I, Brittany M Reinert, 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 Home Mealtime Behavior and Availability and Accessibility of Healthful Foods in the Home and Adherence to a Blood Pressure Lowering Diet among Adolescents with Hypertension

Student's name: Brittany M Reinert

This work and its defense approved by:

Committee chair: Sarah Couch, Ph.D.

Committee member: Graciela Falciglia, Ph.D.
The Relationship between Home Mealtime Behavior and Availability and Accessibility of Healthful Foods in the Home and Adherence to a Blood Pressure Lowering Diet among Adolescents with Hypertension

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 Master of Science in the Department of Nutrition Sciences of the College of Allied Health Sciences 2012 by

Brittany M. Reinert B.S., University of Dayton 2011

Committee Chair:
Sarah C. Couch, PhD, RD
ABSTRACT

Objective: While there have been some studies examining relationships between home food environment (HFE) factors and adolescent’s dietary quality, there are no studies that have examined aspects of the HFE in relation to compliance to therapeutic diets to manage health problems, such as high blood pressure in youth.

Purpose: This randomized clinical trial explored the relationship between factors within the HFE of adolescents and change in dietary quality in response to a therapeutic nutrition intervention emphasizing the Dietary Approaches to Stop Hypertension (DASH) dietary pattern to lower blood pressure in adolescents with elevated blood pressure.

Method: Participants were adolescents aged 11 to 18 years with diagnosed pre-hypertension or hypertension who participated in a 6–month clinic-based nutrition intervention focused on either the DASH dietary pattern (DASH, n=26) or standard guidelines for blood pressure management (usual care, n=24). Demographics and HFE factors were measured pre-intervention by parent report and included family meal time behaviors, healthful versus unhealthful food availability and accessibility in the home, and frequency of home cooked meals and take-out. Dietary intake was measured pre-and post-intervention by 3 day recall and diet quality indicators included change in DASH score and DASH component scores for fruits, vegetables, low fat dairy foods and sodium. Multiple linear regression analysis adjusted for HFE and demographic factors and child BMI z-score were used to examine relationships.

Results: Change in DASH score and DASH sodium score were positively associated with frequency of sitting together at meals (trend, p<0.10). Change in DASH sodium score was negatively related to frequency of fast food intake at baseline (trend, p<0.10). Frequency of having vegetables, fruits and low fat foods with meals, and availability and accessibility of
healthful foods in the home were positively associated with change in DASH vegetable score (p<0.05 for all).

**Conclusion/Application:** These findings suggest that adherence to a therapeutic DASH dietary pattern may be related to sitting down for meals as a family, eating out less frequently and having more healthful foods available and accessible in the home. These HFE factors should be considered in the design of interventions directed at improving adolescent eating behaviors toward blood pressure management.
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INTRODUCTION
Hypertension is a growing public health concern in the United States. Although previously adolescence was considered to be a period in the lifecycle associated with low risk of developing hypertension, the prevalence of this health problem is increasing in this age group. Pediatric hypertension is defined as a systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) ≥ the 95th percentile for age, gender and height (Musil V., 2012). In pediatrics, there is also a classification of pre-hypertension which is defined as a SBP and/or a DBP at or above the 90th percentile but below the 95th percentile for age, gender, and height. Children with pre-hypertension are at high risk of developing hypertension, and therefore, early intervention is recommended for these youth as well as those with hypertension.

Risk factors for pre-/hypertension include poor diet quality and lack of physical activity (Musil, V. 2012). An unhealthful food environment in the home has been shown to contribute to poor diet quality among youth, specifically low intakes of vegetables, fruits, whole grains, and low fat dairy and high intakes of sodium and fats (Aeberli et al. 2007). This dietary pattern has been correlated with high blood pressure in adults and youth (Aeberli et al. 2007). Poor diet quality may impact blood pressure directly through a variety of biological mechanisms (Christofaro DG et al., 2011). Therefore lifestyle approaches to modify diet quality may favorably impact blood pressure.

The Dietary Approaches to Stop Hypertension (DASH) diet, composed of high amounts of fruits and vegetables (8-10 daily servings), and low fat dairy foods (3 daily servings) and low amounts of sodium and high fat foods has been shown to lower blood pressure and weight status in adults (Karanja et al, 1999) and preliminary evidence suggests that it may be equally effective in adolescents (Couch et al., 2008). However, it is not clear whether adolescents can achieve and maintain a DASH dietary pattern given that their current daily intake is well below the DASH
serving recommendations (Couch et al, 2008). There is some research to suggest that an adolescent’s diet quality can be improved significantly by modifying aspects of the home food environment (Ventura AK and Birch LL, 2008). However, which aspects of the home food environment significantly impact a teen’s ability to comply with a DASH dietary pattern has not been ascertained. This study will examine family mealtime behaviors and availability and accessibility of healthful foods in the home to determine whether these aspects of the home food environment impact compliance to a DASH dietary pattern among youth with pre-/hypertension enrolled in a blood pressure lowering program.
REVIEW OF LITERATURE

Hypertension – a growing public health crisis in youth

Hypertension is of growing concern in the U.S. population as obesity and cardiovascular disease (CVD) rates climb rapidly amongst children and teens. Once viewed as a subgroup of the population at low risk of diabetes, metabolic syndrome, and CVD, children and adolescents are now known to be at increasingly greater risk than several decades ago of these chronic diseases due to many factors including poor eating habits, lack of exercise, and an unhealthy food environment.

