre-sweet (GRW0700) Popcorn (GRW1100) Flavored popcorn (GRW1200) Loaf Bread (GRS0200) Other Breads (GRS0300) Snack Bars (GRS1000) Crackers (GRS0400) Pasta (GRS0500) Cereal not pre-sweet (GRS0600) Cereal pre-sweet (GRS0700)
Refined Grains	**Higher Fat** Cakes, cookies, pies (GRR0800) Snack Chips (GRR0900) **Lower Fat** Loaf Bread (GRR0200) Other Breads (GRR0300) Snack Bars (GRR1000) Crackers (GRR0400) Pasta (GRR0500) Cereal not pre-sweet (GRR0600) Cereal pre-sweet (GRR0700)	Loaf Bread (GRR0200) Other Breads (GRR0300) Snack Bars (GRR1000) Crackers (GRR0400) Pasta (GRR0500) Cereal not pre-sweet (GRR0600) Cereal pre-sweet (GRR0700)

Table 1. (continued).

Food Group	Food Guide Pyramid	MyPlate
Vegetables		
Dark Green Vegetables	**Higher Fat** N/A **Lower Fat** Dark Green Vegetables (VEG0100)	Dark Green Vegetables (VEG0100)
Starchy Vegetables	**Higher Fat** N/A **Lower Fat** White Potatoes (VEG0400) Other Starchy (VEG0450)	White Potatoes (VEG0400) Other Starchy (VEG0450)
Red/ Orange Vegetables	**Higher Fat** N/A **Lower Fat** Tomatoes (VEG0300) Yellow Vegetables (VEG0200)	Tomatoes (VEG0300) Yellow Vegetables (VEG0200)
Beans and Peas	**Higher Fat** N/A **Lower Fat** Legumes (VEG0700)	Legumes (VEG0700)
Other Vegetables	**Higher Fat** Fried Vegetables (VEG0900) **Lower Fat** Other Vegetables (VEG0600) Vegetable Juice (VEG0500)	Other Vegetables (VEG0600) Vegetable Juice (VEG0500)
Fruit	**Higher Fat** Avocado and similar (FRU0500) Fried Fruits (FRU0600) Fruit-based savory snacks (FRU0700) **Lower Fat** Citrus Juice (FRU0100) Fruit Juice, not citrus (FRU0200) Citrus Fruits (FRU0300) Fruits, not citrus (FRU0400)	Avocado and similar (FRU0500) Citrus Juice (FRU0100) Fruit Juice, not citrus (FRU0200) Citrus Fruits (FRU0300) Fruits, not citrus (FRU0400)
Milk/Dairy	**Higher Fat** Whole Milk (DMF0100) Whole Flavored Milk (DMF0200) Cheese (DCF0100) Whole, sweetened Yogurt (DYF0100) Cream (FCF0100) Frozen Dairy Dessert (DOT0200) Pudding (DOT0300)	Whole Milk (DMF0100) Whole Flavored Milk (DMF0200) Cheese (DCF0100) Whole sweetened Yogurt (DYF0100) Cream (FCF0100) Nondairy Milk (DMN0100) Nondairy Cheese (DCN0100)

Table 1. (continued).

Food Group	Food Guide Pyramid	MyPlate
Milk/Dairy	**Lower Fat** Nondairy Milk (DMN0100) Nondairy Cheese (DCN0100) Nondairy Yogurt (DYN0100) Nondairy Cream (FCN0100)	Nondairy Yogurt (DYN0100) Cream (FCF0100) Nondairy Cream (FCN0100) Pudding (DOT0400)
Protein		
Meats	**Higher Fat** Beef (MRF0100) Veal (MRF0200) Lamb (MRF0300) Fresh Pork (MRF0400) Cured Pork (MCF0200) Cold Cuts/Sausage (MCF0100) **Lower Fat** Lean Beef (MRL0100) Lean Veal (MRL0200) Lean Lamb (MRL0300) Lean Fresh Pork (MRL0400) Lean Cured Pork (MCL0200) Lean Cold Cuts/Sausage (MCL0100) Meat Alternatives (MOF0700)	Beef (MRF0100) Veal (MRF0200) Lamb (MRF0300) Fresh Pork (MRF0400) Cured Pork (MCF0200) Cold Cuts/Sausage (MCF0100) Lean Beef (MRL0100) Lean Veal (MRL0200) Lean Lamb (MRL0300) Lean Fresh Pork (MRL0400) Lean Cured Pork (MCL0200) Lean Cold Cuts/Sausage (MCL0100) Meat Alternatives (MOF0700)
Poultry	**Higher Fat** Fried Chicken (MPF0200) Poultry (MPF0100) **Lower Fat** Lean Poultry (MPL0100)	Poultry (MPF0100) Lean Poultry (MPL0100)
Seafood	**Higher Fat** Fried Fish (MFF0200) Fish (MFF0100) Fried Shellfish (MSF0100) **Lower Fat** Lean Fish (MFL0100) Shellfish (MSL0100)	Fish (MFF0100) Shellfish (MSL0100) Lean Fish (MFL0100)
Eggs	**Higher Fat** Eggs (MOF0300) Egg Substitute (MOF0400) **Lower Fat** N/A	Eggs (MOF0300) Egg Substitute (MOF0400)
Nuts and Seeds	**Higher Fat** Nuts and Seeds (MOF0500) Nut and Seed Butters (MOF0600)	Nuts and Seeds (MOF0500) Nut and Seed Butters (MOF0600)

Table 1. (continued).

