I, Margaret Graeter, hereby submit this original work as part of the requirements for the degree of Master of Science in Nutrition.

It is entitled:
The relationship between dietary self-monitoring and blood pressure changes in adolescents with pre-hypertension or hypertension participating in a nutrition intervention emphasizing the DASH diet

Student's name: Margaret Graeter

This work and its defense approved by:

Committee chair: Sarah Couch, PhD

Committee member: Seung-Yeon Lee, PhD
The relationship between dietary self-monitoring and blood pressure change in adolescents with pre-hypertension or hypertension participating in a nutrition intervention emphasizing the DASH diet

A thesis submitted to the Division of Research and Advanced Studies of the University of Cincinnati in partial fulfillment of the requirements for the degree of Masters of Science in Nutrition in the Department of Nutrition Sciences of the College of Allied Health Sciences

2011

by

Margaret Graeter

B.S., University of Akron, 2009

Committee Chair:

Sarah C. Couch, PhD, RD
Abstract

The relationship between dietary self-monitoring and blood pressure change in adolescents with pre-hypertension or hypertension participating in a nutrition intervention emphasizing the DASH diet

by

Margaret Graeter

Objective: Examine the relationship between dietary self-monitoring and change in blood pressure in adolescents with pre-/hypertension following a clinic-based nutrition intervention to lower blood pressure.

Subjects: Adolescents 11 to 18 years of age with a clinical diagnosis of pre-hypertension or primary stage 1 hypertension who participated in a 3-month behavioral, nutrition intervention emphasizing the DASH diet.

Methods: Adolescents were asked to monitor their dietary intake for 5 of 7 days each week for the duration of the nutrition intervention. Food trackers were reviewed by research personnel. Adolescents who went 2 weeks without mailing in a food tracker were offered a simpler goal tracking form to record their goals met. Food and goal trackers were independently coded to assess compliance to the skill of dietary self-monitoring. Basic compliance was assessed by determining actual days of food recording, recording sufficiency, complete recording of food descriptions, and complete recording of food amounts. Category compliance was determined based on a participant’s ability to categorize foods correctly into DASH food groups. Serving
compliance was determined based on a participant’s ability to calculate the number of DASH food servings from foods recorded. Baseline and 3-month blood pressures were assessed at the Cincinnati Children’s Hypertension Center using standard protocol. Relative blood pressure change was calculated as 3-month blood pressure minus baseline blood pressure.

**Results:** Over 85% of participants demonstrated excellent compliance to recording sufficiency, recording complete food descriptions and recording food amounts. Forty-six percent of participants were able to correctly classify fruits & vegetables, 21% were able to correctly classify low-fat dairy foods, and 5% were able to correctly classify DASH unfriendly foods (e.g., high fat/high sodium). Approximately half of participants (51%) demonstrated at least good proficiency in correctly calculating DASH serving amounts for low-fat dairy foods. Most demonstrated difficulty in correctly calculating DASH serving amounts for fruit & vegetables (70%) and DASH unfriendly foods (98%).

Poor versus good compliance to food tracking predicted a trend for an increase in systolic blood pressure z-score (p=0.08), as did poor versus excellent proficiency at determining the number of DASH low-fat dairy servings from foods eaten (p=0.10). Being an under-classifier versus an accurate-classifier of DASH unfriendly foods predicted an increase in systolic blood pressure z-score (p=0.04). Poor versus fair compliance to dietary self-monitoring using any form of tracking predicted a significant increase in diastolic blood pressure z-score (p=0.04), while fair versus excellent compliance predicted a significant decrease in diastolic blood pressure z-score (p=0.03). Being an under- versus accurate classifier of DASH unfriendly foods predicted a trend toward an increase in diastolic blood pressure z-score (p=0.08).
Conclusion: Good to excellent compliance to dietary self-monitoring and related skills can be a valuable adjunct to a behaviorally-based, nutrition intervention to help hypertensive adolescents lower their blood pressure.
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I. Literature Review

A. Cardiovascular Disease (CVD) Risk Factors in Youth: Cause for Concern

Currently, the prevalence of obesity in the US exceeds 30 percent in most age and sex groups (Flegal, Caroll, Ogden, & Curtin, 2010). Obesity is a major contributor to morbidity from CVD and related risk factors including dyslipidemia, hypertension, and insulin resistance (NIH, NHLBI, 1998). Of growing concern is the recent epidemic of adolescent overweight and obesity. The High School Youth Risk Behavior Survey reported that 15.8 percent of high school students were overweight in 2010 while 12 percent were obese. This report also suggested that these percentages in overweight and obesity rates among adolescents have increased since 2001 by 2.2 percent and 3.8 percent, respectively (Youth Risk Behavior Survey, 2010). Overweight, which is defined in youth as a Body Mass Index (BMI) above the 85th percentile, tracks into adulthood (Engeland, Bjorge, Tverdal, & Sogaard, 2004) and has been associated with adverse changes in the cardiovascular system in children and adolescents before the second decade of life. The Bogalusa Heart Study showed that compared with other children, overweight children were 9.7 times more likely to have two or more cardiovascular related risk factors (Freedman, Dietz, Srinivasan, & Berenson, 1999). Moreover, overweight and obesity are major contributing factors to the increasing prevalence of hypertension in the US population (Sorof, Lai, Turner, Poffenbarger, & Portman, 2004). Given that about 28 percent of teenagers in the US have BMIs above the normal range, preventative measures to reduce obesity and associated morbidity in youth are warranted.
Experts agree that hypertension in children and adolescents should be addressed early on because elevated blood pressure is easily diagnosed and associated health risks are established at a young age. In the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents (National High Blood Pressure Education Program, 2004), hereafter referred to as the Fourth Pediatric Report on Hypertension, stage 1 hypertension in children and adolescents is defined as a systolic and/or diastolic blood pressure greater than or equal to the 95th percentile but less than or equal to the 99th percentile plus 5 mmHg for age, gender, and height. According to this report, stage 2 hypertension in children and adolescents is defined as a systolic and/or diastolic blood pressure greater than the 99th percentile plus 5 mmHg for age, gender, and height. Pre-hypertension is defined as a systolic and/or diastolic blood pressure greater than or equal to the 90th percentile but less than the 95th percentile for age, gender, and height.

Increased peripheral resistance as a result of hypertension at any age may result in structural and functional alterations to the heart and vascular system (Sihm, Schroeder, Aalkjaer, Holm, et al., 1995). Arterioles respond to higher blood pressure via smooth muscle hypertrophy, or narrowing of the lumen of the blood vessels. Development of left ventricular hypertrophy and increased posterior arterial wall thickness subsequently lead to an increase in the ratio of heart wall thickness to lumen diameter of the blood vessels (Akintunde, Akinwusi, Opadio, Adebayo, & Ogunyemi, 2009; Heagerty et al., 2003; & Sihm et al., 1995). Presence of cardiovascular risk factors, e.g. high blood pressure, as early as 8 to 11 years of age are predictive of an increased carotid intimal-medial thickness in adulthood (Davis, Dawson, Riley, & Lauer, 2001). Hypertrophy of
the left ventricle (Casale, Devereux, Milner, Zullo, Harshfield, et al., 1986) and presence of a high media to lumen ratio of small resistance arteries in childhood (Rizzoni, Porteri, Boari, De Ciuceis, & Sleiman 1993) are cardiovascular structural changes that can lead to adverse CVD outcomes into adulthood.

B. Therapeutic treatment options of managing blood pressure in youth

Therapeutic lifestyle changes are recommended as the first line of treatment for pre-hypertension and stage 1 hypertension without compelling indications (i.e., heart and vascular damage) in youth (NHBPEP, 2004). Lifestyle changes are typically employed for a period of six months, and if blood pressure remains unchanged or increases, medication is considered for managing stage 1 hypertension. Recommendations from the Fourth Pediatric Report on Hypertension (NHBPEP, 2004), suggest that children and adolescents with stage 1 hypertension with compelling indications, and stage 2 hypertension should be managed with a combination of therapeutic lifestyle changes and antihypertensive medications (NHBPEP, 2004). Antihypertensive drugs of different classes including angiotensin-converting enzyme (ACE)- inhibitors (Thybo, Stephens, Cooper, Aalkjaer, Heagerty, & Mulvany, 1995) and those targeting Angiotensin II type 1 receptors (Smith, Yokoyama, Averill, Schiffrin, & Ferrario, 2008) have been shown to decrease peripheral resistance and normalize blood pressure in adults in as little as two weeks. However, long-term clinical end point data are unavailable regarding the safety and effectiveness of these same medications for use in the treatment of elevated blood pressure in children and adolescents. Nonetheless, current recommendations for the treatment of stage 1 and stage 2 hypertension in children and adolescents advise the use of single-drug therapy from several antihypertensive drug classes including ACE
inhibitors, angiotensin receptor blockers, alpha and beta-blockers, calcium channel blockers, and diuretics (NHBPEP, 2004).