Developed countries are experiencing dramatic changes in CVD morbidity and mortality due to rising rates of hypertension. Estoppey (2011) estimated that in the US, 75% of the expected increase in the CVD burden would come from hypertension by the year 2020. International epidemiologists have predicted that similar trends will be observed in both Germany and Switzerland because of rising rates of obesity in these countries (Estoppey, D. 2011).

The prevalence rate of hypertension among school-aged children ranges from 2.2% to 19.4%; larger prevalence rates are most often observed in studies that use only one blood pressure measurement to make the diagnosis of hypertension (Musil, V. 2012). Hypertension in children is defined as an average SBP or DBP that is ≥95th percentile for gender, age and height on three separate occasions. SBP or DBP values that are ≥90th percentile but <95th percentile for age, gender and height are designated as high normal or pre-hypertensive and are considered to be indicative of heightened risk for developing hypertension (Musil, V. 2012). Pediatric hypertension is classified as either stage 1 or stage 2. Stage 1 is a SBP or DBP between the 95th-99th percentile for age, gender and height plus 5 mm Hg. Stage 2 is defined as a SBP or DBP
greater than the 99th percentile plus 5 mmHg (Musil, V. 2012). Many studies in the pediatric literature use only one blood pressure reading to diagnose hypertension; this should be noted as a weakness as blood pressure tends to decline with repeated assessment (The National Heart Lung and Blood Institute, NHLBI, 2004).

**Causes of Hypertension in Youth**

One of the major risk factors for hypertension in youth is obesity (Christofaro DG et al., 2011). Children in the U.S. are experiencing an increase in the prevalence of obesity, and this increase has occurred concurrent with hypertension trends over the last decade (Christofaro DG et al., 2011). Children are classified as overweight, according to the Centers for Disease Control (CDC, 2011), if their measured body mass index (BMI) is ≥ 85th percentile and < 95th percentile for children of the same age and sex. The CDC defines obesity in youth as a BMI ≥ 95th percentile for children of the same age and sex. BMI is determined by the child’s weight in kilograms divided by their height in meters squared. Recent statistics show that the rates of hypertension in teenage girls who are obese are double those of girls who are not obese. Likewise, the rates of hypertension in obese adolescent boys are approximately three times as great as those who are not obese (Musil, V. 2012). Recent national predictions on pediatric obesity are that rates will continue to grow; since obesity and hypertension rates in youth are correlated, it is expected that hypertension rates will increase as well (Christofaro DG et al., 2011).

A higher prevalence of elevated blood pressure has been reported among children with larger waist circumference, suggesting that visceral adipose mass may play a role in blood pressure regulation. In a cross-sectional study, Choy et al. (2011) showed that the prevalence of elevated blood pressure for boys and girls was greater for those in the highest quartile of waist
circumference compared to the lowest. These findings suggest that fat distribution, particularly fat that is located in the abdominal region, is a risk factor for hypertension.

Several studies in youth have shown a relationship between poor diet quality and blood pressure elevation. A study done by Aeberli et al. (2007) showed that a high intake of protein from meats was significantly associated with BMI and was a positive predictor of hypertension in adolescents. In an observational study of children’s diets and blood pressure, Obarzanek et al. (2010) found that diets that were low in fiber, potassium, magnesium, and calcium and high in caffeine and calories were significantly associated with high blood pressure. Conversely children who ate more fruits and vegetables in their diet were found to have significantly lower blood pressure. McNaughton et al., (2008) studied three different dietary patterns among children in the US and examined their effect on blood pressure. The first dietary pattern was a fruit, salad, cereals, and fish pattern; the second was a high fat and sugar pattern; and the third was a fried vegetables pattern. The results of the study found that the fruit, salad, cereals, and fish pattern and not the others was inversely associated with DBP, after adjustment for age, sex, and physical activity.

Moore et al. (2005) looked into diets of children that were characterized by high intakes of fruits and vegetables and low-fat dairy products, such as the DASH diet, in relation to their blood pressure measurements. They discovered that when children consumed more fruits and vegetables (4 or more servings per day) or more dairy products (2 or more servings per day) during the preschool years they had smaller yearly gains in SBP throughout childhood. By the time of early adolescence, children with higher intakes of fruits and vegetables and dairy products had an adjusted mean (+/- standard deviation) SBP of 106 +/- 2.9 mm Hg, whereas those with lower intakes in both food groups had a mean SBP of 113 +/- 1.5 mm Hg. Those with
higher intakes of fruits and vegetables alone or dairy alone had intermediate levels of SBP compared to adolescents consuming a diet enriched in both food groups (Moore et al. 2005).

Physical activity has been shown to be low among children with hypertension versus without hypertension. In a study conducted by Aeberli et al. (2007), 6-14 year old normal and overweight children were assessed for dietary intake, physical activity level, and CVD risk factors including blood pressure. These researchers found that time spent watching television and in organized sports activities were significantly correlated with BMI standard deviation score (SDS) and blood pressure. Specifically, when children spent more time watching television their BMI SDS and blood pressure were higher compared to children who were more physically active. These findings suggest that physical activity may decrease the associated risk factors for high blood pressure such as BMI, which in turn may lead to a reduction in blood pressure.