Food Group	Food Guide Pyramid	MyPlate
Nuts and Seeds	**Lower Fat** N/A	
*SoFAS**	N/A	Fried Potatoes (VEG0800) Fried Chicken (MPF0200) Fried Fish (MFF0200) Fried Shellfish (MSF0100) Cakes, cookies, pies (GRW0800) Snack Chips (GRW0900) Cakes, cookies, pies (GRR0800) Snack Chips (GRR0900) Cakes, cookies, pies (GRS0800) Snack Chips (GRS0900) Fried Vegetables (VEG0900) Vegetable-based savory snacks (FMC0100) Fried Fruits (FRU0600) Fruit-based savory snacks (FRU0700) Margarine (FMF0100) Butter, Other animal fats (FAF0100) Salad Dressing (FDF0100) Salad Dressing (FDF0100) Sugar (SWT0400) Syrup (SWT0500) Sweet Sauces (SWT0700) Gravy (MSC0100) Condiments (MSC0300) Frozen nondairy Dessert (DOT0200) Chocolate candy (SWT0100) Non-chocolate candy (SWT0200) Frosting/glaze (SWT0300) Frozen Dairy Dessert (DOT0100)
Oils	N/A	Oils (FOF0100)

Table 1. (continued).

Food Group	Food Guide Pyramid	MyPlate
Fats, Oils, Sweets		
Fats	**Higher Fat** Margarine (FMF0100) Butter, Other animal Fats (FAF0100) Salad Dressing (FDF0100) Gravy (MSC0100) Condiments (MSC0300) Vegetable-based savory snacks (FMC0100) **Lower Fat** N/A	
Oils	**Higher Fat** Oils (FOF0100) **Lower Fat** N/A	N/A
Sweets	**Sugar Sweetened** Sugar (SWT0400) Syrup (SWT0500) Sweet Sauces (SWT0700) Frozen Nondairy Dessert (DOT0200) Chocolate candy (SWT0100) Non-chocolate candy (SWT0200) Frosting/Glaze (SWT0300) **Artificially Sweetened** N/A	N/A

*SoFAS = Solid Fats and Added Sugars

Table 2. Modified foods coded into food groups by Food Guide Pyramid and MyPlate

Food Group	Food Guide Pyramid	MyPlate
Milk/Dairy	**Regular Fat** Whole Milk (DMF0100) Cheese (DCF0100) Cream (FCF0100) **Regular Fat Sugar Sweetened** Whole Flavored Milk (DMF0200) Whole, sweetened Yogurt (DYF0100) Pudding (DOT0300) Frozen Dairy Dessert (DOT0100) **Regular Fat Artificially Sweetened** Whole, artificially, Yogurt (DYF0200) **Lower Fat** Reduced-Fat Milk (DMR0100) Low-fat, Fat-free Milk (DML0100) Reduced-fat Cheese (DCR0100) Low-fat, Fat-free Cheese (DCL0100) Nondairy Cheese (DCN0100) Nondairy Yogurt (DYN0100) Reduced-fat Cream (FCR0100) Low-fat, Fat-free Cream (FCL0100) Nondairy Cream (FCN0100) **Lower Fat Sugar Sweetened** Reduced-fat Flavored Milk (DMR0200) Low-fat, Fat-free Flavored Milk (DML0200) Low-fat, sweetened Yogurt (DYR0100) Fat-free, sweetened Yogurt (DYL0100) **Lower Fat Artificially Sweetened** Low-fat, artificially, Yogurt (DYR0200) Fat-free, artificially, Yogurt (DYL0200)	**Regular Fat** Whole Milk (DMF0100) Cheese (DCF0100) Cream (FCF0100) **Regular Fat Sugar Sweetened** Whole Flavored Milk (DMF0200) Whole, sweetened Yogurt (DYF0100) Pudding (DOT0300) Frozen Dairy Dessert (DOT0100) **Regular Fat Artificially Sweetened** Whole, artificially, Yogurt (DYF0200) **Lower Fat** Reduced-Fat Milk (DMR0100) Low-fat, Fat-free Milk (DML0100) Reduced-fat Cheese (DCR0100) Low-fat, Fat-free Cheese (DCL0100) Nondairy Cheese (DCN0100) Nondairy Yogurt (DYN0100) Reduced-fat Cream (FCR0100) Low-fat, Fat-free Cream (FCL0100) Nondairy Cream (FCN0100) **Lower Fat Sugar Sweetened** Reduced-fat Flavored Milk (DMR0200) Low-fat, Fat-free Flavored Milk (DML0200) Low-fat, sweetened Yogurt (DYR0100) Fat-free, sweetened Yogurt (DYL0100) **Lower Fat Artificially Sweetened** Low-fat, artificially, Yogurt (DYR0200) Fat-free, artificially, Yogurt (DYL0200)

Table 2. (continued).

Food Group	Food Guide Pyramid	MyPlate
SoFAs*	N/A	**Higher Fat** Margarine (FMF0100) Butter, Animal Fats (FAF0100) Salad Dressing (FDF0100) Gravy (MSC0100) Condiments (MSC0300) **Higher Fat Sugar Sweetened** Chocolate Candy (SWT0100) Sweet Sauces (SWT0700) **Higher Fat Artificially Sweetened** Dessert (DOT0400) **Lower Fat** Reduced-fat Margarine (FMR0100) Reduced-fat Butter, Animal Fats (FAR0100) Reduced-fat/kcal Salad Dressing (FDR0100) Reduced-fat Gravy (MSC0400) Reduced-fat Condiments (MSC0400) **Lower Fat Sugar Sweetened** Sugar (SWT0400) Frozen Nondairy Dessert (DOT0200) Non-Chocolate Candy (SWT0200) Frosting/Glaze (SWT0300) Reduced-fat/kcal Sweet Sauces (SWT0800) **Lower Fat Artificially Sweetened** Sugar Substitute (MSC1200)
Fats, Oils, Sweets	**Higher Fat** Margarine (FMF0100) Butter, Animal Fats (FAF0100) Salad Dressing (FDF0100) Gravy (MSC0100) Condiments (MSC0300) **Lower Fat** N/A **Higher Fat Sugar Sweetened** Chocolate Candy (SWT0100) Sweet Sauces (SWT0700)	N/A

Table 2. (continued).