Recommended non-pharmaceutical approaches to reduce high blood pressure in adults and youth include behavioral and lifestyle changes. Many epidemiological studies and clinical trials have been completed in both adults and children and provide evidence that specific dietary modifications can lead to a decrease in blood pressure. Preliminary data obtained from the National Health and Nutrition Examination Survey I (NHANES I) found that significant decreases in the consumption of calcium and potassium were identified as primary nutritional markers of hypertension (National Center for Health Statistics, 1997). A similar cohort study examining correlations between nutrients and blood pressure determined direct relationships between dietary sodium and saturated fatty acids with systolic and diastolic blood pressure. An inverse relationship between dietary potassium and dietary consumption of fiber with systolic and diastolic blood pressure was also determined in this study (Stamler, Caggiula, & Grandits, 1997). Findings from these studies offered potentially important associations among nutrients and blood pressure regulation. The INTERSALT study was one of the first landmark epidemiological studies conducted in adults to show that urinary sodium excretion, an objective measure of sodium intake, was significantly positively related to systolic blood pressure. An important finding from this study was that the combination of a dietary reduction of 100 mmol (2.3g) in sodium and an increase in dietary potassium by 15 mmol (0.6g) was associated with a significant decrease in average systolic and diastolic blood pressure (Stamler, Rose, Stamler, Elliott, Dyer, & Marmot, 1989). Since the late 1980’s supporting correlation studies have been completed.
showing that a combination of nutrients, and perhaps other food components like fiber, may be more effective than single nutrient modifications in the diet for lowering blood pressure. A review of the literature examining results from crossover trials and randomized control trials support a beneficial role of a moderate dietary salt reduction (50 mmol/day) in reducing systolic and diastolic blood pressure in adults (Law et al., 2001). An epidemiological trial found that increasing dietary fiber as part of a lacto-ovo-vegetarian diet low in saturated fat, cholesterol, and sodium was effective in lowering blood pressure in adults compared to those consuming an omnivorous diet lower in fresh fruits and fiber content (Rouse et al., 1983). A high fiber diet containing fresh fruits compared to a lower fiber diet containing fruit juices was also found to be effective in lowering diastolic blood pressures in adult participants (Kelsay, Behall, Prather, 1978). Studies, such as these, that focus on dietary patterns rather than single nutrients and blood pressure have greatly changed the way health professionals view the dietary management and treatment of high blood pressure. Current dietary treatment recommendations for both adults and children recommend a dietary pattern that is based on The Dietary Approaches to Stop Hypertension (DASH) trial. This trial manipulated complete dietary patterns and found that one pattern in particular was effective in lowering blood pressure quickly and effectively. This dietary pattern and findings from the DASH trial are described below.

C. Dietary Approaches to Stop Hypertension (DASH) study

The DASH trial sought to determine the effects of different dietary patterns on blood pressure in adults (Appel et al, 1997). In this multi-centered, randomized control trial, adults with pre-hypertension or stage 1 hypertension were placed on one of three
intervention diets. During the initial run-in phase, participants were given a control diet that was designed to be equivalent to the typical American diet, i.e., low in fruits, vegetables, and low-fat dairy products, and high in fat, for a three-week period. Subjects were then randomly assigned to one of three diets for an eight-week period; they either stayed on the control diet or were given a diet similar to the control diet except rich in fruits and vegetables, or a “combination” diet rich in fruits and vegetables and low-fat dairy products and low in total and saturated fat and cholesterol. The DASH study was a controlled feeding study in which meals specific for each diet were provided to participants. In terms of nutrient profiles, the control diet reflected the potassium, magnesium, and calcium levels near the 25th percentile of U.S. consumption and a macronutrient profile and fiber content comparable to that of the average American (US Dept of Agriculture, Human Nutrition Information Service, 1986; Caroll & Dresser, 1983). The diet rich in fruits and vegetables reflected potassium and magnesium levels near the 75th percentile of U.S. consumption and contained high amounts of fiber. The “combination” DASH diet reflected potassium, magnesium, and calcium levels near the 75th percentile of U.S. consumption. The combination diet was also moderate in protein, high in fiber, and low in fat and cholesterol. The sodium content of all three diets was comparable, at levels of 3g of sodium per day.

The results of the DASH-trial demonstrated a significant relationship between a dietary pattern emphasizing fruits and vegetables and lowered blood pressure. Blood pressure reductions were seen in as little as two weeks. The diet rich only in fruits and vegetables reduced systolic blood pressure by 2.8mmHg (p< 0.001) and diastolic blood pressure by 1.1mmHg (p=0.07) in hypertensive adults compared to the control diet.
The “combination” DASH diet high in fruits, vegetables and low-fat dairy and low in saturated fat, total fat, and cholesterol reduced systolic blood pressure by 5.5mmHg (p<0.001) and diastolic pressure by 3.0mmHg (p<0.001) in pre-hypertensive and hypertensive adults compared to the control diet. Additionally, this dietary pattern significantly decreased systolic blood pressure by 3.5mmHg and diastolic blood pressure by 2.1mmHg in normotensive participants.

Following publication of the landmark DASH trial in adults, investigators examined whether sodium reduction in combination with a DASH diet could result in blood pressure reductions that were greater than those achieved with a DASH diet alone. Sacks and colleagues (2001) examined the effect of three different levels of sodium (150 mmol, 100 mmol, and 50 mmol) in combination with a DASH diet or a control diet on blood pressure in adults. There was a positive effect of this intervention on decreasing systolic blood pressure in hypertensive and normotensive individuals. The diet that was associated with the greatest lowering in systolic blood pressure was the 50 mmol sodium intake in combination with a DASH diet. This low sodium/ DASH combination reduced systolic blood pressure by 11.5 mm Hg in hypertensive subjects and by 7.1 mmHg in normotensive subjects compared to the control diet with the highest amounts of dietary sodium. These findings support use of a DASH dietary pattern combined with a low sodium intake (50 mmol/day) as an effective dietary approach to reducing blood pressure in adults.

The rising rates of adolescent primary hypertension warranted a need for the NHBPEP to construct guidelines for the management of pediatric hypertension. Given the very strong evidence of a positive effect of the DASH diet on lowering blood
pressure in adults, the NHBPEP advocated the DASH diet as a means of lowering blood pressure in children and adolescents with pre-hypertension and primary hypertension. However, this recommendation was based on adult data, and it was not known at the time if children or adolescents could comply with a DASH diet or whether the diet could effectively lower blood pressure among youth. Towards this purpose, Couch and colleagues (2008) completed a three-month intervention trial to determine the effectiveness of the DASH diet in reducing blood pressure in adolescents with pre-hypertension or primary hypertension. Adolescents aged 11-18 years diagnosed with pre-hypertension and hypertension received either routine hospital-based nutrition care to manage high blood pressure or a diet similar to the DASH diet (slightly modified to ensure nutrient needs of adolescents were met). Routine care participants were encouraged to consume a general diet consistent with the NHBPEP’s guidelines, which encouraged the majority of servings from fruits and vegetables, grains, lean meats and low-fat dairy products. No specific calorie or serving size recommendations were made, although recommendations were made to reduce dietary sodium and to control weight by limiting high-fat foods, reduce portion sizes and to eat nutrient-dense forms of foods. DASH participants were encouraged to gradually achieve eight to ten servings of fruits and vegetables per day, three servings of low-fat dairy foods per day, and two servings or less of foods with greater than 3g fat per serving and/or greater than 480 mg sodium per serving (referred to as DASH unfriendly foods) per day. Serving size recommendations were given to the DASH participants.

The routine care intervention consisted of one 60-minute face-to-face counseling session with a dietitian, the participant, and a parent. Participants received the booklet
Eat Right to Lower Blood Pressure. Participant education promoted dietary sodium reduction to a level of 2400mg per day, fat consumption to a level of 30% or less of calories and consumption of a well-balanced diet consistent with the Food Guide Pyramid. The DASH intervention was more intense in that DASH participants received a 60-minute face-to-face counseling session with a dietitian and a parent, at which time a ten module, illustrated manual was provided and reviewed. These materials explained the DASH diet, providing food lists and tips for including DASH foods into the participants daily diet, and included self-assessments to support the participants in adapting their current diet to be more DASH friendly. To determine progress toward goals, DASH participants were asked to record their intake for 5 of 7 days each week, specifically tracking their intake of fruits and vegetables, low-fat dairy, and DASH unfriendly foods. Participants did not track calories. The DASH participants also received 8 weekly and 2 biweekly phone calls by trained interventionists and biweekly mailings that provided information supplementing the modules of the DASH manual. The module and counseling included an explanation of the benefits of the DASH diet. DASH serving recommendations, tips for incorporating DASH foods into the diet, and guidelines for goal-setting, action planning, self-rewarding, social support, and handling high risk situations were also outlined in the modules.