**Therapies for Managing Hypertension in Youth**

Therapies for managing high blood pressure include pharmacological and non-pharmacological approaches. Pharmacological therapies are those that are used to manage blood pressure with medication rather than lifestyle factors such as exercise and diet. Several drugs have been approved for use by the Food and Drug Administration to treat hypertension among children and adolescents. Guidelines for managing pediatric hypertension suggest that medications be used only after a period of diet therapy has been tried, unless the child has stage 1 hypertension with compelling indications (e.g., renal disease, diabetes, or signs of left ventricular hypertrophy) or stage 2 hypertension with or without compelling indications (NHLBI, 2003). It is recommended that pharmacologic therapy begin with a single drug, such as an angiotensin-converting enzyme inhibitor, angiotensin receptor blocker, beta-blocker, calcium channel
blocker, or diuretic (NHLBI, 2003). Liberman et al (2009) examined the success rates of blood pressure medications as well as possible side effects associated with those common blood pressure medications in youth. Among antihypertensive medications, beta-blockers had the highest prevalence of prescription and usage (1.5 per 1000 youths), followed by angiotensin-converting enzyme inhibitors, diuretics, calcium channel blockers, and angiotensin II receptor blockers (Liberman, J.N. 2009).

Non-pharmacological approaches to blood pressure reduction emphasize diet and lifestyle habits to achieve blood pressure normalization. The national guidelines for BP management in children (NHLBI, 2004) suggest that children with normal BP as well as those with pre-hypertension should be prescribed lifestyle intervention over medication. In stage 1 hypertensive children without compelling indications, it is recommended that dietary approaches be tried for a period of three to six months before medication be considered to lower blood pressure. For children with stage 1 hypertension with compelling indications and stage 2 hypertension it is recommended the diet therapy be used in combination with medications to lower blood pressure (NHLBI, 2004). Several clinical trials have investigated the efficacy of non-pharmacological interventions to reduce BP. A meta-analysis conducted of randomized controlled clinical trials in adults supports significant BP-lowering effects of weight loss, the DASH diet, and dietary sodium reduction in those with pre-/hypertension, with more pronounced effects in those with hypertension. In hypertensive participants, those assigned to a DASH diet or a reduced calorie DASH diet experienced a blood pressure reduction greater or equal to those undergoing single drug therapy. (Hedayati, S.S. 2011).

The DASH diet has also been shown to effectively lower blood pressure in youth in a small, short term study. Couch et al. (2008) showed that the DASH dietary pattern, when provided
through one face-to-face diet instruction with weekly follow-up phone counseling to teenagers with hypertension resulted in a significant drop in SBP after 3 months compared to adolescents who were given one counseling session only on a low sodium diet. No researchers have yet determined whether youth with hypertension can comply with a DASH diet for longer than 3 months with sustained blood pressure lowering.

**Behavioral Approaches to Modifying Diets in Youth**

Changing dietary intake among children and adolescents to be more healthful can be challenging for several reasons. First, the diets of children and teenagers are generally high in fat and sodium and low in fruits, vegetables and lean sources of protein (McNaughton, SA et al, 2008). Therefore, helping children and teens conform to current dietary standards may be problematic. Second, teenagers live very busy lifestyles and are often mobile during meals (McNaughton, SA et al, 2008). This often leads to a grab-and-go style of eating, leading to poor overall diet quality (McNaughton, SA et al, 2008). Third, teens want autonomy with respect to making food choices (McNaughton, SA et al, 2008). However, they often don’t have the necessary knowledge and skills to make informed decisions regarding their diet. It is therefore important to teach them about nutrition and health and empower them with the skills necessary to change their eating behavior toward a more healthful diet.

Dietary interventions that are developed based on sound behavioral theories have proven to be more efficacious in changing adolescent eating behaviors than those that are not based on theory (Ribeiro AG et al., 2011). Most behavioral theories used to design dietary intervention trials generally consider many of the psychosocial factors that play into teenage food choice, such as parenting strategies, family mealtime dynamics, and home food environment in the broader sense. The Social Cognitive Theory (SCT) encompasses all of these factors and has
been used to improve dietary quality in several intervention studies that examined the impact of diet change on CVD risk reduction.

The SCT is defined as gaining knowledge or behaviors from observing others in social environments. Rankins et al (2005) designed a DASH-diet focused intervention using elements of the SCT to lower blood pressure among African American adults with hypertension. The participants were divided into six groups of 12 to 15 participants per group, each taking antihypertensive medications. The intervention featured dinners based on the DASH diet plan. Blood pressure was significantly lowered among participants who missed no more than 2 of 8 sessions compared to those who attended fewer sessions. Weekly programs incorporated behavioral concepts including risk factor identification, meal planning and cooking with DASH appropriate foods, social support, and rewarding for compliance.

