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I, Jessica A Blaut, 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 diet self-monitoring and healthful dietary pattern changes in adolescents with elevated blood pressure

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The relationship between diet self-monitoring and healthful dietary pattern changes in adolescents with elevated blood pressure

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Abstract

Objective:
To examine the usefulness of dietary self-monitoring in promoting adherence to a diet (the DASH diet), which requires food pattern changes including increasing intake of fruits, vegetables and low fat dairy foods, in youth with pre-/hypertension following a clinic based intervention to lower blood pressure.

Methods: Participants (n=41) completed a 24-week nutrition intervention including x 2 counseling sessions by a registered dietitian (RD) on the DASH diet; written material including a manual with DASH food serving and meal planning recommendations; 15 behavioral counseling phone calls; and biweekly mailings. Adolescents were asked to monitor their intake for 5 days/week using a detailed record form or a simple tracking form and return completed records weekly to the RD. Degree of compliance to dietary self-monitoring was calculated as number of days of food recording/total possible days x 100. Degree of compliance to recording at 68-100% = high; 34-67%= moderate; 0-33% = low. Compliance to the DASH diet was calculated as change in DASH Score measured by the DASH Diet Index based on 3-day diet recall data collected pre and post intervention. Results: Compliance to tracking using the detailed or simple form was 41% high, 29% moderate, and 31% low and using the detailed form only was 22% high, 27% moderate, and 51% low. In multiple linear regression models, adjusted for age, race, gender, income, and BMI z score, a moderate or high level of self-monitoring compared to a low level was a positive predictor of change in overall DASH Score (p<0.01 detailed or simple tracking, p<.05 detailed tracking only).

Conclusion/Application: Dietary self-monitoring for at least a third of intervention days was related to success in changing dietary patterns to be more DASH-like (higher in fruits, vegetables and low fat dairy...
foods). This skill may be an important adjunct to dietary intervention programs to manage blood pressure with lifestyle therapy among youth.
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I. Introduction/Literature Review

A. Introduction

Recent surveys and studies have shown that adolescents consume excess amounts of fat, sugar and salt, and inadequate amounts of fruits, vegetables, whole grains, calcium containing foods and iron (Lytel, 2002; McClain et al., 2009; Hoelscher et al., 2002; Gaines and Turner, 2009). Inadequate physical activity is also a characteristic of the adolescent lifestyle. Energy imbalances and poor nutrient quality of diets are linked to an increased risk for and the development of chronic diseases, such as obesity, cardiovascular disease (CVD), type 2 diabetes and some cancers (Chappuis et al., 2009; Hoelscher et al., 2002; Gaines and Turner, 2009). Fruit and vegetable intake during childhood often reflects intake of these foods in adolescence and adulthood. Nutritional interventions used to alter unhealthy dietary behaviors during adolescence have been related to improvements in risk factors for diseases in adults (Hoelscher et al., 2002). Identifying intervention strategies that are related to long term compliance to a healthy diet are essential. This literature review will provide evidence for the importance of modifying diet quality in adolescents with risk factors for adult diseases. The review will also discuss the nutrition intervention studies that have been done with hypertensive youth as the target audience. Successful intervention strategies will be discussed and gaps in the literature on this topic will be identified.

B. Cardiovascular Disease Risk Factors in Youth and the Obesity Epidemic

Obesity is a chronic, multidimensional problem that is reaching epidemic proportions among youth in the United States. The prevalence of obesity in the United States currently exceeds 30 percent in most age and sex groups (Flegal et al., 2010). Obesity is a major contributor to morbidity from CVD and other related risk factors including dyslipidemia, hypertension and insulin resistance (National Institutes of Health, National Heart Lung and Blood Institute, 1998). Over the past three decades from 1980 to 2010,
the prevalence of obesity among children 6-11 years of age has increased from 6.5% to 17.0%, and among adolescents 12-19 years of age, from 5.0% to 17.6% (NHI, NHLBI, 1998). The Centers for Disease Control (CDC) has established a consensus definition for obesity in youth based on input from an expert panel of clinicians. This definition is based on body mass index (BMI), and is gender and age specific (Dietz & Robinson 2005). According to the CDC definition, children with a BMI between the 5th-84th percentiles have a “healthy weight”. Children with BMIs between the 85th to 94th percentiles are “overweight” while children with BMIs greater than or equal to the 95th percentile are classified as “obese” (Dietz & Robinson, 2005). Of concern, these trends in weight status among youth have the potential to adversely impact an individual’s physical health. Along with obesity, these metabolic and physiologic changes tend to track into adulthood and can eventually increase an individual’s risk of disease, disability and death (Wang, et al, 2010). Metabolic Syndrome, type 2 diabetes mellitus (T2DM), non-alcoholic fatty liver disease, sleep apnea and Blount’s Disease are co-morbidities that can track from childhood to adulthood (Deckelbaum & Williams, 2001). Obesity can also increase a child’s risk for CVD. Studies show that approximately 60% of overweight children between 5-10 years had one risk factor for CVD including hypertension, dyslipidemia, and insulin resistance, while 20% had two or more of these risk factors (Freedman et al, 1999). Obesity can induce a multitude of cardiovascular transformations that significantly alter hemodynamics through increased blood volume and cardiac output (Dietz & Gortmaker, 2001). Increased BMI in adults and youth has consistently been identified by leading health organizations as a major cause of hypertension (Deckelbaum & Williams, 2001).