Food Group	Food Guide Pyramid	MyPlate
Fats, Oils, Sweets	**Higher Fat Artificially Sweetened** Artificially Dessert (DOT0400) **Lower Fat** Reduced-fat Margarine (FMR0100) Reduced-fat Butter, Animal Fats (FAR0100) Reduced-fat/kcal Salad Dressing (FDR0100) Reduced-fat Gravy (MSC0400) Reduced-fat Condiments (MSC0400) **Lower Fat Sugar Sweetened** Sugar (SWT0400) Frozen Nondairy Dessert (DOT0200) Non-Chocolate Candy (SWT0200) Frosting/Glaze (SWT0300) Reduced-fat/kcal Sweet Sauces (SWT0800) **Lower Fat Artificially Sweetened** Sugar Substitute (MSC1200)	N/A

*SoFAS = Solid Fats and Added Sugars

Table 3. Beverages coded by Food Guide Pyramid and MyPlate

Food Group	Food Guide Pyramid	MyPlate
Fats, Oils, Sweets	**Higher Fat Sugar Sweetened** N/A **Lower Fat Sugar Sweetened** Sweetened Soft Drinks (BVS0400) Sweetened Fruit Drinks (BVS0300) Sweetened Tea (BVS0500) Sweetened Coffee (BVS0100) Sweetened Coffee Substitutes (BVS0200) Sweetened Water (BVS0600) **Higher Fat Artificially Sweetened** N/A **Lower Fat Artificially Sweetened** Artificially Sweetened Soft Drinks (BVA0400) Artificially Sweetened Fruit Drinks (BVA0300) Artificially Sweetened Tea (BVA0500) Artificially Sweetened Coffee (BVA0100) Artificially Sweetened Coffee Substitutes (BVA0200) Artificially Sweetened Water (BVA0600) **Higher Fat Unsweetened** N/A **Lower Fat Unsweetened** Unsweetened Soft Drinks (BVU0300) Unsweetened Tea (BVU0400) Unsweetened Coffee (BVU0100) Unsweetened Coffee Substitutes (BVU0200) Unsweetened Water (BVU0500)	N/A

Table 3. (continued).

Food Group	Food Guide Pyramid	MyPlate
SoFAS*	N/A	**Higher Fat Sugar Sweetened** N/A **Lower Fat Sugar Sweetened** Sweetened Soft Drinks (BVS0400) Sweetened Fruit Drinks (BVS0300) Sweetened Tea (BVS0500) Sweetened Coffee (BVS0100) Sweetened Coffee Substitutes (BVS0200) Sweetened Water (BVS0600) Non-alcoholic Beer (BVO0100) Beers and Ales (BVE0100) Cordial and Liqueur (BVE0400) Distilled Liquor (BVE0300) Wine (BVE0200) **Higher Fat Artificially Sweetened** N/A **Lower Fat Artificially Sweetened** Artificially Sweetened Soft Drinks (BVA0400) Artificially Sweetened Fruit Drinks (BVA0300) Artificially Sweetened Tea (BVA0500) Artificially Sweetened Coffee (BVA0100) Artificially Sweetened Coffee Substitutes (BVA0200) Artificially Sweetened Water (BVA0600) Non-alcoholic Light Beer (BVO0200) **Higher Fat Unsweetened** N/A **Lower Fat Unsweetened** Unsweetened Soft Drinks (BVU0300) Unsweetened Tea (BVU0400) Unsweetened Coffee (BVU0100) Unsweetened Coffee Substitutes (BVU0200) Unsweetened Water (BVU0500)

Table 3. (continued).

Food Group	Food Guide Pyramid	MyPlate
SoFAS*	N/A	**Higher Fat Sugar Sweetened** N/A **Lower Fat Sugar Sweetened** Non-alcoholic Beer (BVO0100) Beers and Ales (BVE0100) Cordial and Liqueur (BVE0400) Distilled Liquor (BVE0300) Wine (BVE0200) **Higher Fat Artificially Sweetened** N/A **Lower Fat Artificially Sweetened** Non-alcoholic Light Beer (BVO0200)
Alcohol	**Higher Fat Sugar Sweetened** N/A **Lower Fat Sugar Sweetened** Non-alcoholic Beer (BVO0100) Beers and Ales (BVE0100) Cordial and Liqueur (BVE0400) Distilled Liquor (BVE0300) Wine (BVE0200) **Higher Fat Artificially Sweetened** N/A **Lower Fat Artificially Sweetened** Non-alcoholic Light Beer (BVO0200)	N/A

*SoFAS = Solid Fats and Added Sugars

Table 4. Baseline characteristics for participants included vs. those not included in secondary analyses

Variable	Not Included (n = 38)	Included (n = 162)
Age* (y)	48.0 ± 10.2	52.5 ± 8.4
Weight (lb)	218.8 ± 27.7	222.7 ± 42.0
BMI (kg/m^2)	34.8 ± 3.3	34.9 ± 4.5
Female (%)	63.1	57.4
White (%)	92.1	92.0
Non-Hispanic (%)	100	97.5
Some college education or higher (%)	84.2	88.9
Married (%)	60.1	76.5
Lifestyle assignment (%)	39.5	52.5

Note: *Significant at $p < 0.05$. BMI = body mass index.

Table 5. Baseline characteristics, self-reported dietary intake, and self-reported energy expenditure from physical activity for Limited Variety and Lifestyle Conditions (M ± SD)