The SCT has also been studied relative to adolescent’s dietary behavior. Lubans et al (2012) conducted a study examining aspects of the SCT in relation to adolescent girls’ dietary intake. The adolescent girls completed validated scales based on SCT constructs assessing nutrition-related self-efficacy, behavioral capabilities, social support, and outcome expectations. They also completed a food frequency questionnaire to assess dietary intake. The results showed that scores on the SCT constructs explained 13-19% of the variance in dietary behavior among the teens (Lubans et al 2012). Stephens et al (2011) conducted an investigation on the use of SCT among socioeconomically disadvantaged adolescents in relation to intrapersonal, social, and environmental factors associated with more favorable dietary intakes. These researchers found that a greater perceived importance of health along with a healthful home environment that included a greater frequency of vegetables served at dinner were positively associated with more frequent vegetable and fruit intakes among the teens studied. Also, peer support for healthy
eating was significantly associated with more frequent vegetable intake among boys but not girls (Stephens et al 2011). In summary, these studies show how different aspects of an adolescent’s social and physical surroundings are related to the quality of their diets.

As previously noted, a major tenet of the SCT is that the environment plays a key role in determining one’s behavior, including what one chooses to eat. The environment may encompass many different psychosocial and physical aspects such as parenting practices around eating, where the family food is bought and cooked, family mealtime behaviors, household rules related to eating, distractions while eating, and availability and accessibility of healthful foods in the home. Several studies have shown that the family food environment impacts children’s diet quality. Boutelle and colleagues (2005) examined the association between the frequency of fast food meals served in the home and dietary quality, and weight status in parents and adolescents. Results from this study showed that adolescents in homes with fewer than 3 fast food meals a week were significantly more likely to report having vegetables and milk served with meals than adolescents in homes with more fast food served at family meals. These researchers also found a positive association between frequency of fast food served at meals in the home and weight status of parents but not teens (Boutelle et al, 2005). Downs et al (2007) explored the relationship between children’s diet quality, weight status, and food environment in a cross sectional study in which dietary recalls were collected from children and parents were surveyed about their home food environment. These researchers found that the 18% of children who consumed three or more restaurant meals in the three days of recall consumed, on average, 479 kcals more and had higher intakes of total fat, saturated fat and soda than children consuming no restaurant meals (Downs et al., 2007).

Since diet quality has been associated with many aspects of health, such as weight and blood
pressure in children and adolescents, it stands to reason that modifying aspects of the home food environment to improve overall diet quality, could in turn favorably impact weight, blood pressure and overall health in youth. As evidence, a literature review was done between October 2006 and January 2007 including over 66 cross-sectional studies examining the association between parenting practices and styles around eating and children’s diet quality and weight status (Ventura & Birch, 2008). The major findings from this review were that children with indulgent parents had higher BMI-z scores than those with more authoritative parents and families with overweight children had parents that used more permissive feeding styles and maladaptive control strategies in comparison to families with non-overweight children. Ventura and Birch noted that while permissive parenting style was significantly associated with higher child BMI as well as total sugar and energy intakes, these associations do not infer causality; these authors suggest that it is also likely that child weight and eating behaviors impact parenting practices around eating. Therein lays the major limitation of findings from cross-sectional studies.

While there has been some research examining relationships between parenting practices around eating and children’s dietary quality and weight status, there is little research examining other aspects of the home food environment in relation to children’s dietary intake and health. Further, no studies have examined aspects of the home food environment in relation to compliance to therapeutic diets to manage health problems, such as obesity or high blood pressure in youth. The study proposed in this thesis will help to fill this gap. Specifically, this study will address whether aspects of the home food environment are related to compliance to a therapeutic diet emphasizing the DASH dietary pattern to lower blood pressure in adolescents with hypertension. Findings from this study may help to define aspects of the home food
environment that might be addressed in nutrition interventions directed at improving blood pressure and general health status in teenagers.
MAJOR RESEARCH QUESTIONS

**Research Question 1:** Are hypertensive adolescents that frequently sit with their families at mealtime and perceive family mealtime as important more compliant to a therapeutic DASH diet to lower blood pressure compared to those that infrequently sit with their families at mealtime and perceive family mealtime as not important?

**Research Question 2:** Are hypertensive adolescents that infrequently eat fast foods and frequently eat home cooked meals more compliant to a therapeutic DASH diet to lower blood pressure compared to those that frequently eat fast foods and infrequently eat home cooked meals?

**Research Question 3:** Are hypertensive adolescents that have a greater availability and accessibility of healthful foods at home more compliant to a therapeutic DASH diet to lower blood pressure compared to those that have a greater availability and accessibility of unhealthful foods at home?
METHODS

Participants

All study participants took part in the DASH-4-Teens clinical trial between February 2008 and September 2012. Inclusion criteria for the study were as follows: participants were newly admitted to the Cincinnati Children’s Hypertension Center (CCHC), between the ages of 11 to 18 years, and had a diagnosis of prehypertension or hypertension. Hypertension status was based on the criteria established by the Fourth Pediatric Report on Hypertension (National High Blood Pressure Education Program, 2004), which defines pediatric pre-hypertension as an average systolic blood pressure (SBP) or diastolic blood pressure (DBP) ≥90th percentile and < 95th percentile for age, gender, and height, and hypertension as an average SBP or DBP ≥ 95th percentile but < 99th percentile + 5 mm Hg based on gender, age, and height, as measured on 3 or more occasions. The subset of participants for this thesis was comprised of 26 participants randomized to the 24-week DASH-4-Teens intervention group (DASH) and 24 participants randomized to the Usual Care (UC) group. The intervention groups are defined below under “Intervention”.