Findings from this study showed a greater reduction in systolic blood pressure and systolic blood pressure z-scores (SBP z-scores) in the DASH participants compared to routine care participants from baseline to post-intervention. The relative change in systolic blood pressure among DASH participants was -7.9% versus -1.5% in the routine care group (p<0.01). Normalization of blood pressure was achieved in 50%
of the DASH participants compared with 36% of the routine care participants from baseline to post-treatment. By 3-month follow-up, 61% of the DASH adolescents had normal blood pressures compared with 44% of those following the routine care intervention. A greater increase in fruit servings and a greater decrease of high-fat, high-sodium foods were consumed among DASH participants compared with routine care participants from baseline to post-treatment. Among DASH participants, dietary intake of potassium and magnesium increased and total fat decreased from baseline to post-intervention compared with intakes among routine care participants.

There has not been a lot of research examining any individual behavioral skills learned in behavioral interventions that are related to change in blood pressure management. Given that dietary behavior change in children and adolescents is difficult to achieve, identifying which components of the behavioral intervention, if any, contribute to success of behavioral interventions is warranted. This knowledge may assist health professionals in the design of effective dietary intervention trials to tackle other diet-related risk factors and diseases.

D. Behavioral Skills Associated with Healthful Dietary Compliance in Youth

Many behavioral skills collectively contribute to the effectiveness of dietary interventions. A review of behaviorally based, nutrition and exercise intervention trials for weight loss showed significant effects of dietary self-monitoring on weight loss. More frequent self-monitoring was consistently and significantly associated with degree of weight loss compared to less frequent self-monitoring (Burke, Wang, & Sevick, 2011). Self-monitoring is the systematic observation and recording of targeted behaviors in an intervention (Germann, Kirschenbaum, & Rich, 2007). In dietary intervention trials, self-
monitoring usually refers to writing down of all the foods and beverages one consumes daily along with amounts. A review of the literature examining dietary interventions that engaged participants in behavioral skills directed at modifying dietary intake for the purpose of losing weight concluded that dietary self-monitoring combined with one other self-regulatory behavior were most likely to improve effectiveness of interventions targeted at promotion of healthy eating and physical activity (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). Baker & Kirschenbaum (1993) investigated the importance of self-monitoring to gain a better understanding of its role in effective weight control. These researchers sought to determine whether the monitoring of certain variables such as weight and dietary intake was more clearly related to weight control than monitoring of other variables (i.e. participant’s mood and with whom the food was consumed). Participants received self-monitoring booklets with columns for time, food, and calories. The researchers found that participants lost significantly more weight by monitoring any foods consumed, all foods eaten for the entire day, the time food was eaten, the quantity of food eaten, and the grams of fat consumed compared to those who did not monitor these factors. The findings of this study also demonstrated that greater percentages of subjects lost weight in the quartiles that reflected greater levels of consistency and completeness of self-monitoring (Baker & Kirschenbaum, 1993).

Detailed evaluation of self-monitoring adherence has not been reported extensively. A recent study objectively measured dietary self-monitoring adherence as a secondary analysis of a behavioral weight loss trial. In the PREFER study, Burke et al. (2006) compared self-reported monitoring versus electronically recorded (actual) self-
monitoring of foods to investigate patterns of self-monitoring among participants. The authors of this study were interested in examining the consistency and accuracy of self-monitoring using a food diary. Subjects were given a paper-and-pencil diary to track all foods and beverages consumed. The paper diary was housed in a zippered binder that had photo-sensors unobtrusively embedded in the spine that detected when the binder was opened and closed by recording a time and date stamp for each action. Subjects were not aware that recording times were being monitored. The results of this study found a significant correlation between the percent of weight loss and frequency of recording in the diary and between the percent of diary entries made within fifteen minutes of opening the diary. However, the electronic data were compared to the self-reported record of self-monitoring and indicated a lack of concordance between self-reported time of self-monitoring and objectively documented times of recording from the binder photo-sensors (Burke et al., 2006). Taken together, these studies suggest that self-monitoring adherence appears to contribute to better adherence in a weight loss trial. The importance of learning the skill of self-monitoring may allow individuals to increase adherence and consistency to behavioral skills involved in an intervention and have a more successful outcome as a result.

Of note, studies have shown that once the behavior of self-monitoring is learned, individuals can maintain the effectiveness of the behavioral change using a simpler self-monitoring tool. In a behavioral weight loss program for adults, subjects were assigned to a detailed self-monitoring group or a transitional self-monitoring group. In the detailed self-monitoring group, subjects were instructed to record the types, quantities, kilocalories, and fat grams of the food for each meal and snack consumed throughout
the day. They were also instructed to record the type, duration and intensity of exercise each day. In the transitional self-monitoring group, subjects were instructed to self-monitor behaviors using the detailed approach for eight weeks and then transition to an abbreviated approach, where they placed check marks in boxes to estimate the fat content and size of their meals and snacks. The transitional approach also instructed subjects to record their exercise duration by checking off the appropriate time frame (e.g. ≤ 15 minutes, 16 to 30 minutes, 31 to 45 minutes, etc.). Subjects recorded their eating and exercise behaviors for sixteen weeks. The results of this study demonstrated that self-monitoring in either the detailed or abbreviated form led to a significant amount of weight loss. These findings suggest that the learned behavior of self-monitoring, rather than the detail of self-monitoring, is an important aspect in maintaining adherence to weight loss interventions (Helsel, Jakcic, & Otto, 2007).

To further improve self-monitoring adherence over a long-term period, adjunctive strategies can be employed. In an intervention in obese adults randomly assigned to a two-week intervention of self-monitoring versus self-monitoring plus daily phone calls and mailings to control weight, those that received self-monitoring reminders were more consistent in self-monitoring than those that did not receive reminders (Boutelle, Kirschenbaum, Baker, & Mitchell, 1999). The findings of this study indicate a more intense intervention that includes contact through telephone and mailings may improve adherence to self-monitoring behaviors. As part of a behavioral intervention to evaluate the relation among self-monitoring, the adoption of a low Glycemic Index, high-fiber diet, and weight control among adults with type 2 diabetes intervention, Miller and colleagues, 2009 encouraged diabetic participants to complete self-monitoring records.
for four out of seven days per week. Participants were asked to record the type and quantity of food consumed, GI and carbohydrate values of the food consumed, and physical activity performed. The results of this study showed that each additional day of self-monitoring was associated with a decrease in mean weight of -0.95kg (95% CI). These results support recommendations of greater length of self-monitoring and greater adjunctive support of such behaviors to ensure adherence to dietary interventions.

Evidence clearly supports a relationship between self-monitoring techniques and effectiveness of behavioral change in adults, however few studies have examined the variables contributing to the effectiveness of behavioral changes in youth. Saelens and colleagues (2002) examined daily tracking of specific foods, amounts, calories, and category of each food in a behavioral weight control intervention in obese adolescent subjects enrolled in a behavioral weight control intervention. Recording sufficiency, particularly recording more days versus fewer days, and summing calories were found to be related to lower dietary fat intake in adolescents (Saelens et al, 2002). In a follow-up study by Saelens et al (2003), adolescent participants received either a single session in clinic weight counseling session or a phone- and mail-based behavioral intervention for weight control. Throughout the intervention, adolescents were encouraged to self-monitor all food and beverage intake. The researchers created five self-monitoring indexes to interpret results. “Day-recorded” indicated if a participant recorded any food or beverage item. “Recording sufficiency” indicated if participants recorded at least five food or beverage items. “Amounts recorded” indicated the fraction of food or beverage items that were recorded for which an amount or serving size was recorded. “Calories recorded” indicated the fraction of food or beverage items that were
recorded for which calories were recorded. “Calories summed” indicated whether or not calories were summed. The results of this study determined recording sufficiency in regards to self-monitoring behaviors was related to change in adolescent’s relative weight. Mean recording sufficiency was significantly negatively related to lower BMI z-scores at post-treatment (p<0.10) and follow-up (p<0.05). This body of evidence supports teaching youth self-monitoring behavioral techniques is an integral part of adherence to behavioral interventions.

I. Purpose

The behavioral skill of food monitoring and certain aspects of the skill of food monitoring, e.g., ability to write complete descriptions with amounts, may be an important component of treatment for adolescents participating in a dietary intervention to lower blood pressure. In previous nutrition intervention studies, food monitoring has been examined to determine its relationship with diet and weight change. However, food monitoring has not been examined to see if it positively affects blood pressure change, or modifies other cardiovascular risk factors in adolescents with hypertension and pre-hypertension.