Variables	Limited Variety (n = 77)	Lifestyle (n = 85)
Age (y)	52.6 ± 8.7	52.6 ± 8.2
Weight (lb)	216.6 ± 40.7	228.1 ± 42.6
BMI (kg/m^2)	34.3 ± 4.4	35.4 ± 4.6
Female (%)	57.1	57.6
White (%)	92.2	91.8
Not Hispanic (%)	96.1	98.8
Some College Education or Higher (%)	90.9	87.1
Married (%)	81.8	71.8
Higher Fat Whole Grains (servings/day)	0.25 ± 0.52	0.24 ± 0.46
Lower Fat Whole Grains (servings/day)	1.52 ± 1.33	1.57 ± 1.38
Higher Fat Refined Grains (servings/day)	0.77 ± 0.93	0.77 ± 0.91
Lower Fat Refined Grains (servings/day)	3.41 ± 2.34	2.78 ± 1.88
Lower Fat Dark Green Vegetables (servings/day)	0.49 ± 0.61	0.52 ± 0.57
Lower Fat Starchy Vegetables (servings/day)	0.58 ± 0.67	0.48 ± 0.53
Lower Fat Red/Orange Vegetables (servings/day)	0.70 ± 0.51	0.76 ± 0.62
Lower Fat Beans and Peas (servings/day)	0.18 ± 0.33	0.18 ± 0.38
Higher Fat Other Vegetables (servings/day)	0.06 ± 0.19	0.01 ± 0.09
Lower Fat Other Vegetables (servings/day)	1.04 ± 0.90	0.96 ± 0.70
Higher Fat Fruit* (servings/day)	0.03 ± 0.13	0.00 ± 0.00
Lower Fat Fruit (servings/day)	1.21 ± 1.12	1.19 ± 1.13
Higher Fat Milk/Dairy (servings/day)	0.61 ± 0.58	0.55 ± 0.59
Lower Fat Milk/Dairy (servings/day)	0.28 ± 1.05	0.44 ± 1.09
Higher Fat Meat (servings/day)	1.50 ± 1.65	1.37 ± 1.31
Lower Fat Meat (servings/day)	1.50 ± 1.34	1.24 ± 1.31
Higher Fat Poultry (servings/day)	0.27 ± 0.59	0.35 ± 0.65
Lower Fat Poultry (servings/day)	1.36 ± 1.34	1.28 ± 1.24
Higher Fat Seafood (servings/day)	0.04 ± 0.21	0.09 ± 0.40
Lower Fat Seafood (servings/day)	0.54 ± 0.92	0.56 ± 1.00
Higher Fat Eggs* (servings/day)	0.54 ± 0.58	0.35 ± 0.40
Higher Fat Nuts* (servings/day)	0.35 ± 0.64	0.85 ± 1.16
Higher Fat Fats (servings/day)	1.96 ± 1.81	1.76 ± 1.32
Higher Fat Oils (servings/day)	1.09 ± 1.19	1.00 ± 1.15
Sugar Sweetened Sweets (servings/day)	0.99 ± 1.08	1.04 ± 1.46
Modified Regular Fat Dairy (servings/day)	0.57 ± 0.53	0.50 ± 0.57
Modified Regular Fat Sugar Sweetened Dairy (servings/day)	0.42 ± 0.60	0.30 ± 0.58
Modified Regular Fat Artificially Sweetened Dairy (servings/day)	0.00 ± 0.01	0.00 ± 0.03

Table 5. (continued).

Variables	Limited Variety (n = 77)	Lifestyle (n = 85)
Modified Lower Fat Dairy (servings/day)	1.32 ± 1.34	1.43 ± 1.41
Modified Lower Fat Sugar Sweetened Dairy (servings/day)	0.07 ± 0.19	0.06 ± 0.16
Modified Lower Fat Artificially Sweetened Dairy (servings/day)	0.05 ± 0.14	0.04 ± 0.14
Modified Higher Fat Fats Oils and Sweets (servings/day)	1.79 ± 1.75	1.57 ± 1.23
Modified Higher Fat Sugar Sweetened Fats Oils and Sweets (servings/day)	0.20 ± 0.38	0.15 ± 0.34
Modified Higher Fat Artificially Sweetened Fats Oils and Sweets (servings/day)	0.01 ± 0.04	0.02 ± 0.08
Modified Lower Fat Fats Oils and Sweets (servings/day)	1.39 ± 1.84	1.29 ± 1.78
Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (servings/day)	0.55 ± 0.94	0.79 ± 1.43
Modified Lower Fat Artificially Sweetened Fats Oils and Sweets (servings/day)	0.90 ± 2.02	1.16 ± 1.79
Lower Fat Sugar Sweetened Beverages (servings/day)	0.36 ± 0.72	0.35 ± 0.63
Lower Fat Artificially Sweetened Beverages (servings/day)	1.35 ± 1.45	1.34 ± 1.61
Lower Fat Unsweetened Beverages (servings/day)	3.50 ± 2.67	3.36 ± 2.12
Lower Fat Sugar Sweetened Alcohol (servings/day)	0.29 ± 0.52	0.30 ± 0.71
Lower Fat Artificially Sweetened Alcohol (servings/day)	0 ± 0	0 ± 0
Energy Intake (Calories/day)	2066.0 ± 604.6	1907.5 ± 526.3
Percent Energy from Fat Intake (%)	35.0± 6.2	35.4 ± 6.5
Physical Activity* (Calories/week)	766.9 ± 1023.4	1348.9 ± 1587.7

Note: *Significant at $p < 0.05$. BMI = body mass index

Table 6. Self-reported dietary intake, self-reported physical activity, and weight at 0, 6, and 18 months (M ± SD)

Variable	0 Months (n = 162)	6 Months (n = 162)	18 Months (n = 162)
Higher Fat Whole Grains (servings/day)	0.25 ± 0.49	0.16 ± 0.35	0.13 ± 0.28
Lower Fat Whole Grains (servings/day)	1.54 ± 1.35	1.93 ± 1.35	1.99 ± 1.49
Higher Fat Refined Grains (servings/day)	0.77 ± 0.92	0.39 ±0.61	0.47 ± 0.62
Lower Fat Refined Grains (servings/day)	3.07 ± 2.13	1.92 ± 1.57	2.24 ± 1.72
Lower Fat Dark Green Vegetables (servings/day)	0.51 ± 0.59	0.53 ± 0.67	0.58 ± 0.76
Lower Fat Starchy Vegetables (servings/day)	0.53 ± 0.60	0.38 ± 0.41	0.49 ± 0.58
Lower Fat Red/Orange Vegetables (servings/day)	0.73 ± 0.57	0.77 ± 0.57	0.81 ± 0.66
Lower Fat Beans and Peas (servings/day)	0.18 ± 0.35	0.15 ± 0.28	0.16 ± 0.30
Higher Fat Other Vegetables (servings/day)	0.04 ± 0.15	0.02 ± 0.09	0.02 ± 0.09
Lower Fat Other Vegetables (servings/day)	0.99 ± 0.80	1.18 ± 0.98	1.26 ± 1.00
Higher Fat Fruit (servings/day)	0.02 ± 0.09	0.00 ± 0.03	0.01 ± 0.06
Lower Fat Fruit (servings/day)	1.20 ± 1.12	1.66 ± 1.24	1.65 ± 1.40
Higher Fat Milk/Dairy (servings/day)	0.58 ± 0.58	0.32 ± 0.40	0.38 ±0.45
Lower Fat Milk/Dairy (servings/day)	0.37 ±1.07	0.37 ± 1.04	0.43 ± 1.11
Higher Fat Meat (servings/day)	1.42 ± 1.48	0.62 ± 0.89	0.84 ± 1.09
Lower Fat Meat (servings/day)	1.37 ± 1.33	1.53 ± 1.36	1.49 ± 1.30
Higher Fat Poultry (servings/day)	0.31 ± 0.62	0.14 ± 0.50	0.20 ± 0.60

Table 6. (continued).