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. Hypertension is a medical condition in which blood pressure, measured on three separate occasions, is above normal levels. In youth, normal levels are based on a percentile distribution for height, age and gender. Blood pressure above the 90th percentile but below the 95th percentile for age, gender and
height is considered pre-hypertension. Blood pressure at or above the 95th percentile is considered hypertensive in youth (Appel, et al., 1997). Hypertension can be classified as either primary or secondary. Primary hypertension is defined as elevated blood pressure that has no specific medical cause. Secondary hypertension refers to elevated blood pressure resulting from another medical condition, such as kidney disease (Hansen, Gunn & Kaelber, 2007). In the United States, pediatric hypertension, either primary or secondary, has an estimated prevalence of between 2% and 5% (Sinaiko, 1968-1973). Secondary hypertension is more common in children than adults and common causes of secondary hypertension in children include renal disease, coarctation of the aorta and endocrine disease (Sinaiko, 1968-1973). The majority of children and adolescents with mild to moderate hypertension have primary hypertension. This condition once considered relatively rare, in children and adolescents has become increasingly common and is often associated with other cardiovascular risk factors including obesity, insulin resistance and dyslipidemia (Sorof, et al., 2004). Hypertension during childhood and adolescents has been shown to be an independent risk factor for hypertension in adulthood (Arnett et al., 2001, Berenson et al., 1998, Burke et al., 1987, Johnson et al., 1999, Knoflach et al. 2003, Lauer and Clark, 1989, Malcolm et al., 1993, ). 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 (National High Blood Pressure Education Program, 2004). Hypertrophy of the left ventricle and presence of a high media to lumen ratio of small resistance arteries in childhood are cardiovascular structural changes that can lead to adverse CVD outcomes into adulthood (Karanja, et al., 2007).

**Therapeutic Options for Managing Hypertension in Youth and Adolescents**

According to national guidelines for the management of pre-hypertension and hypertension in youth, primary hypertension should be addressed with a medically-supervised program of lifestyle changes and monitoring for a period of 6 months before considering the initiation of drug therapy (Karanja, et al., 2007). Recommended life style modifications to lower blood pressure in children and
adolescents include losing weight if overweight or obese, eating a low fat, fruit and vegetable enriched diet, reducing the amount of dietary sodium, and getting regular aerobic exercise. It has been shown that, in addition to lowering blood pressure, these lifestyle changes may enhance the effectiveness of antihypertensive medications (Appel, et al. 2006). Recommendations from the Fourth Pediatric Report on Hypertension, 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). All drug treatments have side effects, and while the evidence of benefit at higher blood pressures is overwhelming, drug trials to lower moderately-elevated blood pressure have failed to reduce overall death rates (Gunther, et al. 2009). Antihypertensive drugs of different classes including angiotensin-converting enzyme (ACE)- inhibitors and those targeting angiotensin II type 1 receptors have been shown to decrease peripheral resistance and normalize blood pressure in adults in as little as two weeks (Smith et al., 2008). 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 (Smith, et al., 2008).

The recommended non-pharmaceutical approaches to reduce high blood pressure in adolescents and adults include behavioral and lifestyle changes. Many studies and clinical trials have been completed in both adults and adolescents that provide evidence that specific dietary modifications can lead to a decrease in blood pressure. One of the first of these studies was the National Health and Nutrition Examination Survey I or NHANES I (National Center for Health Statistics, 1997). Preliminary data obtained from NHANES I found that significant decreases in the consumption of calcium and
potassium were identified as primary nutritional markers of hypertension. In a study done by McCarron et al. (1984) low consumption of dairy products was related to elevated blood pressure. Similarly, other studies have shown correlations between nutrients and blood pressure. The most consistent associations have included positive relationships between dietary sodium and saturated fatty acids and systolic and diastolic blood pressure, as well as, inverse negative relationships between dietary potassium and dietary fiber and systolic and diastolic blood pressure (Stamler, et al., 1997). One of the landmark epidemiological studies on the relationship between sodium and blood pressure in adults was the INTERSALT study (Stamler, et al., 1989). The study showed that urinary sodium excretion, an objective measure of sodium intake, was significantly positively related to systolic blood pressure. Another important finding from this study was that the combination of reduced dietary sodium and increased dietary potassium intake was more effective in lowering systolic and diastolic blood pressure than either nutrient alone (Stamler, et al., 1989).

Intake of foods high in fiber and benefits on blood pressure has been the focus of several studies. One epidemiological trial found that increasing dietary fiber as part of a lacto-ovo-vegetarian diet low in saturated fat, cholesterol, and sodium was more effective in lowering blood pressure in adults compared to those consuming an omnivorous diet low 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 more effective in lowering diastolic blood pressures in adult participants (Kelsay, et al., 1978). Studies such as these supports the fact that dietary patterns and combinations of dietary modifications rather than single nutrients have changed the way health professionals view the treatment of high blood pressure. Recent guidelines recommend a dietary pattern that is high in fruits and vegetables and low fat dairy foods to lower blood pressure in youth (NHBPEP, 2004). This dietary pattern is based on a randomized clinical trial in adults that showed success of this combination of foods
in lowering blood pressure within a short period of time (Appel, et al., 1997). The efficacy of this dietary approach is reviewed below.

**Dietary Approaches to Stop Hypertension (DASH)**

The Dietary Approaches to Stop Hypertension Diet or DASH diet is a diet advocated by the National High Blood Pressure Education Program to control hypertension in both adults and youth (NHBPEP, 2004). The DASH diet is based on an eating plan rich in fruits and vegetables and low fat or non-fat dairy foods. The dietary pattern also includes whole grain products, fish, poultry, and nuts, and is reduced in red meats, sweets, added sugars and added sugar containing beverages. The DASH diet was developed with the intent of increasing food sources of key nutrients, shown in single nutrient studies, to lower blood pressure in adults, including potassium, calcium, magnesium, moderate protein and dietary fiber (Appel, et al., 1997). These nutrients are found in high levels in fresh fruits and vegetables and low fat dairy foods, hence the emphasis on these food groups as a major part of the dietary pattern. In addition, numerous studies have found individuals that eat a plant-based diet have a lower risk of developing hypertension (Appel, et al., 1997, Stamler, et al. 1989, Stamler et al., 1993).