1. This study will examine the relationship between self-monitoring of diet (as measured by any versus some versus no food monitoring) and change in blood pressure following a clinic-based dietary intervention to lower blood pressure in adolescents with hypertension.

2. This study will also investigate the relationship between the quality of self-monitoring of diet (as measured by completeness of details and completeness of
food amounts) and blood pressure following a clinic-based dietary intervention to lower blood pressure in adolescents with hypertension.

It is hypothesized that adolescents who complete a greater number of food records, and are more complete in terms of the manner in which they describe foods, estimate food amounts and categorize foods, will have a greater response to treatment e.g. greater blood pressure reduction compared to those adolescents who do some or no food recording or whose tracking is of poorer quality.

**Methods**

**Subjects**

The data evaluated in this thesis were derived from a subset of two larger clinical trials that were similar in design. The first clinical trial, the DASH-4-teens pilot study, (Couch et al. 2008), was a three-month behavioral nutrition intervention trial evaluating the effect of a DASH-like diet on blood pressure in teens with elevated blood pressure. Data from subjects who participated in this trial from September 2003 to December 2005 were included in this thesis. The second study from which data were derived is an ongoing randomized clinical trial similar in intervention design compared to the first, but involves a longer duration for the behavioral nutrition intervention (Couch et al, 2011). The second trial, DASH-4-TEENS, involves a six-month intervention evaluating the effects of a DASH-like diet on blood pressure in adolescents with pre-hypertension and hypertension. In this trial participants were assessed at baseline, 3 months and post-treatment (6 months). The baseline and 3-month assessment data from subjects who participated from February 2008- January 2011 were included in this thesis.
For this thesis, we only considered participants in the treatment group in each trial and did not include those that were in the control group (routine care) because those in the treatment group were required to do dietary self-monitoring and the controls were not. Since dietary self-monitoring is the focus of this thesis, it was determined that the control group data were not relevant for use in addressing the research questions for this thesis (see purpose).

There were 22 participants from the pilot study that had baseline and 3 month data (herein referred to as completers) and 23 completers in the DASH-4-teens intervention, for a total of 45 completers whose data were used to address the research questions proposed in this thesis. The CCHMC and University of Cincinnati Institutional Review Boards approved all study methods. Assent was obtained from adolescents less than eighteen years of age and consent was obtained from adolescents 18 years of age and their parents.

Inclusion criteria - Adolescents were included who were between 11 to 18 years of age with a clinical diagnosis of pre-hypertension or primary stage 1 hypertension that were newly admitted to the Cincinnati Children's Hypertension Center (CCHC) at the Cincinnati Children’s Hospital Medical Center. Based on criteria from the Fourth Pediatric Report on Hypertension (NHBPEP, 2004), pre-hypertension was defined as an average of three SBP and/or DBP measures that were greater than the 90th percentile and less than the 95th percentile for age, gender, and height. Stage 1 hypertension was defined as an average SBP and/or DBP measure that was > or equal to the 95th and <99th percentile + 5 mm Hg for age, gender, and height.
Exclusion Criteria - Adolescents were excluded from the study if they had stage 2 hypertension, defined as a SBP or DBP > or equal to the 99th percentile + 5 mm Hg for age, gender and height, or secondary hypertension, defined as high blood pressure diagnosed secondary to another cause such as chronic renal disease, hyperthyroidism, and Cushing syndrome. Adolescents were also excluded if they were being treated with anti-hypertensive medications, had received prior formalized diet therapy to manage their blood pressure within the past 6 months, had diagnosed target organ damage (TOD), had diagnosed Type 1 or Type 2 diabetes, used medication know to alter blood pressure (e.g. Ritalin), were unwilling to stop use of vitamins, minerals or antacids containing magnesium or potassium, did not speak English, had a diagnosed eating disorder, had a psychological or medical condition that precluded them from full participation or who do not have full medical clearance from a physician to participate.

Intervention

Both the DASH-pilot study and the DASH-4-Teens interventions included a behavioral nutrition education program that emphasized a version of the DASH diet that was slightly modified from the original that was empirically tested on adults so as to adjust to the nutritional recommendations of adolescents. A 10-module illustrated DASH-4-Teens manual was given to participants to promote dietary behavior changes. Behavioral strategies emphasized in the intervention included food monitoring, goal setting, action planning, problem solving and decision making, social support, and long term planning. At baseline, participants received a 60-minute face-to-face counseling session in clinic with a dietitian. Food monitoring forms were also provided. From baseline to twelve-weeks, participants received a total of eight weekly phone calls and 4
biweekly mailings. The dietary food plan for both the DASH-pilot study and DASH-4-Teens intervention included daily recommendations for calories and servings per day. The dietary plan was based on recommendations from the DASH diet in adults, the Dietary Guidelines for Americans (2005) and conformed to the Dietary Reference Intakes for energy, macronutrients, micronutrients and fiber of adolescents (Dietary Guidelines for Americans, 2005). Calorie adjustments were made for different physical activity levels. Participants were encouraged to gradually increase intake of fruits and vegetables to 8-10 servings per day and low-fat dairy products to 3 servings per day while also reducing intake of high-fat, high-sodium foods to meet DASH recommendations. Participants were also encouraged to decrease DASH unfriendly foods (foods with > 480 mg sodium and > 3 grams fat per serving) to no more than 2 servings per day. The complete details of the DASH intervention have been previously published (Couch et al. 2008).

*Dietary-Self Monitoring*

Weekly dietary goals and strategies to achieve goals were emphasized on each weekly DASH phone call. Additionally participants were encouraged to maintain a detailed food record to determine progress toward goals. This skill was taught to adolescents in an effort to help them comply with the diet. Adolescents were asked to self-monitor all foods and beverages consumed for 5 out of 7 days each week, specifically recording intake of fruits, vegetables, low-fat dairy, and DASH unfriendly foods. Instructions for the self-monitoring booklets included recording the time the foods was consumed, a description of the food or beverage consumed, the amount of food or beverage consumed, and weather the food or beverage was a fruit, vegetable,
low-fat dairy product or a DASH unfriendly food. Adolescents were awarded monetary incentives ($2.00 per week of food monitoring) for meeting weekly goals. Adolescents who did not return a goal tracker after two weeks received a simpler goal-tracking form. This simpler version included areas for the adolescent to check off the number of servings consumed of fruits, vegetables and low-fat dairy each day. There was also space provided for adolescents to write in the DASH unfriendly foods they consumed each day.

**Measures**

All measures were collected at baseline and 3 months.

**Blood pressure measurements** were performed using a mercury sphygmomanometer according to standardized procedures as outlined in the Fourth Pediatric Report on Hypertension (NHBPEP, 2004). The mean of two blood pressure measurements per visit were used to compare outcomes from baseline and 3 months after baseline. SBP and DBP z scores and corresponding percentiles were calculated based on established computations (NHBPEP, 2004).

**Anthropometric measurements** and body mass index (BMI) calculations were done in the CCHC by trained nursing personnel masked to treatment assignment. Weight was measured using a calibrated triple-beam balance scale. Standing height was measured using a wall-mounted stadiometer. Each measurement was taken twice, and the average of the 2 ratings was calculated. BMI was measured as weight in kilometers divided by the square of height in meters. BMI z-scores were determined from Centers for Disease Control growth charts.
Demographic information was collected from self-report of birth date, gender, and ethnicity of adolescents at baseline. Parents self-reported ethnicity, marital status, highest level of education attained, and household income.

Dietary self-monitoring - Food tracking was measured using daily food tracking forms. Food trackers were independently reviewed and coded by a registered dietitian and graduate student using a tool that was developed to measure the quality of tracking (Appendix A). This coding tool was designed to assess both basic compliance to the skill of dietary self-monitoring and more advanced compliance to categorizing foods recorded into DASH food groups and calculating DASH serving sizes from foods recorded. Basic compliance was defined using the following three coding items (Appendix A): 1) how many foods were recorded per day 2) from foods recorded, how many were completely described, and 3) from foods recorded, for how many were the amounts specified. A description of the food was considered complete if it included all adjectives on the food label (e.g. low-fat, 100%, 1%, no-sodium, low-sodium, sugar-free, etc.) and cooking method if the method affected the fat or sodium content of the food item (baked, fried, scrambled, hard-boiled, etc.). To be considered a complete description enough information was required by participants to determine whether the food was DASH friendly or unfriendly. Default coding guidelines were used in some cases to determine completeness of food descriptions (Appendix B). Amounts were considered “specified” if they were written in common units of measure (e.g. cups, Tbsp., tsp., ounces) or counts for foods with standard serving sizes (e.g. 1 small apple, 1 large banana). Basic compliance to food tracking was assessed from weekly food tracking booklets completed by each participant per day. Participants were asked to
record their dietary intake for 5 days out of 7 each week. If the subject did not complete all 5 days in their food tracking booklet, only those days that were completed were coded, and if the subject completed more than 5 days, only the first 5 days recorded were coded. The maximum possible days of dietary self-monitoring was 60.