Variable	0 Months (n = 162)	6 Months (n = 162)	18 Months (n = 162)
Lower Fat Poultry (servings/day)	1.32 ± 1.29	1.26 ± 1.19	1.35 ± 1.33
Higher Fat Seafood (servings/day)	0.07 ± 0.32	0.01 ± 0.08	0.04 ± 0.22
Lower Fat Seafood (servings/day)	0.55 ± 0.96	0.64 ± 1.09	0.64 ± 1.08
Higher Fat Eggs (servings/day)	0.44 ± 0.50	0.31 ± 0.45	0.33 ± 0.48
Higher Fat Nuts (servings/day)	0.61 ± 0.98	0.32 ± 0.79	0.40 ± 0.74
Higher Fat Fats (servings/day)	1.85 ± 1.57	0.71 ± 0.87	0.95 ± 1.03
Higher Fat Oils (servings/day)	1.04 ± 1.17	0.57 ± 0.84	0.84 ± 1.27
Sugar Sweetened Sweets (servings/day)	1.02 ± 1.29	0.70 ± 0.99	0.70 ± 0.99
Modified Regular Fat Dairy (servings/day)	0.53 ± 0.55	0.27 ± 0.35	0.35 ± 0.45
Modified Regular Fat Sugar Sweetened Dairy (servings/day)	0.36 ± 0.59	0.23 ± 0.39	0.26 ± 0.42
Modified Regular Fat Artificially Sweetened Dairy (servings/day)	0.00 ± 0.02	0.01 ± 0.04	0.00 ± 0.00
Modified Lower Fat Dairy (servings/day)	1.38 ± 1.38	1.22 ± 1.24	1.32 ± 1.31
Modified Lower Fat Sugar Sweetened Dairy (servings/day)	0.07 ± 1.72	0.05 ± 1.35	0.03 ± 0.11
Modified Lower Fat Artificially Sweetened Dairy (servings/day)	0.04 ± 0.14	0.10 ± 0.19	0.10 ± 0.22
Modified Higher Fat Fats Oils and Sweets (servings/day)	1.67 ± 1.50	0.60 ± 0.77	0.82 ± 0.97
Modified Higher Fat Sugar Sweetened Fats Oils and Sweets (servings/day)	0.17 ± 0.36	0.54 ± 0.18	0.09 ± 0.27

Table 6. (continued).

Variable	0 Months (n = 162)	6 Months (n = 162)	18 Months (n = 162)
Modified Higher Fat Artificially Sweetened Fats Oils and Sweets (servings/day)	0.01 ± 0.06	0.02 ± 0.07	0.02 ± 0.07
Modified Lower Fat Fats Oils and Sweets (servings/day)	1.34 ± 1.80	1.00 ± 0.92	1.41 ± 1.31
Modified Lower Fat Sugar Sweetened Fats Oils and Sweets (servings/day)	0.68 ± 1.23	0.49 ± 0.89	0.44 ± 0.85
Modified Lower Fat Artificially Sweetened Fats Oils and Sweets (servings/day)	1.03 ± 1.90	1.40 ± 2.75	1.90 ± 3.16
Lower Fat Sugar Sweetened Beverages (servings/day)	0.35 ± 0.67	0.09 ± 0.29	0.19 ± 0.45
Lower Fat Artificially Sweetened Beverages (servings/day)	1.35 ± 1.53	1.54 ± 1.67	1.86 ± 2.00
Lower Fat Unsweetened Beverages (servings/day)	3.43 ± 2.40^{a}	4.67 ± 3.21^{b}	4.65 ± 2.70^{b}
Lower Fat Sugar Sweetened Alcohol (servings/day)	0.29 ± 0.62	0.26 ± 0.66	0.30 ± 0.60
Lower Fat Artificially Sweetened Alcohol (servings/day)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Energy Intake (kcal/day)	1982.8 ± 568.7	1372.9 ± 413.0	1549.9 ± 502.5
Percent Energy from Fat Intake (%)	35.2 ± 6.4	25.1 ± 6.6	28.6 ± 6.9
Weight (lb)	222.7 ± 42.0	196.2 ± 37.6	198.8 ± 42.0
Physical Activity (kcal/week)	1072.3 ± 1376.4^{a}	2150.9 ± 2005.2^{b}	1922.4 ± 1835.0^{b}

Note: Values with differing superscripts are significant at $p < 0.05$.