While the DASH diet has been empirically shown to lower CVD risk by improving blood pressure and lipid levels, there is still much debate on whether or not patients can follow the diet pattern long term. The DASH trial sought to determine the effects of different dietary patterns on blood pressure in adults (Appel, et al., 1997). The DASH trial was a multi-center, randomized control trial, for adults with pre-hypertension or stage 1 hypertension. The subjects were placed on one of three intervention diets. The DASH study was a controlled feeding study which means meals specific for each diet prescribed were provided to the subjects. The initial 3 week run-in phase consisted of a control diet designed to be the equivalent to the typical American diet, i.e., low in fruits, vegetables and low fat dairy and high in fat. Following the three week run in period subjects were randomly assigned to one of three diets for an
eight week period. The subjects either remained 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 fats and cholesterol (the DASH diet). Each diet contained a different nutrient profile. The control diet reflected potassium, magnesium and calcium levels near the 25th percentile of U.S. consumption and a macronutrient profile comparable to that of the average America. 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 DASH diet reflected potassium, magnesium and calcium levels near the 75th percentile of U.S. consumption and was moderate in protein, high in fiber and low in fat and cholesterol. All three diets had comparable sodium levels at 3 grams 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 in groups on the fruits and vegetable based diets were seen in as little as two weeks. When compared to the control group the DASH diet group showed the greatest changes in systolic and diastolic blood pressure in prehypertensive and hypertensive adults with changes of 5.5mmHg and 3.0mmHg respectively as well as changes of 3.5mmHg and 2.1mmHg in normotensive patients. The diet high in fruits and vegetables also showed significant changes in systolic and diastolic blood pressure when compared to the control group, but these changes were not as great as those with DASH.

In 2003 the PREMIER study was conducted as a follow-up to the DASH study to determine whether individuals could follow a DASH diet when given instructions under free-living conditions. The design of the Premier study was a randomized clinical trial of 810 adults with above optimal blood pressure who were not taking antihypertensive medications (Appel, et al., 2003). The patients were randomized into one of three intervention groups. The first intervention group was the “established”
group, which was a behavioral intervention that implemented established recommendations; the second group was the “established plus DASH”, which also implemented the DASH diet; the third group was an “advice only” comparison group. The “established” and “established plus DASH” differed from each other with respect to certain dietary goals and the strategies to achieve weight loss. Only the participants in the “established plus DASH” intervention received instruction and counseling on the DASH diet.

The PREMIER trial documented that individuals with above-optimal blood pressure, including stage 1 hypertension, could make multiple lifestyle changes that lowered blood pressure and controlled hypertension (Apple, et al., 2003). Both behavioral interventions resulted in significant weight loss, reduced sodium intake and increased physical fitness compared to the advice only group. Individuals assigned to the “established plus DASH” intervention also made dietary changes consistent with the DASH diet, i.e. increased their intake of fruits, vegetables and dairy products. The PREMIER study also showed changes in blood pressure across the three groups with the smallest reduction occurring in the “advice only” group while the greatest reduction occurred in the “established plus DASH” group. The “established” and “established plus DASH” interventions also reduced blood pressure in individuals with pre-hypertension.

Notably, the blood pressure reductions achieved in the PREMIER study in the “established plus DASH” and the “established” interventions were less than previously found in the DASH feeding study and were not significantly different from each other. The author’s site several reasons for this lack of significance including the fact that subjects were not provided with all of the foods for their meals and snacks and that the established plus DASH had a lower percentage change in fruit and vegetable intake compared to that achieved in the DASH feeding study. Notable, the PREMIER trial demonstrated the
feasibility of a behavioral intervention for increasing fruit and vegetable intake and the beneficial effects increasing these foods have on blood pressure in hypertensive individuals.

The rising rates of adolescent hypertension prompted the National High Blood Pressure Education Program (NHBPEP) to construct guidelines for the management of pediatric hypertension. The NHBPEP advocated the DASH diet as a means of lowering blood pressure in children and adolescents with pre-hypertension and primary hypertension despite the fact all of the data to support the blood pressure lowering effects of the DASH diet has been reported in adults only (NHBPEP, 2004). Although the DASH diet was being advocated for children and teens to manage blood pressure 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. In order to determine if the DASH diet was appropriate for adolescents Couch and Colleagues 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 stage 1 hypertension (Couch, et al., 2008). Adolescents aged 11-18 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 the nutrient needs of adolescents were met. Routine care subjects were encouraged to consume a general diet consistent with the NHBPEP’s guidelines at the time, which encouraged the majority of servings from fruits and vegetables, grains, lean meats and low-fat dairy products. DASH participants were encouraged to gradually achieve eight servings of fruits and vegetables per day, three servings of low-fat dairy foods per day, and no more than two servings of foods with greater than 3g fat per serving and/or greater than 480 mg sodium per day. Serving size recommendations for all recommended food groups were given to the DASH participants.
The routine care intervention consisted of one 60-minute face to face counseling session with a dietitian, the subject, and a parent. Subject’s received a booklet that promoted dietary sodium reduction to a level of 2400 mg 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 60 minute face to face counseling sessions with a dietitian and a parent. During this session the subject received a ten module, illustrated manual and supplemental materials were provided and reviewed. These materials detailed the DASH diet, providing food lists and tips for including DASH foods into their daily diet, and included self-assessments to support the subjects in adapting their current diet to be in line with the DASH dietary pattern. In order to determine the subjects progress toward goals, the 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, which were foods with greater than 3g fat per serving and/or greater than 480mg sodium. 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.