From the Basic Compliance data, the mean number of days each participant recorded some foods throughout the 60 days of treatment (referred to as actual days of food recording), and the number of days each participant recorded at least five foods out of the days they recorded some foods (referred to as recording sufficiency) were determined. Recording sufficiency was defined as the ability of participants to record at least five food or beverage items per day, based on a previous study by Saelens and colleagues (2003). Additionally, the fraction of complete food descriptions among the foods recorded (referred to as foods described) and the fraction of complete food amounts among the foods recorded (referred to as food amounts) was determined.

Advanced compliance to dietary self-monitoring was measured by examining aspects of category compliance and serving compliance (see Appendix A). Category compliance was defined as the accuracy with which foods were placed into the DASH categories of fruits & vegetables, low-fat dairy foods, and DASH unfriendly foods. The two coding items that assessed category compliance in each food category were 1) how many foods were recorded in either the fruit & vegetable, or low-fat dairy or DASH unfriendly food category and 2) from food descriptions provided, how many food items should have been recorded in either the fruit & vegetable, or low-fat dairy or DASH unfriendly food category. The coding rules specified that if any of the foods consumed were DASH unfriendly, the food could not count as a fruit or vegetable or low-fat dairy
serving. From the category compliance data, the fraction of DASH foods correctly categorized was determined (referred to as correctly categorizing fruits & vegetables, low-fat dairy foods, and DASH unfriendly foods).

Serving compliance was determined based on a participant’s ability to calculate the number of DASH food servings from foods recorded. The one coding item that assessed serving compliance to food tracking was out of those foods that should have been recorded in the <fruits & vegetables or low-fat dairy or DASH unfriendly foods> category, how many was the participant able to identify the correct DASH serving amount.

From the serving compliance data, the fraction of correctly recorded serving amounts in each DASH foods category was determined (referred to as correctly recorded serving amounts for fruits & vegetables low-fat dairy foods, and DASH unfriendly foods).

Statistical Analysis

The coding method used to evaluate food tracking data was validated by performing the Cronbach α test for each survey item (Appendix A) for 10 independent food trackers coding by 2 researchers. All survey items had Cronbach α values >0.7, which was deemed appropriate for inter-rater reliability.

Means and standard deviations were derived at baseline and 3- months post-treatment for continuous variables and frequencies for categorical variables. Mixed effects models were used to assess relationships between change in blood pressure (from baseline to post-treatment) and basic and advanced dietary self-monitoring
compliance measures. All models were adjusted for BMI z-score, age, race, and gender. Statistical analyses were performed with SAS software (version 9.2, SAS Institute, Cary, North Carolina. P values <0.05 were considered to be statistically significant.

Results

I. Participant Characteristics

Table 1 describes the DASH-4-Teen baseline participant characteristics. The group was mostly white (58%) and male (69%).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Baseline Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>45</td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>14.2 (1.96)</td>
</tr>
<tr>
<td>Gender (Female/Male), n</td>
<td>(14/31)</td>
</tr>
<tr>
<td>Race (White/African American/Other), n</td>
<td>(26/16/3)</td>
</tr>
<tr>
<td>Body mass index, kg/m2, mean (SD)</td>
<td>29.2 (6.95)</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg (SD)</td>
<td>130.7 (8.03)</td>
</tr>
<tr>
<td>Diastolic blood pressure, mm Hg (SD)</td>
<td>78.36 10.98</td>
</tr>
</tbody>
</table>

II. Compliance to Food Monitoring

As noted in the ‘Methods’ section, DASH participants were counseled to monitor everything they ate and drank, with complete descriptions and amounts for 5 out of 7 days each week for a total of 12 weeks (60 possible days). These food records were then submitted to DASH counselors for review. If the participant went more than 2 weeks without submitting a food tracking booklet, they were given the option of keeping a more simplified goal tracking form 5 out of 7 days each week. Based on review of participant monitoring booklets and forms, the mean number of days participants recorded using either the food tracking booklet or goal tracking form was 38.6 (SD=16.8) days out of a possible 60 days (equal to a 64% return rate of completed food
tracking booklets and goal tracking forms). The mean number of days participants recorded using more detailed food tracking booklets only was 33.5 (SD=19.4) days out of a possible 60 days (equal to a 59% return rate of completed food tracking booklets only).

In the present study, compliance to the skill of food monitoring was defined as follows: self-monitoring using the food tracking booklet or goal tracking form over 0-25% of intervention days was considered poor compliance, over 26-50% of intervention days was considered fair compliance, over 51-75% of intervention days was considered good compliance, and >75% of intervention days was considered excellent compliance.

As shown in Figure 1, approximately 67% of DASH participants demonstrated good to excellent compliance to food self-monitoring using food tracking booklets or goal tracking forms, while a third demonstrated fair to poor compliance. When use of food tracking booklet compliance was examined exclusively, slightly less than 50% were able to comply with the skill as measured by good to excellent standards. Approximately 51% of DASH participants demonstrated fair to poor compliance to food recording using food tracking booklets exclusively.

Completeness of recording (aka recording sufficiency) was also examined for only those who self-monitored using the food tracking booklets. A day of food recording was considered complete if at least 5 foods were recorded. Compliance to this skill was assessed by the same standards as food monitoring where those that recorded completely 0-25% of the time were considered to have poor compliance, 26-50% of the time were considered to have fair compliance, 51-75% of the time were considered to have good compliance, and >75% of the time were considered to have excellent compliance.
have good compliance, and >75% of the time were considered to have excellent compliance.

Among DASH participants, most (86%) demonstrated excellent compliance to recording sufficiency (Figure 2). Among days with complete recording, food descriptions were also examined to determine compliance to the skill of recording complete descriptions for foods eaten. Food descriptions were considered complete if they included all adjectives on the food label (low-fat, 100%, 1% fat, no-sodium, low-sodium, sugar-free, etc.) and type of cooking appropriate (baked, fried, scrambled, hard-boiled, etc.). Compliance was assessed with the same standards as recording sufficiency, e.g., >75% of foods with complete descriptions equaled excellent compliance. Eighty-nine percent of participants demonstrated excellent compliance to recording complete food descriptions (Figure 3).

Additionally, among days with complete recording, food amounts were also examined to determine compliance to the skill of recording complete quantities for foods eaten. Food amounts were considered complete if specific amounts were listed for foods and drinks in unit measures (cups, ounces, tablespoons, teaspoons). Compliance was assessed with the same standards as record sufficiency, e.g., >75% of foods with complete amounts equaled excellent compliance. Among days with complete recording, 60% of participants demonstrated excellent compliance to recording food amounts while nearly 90% of participants demonstrated at least good compliance to recording complete food amounts (Figure 4).
Figure 1  Percentage of days recorded by participants (n=45) out of a possible 60 treatment days by completing food tracking booklets and/or goal tracking forms(A). Percentage of days recorded by participants (n=43) out of a possible 60 treatment days by completing food tracking booklets only(B).

Figure 2  Fraction of participants able to correctly record food amounts for food items they recorded. A day of food recording was considered complete if at least 5 foods were recorded. Compliance to this skill was assessed as those that recorded completely 0-25% of the time were considered to have poor compliance, 26-50% of the time were considered to have fair compliance, 51-75% of the time were considered to have good compliance, and >75% of the time were considered to have excellent compliance.
Figure 3  Fraction of participants able to correctly record food descriptions for food items they recorded. Food descriptions were considered complete if they included all adjectives on the food label (low-fat, 100%, 1% fat, no-sodium, low-sodium, sugar-free, etc.) and type of cooking appropriate (baked, fried, scrambled, hard-boiled, etc.). Compliance to this skill was assessed by those that recorded complete food descriptions 0-25% of the time were considered to have poor compliance, 26-50% of the time were considered to have fair compliance, 51-75% of the time were considered to have good compliance, and >75% of the time were considered to have excellent compliance.

Figure 4  Fraction of participants able to correctly record food amounts for food items they recorded. Food amounts were considered complete if specific amounts were listed for foods and drinks in unit measures (cups, ounces, tablespoons, teaspoons). Compliance to this skill was assessed by those that recorded complete food amounts 0-25% of the time were considered to have poor compliance, 26-50% of the time were considered to have fair compliance, 51-75% of the time were considered to have good compliance, and >75% of the time were considered to have excellent compliance.
III. Compliance to Food Categorization and Specifying DASH Servings

The ability to place foods and drinks into the correct DASH food categories, e.g. fruits & vegetables, low-fat dairy foods, and DASH unfriendly foods, and indicate the number of servings of these DASH food groups was an important component of the skill of food monitoring in the DASH-4-Teens intervention as it allowed participants to determine whether they were meeting their DASH food goals each day. A participant was identified as being an accurate-classifier, an over-classifier or an under-classifier in categorizing foods into DASH food groups based on how close they came to correctly categorizing all foods they had eaten into DASH food groups 100% of the time (e.g., # of foods correctly categorized in the DASH food category) / (# foods that belonged in the DASH category x 100). More specifically, participants were classified as being an accurate-classifier, over-classifier, or under-classifier if the percentage of correctly classified foods eaten was between 90-110%, >110% or <90%, respectively. Among days with complete food recording, less than half (46%) of participants were able to accurately classify the fruits and vegetables they had eaten into the fruit & vegetable DASH food group, substantially less (21%) were able to accurately classify low-fat dairy foods into this DASH food group. Very few participants were able to correctly classify foods into the DASH unfriendly food group (5%) (Figure 5).