Table 7. Relationship between changes in food group intake and energy, percent energy from fat, and weight from 0 to 6 months

Food Group	Kcal	% kcal from fat	Weight
Higher Fat Whole Grains	β=0.117 p=0.116	β= - 0.052 p=0.519	β= -0.109 p=0.172
Lower Fat Whole Grains	β=0.006 p=0.935	β= -0.147 p=0.070	β= -0.043 p=0.597
Higher Fat Refined Grains	β=0.099 p=0.179	β=0.057 p=0.476	β= -0.016 p=0.838
Lower Fat Refined Grains	β=0.408 p=0.00*	β=0.118 p=0.142	β=0.164 p=0.038*
Lower Fat Green Vegetables	β=0.129 p=0.898	β= -0.132 p=0.095	β= -0.071 p=0.370
Lower Fat Starchy Vegetable	β=0.068 p=0.357	β=0.102 p=0.199	β= -0.055 p=0.486
Lower Fat Red/Orange Vegetables	β=0.145 p=0.049*	β= -0.030 p=0.707	β= -0.138 p=0.079
Lower Fat Beans and Peas	β=0.081 p=0.273	β= -0.108 p=0.176	β=0.063 p=0.431
Higher Fat Other Vegetables	β= -0.090 p=0.221	β=0.032 p=0.691	β= -0.017 p=0.834
Lower Fat Other Vegetables	β= -0.075 p=0.312	β= -0.001 p=0.989	β= -0.065 p=0.406
Higher Fat Fruit	β=0.064 p=0.384	β=0.128 p=0.107	β=0.011 p=0.890
Lower Fat Fruit	β=0.085 p=0.254	β= -0.282 p=0.000*	β=0.026 p=0.745
Higher Fat Milk/Dairy	β=0.317 p=0.000*	β=0.193 p=0.017	β=0.004 p=0.958
Lower Fat Milk/Dairy	β= -0.012 p=0.878	β= -0.018 p=0.818	β= -0.025 p=0.752
Higher Fat Meats	β=0.232 p=0.001*	β=0.328 p=0.000*	β=0.178 p=0.024*
Lower Fat Meats	β=0.108 p=0.169	β= -0.062 p=0.462	β= -0.076 p=0.367
Higher Fat Poultry	β=0.042 p=0.571	β=0.109 p=0.170	β= -0.021 p=0.792
Lower Fat Poultry	β=0.033 p=0.666	β= -0.194 p=0.016	β= -0.071 p=0.379
Higher Fat Seafood	β=0.096 p=0.192	β=0.030 p=0.702	β=0.036 p=0.652
Lower Fat Seafood	β= -0.131 p=0.081	β= -0.081 p=0.321	β= -0.142 p=0.077

Table 7. (continued).

Food Group	Kcal	% kcal from fat	Weight
Higher Fat Eggs	β=0.055 p=0.455	β=0.181 p=0.022	β=0.115 p=0.141
Higher Fat Nuts	β=0.298 p=0.000*	β=0.094 p=0.245	β=0.061 p=0.449
Higher Fat Fats	β=0.289 p=0.000*	β=0.396 p=0.000*	β=0.029 p=0.720
Higher Fat Oils	β=0.371 p=0.000*	β=0.285 p=0.000*	β=0.141 p=0.073
Sugar Sweetened Sweets	β=0.346 p=0.000*	β=0.127 p=0.108	β=0.187 p=0.016*
Modified Regular Fat Diary	β=0.323 p=0.000*	β=0.261 p=0.001	β= -0.015 p=0.850
Modified Regular Fat Sugar Sweetened Dairy	β=0.073 p=0.325	β= -0.085 p=0.287	β= -0.156 p=0.048*
Modified Regular Fat Artificially Sweetened Dairy	β=0.001 p=0.989	β= -0.039 p=0.630	β=0.160 p=0.042*
Modified Lower Fat Dairy	β=0.200 p=0.006*	β=0.069 p=0.386	β=0.033 p=0.675
Modified Lower Fat Sugar Sweetened Dairy	β=0.186 p=0.010*	β= -0.178 p=0.024	β= -0.066 p=0.403
Modified Lower Fat Artificially Sweetened Dairy	β=0.007 p=0.922	β=0.446 p=0.000*	β= -0.159 p=0.042*
Modified Higher Fat Fats Oils and Sweets	β=0.239 p=0.001*	β=0.133 p=0.098	β=0.064 p=0.414
Modified Higher Fat Sugar Sweetened Fats Oils and Sweets	β=0.179 p=0.016*	β= -0.060 p=0.458	β=0.125 p=0.115
Modified Higher Fat Artificially Sweetened Fats Oils and Sweets	β=0.050 p=0.505	β=0.147 p=0.077	β= -0.118 p=0.138
Modified Lower Fat Fats Oils and Sweets	β=0.225 p=0.003*	β=0.161 p=0.042	β=0.026 p=0.756
Modified Lower Fat Sugar Sweetened Fats Oils and Sweets	β=0.286 p=0.000*	β= -0.010 p=0.905	β=0.186 p=0.018*
Modified Lower Fat Artificially Sweetened Fats Oils and Sweets	β=0.040 p=0.590	β= -0.068 p=0.403	β= -0.150 p=0.058
Lower Fat Sugar Sweetened Beverages	β=0.254 p=0.001*	β=0.019 p=0.814	β= -0.050 p=0.531

Table 7. (continued).

Food Group	Kcal	% kcal from fat	Weight
Lower Fat Artificially Sweetened Beverages	β= -0.118 p=0.113	β=0.013 p=0.868	β= -0.215 p=0.007*
Lower Fat Unsweetened Beverages	β= -0.031 p=0.683	β= -0.136 p=0.088	β= -0.157 p=0.048*
Lower Fat Sugar Sweetened Alcohol	β=0.148 p=0.045	β= -0.136 p=0.088	β= -0.051 p=0.525

Note: *Significant at $p < 0.05$

Table 8. Hierarchical regressions of change of intake of food groups and change in intake of energy and percent energy from fat and weight from 0 to 6 months

Change in energy intake from 0 to 6 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.134	0.000
	Age	-0.094		
	Sex	-0.104		
II	Group Assignment	0.135	0.022	0.043
III	Physical Activity	-0.040	0.002	0.590
IV			0.431	0.001
	Lower Fat Refined Grains	0.213		
	Higher Fat Oils	0.272		
	Higher Fat Nuts	0.295		
	Higher Fat Dairy	0.221		
	Higher Fat Meat	0.207		
	Higher Fat Fats	0.190		
	R^2_{cum} =0.590, F(10, 151)=21.745, P<0.000			

Change in percent energy from fat intake from 0 to 6 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.017	0.246
	Age	0.091		
	Sex	-0.041		
II	Group Assignment	-0.064	0.001	0.633
III	Physical Activity	-0.050	0.015	0.125
IV			0.366	0.001
	Higher Fat Fats	0.388		
	Higher Fat Meat	0.280		
	Higher Fat Oils	0.275		
	Lower Fat Fruits	-0.215		
	R^2_{cum} =0.399, F(8, 153)=12.711, P<0.000			

Table 8. (continued).