Findings from the study done by Couch and Colleagues showed a greater reduction in systolic blood pressure and systolic blood pressure z-scores in the DASH participants compared to routine care participants from baseline to post-intervention (Couch et al. 2008). Among DASH participants the systolic blood pressure change was -7.9% versus -1.5% in the routine care group. Fifty-percent of DASH participants compared with 36% of routine care patients reached normalization of blood pressure. By the 3-month follow-up, 61% of DASH subjects had normal blood pressures compared with 44% of the routine care subjects. Not only were changes in blood pressure observed but there were also significant changes to diet and nutrient intake. 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.

The different components of the DASH intervention e.g., food tracking and goal setting were not examined as mediators of change in blood pressure in this study; however it could be expected that some of the behavioral skills learned in the intervention were a contributor to positive study outcomes. Given that dietary behavior change in children and adolescents is difficult to achieve, identifying which components of the behavioral intervention, if any, contributed to the program’s success is warranted. With this knowledge healthcare professions may be able to design effective dietary intervention programs to help overcome diet related risk factors and diseases.

**Skills Associated with Healthful Dietary Compliance in Youth**

Behavioral skills related to adherence to diet therapy have mostly been examined in weight loss intervention trials. Dietary self-monitoring has been one of the most widely studied of these skills. In general, weight loss studies in adults and children have shown that more compared to less frequent self-monitoring of dietary intake has been consistently and significantly associated with the degree of weight loss (Burke, et al., 2011). Self-monitoring can be defined as the systematic observation and recording of targeted behaviors in an intervention (Germann, et al., 2007). Self-monitoring of dietary intake usually refers to writing down of all the foods and beverages one consumes throughout the day along with the amounts of food. 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, et al., 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 in this study received self-monitoring booklets to record their intake. Within these booklets they were to record time of eating, the food or beverage consumed with an amount, and how many calories the foods eaten contained. The results showed 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 calories compared to those who did not monitor these factors. The findings of this study also demonstrated that greater percentages of weight were lost by subjects who monitored more consistency and completely (included descriptions and amounts).

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. 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.

The behavior of self-monitoring is learned and studies suggest that once this behavioral skill has been learned and proves efficacious (e.g., helps the person lose weight), individuals can maintain the positive outcome using a simpler 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 both groups the subjects recorded their eating and exercise behaviors for sixteen weeks. In the detailed group, subjects were instructed to record the types, quantities, kilocalories, and fat grams of the food consumed daily. They were also instructed to record the type, duration and intensity of exercise daily. The transitional 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, ranging from less than 15 minutes, 16-30 minutes or 31-45 minutes. The results of this study demonstrated that both the detailed and abbreviated forms of self-monitoring led to similar and significant amounts of weight loss. (Helsen, et al., 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 remind participants to track, those that received reminders were more consistent in self-monitoring than those that did not receive reminders (Boutelle, et al., 1999). As part of a behavioral intervention to evaluate the relationship
between self-monitoring and the adoption of a low glycemic index (GI), 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 the GI and carbohydrate values of the food consumed, and amount of physical activity performed. The results of this study showed the number of days of self-monitoring, with any level of detail, was positively associated with a mean weight loss of -0.95kg (95% CI). These results support encouraging diary intervention participants to self-monitor for as many days in the week as possible to achieve the most benefit.

While the results of these studies support a positive relationship between the quantity and quality of dietary self-monitoring and positive health outcomes in adults, few studies have examined these same relationships in youth. Saelens and colleagues (2002) examined daily tracking of specific foods, amounts, calories, and categories of food in a behavioral weight control intervention for obese adolescents. The participants were randomly assigned one of two groups: multiple component weight counseling or a single session of physical weight counseling. These researchers found that greater recording sufficiency (recording for at least 5 days with at least 5 foods per day), in particular recording more days versus fewer days and summing the calories of foods eaten were related to lower dietary fat intake and better weight control in the adolescents of the multiple component group. Saelens et al (2003) performed a follow up study in which adolescents received either a single session in clinic weight counseling or a phone and mail based intervention for weight control. Throughout the intervention, adolescents were encouraged to self-monitor all food and beverages consumed. Results from the study were interpreted using five self-monitoring indexes. These included: “mean days recorded”, “recording sufficiency”, “recording amounts of food eaten”, “recording calories for foods eaten”, and “summing calories for foods eaten”. The results of the study determined that recording sufficiency in regards to self-monitoring was the only self-monitoring behavior studied that was related to change in adolescent’s
relative weight. A greater mean recording sufficiency was significantly related to lower BMI scores at post treatment and follow up. This supports teaching youth self-monitoring behavioral techniques and having them recording as many days as possible completely in the week to promote improved adherence to behavioral interventions and enhance health outcomes in response to the intervention.

The research sited above supports dietary self-monitoring as a useful tool to promote dietary adherence in nutrition intervention programs. However, there have been few clinically-based interventions focusing on the treatment of hypertension in adolescents. There is also a lack of studies in which dietary self-monitoring has been used to track more than fat or calories. Many interventions are currently attempting to improve overall dietary patterns to manage disease conditions as opposed to just certain nutrients and diet quality. The DASH diet, for example, encourages increasing certain foods while decreasing others. There are currently not studies in which dietary self-monitoring has been examined to determine the utility of this behavioral skill to improve overall diet quality or dietary patterns to be more healthful, particularly in children.

I. Purpose

The behavioral skill of dietary self-monitoring has been used successfully to improve compliance to calorie and nutrient controlled diets in children. However, the usefulness of this behavioral approach in promoting adherence to diets requiring food pattern changes, such as those required in the DASH diet, has not been evaluated in children.

This study will examine the relationship between compliance to dietary self-monitoring among participants in a behavioral nutrition intervention focused on the DASH diet to lower blood pressure (DASH-4-Teens) and compliance to the DASH diet, as measured by change in DASH score from pre- to post-intervention. The study will also examine the relationship between the use of a detailed food
tracking form versus the use of a simpler goal tracker form to self-monitoring and change in overall DASH score from pre- to post-intervention.