To determine how well participants were able to correctly identify how many servings of DASH target foods (e.g., fruits & vegetables, low-fat dairy and DASH unfriendly foods) they had eaten, participants were classified as demonstrating excellent, good, fair or poor proficiency at this skill based on how close they came to 100% in recording the correct DASH serving amount out of the # of DASH food servings eaten (e.g., #
foods correctly recorded in the target food category / (# foods that belonged in the target food category x 100). More specifically, participants were classified as being excellent, good, fair or poor serving recorders if the percentage of correctly classified foods eaten was between 75-100%, 50-74%, 25-49%, and <25, respectively. Less than a third (30%) of participants demonstrated good or excellent proficiency in correctly calculating DASH serving amounts for fruits & vegetables. Approximately half of participants (51%) demonstrated good or excellent proficiency in correctly calculating DASH serving amounts for low-fat dairy foods (Figure 6). Only one participant demonstrated fair proficiency in correctly calculating DASH serving amounts for DASH unfriendly foods, while all others demonstrated poor proficiency (98%) (Data not shown).

**Figure 5**  Fraction of participants able to determine the correct DASH category for foods belonging in the fruit & vegetable foods category (A), fraction of participants able to determine the correct DASH category for foods belonging in the low-fat dairy foods category (B), and fraction of participants able to determine the correct DASH category for foods belonging in the DASH Unfriendly foods category. Participants were classified as being excellent, good, fair or poor category classifiers if the percentage of correctly classified foods eaten was between 75-100%, 50-74%, 25-49%, and <25%, respectively.
IV. Relationship between Compliance to Food Monitoring, Food Categorization and Specifying DASH Food Servings and Systolic and Diastolic Blood Pressure z-score

Tables 2 and 3 presents results of mixed effects models to address the question of whether greater compliance to food monitoring and the skills of food categorization and specifying DASH food servings was related to change in systolic blood pressure z-score (Table 2) and diastolic blood pressure z-score (Table 3). In the mixed effects models, compliance to food monitoring, ability to classify DASH foods, and proficiency at estimating DASH serving sizes were entered into models as categorical variables; participant categories for each of these variables are described above and in the footnote below the tables. Poor versus good compliance to food tracking predicted a trend for an increase in systolic blood pressure z score (p=0.08), as did poor versus
excellent proficiency at determining the number of DASH low-fat dairy servings from foods eaten (p=0.10). Being an under-classifier versus an accurate-classifier of DASH unfavorable foods predicted an increase in systolic blood pressure z-score over the intervention (p=0.04).

Table 2. Food Monitoring Compliance, Food Categorization Proficiency, and Specifying DASH Food Servings Proficiency as Predictors of Change in Systolic Blood Pressure z-score

<table>
<thead>
<tr>
<th>Compliance to Food Tracking and Goal tracking</th>
<th>Estimate</th>
<th>SE</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor versus Fair</td>
<td>0.1863</td>
<td>0.55</td>
<td>0.34</td>
<td>0.74</td>
</tr>
<tr>
<td>Poor versus Good</td>
<td>0.3599</td>
<td>0.54</td>
<td>0.66</td>
<td>0.51</td>
</tr>
<tr>
<td>Poor versus Excellent</td>
<td>0.0113</td>
<td>0.52</td>
<td>0.02</td>
<td>0.98</td>
</tr>
<tr>
<td>Fair versus Good</td>
<td>0.1736</td>
<td>0.50</td>
<td>0.35</td>
<td>0.73</td>
</tr>
<tr>
<td>Fair versus Excellent</td>
<td>-0.1750</td>
<td>0.45</td>
<td>-0.39</td>
<td>0.71</td>
</tr>
<tr>
<td>Good versus Excellent</td>
<td>-0.03485</td>
<td>0.41</td>
<td>-0.86</td>
<td>0.39</td>
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<table>
<thead>
<tr>
<th>Compliance to Food Tracking only</th>
<th>Estimate</th>
<th>SE</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor versus Fair</td>
<td>0.1958</td>
<td>0.44</td>
<td>0.44</td>
<td>0.66</td>
</tr>
<tr>
<td>Poor versus Good</td>
<td>0.9033</td>
<td>0.50</td>
<td>1.80</td>
<td>0.08 ±</td>
</tr>
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<td>Poor versus Excellent</td>
<td>0.2912</td>
<td>0.45</td>
<td>0.65</td>
<td>0.52</td>
</tr>
<tr>
<td>Fair versus Good</td>
<td>0.7074</td>
<td>0.49</td>
<td>1.45</td>
<td>0.16</td>
</tr>
<tr>
<td>Fair versus Excellent</td>
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<td>0.40</td>
<td>0.24</td>
<td>0.81</td>
</tr>
<tr>
<td>Good versus Excellent</td>
<td>-0.6121</td>
<td>0.45</td>
<td>-1.35</td>
<td>0.19</td>
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<table>
<thead>
<tr>
<th>Compliance to Recording Complete Food Descriptions</th>
<th>Estimate</th>
<th>SE</th>
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<th>P value</th>
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<tr>
<td>Good versus Excellent</td>
<td>0.2804</td>
<td>0.64</td>
<td>0.44</td>
<td>0.66</td>
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<table>
<thead>
<tr>
<th>Compliance to Recording Complete Food Amounts</th>
<th>Estimate</th>
<th>SE</th>
<th>T value</th>
<th>P value</th>
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<tr>
<td>Fair versus Good</td>
<td>0.6653</td>
<td>0.76</td>
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<td>Fair versus Excellent</td>
<td>0.7921</td>
<td>0.74</td>
<td>1.07</td>
<td>0.29</td>
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<tr>
<td>Good versus Excellent</td>
<td>0.1268</td>
<td>0.35</td>
<td>0.36</td>
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<table>
<thead>
<tr>
<th>Proficiency at Categorizing Foods into DASH Fruit &amp; Vegetable Category</th>
<th>Estimate</th>
<th>SE</th>
<th>T value</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td>Over versus Accurate Classifier</td>
<td>0.2273</td>
<td>0.39</td>
<td>0.59</td>
<td>0.56</td>
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<tr>
<td>Over versus Under Classifier</td>
<td>0.7321</td>
<td>0.45</td>
<td>1.62</td>
<td>0.11</td>
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<tr>
<td>Accurate versus Under Classifier</td>
<td>0.5048</td>
<td>0.45</td>
<td>1.12</td>
<td>0.27</td>
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<table>
<thead>
<tr>
<th>Proficiency at Determining # of DASH servings Eaten from Fruit &amp; Vegetable Category</th>
<th>Estimate</th>
<th>SE</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor versus Fair</td>
<td>0.1105</td>
<td>0.42</td>
<td>0.26</td>
<td>0.80</td>
</tr>
<tr>
<td>Comparison</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
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<td>----------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Poor versus Good</td>
<td>0.3251</td>
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<td>0.80</td>
<td>0.43</td>
</tr>
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<td>Poor versus Excellent</td>
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<tr>
<td>Fair versus Good</td>
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<tr>
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<td>-0.6050</td>
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<td>Good versus Excellent</td>
<td>-0.8197</td>
<td>1.14</td>
<td>-0.72</td>
<td>0.48</td>
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**Proficiency at Categorizing Foods into Low-Fat Dairy Category**

<table>
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<tr>
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<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over versus Accurate Classifier</td>
<td>-0.0377</td>
<td>0.55</td>
<td>-0.07</td>
<td>0.95</td>
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<tr>
<td>Over versus Under Classifier</td>
<td>0.0116</td>
<td>0.43</td>
<td>0.03</td>
<td>0.98</td>
</tr>
<tr>
<td>Accurate versus Under Classifier</td>
<td>0.0492</td>
<td>0.47</td>
<td>0.10</td>
<td>0.92</td>
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**Proficiency at Determining # of DASH serving Eaten from Low-Fat Dairy Category**