Study exclusion criteria included stage 2 hypertension status (BP > 99th percentile + 5 mm Hg for age, gender, and height), secondary hypertension, use of anti-hypertensive medications, prior exposure to formal dietary therapy to manage BP, target organ damage, diagnosed type 1 or 2 diabetes, presence of a diagnosed eating disorder, and any psychological or medical condition that would prevent full participation in the study. Adolescents were also excluded for use of BP altering medications, and unwillingness to stop the use of vitamins, minerals, and certain antacids. Potential participants had to be English speaking and had to have full medical clearance from a physician to participate. Adolescents under the age of 18 years signed informed
assent forms and a parent signed a parental permission form and adolescents 18 years of age and older signed informed consent forms, prior to participation in the study. The study was approved by the Cincinnati Children’s Hospital Medical Center (CCHMC) Institutional Review Board and the University of Cincinnati Institutional Review Board.

**Intervention**

The DASH intervention was based on the principles of the SCT. It was designed to encourage a healthful eating pattern for lowering blood pressure and sustained dietary behavior change. DASH is a dietary pattern, originally developed for adults with hypertension. The DASH diet was shown to be effective for lowering blood pressures without weight loss in adults (Svetkey et al., 1999). The DASH eating pattern emphasizes fruits, vegetables and low-fat dairy foods, whole grains, poultry, fish, and nuts. DASH also encourages reduction in fats, red meat, sweets, sugar-containing beverages, and high salt foods (Svetkey et al., 1999). In this study, DASH group participants were given a behaviorally based curriculum in order to encourage adherence to the DASH eating pattern.

The curriculum explained all aspects of the DASH dietary pattern, and included recommendations for healthy calorie levels and food serving sizes for weight maintenance based on participants’ gender, age, and activity level. Activities, recipes, and tips were included to encourage the gradual incorporation of fruits, vegetables, whole grains, lean meats, low-fat dairy, low sodium foods, and low fat foods into their diets to achieve individual goals. The manual also explained the limitations and examples of “DASH Unfriendly” foods, which were foods with > 3 grams of fat and 480mg of sodium per serving. Behavioral strategies emphasized in the curriculum included: food monitoring, goal setting, problem solving, managing social situations and planning for long-term maintenance.
Over the course of the 24-week intervention, DASH subjects participated in 2 individual counseling sessions (baseline and 12 weeks) and 14 telephone conversations (weekly for weeks 2 – 10, then bi-weekly) with a registered dietitian (RD) that focused on behavioral strategies to enable the adoption of the DASH diet at home and elsewhere. They also received mailings of additional manual sections that coincided with topics addressed by the dietitians in telephone conversations such as, meal planning and social support.

DASH teens were shown how to use food trackers for 5 days of each week of the trial. On each food tracking form, the participants noted the numbers of servings of fruits, vegetables, low-fat dairy, and “DASH unfriendly” foods they ate that day. Each adolescent was offered an incentive of $2 per goal met over the 24-week intervention period (maximum $196) based on their compliance with the tracking and meeting their DASH food goals, as assessed by the study dietitians. The food tracking system was devised to encourage study participation, compliance with the DASH eating pattern, and to help identify problem foods. This information was not used to assess dietary outcomes for this study.

Adolescents randomized to the Usual Care group were provided with nutrition counseling that did not differ from the usual dietary counseling given to all newly diagnosed hypertensive patients at the CCHC. This counseling was in line with the recommendations set forth by the Fourth Pediatric Report of the National High Blood Pressure Education Program (National High Blood Pressure Education Program, 2004). Each participant was given a booklet called Your Guide to Lowering Blood Pressure. This booklet discussed the importance of decreasing fat and sodium, increasing fruit and vegetable consumption, and recommended a DASH-type diet (US Department of Health and Human Services, National Institutes of Health, National Heart, Lung, and Blood Institute, 2004). The nutrition counseling included weight loss tip suggestions for
overweight adolescents, although these tips were not individualized. Practical information was also offered on how to change eating habits and lower blood pressure.

Usual Care participants received 2 individual counseling sessions with a RD, in which dietary recommendations were reviewed and dietary deficiencies and excesses were addressed. These sessions were done at baseline and at week 12. Consistent with routine care at CCHC, behavioral skills and strategies were not individualized.

**Outcome Measures: Demographic and Anthropometric**

Adolescents’ self-reported their date of birth, gender, and ethnicity. At baseline and six months, trained nursing personnel measured height and weight at the CCHC. Height was measured using a wall-mounted stadiometer and weight was measured using a calibrated triple-beam balance scale. The average of 2 readings were used to calculate body mass index (BMI) calculated as weight in kilograms divided by the square of height in meters. BMI z-scores were then calculated using the Centers for Disease Control growth charts and age-specific medians, standard deviations, and distribution skewness correction information (Cole, Freeman, & Preece, 1998).