It is hypothesized that adolescents who have higher compliance to self-monitoring will have a greater increase in DASH score from pre to post-intervention when compared to those who have a low or moderate level of compliance to dietary self-monitoring. It is also hypothesized that the type of tracking (e.g., using a detailed form or simple goal tracking form) will not play a role in the change in DASH score.

II. Methods

Recruitment

Adolescents between the ages of 11-18 years were recruited from the Cincinnati Children’s Hypertension Clinic (CCHC). The CCHC is a referral program for the diagnosis and treatment of children with hypertension. Children are admitted to the CCHC after being referred by their primary health provider after a systolic blood pressure (SBP) or diastolic blood pressure (DBP) reading above the 90th percentile for their age and height has been attained. For this study, eligible adolescents must have presented with a clinical diagnosis of pre-hypertension or stage 1 hypertension based on criteria established by the NHBPEP Working Group on High Blood Pressure in Children and Adolescents (2004). According to this criteria stage 1 hypertension is defined as an average SBP or DBP that is ≥95th percentile for gender, age and height on 3 separate occasions. Pre-hypertension is defined as an average SBP or DBP level that is ≥90th percentile but <95th percentile for gender, age and height on at least 3 separate occasions.

Subjects

The subjects and the data evaluated in this thesis were a subset of an ongoing randomized clinical trial examining the efficacy of a six month telephone and mail based behavioral nutrition
intervention initiated in clinic (the DASH-4-Teens trial) emphasizing the DASH diet on blood pressure change in adolescents with pre-hypertension and hypertension (Kampman, 2011). During the DASH-4-Teens trial the teens were assessed at baseline, 6 months immediately after the intervention, and post treatment or 18 months. The baseline and 6 month data from subjects who participated in the DASH-4-Teens intervention from March 2008-November 2011 were included in this thesis. Participants in the Usual Care group were not included in this thesis since they were not asked to self-monitor their diet during the intervention.

There were 41 subjects from the DASH-4-TEENS intervention whose data were used to address the research questions proposed in this thesis. The CCHMC and University of Cincinnati Institutional Review Board approved all study methods. Consent to participate in this study was obtained from all adolescents over 18 years of age as well as assent from adolescents under 18 years of age.

**Exclusion Criteria**

Adolescents were excluded if they did not have a diagnosis of pre-hypertension or stage 1 hypertension, were being treated with anti-hypertensive medication or had received prior formalized diet therapy to manage their blood pressure. Adolescents that presented with secondary causes of hypertension such as, renal disease or diabetes were also excluded. Other exclusion criteria included the use of medications known to alter blood pressure, were unwilling to stop the use of vitamins, minerals or antacids containing magnesium or calcium, did not speak English, had a psychological or medical condition that may preclude them from full participation, had a diagnosed eating disorder or did not have full medical clearance from a physician to participate.

**Study Design and Intervention**
The DASH-4-TEENS interventions included a behavioral nutrition education program that emphasized a version of the DASH diet that was modified slightly from the original formulation for adults to adjust to the nutritional recommendations of adolescents (Table 1).

### Table 1. DASH-4-Teens Food Plan

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th></th>
<th></th>
<th>Male</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>1600</td>
<td>1800</td>
<td>1800</td>
<td>2200</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>11-13</td>
<td>14-18</td>
<td>11-13</td>
<td>14-18</td>
<td></td>
</tr>
<tr>
<td>Daily Serving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recommendations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains</td>
<td>5 oz.</td>
<td>6 oz.</td>
<td>6 oz.</td>
<td>7 oz.</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>2 cups</td>
<td>2.5 cups</td>
<td>2.5 cups</td>
<td>3 cups</td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>1.5 cups</td>
<td>1.5 cups</td>
<td>1.5 cups</td>
<td>2 cups</td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>3 cups</td>
<td>3 cups</td>
<td>3 cups</td>
<td>3 cups</td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>5 oz.</td>
<td>5 oz.</td>
<td>5 oz.</td>
<td>6 oz.</td>
<td></td>
</tr>
<tr>
<td>Nuts/seeds</td>
<td>¼ cup</td>
<td>¼ cup</td>
<td>¼ cup</td>
<td>¼ cup</td>
<td></td>
</tr>
</tbody>
</table>

The intervention emphasized several behavioral strategies to promote dietary change including food monitoring, goal setting, action planning, problem solving and decision making. At baseline patients went to the hypertension clinic for a 60 minute face to face counseling session with a dietitian. During this session, they received the DASH-4-TEENS manual containing information about the DASH diet, DASH serving recommendations, meal planning and label reading. The adolescent’s parent received fact sheets about the DASH diet and these were reviewed. The adolescent also received their food monitoring forms and were counseled on how to properly monitor their intake for 5 out of 7 days.
each week during the intervention. During weeks 2-10 of the intervention, the adolescents received weekly phone calls that were designed to monitor their food tracking skills, help them set food goals, come up with an action plan for meeting goals, self-reward, obtain social support, and handle high risk situations. During this time they also received bi-weekly mailings that reviewed these same behavioral skills. On week 12 the adolescent returned to the hypertension clinic for an in clinic 30 minute face to face meeting with a dietitian. During that time the dietitian assessed their dietary intake, reviewed their progress on goals and provided feedback. The dietitian also helped the adolescent to set new food goals, revise their action plan, and encouraged self-monitoring. The adolescent received biweekly phone calls for the next 12 weeks in which the discussion covered eating out, meal planning, long term planning and how to prevent relapse. During this time the teen also received monthly mailings. At week 24 a follow up face to face counseling session with a registered dietitian at CCHC was completed and post-treatment assessment measures were collected as described below.

**Assessment Measures**

Assessment measures were collected at baseline and 6 months (immediately post-intervention) unless otherwise noted.