<table>
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<th>Comparison</th>
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<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>Poor versus Fair</td>
<td>0.7678</td>
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<td>1.62</td>
<td>0.11</td>
</tr>
<tr>
<td>Poor versus Good</td>
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<td>0.44</td>
<td>1.55</td>
<td>0.13</td>
</tr>
<tr>
<td>Poor versus Excellent</td>
<td>0.7490</td>
<td>0.45</td>
<td>1.65</td>
<td><strong>0.10 ±</strong></td>
</tr>
<tr>
<td>Fair versus Good</td>
<td>-0.0767</td>
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<td>-0.16</td>
<td>0.87</td>
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<tr>
<td>Fair versus Excellent</td>
<td>-0.0187</td>
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<td>-0.04</td>
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<tr>
<td>Good versus Excellent</td>
<td>0.0580</td>
<td>0.47</td>
<td>0.12</td>
<td>0.90</td>
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</table>

**Proficiency at Categorizing Foods into DASH Unfriendly Foods Category**

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<tr>
<th>Comparison</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under versus Accurate Classifier</td>
<td>0.7151</td>
<td>0.36</td>
<td>1.68</td>
<td><strong>0.04</strong></td>
</tr>
</tbody>
</table>

1 Compliance to the skill of food monitoring was defined as follows: self-monitoring using the food tracking booklet/ goal tracking form over 0-25% of intervention days was considered poor compliance, over 26-50% of intervention days was considered fair compliance, over 51-75% of intervention days was considered good compliance, and >75% of intervention days was considered excellent compliance.

2 Food descriptions were considered complete if they included all adjectives on the food label (low-fat, 100%, 1% fat, no-sodium, low-sodium, sugar-free, etc.) and type of cooking appropriate (baked, fried, scrambled, hard-boiled, etc.). Compliance to writing complete food descriptions was assessed with the same standards as recording sufficiency, e.g., >75% of foods with complete descriptions equaled excellent compliance.

3 Food amounts were considered complete if specific amounts were listed for foods and drinks in unit measures (cups, ounces, tablespoons, teaspoons). Compliance to writing complete food amounts was assessed with the same standards as record sufficiency, e.g., >75% of foods with complete amounts equaled excellent compliance.

4 Comparisons adjusted for age, race, gender and BMI z-score; ± (p<0.10); * p<0.05

Poor versus fair compliance to self-monitoring using either the food tracking booklets or goal tracking records predicted a significant increase in diastolic blood...
pressure z-score (p=0.04), while fair versus excellent compliance predicted a significant
decrease in diastolic blood pressure z-score (p=0.03). Also, being an under- versus
accurate classifier of DASH unfriendly foods predicted a trend toward an increase in
diastolic blood pressure z-score (p=0.08) (Table 3). No other self-monitoring
compliance measures were significantly related to systolic or diastolic blood pressure z-
score changes.

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1 Compliance to the skill of food monitoring was defined as follows: self-monitoring using the food tracking booklet/goal tracking form over 0-25% of intervention days was considered poor compliance, over 26-50% of intervention days was considered fair compliance, over 51-75% of intervention days was considered good compliance, and >75% of intervention days was considered excellent compliance.

2 Food descriptions were considered complete if they included all adjectives on the food label (low-fat, 100%, 1% fat, no-sodium, low-sodium, sugar-free, etc.) and type of cooking appropriate (baked, fried, scrambled, hard-boiled, etc.). Compliance to writing food descriptions was assessed with the same standards as recording sufficiency, e.g., >75% of foods with complete descriptions equaled excellent compliance.

3 Food amounts were considered complete if specific amounts were listed for foods and drinks in unit measures (cups, ounces, tablespoons, teaspoons). Compliance to writing food amounts was assessed with the same standards as record sufficiency, e.g., >75% of foods with complete amounts equaled excellent compliance.

4 Comparisons adjusted for age, race, gender and BMI z-score; ± (p<0.10); * p<0.05
Discussion

In the present trial, there was a 64% return rate on the two methods employed for dietary self-monitoring, food tracking booklets and goal tracking forms. This rate of return is comparable, if not higher than reported by others who have examined the skill of food self-monitoring in clinical trials (Helsel, Jakcic, & Otto, 2007; Germann, Kirschenbaum, & Rich, 2007; Saelens et al, 2003). For example, in a study examining the effects of drug therapy and caloric restriction on degree of adolescent weight loss, the mean rate of return of food records, which was used to assess dietary compliance in this study, was 49% for those receiving the placebo and 51% for those receiving the drug and diet therapy combination (Berkowitz, 2003). In this study, it was shown that adolescents who adhered more closely to the behavioral skill of dietary self-monitoring compared to those with poor compliance achieved a greater decrease in BMI over the 6-month intervention period. This finding supports the importance of dietary self-monitoring in dietary intervention work.

Food self-monitoring has been shown to be essential for promoting dietary compliance and change in a number of nutrition intervention studies in both adults and children (Burke, Wang, & Sevick, 2011; Baker & Kirschenbaum, 1993; Miller et al., 2009; Saelens et al, 2002, 2003). An important finding of the present study was that adolescents who self-monitored their diet did the skill well. As evidence of this, 87% of participants in the trial demonstrated excellent compliance to complete food recording, and for those that recorded completely, about 90% showed at least good compliance to recording complete food descriptions and amounts. Participants were given training materials and training sessions to help grasp the skills of food tracking. More
specifically, the skill of tracking foods was introduced to the participants by a DASH research assistant in a face-to-face counseling session. The research assistant reviewed examples of what a good and poor tracker looked like, how to write complete descriptions, and gave measuring cups and training on how to measure and estimate serving sizes using specific units of measurement. Food tracking forms were reviewed with participants each week by telephone interventionists and feedback on tracking was mailed back to participants each week to improve the quality of writing complete descriptions and amounts of foods eaten. Based on frequency data from this trial, the training materials, participant training, and feedback was effective in achieving a high rate of complete food tracking, complete food and beverage descriptions and recording of specific amounts for foods eaten.

Importantly, adolescents demonstrating good compliance to the skill of dietary self-monitoring, as measured by the number of complete food records returned, versus poor compliance showed a trend towards improvement in systolic blood pressure, the primary outcome of this trial. Those demonstrating poor compliance to any food tracking (whether it was using the more detailed food recording forms or the simpler goal tracking sheets) versus fair compliance showed a significant increase in diastolic blood pressure. These results suggest that the skill of food tracking, at the minimum of a fair skill level, was an important component of the behavioral therapy to improvement of blood pressure in adolescents. It was expected that excellent compliant to food recording, writing food descriptions and amounts would have predicted a decrease in blood pressure compared to good, fair or poor compliance. However, this was not the case. In fact, in this trial, fair compared to excellent compliance to any food tracking
predicted a significant decrease in diastolic blood pressure. It is not clear why a fair level of food tracking would be more optimal than excellent tracking as a means of lowering blood pressure. Since incentives were given for each complete food tracker or goal tracker returned, it may be that some adolescents, particularly those that used the simpler goal tracking forms where the participant crossed off a picture of a fruit/vegetable or low-fat dairy food when eaten, recorded meeting DASH food groups, but were not actually compliant to the DASH diet. Therefore, the blood pressure of the group that showed excellent compliance to food recording using this tool did not correlate with completed records. This hypothesis warrants investigation.

In this trial, it was hypothesized that the ability to categorize foods eaten into DASH food groups (fruit, vegetable, low-fat dairy, DASH unfriendly foods) and calculate the number of DASH servings eaten, would be important skills to achieve improvements in diet quality and decreases in both systolic and diastolic blood pressure. The results of this study showed that participants experienced a high degree of difficulty in achieving proficiency at these skills. In particular, classifying foods eaten into the DASH unfriendly foods category was shown to be a more difficult task than classifying foods eaten as fruits & vegetables or low-fat dairy foods. While 50% of the teens were able to correctly classify the foods they ate as fruits and vegetables and 19% as low-fat dairy foods, only 5% were able to correctly classify foods eaten as DASH unfriendly foods. The results of this study also showed that under versus accurate classifiers of DASH unfriendly foods predicted higher systolic blood pressure. Therefore, these findings suggest that the skill of correctly classifying high fat, high sodium foods was an important therapeutic component of the intervention to lower blood pressure.
In this intervention, participants were given many different forms of education to help them understand which foods went into each DASH food category. A self-assessment in clinic was performed by a registered dietitian, who helped teens identify foods they were currently eating that counted as a fruit/vegetable, low-fat dairy food or DASH unfriendly food. Extensive food lists, including common foods from local grocery stores and restaurants, were included in the DASH-4-Teens manual to help participants determine which foods counted as target DASH foods. Additionally, telephone counselors reviewed food records with teens each week and assisted them in putting foods eaten into DASH food groups. However, having teens identifying low-fat foods and low sodium foods (e.g., low-fat dairy, and DASH unfriendly foods) was particularly problematic in this study.