Change in weight from 0 to 6 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.029	0.099
	Age	0.005		
	Sex	-0.190		
II	Group Assignment	0.090	0.007	0.277
III	Physical Activity	-0.319	0.103	0.000
IV			0.025	0.031
	Sugar Sweetened Sweets	0.160		
	R^2_{cum} =0.164, F(5, 156)=6.124, P<0.000			

Note: R^2_{Δ} = change in variance accounted for by each block. R^2_{cum} = variance accounted for by entire model.

Table 9. Hierarchical regressions of change of intake of modified food groups and change in intake of energy and percent energy from fat and weight from 0 to 6 months

Change in energy intake from 0 to 6 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.134	0.000
	Age	-0.213		
	Sex	-0.120		
II	Group Assignment	0.098	0.022	0.043
III	Physical Activity	0.009	0.002	0.590
IV			0.295	0.016
	Modified Regular Fat Dairy	0.264		
	Modified Lower Fat Sugar Sweetened Fats Oils and Sweets	0.260		
	Lower Fat Sugar Sweetened Beverages	0.179		
	Modified Lower Fat Dairy	0.185		
	Modified Lower Fat Fats Oils and Sweets	0.172		
	Modified Lower Fat Sugar Sweetened Dairy	0.155		
	R^2_{cum} =0.454, F(10, 151)=12.540, P<0.000			

Change in percent energy from fat intake from 0 to 6 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.017	0.246
	Age	0.079		
	Sex	-0.081		
II	Group Assignment	-0.031	0.001	0.633
III	Physical Activity	-0.083	0.015	0.125
IV			0.213	0.038
	Modified Higher Fat Fats Oils and Sweets	0.409		
	Modified Regular Fat Dairy	0.156		
	R^2_{cum} =0.247, F(6,155)=8.453, P<0.000			

Table 9. (continued).

Change in weight from 0 to 6 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.029	0.099
	Age	-0.058		
	Sex	-0.217		
II	Group Assignment	0.094	0.007	0.277
III	Physical Activity	-0.324	0.103	0.000
IV			0.111	0.012
	Lower Fat Artificially Sweetened Beverages	-0.250		
	Modified Lower Fat Sugar Sweetened Fats Oils and Sweets	0.190		
	Lower Fat Unsweetened Beverages	-0.184		
	R^2_{cum} =0.250, F(7, 154)=7.326, P<0.000			

Note: R^2_{Δ} = change in variance accounted for by each block. R^2_{cum} = variance accounted for by entire model.

Table 10. Relationship between changes in food group intake and energy, percent energy from fat, and weight from 6 to 18 months

Food Group	Kcal	% kcal from fat	Weight
Higher Fat Whole Grains	β=0.031 p=0.695	β=0.173 p=0.030	β=0.095 p=0.237
Lower Fat Whole Grains	β=0.039 p=0.625	β= -0.060 p=0.457	β= -0.057 p=0.480
Higher Fat Refined Grains	β=0.140 p=0.076	β=0.059 p=0.465	β= -0.162 p=0.043
Lower Fat Refined Grains	β=0.492 p=0.000*	β=0.166 p=0.048	β=0.135 p=0.108
Lower Fat Green Vegetables	β= -0.023 p=0.768	β= -0.048 p=0.547	β=0.027 p=0.739
Lower Fat Starchy Vegetable	β=0.017 p=0.834	β=0.035 p=0.670	β= -0.053 p=0.514
Lower Fat Red/Orange Vegetables	β=0.028 p=0.722	β= -0.110 p=0.173	β= -0.034 p=0.675
Lower Fat Beans and Peas	β=0.078 p=0.338	β= -0.016 p=0.843	β= -0.117 p=0.155
Higher Fat Other Vegetables	β=0.003 p=0.974	β=0.071 p=0.388	β=0.097 p=0.233
Lower Fat Other Vegetables	β= -0.002 p=0.980	β= -0.009 p=0.906	β=0.085 p=0.288
Higher Fat Fruit	β=0.040 p=0.626	β=0.005 p=0.950	β=0.063 p=0.441
Lower Fat Fruit	β=0.069 p=0.390	β= -0.087 p=0.282	β= -0.119 p=0.141
Higher Fat Milk/Dairy	β=0.236 p=0.004*	β=0.267 p=0.001*	β=0.136 p=0.101
Lower Fat Milk/Dairy	β=0.007 p=0.926	β=0.022 p=0.786	β= -0.122 p=0.125
Higher Fat Meats	β=0.381 p=0.000*	β=0.412 p=0.000*	β=0.140 p=0.083
Lower Fat Meats	β=0.111 p=0.166	β= -0.070 p=0.386	β= -0.129 p=0.110
Higher Fat Poultry	β=0.069 p=0.392	β=0.259 p=0.001*	β=0.096 p=0.235
Lower Fat Poultry	β=0.042 p=0.604	β= -0.090 p=0.269	β=0.042 p=0.601
Higher Fat Seafood	β= -0.004 p=0.959	β= -0.143 p=0.074	β=0.004 p=0.958
Lower Fat Seafood	β=0.057 p=0.479	β=0.023 p=0.772	β=0.166 p=0.038

Table 10. (continued).