**Dietary Intake and DASH Score**

Three 24 hour dietary recalls were collected by telephone from each participant on unannounced, random, non-consecutive days. All dietary data were then analyzed using the Nutrient Data System for Research (NDSR) software (Univ. Minnesota, Minneapolis, MN; Version 2.91 2008). The NSDR Serving Food Count File was used to calculate total daily servings from the following food groups: fruit, vegetables, total grains, whole grains, low-fat dairy, total dairy, total meat/poultry/fish/eggs, fats/oils, nuts/seeds/legumes and sweets. DASH adherence was assessed with an index variable, developed by Gunther et al (2009) that was comprised of the previously mentioned food groups (see
table 2). For each food group, a maximum score of 10 could be achieved when a participant’s intake met DASH recommendations, whereas lower intakes were scored proportionately (US Department of Health and Human Services, National Institutes of Health, National Heart Lung and Blood Institute 2006).

According to the DASH eating plan, lower intakes of meat/poultry/fish/eggs, fats/oils and sweets were favored. For these food groups reverse scoring was applied, where a score of 0 was applied to intakes >200% of the upper recommended level. To more closely reflect the recommendations of DASH, the grain and dairy components were divided into 2 items to reflect the recommendation to eat at least 50% of total grains as whole grains and consume at least 75% of dairy as low fat dairy foods. Daily food goals for the DASH index were based on calorie levels consistent with the Dietary Reference Intakes for males and females, ages 11 – 18 years for a sedentary activity level (Food and Nutrition Board of the Institute of Medicine, 2005) The resulting DASH component scores were summed to create the overall DASH adherence score, which could range from 0 to 80. Details of the index and components can be found in Table 2.

Table 2. The DASH Index and Components

<table>
<thead>
<tr>
<th>DASH Score Components</th>
<th>Maximum Score</th>
<th>Standard for Maximum For 1600 kcal diet</th>
<th>Standard for Maximum For 1800 kcal diet</th>
<th>Standard for Maximum For 2200 kcal diet</th>
<th>Standard for Minimum For 1600 kcal diet</th>
<th>Standard for Minimum For 1800 kcal diet</th>
<th>Standard for Minimum For 2200 kcal diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>------------------</td>
<td>----</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Whole</td>
<td>5</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vegetables</td>
<td>10</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fruits</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dairy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Low-fat</td>
<td>5</td>
<td>2.25</td>
<td>2.25</td>
<td>2.25</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Meat, poultry, fish, eggs</td>
<td>10</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Nuts, seeds, legumes</td>
<td>10</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Sweets</td>
<td>10</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*Energy recommendations were for a sedentary activity level for males and females 11-18 years.

**Self-Monitoring**

Throughout the 24 week intervention participants set weekly dietary goals and developed specific strategies to achieve goals based on the DASH manual and food plan. Dietary goals were emphasized on each weekly counseling phone call, and the participants were encouraged to maintain a detailed food record to determine their progress toward meeting intervention goals. Along with their self-monitoring booklets the participants received instructions stating that they needed to record the
time the food or beverage was consumed, a description of the food or beverage, the amount of food or beverage, and whether the food or beverage was a fruit, vegetable, low fat dairy product or a DASH unfriendly food (contained >3 grams of fat and 480 mg of sodium per serving). If an adolescent did not return a food record form after two weeks they received a simpler goal-tracking form. This form included an area for the adolescent to simply check off the number of servings of consumed fruits, vegetables and low fat dairy they consumed each day. The form also included a space for the adolescent to write the DASH unfriendly foods they consumed per day.

Once the self-monitoring booklets or food trackers were turned in they were reviewed by the study dietitian for food goals achieved. This information was used to determine the amount of weekly incentive $ earned by the participant. Participants could earn $2.00 for returning their food tracking booklets or goal tracking forms and earn an additional $2 for meeting their weekly food goals for fruits, vegetables, low fat dairy foods and DASH unfriendly foods. The subjects were asked to record their intake for 5 out of 7 days per week for a total of 120 possible recording days.

**Study Covariates**

**Blood pressure measurements/Hypertension Status**

Blood pressure was collected at 3 separate times over a 2 week period by trained nursing personnel using a mercury sphygmomanometer according to the procedures outlined in the Fourth Pediatric Report on Hypertension (2004). The mean of blood pressures was used to classify participants based on hypertension status: pre-hypertensive = SBP or DBP >90th percentile and <95th percentile for age, gender and height; stage 1 hypertensive = SBP or DBP >95th percentile and <99th + 5 mm Hg for age, gender and height.

**Demographic Information**
Demographic information was collected by self-report from the subjects at baseline. The information included; birth date, gender and ethnicity. Along with the adolescents the parents also self-reported on ethnicity, marital status, highest level of education, and household income.

**Anthropometric measurements**

Trained nursing personnel blinded to treatment measured each participant’s weight using a triple-beam balance scale. Standing height was measured using a wall-mounted stadiometer. From these measures, BMI was calculated as weight in kilograms divided by height in meters squared. BMI z-score were determined from Centers for Disease Control growth charts.

**Statistical Analysis**

Subjects included in these analyses were study completers (those with baseline and post-treatment, e.g., 6-month data). Means and standard deviations were derived at baseline and post-treatment for continuous variables. Distributions of the residuals were checked for normality assumptions and based on these findings; all variables were found to be normally distributed. Frequencies were run to determine percentage of subjects who kept detailed and simple tracking forms (referred to in the results section as “any tracking”) and only detailed tracking forms (referred to in the results as “detailed tracking only”), and level of compliance to any tracking and detailed tracking only. Analysis of variance followed by the Tukey Kramer post-hoc test was used to compare change in DASH score by level of compliance to tracking. Mixed effects models were then used to assess relationships between degree of compliance to tracking and change in total DASH score (baseline to post-treatment). Final models were adjusted for age, gender, race, income, hypertension status, initial DASH score and BMI z-score. 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.