**Outcome Measures: Dietary**

Dietary intake data was collected at both baseline and six months. At each time period, three random, 24-hour recalls were collected from each participant using the multi-pass method, over a two week time period. Trained research dietitians from the Cincinnati Center for Nutrition Research (CCNR) at Cincinnati Children’s Hospital Medical Center, performed the recalls during telephone interviews with the adolescents. Participants were trained in reliable portion size estimation methods, prior to the recalls. The recalls were collected and analyzed using the Minnesota Nutrient Data Systems (NDS) software. Study dietitians then analyzed each
entry for calories, nutrient content, and number of servings of grains, vegetables, fruits, dairy, meat/poultry/fish/eggs, nuts/seeds/legumes, fats/oils, and sweets.

The DASH Score

Averages for nutrients and food servings were calculated for each set of three 24-hour dietary recalls. The resulting data were used to calculate a DASH Score for each participant, for baseline (pre-intervention) and post-intervention. This diet quality index was developed by Guenther et al (2009) and was calculated from mean daily food group servings of 9 food/nutrient groups - grains, vegetables, fruits, dairy, meat/poultry/fish/eggs, nuts/seeds/legumes, fats/oils, sweets and sodium. Goals of intake for each food/nutrient group were based on recommendations specified by the Dietary Guidelines for Americans (USDA, 2010), the DASH Collaborative Research Group (Karanja et al, 1999), and on calorie levels specific for age, gender, and sedentary activity level (Institute of Medicine, 2005). For each of the 9 food/nutrient groups, a maximum score of 10 was achieved when a teen’s intake met the food group recommendation, whereas lower intakes were scored proportionately. If lower intakes were favored by the dietary recommendation, reverse scoring was applied and a score of 0 was applied to intakes >200% of the recommended upper level. To be consistent with the recommendations from the Dietary Guidelines for Americans and the DASH dietary pattern, the grain component of the DASH score was divided into total grains and whole grains and the dairy component was divided into total dairy and low-fat dairy. Therefore, each of these components had a maximum score of 5. The resulting food group component scores were totaled to create an overall DASH Score, which ranged between 0 and 90, with a higher score indicating a higher diet quality.

Family Food Environment Questionnaire
Family food environment questionnaires were given to all participants at baseline. All survey items were derived from published scales. Several scales related to family meal time behavior including one on sitting together at mealtime (2 items, Campbell et al., 2006) and one on the perception of the importance of eating together at meals (1 item, Boutelle et al., 2001); one scale related to frequency of fast food meals (1 item, Gillis and Bar-Or, 2003), another to the frequency of home cooked meals (1 item, Gillman et al., 2000), and a third to the healthfulness of meals overall (2 items, Neumark-Sztainer et al., 2003). Two scales assessed home food availability; one related to high calorie/nutrient poor beverages (1 item, Campbell 2007) and the other to low calorie/nutrient dense foods (4 items, Neumark-Sztainer et al., 2003). A final scale assessed accessibility of low calorie/nutrient dense foods (3 items, Campbell 2007). All questions were scored using a five point Likert scale, which ranged from 1 (low or never) to a 5 (high or frequently), except the question regarding the frequency of fast food, where a 1 on the Likert scale reflected a high frequency (>6 times per week) and a 5 indicated a low frequency (low or never). Responses were summed if more than one item were included in the scale and mean scores were generated.

**Statistical Analysis**

Subjects included in these analyses were study completers (those with baseline and post-treatment assessment data). Means and standard deviations were derived at baseline and post-treatment for continuous variables and frequencies for categorical variables. Distributions of the residuals were checked for normality assumptions and based on these findings, DASH component scores for fruits, vegetables, low fat dairy, and sodium were determined to be non-normally distributed. Scores that were not normally distributed were log-transformed for subsequent statistical analyses. Independent sample t-tests were used to compare intervention
groups for continuous baseline and post treatment subject characteristics, BMI z-score, energy intake overall DASH score, and home environment factors; chi-square tests were used to determine group differences for categorical subject characteristics; and the Wilcoxon Rank Sums Procedure was used to compare intervention groups for baseline and post-treatment DASH component scores. Mixed effects models were used to assess relationships between change in total DASH score (baseline to post-treatment) and home food environment factors. The non-parametric test QUANTREG was used to assess the relationships between changes in DASH component scores (baseline to post-treatment) and home food environment factors. Final models were adjusted for age, gender, race, BMI z-score, intervention group, and energy. 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

Participant Characteristics

As shown in table 1, there were no statistically significant differences between participants in the DASH intervention group compared to those in the usual care group for age, gender, race, or BMI z-score.

Table 1: Characteristics of Study Participants

<table>
<thead>
<tr>
<th></th>
<th>DASH Group N=26</th>
<th>Usual Care Group N=24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs. mean ± SD</td>
<td>14.85 ± 2.26</td>
<td>14.29 ± 2.29</td>
</tr>
<tr>
<td>Gender, % Male/Female</td>
<td>58/42</td>
<td>63/37</td>
</tr>
<tr>
<td>Race, % White/Other*</td>
<td>58/42</td>
<td>58/42</td>
</tr>
<tr>
<td>BMI z score, Mean ± SD</td>
<td>1.81 ± 0.69</td>
<td>1.59 ± 0.89</td>
</tr>
</tbody>
</table>

*Other = African American and Asian

Baseline Scores on Home Food Environment Factors

Results in table 2 show that there were no significant differences between the DASH group and the Usual Care group for any of the baseline home food environment factors assessed.
Mean scores for most factors indicated a neutral to modest level of agreement to the factor.
Exceptions were the items for fast food meals and availability of unhealthy beverages at home.
Mean frequency of fast food meals indicated a low frequency (1-2 per week) among participants in both groups. Mean scores for the factor availability of unhealthy beverages in the home indicated that participants in both groups had high calorie/nutrient poor beverages infrequently in the home.