Notably, the skill of accurately classifying low-fat dairy and DASH unfriendly foods required writing detailed food descriptions for foods eaten. If appropriate descriptions (e.g. 1%, low or reduced sodium, low-fat) were not included of foods and beverages consumed, then food record coders did not count the food as a low-fat or low-sodium item. Therefore, inaccurate food descriptions may have been a source of error in this study. This was particularly true with cheese. May teens did not indicate whether cheese was fat-free, and therefore most cheeses could not be counted as a low-fat dairy food.

Another source of error may have been participant bias towards under classifying foods that did not coincide with the DASH diet plan. DASH participants were encouraged to limit the number of DASH unfriendly foods consumed each day to 2 or less. If a participant knew they were exceeding this goal, they may have avoided
classifying such foods as ‘unfriendly’. While the issue of under-classifying low-fat, low sodium foods has not been examined by others, under-reporting, particularly in weight loss trials, has been shown to be a major source of error in dietary self-monitoring studies, particularly among children and adolescents who are overweight or obese (Ortega et al, 1995; Vance et al, 2008; Singh, 2009; Fisher et al, 2000). Given that approximately 85% of the teens in this trial were overweight or obese, it is likely that both under-reporting and under-classifying foods as DASH unfriendly may have been potential sources of biases in this study.

It may also be hypothesized that the extra effort required to read food labels in order to identify low-fat dairy and DASH unfriendly foods was a factor in the low degree of proficiency at classifying these foods. For many adolescents, the DASH-4-Teens intervention proved to be the first time they had carefully examined a food label to identify fat and sodium. While most schools teach the basic food groups, few teens are learning about how to make healthful choices within food groups, e.g., by reading food labels (Story, M., 1984; Huang et al, 2004; Leger, L., 2001). Consequently, the concept of what makes a food 'unfriendly' (e.g. the fat content/ sodium content) may have been overlooked when consuming a food or beverage. In future iterations of the DASH-4-Teens intervention, including more self-assessments to determine proficiency in the skill of label reading may be warranted. Additionally, providing more education on how to break down combination foods into food components, e.g., cheese burger with fat free cheese into 1 DASH unfriendly and 1 low-fat dairy, would likely increase proficiency in food classification among adolescents in the program.
Along with problems classifying DASH foods, determining or calculating the number of DASH food servings consumed was found to be a difficult skill for teens. Less than a third of participants demonstrated at least good proficiency at calculating DASH servings of fruits and vegetables, and less than 2% of participants demonstrated at least fair proficiency at calculating DASH servings of unfriendly foods. Adolescents were more proficient with low-fat dairy serving calculations as evidenced by over 50% showing good to excellent proficiency calculating DASH servings of this food group. It may be that most low-fat dairy foods come in containers with serving sizes clearly marked making this food group easier than most in calculating servings eaten.

Importantly, excellent versus poor proficiency at calculating number of servings eaten of low-fat dairy foods predicted (trend) lower systolic blood pressure. Therefore, efforts to improve participant’s ability to calculate servings eaten should be emphasized in subsequent iterations of the DASH-4-Teens intervention.

To help participants learn this concept well, educational materials should emphasize comparisons of fruits and vegetables to common objects that they may have available in the home, like sports balls (e.g. tennis ball, golf ball), while a booklet with examples of foods and portion sizes may serve as a beneficial visual to help adolescents more accurately estimate DASH unfriendly food portions. Venter and Vorster (2000) created a food portion photograph book to aid in estimating portion sizes of foods. Using this booklet, participants were able to accurately estimate food portions by matching foods served in front of them with one of the portion photographs found in the booklet (Venter & Vorster, 2000). Tangible visuals demonstrating such portion sizes may improve the accuracy of estimating serving sizes of DASH unfriendly foods such as
pizza, shredded cheese, and brownies. Additionally, it may be hypothesized that difficulty in breaking down combination DASH unfriendly foods into multiple servings may have proved too difficult for most. For example, many fast foods contain multiple DASH unfriendly servings that were often counted as one serving such as a Big Mac with cheese (2 hamburger patties, 4 Tablespoons special sauce, 2 slices of regular cheese = 5 DASH unfriendly foods). Participants may need more education on how to itemize foods such as these to understand the total DASH unfriendly servings.

There were several limitations of the present study that should be noted. Dietary data were not available for all participants in this trial, and therefore could not be examined. It would be expected that dietary change was one of the primary mediators of changes in blood pressure in this study. Therefore, future studies should examine how food monitoring modifies the food consumption of participants as a mediator of blood pressure change. The ongoing DASH-4-Teens, 6-month intervention, being conducted by Couch and colleagues, will examine this relationship. Another limitation was the small sample size, which may have limited the ability to determine significant associations where they exist. In this study there were many variables with respect to food monitoring, that in hindsight, may have increased the need for a larger sample size to enable the detection of significant associations that potentially could not be deciphered in the current study.

Obesity and related chronic disease risk factors, e.g., hypertension, are growing public health issues among youth, and behaviorally-based intervention programs targeting lifestyle habits are crucial in reversing these adverse trends. Adapting one’s diet to a DASH-type diet has proven effective in lowering blood pressure in at risk adults.
and youth. Findings from this study suggest that dietary self-monitoring can be a valuable adjunct to other behavioral skills when used as part of a therapeutic nutrition intervention program to lower blood pressure in adolescents with pre-hypertension and hypertension.
References


Appendix A

Food Tracker Compliance

*Basic Compliance*- Compliance with daily recording of foods, giving accurate descriptions of foods, and including amount for all foods listed.

*Category Compliance*- Accuracy with which foods are placed in the DASH categories of fruits and vegetables, low-fat dairy, and in the DASH unfriendly category.

*Serving Compliance*- Accuracy with which DASH food servings are calculated.

**BASIC COMPLIANCE**

*Compliance with recording per day:*

How many foods were recorded?

Day 1 _____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

*Compliance with food descriptions:*

How many foods were accurately described with accurately described defined as a complete description of kind to include all adjectives on the food label (low-fat, 100%, 1%, no-sodium, low-sodium, sugar-free, etc.) and cooking method if the method effects the kind (baked, fried, scrambled, hard-boiled, etc.)? Enough information should be provided so that a determination can be made as to whether the food was DASH friendly or unfriendly.

Day 1 _____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____
Compliance with food amount recording:

For how many foods was the amount of food recorded? Amounts should be listed in cups, Tbsp., tsp., ounces, or counts for foods with standard serving sizes.

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

CATEGORY COMPLIANCE- Fruit & vegetables

How many foods were recorded in the fruits and vegetables category?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

From foods descriptions provided, how many food items should have been recorded in the fruits and vegetables category? Note: If a fruit or vegetable is unfriendly, it cannot count as a fruit or vegetable serving.

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

SERVING COMPLIANCE- Fruit & vegetables

Of those foods that should have been recorded in fruits and vegetables category, how many was the participant able to identify the correct serving amount?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

CATEGORY COMPLIANCE- Low-fat Dairy

How many foods were recorded in the low-fat dairy category?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____
From foods descriptions provided, how many food items should have been recorded in the low-fat dairy category? Note: *If a dairy food is unfriendly, it cannot count as a low-fat dairy serving.*

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

**SERVING COMPLIANCE- Low-fat Dairy**

Of those foods that should have been recorded in the *low-fat dairy category*, how many was the participant able to identify the correct serving amount?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

**CATEGORY COMPLIANCE- Unfriendly Foods**

How many foods were recorded in the unfriendly foods category?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

From foods descriptions provided, how many food items should have been recorded in the unfriendly foods category?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____

**SERVING COMPLIANCE- Unfriendly Foods**

Of those foods that should have been recorded in the *unfriendly foods* category, how many was the participant able to identify the correct serving amount?

Day 1_____ Day 2 _____ Day 3 _____ Day 4 _____ Day 5 _____
Appendix B

Food Tracker Coding Guidelines

Counting foods

Count each food listed as a separate item

Multiple foods listed on the same food tracker line should be counted as separate food items

For foods that are homogenous mixtures of foods (e.g. fruit cup, mixed vegetables, green salad), even though ingredients may be listed out, count as one food.

Complete Food Descriptions

Take foods at face value- unless a food is written low-sodium or low-fat, assume that it is the full-fat, high-sodium version.

If you can tell that a food is DASH friendly or unfriendly based on a food description, then consider it a complete description.

Homemade foods must have information about food ingredients to be considered food ingredients.

Food Amounts

Amounts should be listed for each food counted (as above)

Slices are ok for meat

Amounts should be listed as cups, ounces, Tbsp, tsp, pounds
Can also use a size comparison with food portion visuals (e.g. a deck of cards for size of meat)

Numbers can be used for foods that come in pieces (e.g. mini carrots, strawberries)

Sizes must be listed for apples, bananas, pizza