**III. Results**
Table 3 describes the DASH-4-Teens baseline participant characteristics and pre- and post-treatment DASH score. Over half the participants were African American /other (56%), and male (65.8%). The majority of participants had stage 1 hypertension (78%), and were middle income ($20,000-50,000; 71%). The average pre-intervention DASH score was 35.0 and the average post-intervention DASH score was 44.4. These DASH scores reflect values that are 43.8% and 55.5%, respectively of the highest possible score. Average BMI z score of the group reflects a moderate level of obesity (Danielsson et al., 2012).

<table>
<thead>
<tr>
<th>Table 3. DASH-4-Teens Participant Characteristics at Baseline and Pre and Post Treatment DASH Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>Age, years mean (SD)</td>
</tr>
<tr>
<td>Gender, n</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Race, n</td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>African American</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>BMI, kg.m2</td>
</tr>
<tr>
<td>BMI z-score, mean (SD)</td>
</tr>
<tr>
<td>Hypertension Status, n</td>
</tr>
<tr>
<td>Pre-Hypertension</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Stage 1 Hypertension</td>
</tr>
<tr>
<td>Income, n</td>
</tr>
<tr>
<td>&lt;20,000</td>
</tr>
<tr>
<td>20,000-50,000</td>
</tr>
<tr>
<td>&gt;50,000</td>
</tr>
<tr>
<td>Pre-intervention DASH Score, mean, (SD)</td>
</tr>
<tr>
<td>Post-intervention DASH Score, mean, (SD)</td>
</tr>
</tbody>
</table>

**Compliance to Food Monitoring**

Figure 1 shows the mean number of days the DASH-4-Teens participants recorded their dietary intake using either the detailed food tracking booklet only (detailed tracking) or the detailed food tracking booklet and the goal tracking form (any tracking). On average, DASH participants self-monitored using the detailed tracker only on 36% of the 120 intervention days or 43.48 days. Those that did any tracking did so on 47.5% of the intervention days or 54 days.
Figure 1. Mean number of days recorded by all DASH-4-Teens participants. The number of intervention days (120) depicts the total number of days the subjects (n=41) could complete tracking. Any tracking refers to those who completed any tracking (goal tracker and/or detailed food tracker) (n=26). Detailed tracking refers to those who completed only the detailed food tracker (n=15).

Figure 2 shows the percentage of participants classified as having low, moderate or high compliance to dietary self-monitoring-using any type of tracker. Approximately two-thirds of participants were at least moderately compliant to tracking using either of the two tracking forms.

As shown in Figure 3 when dietary self-monitoring percentages were calculated considering only those who kept the detailed food tracker over half of the participants were low/non-compliant to tracking.
Figure 2. Days Recorded Any Tracking

Figure 2 Compliance to dietary self-monitoring: Percentage of days recorded by participants (n=41) out of a possible 120 treatment days by completing tracking booklets and/or goal tracking forms (any tracking). Low compliance=0-33% out of the possible 120 possible intervention days, moderate compliance=34-67% out of the possible 120 possible intervention days, high compliance=68-100% out of the possible 120 intervention days.

Figure 3. Days Recorded Detailed tracking
**Figure 3** Percentage of days recorded by participants (n=41) out of a possible 120 treatment days by completing food tracking booklets only. Low compliance=0-33% out of the possible 120 possible intervention days, moderate compliance=34-67% out of the possible 120 possible intervention days, high compliance=68-100% out of the possible 120 intervention days.

**Relationship between Compliance to Food Monitoring and Change in DASH Score**

Table 4 shows change in mean DASH score (baseline – post-treatment least square means, where a more negative value = greater change in DASH score) by level of compliance to any food tracking or with use of the detailed tracker only. These results show that regardless of tracking type, those that did a low level of tracking had a significantly smaller mean change in DASH score compared to those that did a moderate or high level of tracking.

| Table 4. Change (post-treatment-baseline) in mean DASH score by level of compliance to tracking |
|---------------------------------|---------------------------------|---------------------------------|
|                                 | Low compliance                  | Moderate Compliance | High Compliance |
| Any tracking                    | 6.97 (2.8) a, b, c              | 12.96 (3.65) a, b     | 14.83 (3.65) a, c |
| Detailed Tracking only          | 2.67 (2.84) a, b, c             | 11.22 (2.84) a, b     | 12.45 (3.12) a, c |

a b c = Change in DASH score is significantly different in low compared to moderate, and low compared to high compliant individuals (p<.05 for low versus moderate; p<.01 low versus high); a b = change in DASH score is significantly different in low compared to moderate compliant individuals (p<.01); a c = change in DASH score is significantly different in low compared to high compliant individuals (p<.01).

Table 5 presents results of the mixed effects models to address the question of whether greater compliance to dietary self-monitoring is related to change in DASH score (post-post-treatment - baseline) using either the detailed food tracker and/or goal tracking form (any tracking). In the mixed effects models, low versus moderate compliance to any tracking predicted a smaller change in DASH score (p=0.0033), as did low versus high compliance to any tracking (p=0.0003). Moderate versus high compliance to any tracking did not predict a significant difference in DASH score change (p=0.6652).

Table 5 also indicates that low versus moderate compliance with the detailed tracking form predicted a
smaller change in DASH score (p=0.05), as did low versus high level of compliance (p=0.0102). Moderate versus high compliance did not predict a significant difference in change in DASH score change (p=0.5956).

Table 5.