**TABLE 2. Baseline Scores on Home Food Environment Factors**

<table>
<thead>
<tr>
<th>Home Food Environment Factor*</th>
<th>DASH Group (N=26)</th>
<th>Usual Care Group (N=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of Sitting Together at Meals</td>
<td>3.03±1.48</td>
<td>3.54±1.14</td>
</tr>
<tr>
<td>Perception t That Eating Meals Together is important</td>
<td>3.37±0.78</td>
<td>3.45±0.69</td>
</tr>
<tr>
<td>Frequency of Fast Food meals**</td>
<td>4.00±0.69</td>
<td>4.12±0.54</td>
</tr>
<tr>
<td>Frequency of Home Cooked Meals</td>
<td>3.73±1.18</td>
<td>3.91±1.07</td>
</tr>
<tr>
<td>Frequency of serving fruits, vegetables and low fat foods at meals</td>
<td>3.00±1.14</td>
<td>3.14±0.81</td>
</tr>
<tr>
<td>Availability of healthy foods in the home</td>
<td>3.42±1.32</td>
<td>3.37±1.25</td>
</tr>
<tr>
<td>Availability of unhealthy beverages in the home</td>
<td>2.00±1.09</td>
<td>1.83±0.96</td>
</tr>
<tr>
<td>Accessibility of healthy foods in the home</td>
<td>3.97±0.89</td>
<td>4.17±0.68</td>
</tr>
</tbody>
</table>

*Scores are based on Likert scale response where 1=do not agree or never, 2= somewhat disagree or infrequently, 3=neutral, 4=somewhat agree or frequently and 5 = agree or very frequently;
** fast food item is reverse scored where high score = never and low score = >6 times per week

Mean DASH Score and DASH Component Scores

The results in table 3 show that the DASH score post treatment in the DASH group was significantly greater than the DASH score in the Usual Care group (p<0.01). The post-intervention fruit component score, low fat dairy score and sodium score were significantly greater (p<0.01 for fruit, p<0.05 for low fat dairy and sodium) for the DASH group compared to the Usual Care group. There were no significant differences between groups for DASH score or DASH component scores at baseline.

Table 3: DASH Score and DASH Component Scores for Study Participants Pre and Post-Intervention *

<table>
<thead>
<tr>
<th>Overall Score and Component Scores</th>
<th>DASH</th>
<th>Usual Care</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Post-treatment</td>
</tr>
<tr>
<td>DASH</td>
<td>38.49 ± 1.50</td>
<td>48.11 ± 1.81 **</td>
</tr>
<tr>
<td>Fruit</td>
<td>3.09 ± 0.53</td>
<td>5.45 ± 0.63 **</td>
</tr>
<tr>
<td>Vegetables</td>
<td>2.96 ± 0.35</td>
<td>3.70 ± 0.47</td>
</tr>
<tr>
<td>Low Fat Dairy</td>
<td>1.06 ± 0.25</td>
<td>2.69 ± 0.27 *</td>
</tr>
<tr>
<td>Sodium</td>
<td>5.45 ± 0.49</td>
<td>6.59 ± 0.61 *</td>
</tr>
</tbody>
</table>

* Score range for DASH score is 0-90 with higher score indicating greater compliance to the DASH dietary pattern; Scores for DASH fruit, vegetable and sodium component scores range from 0-10, and scores for DASH low fat dairy component range from 0-5 with higher score indicating a greater degree of compliance to recommended DASH servings for these nutrients/food groups. P values reflect significance of group comparisons at baseline and at post-intervention; *p<0.05 **p<0.01

Home Food Environment Factors in Relation to Change in DASH Score and DASH Component Scores
Tables 4-6 show results of general linear mixed models examining relationships between home food environment factors in relation to change in DASH score and DASH component scores. As shown in Table 4, there was a trend for a positive relationship between frequency of sitting together at meals and change in overall DASH score (p<0.1). No other home food environment factors were related to overall DASH score or the DASH fruit component score.