Food Group	Kcal	% kcal from fat	Weight
Higher Fat Eggs	β=0.117 p=0.142	β=0.032 p=0.695	β=0.017 p=0.829
Higher Fat Nuts	β=0.353 p=0.000*	β=0.369 p=0.000*	β= -0.035 p=0.657
Higher Fat Fats	β=0.201 p=0.011*	β=0.388 p=0.000*	β=0.094 p=0.239
Higher Fat Oils	β=0.443 p=0.000*	β=0.170 p=0.033	β=0.199 p=0.012
Sugar Sweetened Sweets	β=0.253 p=0.001*	β= -0.101 p=0.208	β=0.070 p=0.381
Modified Regular Fat Diary	β=0.232 p=0.004*	β=0.271 p=0.001*	β=0.168 p=0.041
Modified Regular Fat Sugar Sweetened Dairy	β=0.142 p=0.076	β=0.075 p=0.359	β=0.054 p=0.507
Modified Lower Fat Dairy	β=0.090 p=0.261	β=0.074 p=0.362	β= -0.150 p=0.061
Modified Lower Fat Sugar Sweetened Dairy	β=0.189 p=0.019	β= -0.029 p=0.721	β=0.061 p=0.455
Modified Lower Fat Artificially Sweetened Dairy	β=0.035 p=0.657	β= -0.158 p=0.049	β= -0.091 p=0.256
Modified Higher Fat Fats Oils and Sweets	β=0.146 p=0.065	β=0.393 p=0.000*	β=0.106 p=0.186
Modified Higher Fat Sugar Sweetened Fats Oils and Sweets	β=0.017 p=0.834*	β= -0.093 p=0.241	β= -0.141 p=0.076
Modified Higher Fat Artificially Sweetened Fats Oils and Sweets	β=0.078 p=0.330	β= -0.015 p=0.853	β= -0.071 p=0.379
Modified Lower Fat Fats Oils and Sweets	β=0.295 p=0.000*	β=0.136 p=0.090	β=0.039 p=0.622
Modified Lower Fat Sugar Sweetened Fats Oils and Sweets	β=0.136 p=0.087*	β= -0.102 p=0.206	β=0.112 p=0.162
Modified Lower Fat Artificially Sweetened Fats Oils and Sweets	β=0.015 p=0.849	β= -0.048 p=0.552	β= -0.009 p=0.910
Lower Fat Sugar Sweetened Beverages	β=0.157 p=0.050	β=0.094 p=0.248	β=0.162 p=0.046
Lower Fat Artificially Sweetened Beverages	β=0.101 p=0.205	β=0.038 p=0.640	β= -0.023 p=0.771

Table 10. (continued).

Food Group	Kcal	% kcal from fat	Weight
Lower Fat Unsweetened Beverages	β= -0.014 p=0.857	β=0.029 p=0.719	β= -0.204 p=0.010
Lower Fat Sugar Sweetened Alcohol	β=0.261 p=0.001*	β= -0.067 p=0.417	β=0.071 p=0.388

Note: *Significant at $p < 0.05$

Table 11. Hierarchical regressions of change of intake of food groups and change in intake of energy and percent energy from fat and weight from 6 to 18 months

Change in energy intake from 6 to 18 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.023	0.152
	Age	-0.036		
	Sex	0.026		
II	Group Assignment	-0.009	0.000	0.963
III	Physical Activity	0.075	0.026	0.041
IV			0.452	0.003
	Lower Fat Refined Grains	0.389		
	Higher Fat Oils	0.367		
	Higher Fat Nuts	0.280		
	Higher Fat Fats	0.178		
	R^2_{cum} =0.501, F(8, 153)=19.230, P<0.000			

Change in percent energy from fat intake from 6 to 18 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.000	0.990
	Age	0.098		
	Sex	-0.032		
II	Group Assignment	0.083	0.001	0.661
III	Physical Activity	-0.105	0.000	0.813
IV			0.438	0.000
	Higher Fat Meats	0.368		
	Higher Fat Fats	0.318		
	Higher Fat Nuts	0.303		
	Higher Fat Poultry	0.231		
	R^2_{cum} =0.439, F(8, 153)=14.974, P<0.000			

Note: R^2_{Δ} = change in variance accounted for by each block. R^2_{cum} = variance accounted for by entire model.

Table 12. Hierarchical regressions of change of intake of modified food groups and change in intake of energy and percent energy from fat from 6 to 18 months

Change in energy intake from 6 to 18 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.023	0.152
	Age	-0.061		
	Sex	-0.002		
II	Group Assignment		0.000	0.963
III	Physical Activity		0.026	0.041
IV			0.182	0.005
	Modified Lower Fat Fats Oils and Sweets	0.282		
	Lower Fat Sugar Sweetened Alcohol	0.215		
	Modified Regular Fat Dairy	0.209		
	R^2_{cum} =0.231, F(7, 154)=6.593, P<0.000			

Change in percent energy from fat intake from 6 to 18 months

Block	Variables	Beta	R^2_{Δ}	*P* value
I			0.000	0.152
	Age	0.004		
	Sex	0.055		
II	Group Assignment	0.059	0.001	0.661
III	Physical Activity	-0.045	0.000	0.813
IV	Modified Higher Fat Fats Oils and Sweets	0.348	0.178	0.031
	Modified Regular Fat Dairy	0.172		
	R^2_{cum} =0.180, F(6, 155)=5.670, P<0.000			

Note: R^2_{Δ} = change in variance accounted for by each block. R^2_{cum} = variance accounted for by entire model.

VITA

Vaishali Keshani was born in Charlotte, North Carolina and raised in Memphis, Tennessee. She received a Bachelor of Science degree in Nutrition from the University of Tennessee, Knoxville in May of 2012 with a 3.5 on a 4.0 scale. While an undergraduate student, Vaishali volunteered with a Dietitian in Genetics at the UT Medical Center, volunteered in the Healthy Eating and Activity Laboratory, and worked at the East Tennessee Children's Hospital as a Nutrition Technician. It was from these experiences that Vaishali developed and further acquired her interest and passion for nutrition and dietetics, specifically weight management, clinical nutrition, and nutrition counseling. In August of 2012, she furthered her education at the University of Tennessee, Knoxville, by pursuing a Master of Science degree in Nutrition with a concentration of Public Health Nutrition. While at the University of Tennessee for her Master degree, Vaishali has served as a Graduate Teaching Assistant for an undergraduate nutrition class, and as a Graduate Research Assistant in the Healthy Eating and Activity Laboratory. Vaishali plans to complete a dietetic internship at the University of Tennessee and graduate with a Master degree in August 2014. Her long-term goals are to work in the area of nutrition counseling or clinical nutrition as a Registered Dietitian.