Food Monitoring Compliance as a Predictor of Change in DASH Score from Baseline*

<table>
<thead>
<tr>
<th>Food Monitoring Variables</th>
<th>Estimate</th>
<th>SE</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance to Any tracking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low versus Moderate</td>
<td>-8.5292</td>
<td>2.6686</td>
<td>0.0033</td>
</tr>
<tr>
<td>Low versus High</td>
<td>-9.7650</td>
<td>2.4001</td>
<td>0.0003</td>
</tr>
<tr>
<td>Moderate versus High</td>
<td>-1.2358</td>
<td>2.8279</td>
<td>0.6652</td>
</tr>
<tr>
<td>Compliance to Detailed tracking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low versus Moderate</td>
<td>-6.0012</td>
<td>2.9703</td>
<td>0.0527</td>
</tr>
<tr>
<td>Low versus High</td>
<td>-7.8616</td>
<td>2.8624</td>
<td>0.0102</td>
</tr>
<tr>
<td>Moderate versus High</td>
<td>-1.8604</td>
<td>3.4665</td>
<td>0.5956</td>
</tr>
</tbody>
</table>

* Compliance to the skill of food monitoring was defined as follows: self-monitoring using the food tracking booklet/goal tracking form over 0-33% of intervention days was considered low compliance, over 34-67% of intervention days was considered moderate compliance, and over 68-100% of intervention days was considered high compliance.

*Comparisons adjusted for age, race, gender, BMI Z score, HTN status and income.

VI. Discussion
Several nutrition intervention studies have shown that dietary self-monitoring is an essential skill for promoting dietary compliance and change in calories and single nutrient outcomes, such as total and saturated fat in both adults and children (Burke, Wang, & Sevick, 2011; Baker & Kirschenbaum, 1993; Miller et al., 2009; Saelens et al., 2002, 2003). In the present study adolescents who were compliant with the behavioral skill of dietary self-monitoring at least to a moderate level compared to those with low or no compliance to the skill achieved a greater change in overall DASH score over the intervention period. This finding supports the importance of dietary self-monitoring, at least to a moderate extent, in promoting changes in overall dietary patterns in this case toward a more heart healthy DASH diet.

Adapting one’s diet to be more DASH-like has proven effective in lowering blood pressure in at risk adults (Appel, 1997) and youth (Couch et al., 2003). Findings from the present study suggest that dietary self-monitoring can be a valuable adjunct to other behavior skills in promoting healthful dietary change when used as part of a therapeutic nutrition intervention program to lower blood pressure in adolescents with pre-hypertension and hypertension. These findings are important in light of the fact that adolescents often don’t comply with dietary treatment in intervention trials. For example, in a study conducted by Sinaiko et al in 1993, none of the girls or the boys participating in a sodium reduction trial were successful in reaching the target level of sodium established by the researchers per day. Others have reported similar discouraging results when assessing dietary compliance in studies of blood pressure reduction trials in adolescents (Simons-Morton, Obarzanek 1997), limiting the ability to draw valid conclusions from these studies. The finding in the present study that even a moderate level of compliance to dietary self-monitoring may improve compliance to diet therapy is an important contribution to the literature and may help other researchers and health care professional promote improved adherence to treatment in their dietary trials.
Participants in the current study were given training material and training sessions to help grasp the skills of food tracking. The skill of tracking foods was introduced to the participants by a DASH research assistant in a face-to-face counseling session. Food tracking forms were reviewed with participants each week by phone and feedback on tracking was mailed to the participants to improve their tracking skills. If participants did not complete tracking for two weeks they were then offered use of a less detailed goal tracking form to track their progress toward meeting intervention goals. In this trial, the training materials, participant training, and feedback contributed to approximately 63% of the participants tracking for more than a third of intervention days. This finding supports the utility of the participant training elements described in this investigation for instruction on dietary self-monitoring to increase compliance to this behavioral skill.

In the present study there was a higher percentage of adolescents who were not compliant to the use of the more detailed tracking form compared to those that used the combination of simple and detailed forms for tracking. The detailed tracking form may be difficult for younger children to master, or may be too tedious and time consuming to keep the attention of a teenager. Participants in this dietary trial represented a large age range (11-18 years); the small subject number, however, does not allow ample power to examine whether age was a significant predictor of compliance to the self-monitoring skill. This would be important to assess in a larger study. Also, it is not clear from this study if the goal tracking form on its own may have contribute to a higher DASH score as compared to the detailed food tracking form. Participants were only offered the simple form after they had “failed” at keeping track of their intake with the detailed record form. Given the fact that the simpler form was likely easier to learn and involved less time to complete, it would be worthwhile to examine whether the simple tracking form if used solely to record dietary intake could achieve similar benefits in terms of dietary change.
The number of days of food tracking was an important factor related to positive dietary outcomes in this study. At least 40 days of food tracking compared to less was positively related to a higher level of dietary compliance. In a study by Miller and colleagues (2009) it was found that a mean average of 3.7 days a week of self-monitoring, with any level of detail of recording, was positively associated with a mean weight loss. Notably, in the present study, there was no difference between a moderate level of tracking and a high level of tracking. This finding has importance in that it shows that it may not be necessary to self-monitor every day throughout an intervention to achieve dietary change. A moderate level of self-monitoring may be enough to produce positive outcomes. Encouraging adolescents to monitor their intake as part of a dietary intervention program for at least a third of the intervention days regardless of detail is important to achieve a significant dietary benefit.

There were several limitations of the present study that should be noted. There are many factors that are potential mediators of dietary changes in the present study that were not considered as covariates in the study analyses. For example, change in physical activity level, home food environment, and weight status should be considered in future studies. The small sample size may have limited the ability to determine significant associations where they exist and to examine sub-group associations with dietary change such as with older versus younger adolescents. These would be important to complete in future trials. 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. This study provides evidence suggesting that a moderate level of self-monitoring compared with low or no self-monitoring achieved a greater change in overall DASH score and dietary patterns. These findings add valuable insight to our understanding of the relationship between the DASH diet and self-monitoring in youth.
References


Wilson, DK & Ampey-Thornhill, G. The Role of Gender and Family Support on Dietary Compliance in African American Adolescent Hypertension Prevention Study.