**TABLE 4. The Relationship between Aspects of the Home Food Environment and Change in DASH score and DASH Fruit Component Score**

<table>
<thead>
<tr>
<th>Home Food Environment Factor</th>
<th>Change in DASH Score</th>
<th>Change in DASH Fruit Component Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimatea</td>
<td>Standard Error</td>
</tr>
<tr>
<td>Frequency of Sitting Together at Meals</td>
<td>1.74 ±</td>
<td>1.00</td>
</tr>
<tr>
<td>Perception that Eating Meals Together is Important</td>
<td>-0.34</td>
<td>1.75</td>
</tr>
<tr>
<td>Frequency of Fast Food/Takeout</td>
<td>-2.65</td>
<td>2.03</td>
</tr>
<tr>
<td>Frequency of Home Cooked Meals</td>
<td>1.09</td>
<td>0.35</td>
</tr>
<tr>
<td>Frequency of having Fruit, Vegetables and Low fat Foods Served at Meals</td>
<td>0.97</td>
<td>1.40</td>
</tr>
<tr>
<td>Availability of Healthy Foods at Home</td>
<td>2.50</td>
<td>1.94</td>
</tr>
<tr>
<td>Availability of Unhealthy Beverages at Home</td>
<td>-0.60</td>
<td>1.29</td>
</tr>
<tr>
<td>Accessibility of Healthy Foods at Home</td>
<td>1.63</td>
<td>1.60</td>
</tr>
</tbody>
</table>

*aAdjusted for adolescent age, gender, race, and BMI z-score; ± p<0.1*

Table 5 shows that the frequency of having fruit, vegetables and low fat foods served at meals, the availability of healthy foods in the home, and the accessibility of healthy foods in the
home were positively related to change in the DASH vegetable component scores at the p<0.05 level. No aspects of the family food environment were related to change in the DASH low fat dairy component score.

### Table 5. The Relationship between Aspects of the Home Food Environment and Change in DASH Vegetable Component Score and DASH Low Fat Dairy Component Score

<table>
<thead>
<tr>
<th>Home Food Environment Factor</th>
<th>Change in DASH Vegetable Component Score</th>
<th>Change in DASH Low Fat Dairy Component Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate(^a)</td>
<td>Standard Error</td>
</tr>
<tr>
<td>Frequency of Sitting Together at Meals</td>
<td>0.04</td>
<td>0.29</td>
</tr>
<tr>
<td>Perception that Eating Meals Together is Important</td>
<td>0.29</td>
<td>0.48</td>
</tr>
<tr>
<td>Frequency of Fast Food/Takeout</td>
<td>0.19</td>
<td>0.57</td>
</tr>
<tr>
<td>Frequency of Home Cooked Meals</td>
<td>0.45</td>
<td>0.32</td>
</tr>
<tr>
<td>Frequency of having Fruit, Vegetables and Low fat Foods Served at Meals</td>
<td>0.82 *</td>
<td>0.37</td>
</tr>
<tr>
<td>Availability of Healthy Foods in the Home</td>
<td>1.37 *</td>
<td>0.53</td>
</tr>
<tr>
<td>Availability of Unhealthy Beverages in the Home</td>
<td>0.09</td>
<td>0.36</td>
</tr>
<tr>
<td>Accessibility of Healthy Foods in the Home</td>
<td>0.97*</td>
<td>0.44</td>
</tr>
</tbody>
</table>

\(^a\)Adjusted for adolescent age, gender, race, and BMI z score; *p<0.05

The results in table 6 show that there was a trend for a positive relationship between frequency of sitting together at meals and change in DASH sodium component score. There was
also a trend for a negative relationship between frequency of fast food and takeout and change in DASH sodium component score (p<0.1). Since this latter factor was reverse scored, this finding indicates that having fast food more frequently (lower score) at baseline was associated with a greater change in the DASH sodium component score.

Table 6. The Relationship between Aspects of the Home Food Environment and Change in DASH Sodium Component Score

<table>
<thead>
<tr>
<th>Home Food Environment Factor</th>
<th>Change in DASH Sodium Component Score</th>
<th>Estimate(^a)</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of Sitting Together at Meals</td>
<td></td>
<td>0.66 ±</td>
<td>0.39</td>
</tr>
<tr>
<td>Perception that Eating Meals Together is Important</td>
<td></td>
<td>-1.02</td>
<td>0.69</td>
</tr>
<tr>
<td>Frequency of Fast Food/Takeout</td>
<td></td>
<td>-1.33 ±</td>
<td>0.79</td>
</tr>
<tr>
<td>Frequency of Home Cooked Meals</td>
<td></td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Frequency of having Fruit, Vegetables and Low fat Foods Served at Meals</td>
<td></td>
<td>0.21</td>
<td>0.55</td>
</tr>
<tr>
<td>Availability of Healthy Foods in the Home</td>
<td></td>
<td>-0.15</td>
<td>0.78</td>
</tr>
<tr>
<td>Availability of Unhealthy Beverages in the Home</td>
<td></td>
<td>-0.17</td>
<td>0.51</td>
</tr>
<tr>
<td>Accessibility of Healthy Foods in the Home</td>
<td></td>
<td>-0.12</td>
<td>0.64</td>
</tr>
</tbody>
</table>

\(^a\) Adjusted for adolescent age, gender, race, and BMI z score; ± p<0.1
DISCUSSION

A major finding from this study was that the DASH intervention had a positive impact on the diet quality of participants as compared with the usual care intervention. As evidence, the overall DASH score and the DASH fruit, low fat dairy and sodium component scores were significantly greater post treatment in the DASH group compared to the usual care group. There was no difference between groups for overall DASH scores or DASH component scores at baseline. Another major finding was that there were several home food environment factors that were favorably related to change in overall DASH score, DASH vegetable score and DASH sodium score. This latter finding suggests that certain aspects of the home food environment may have assisted teens in making positive changes to their diet in an effort to improve their blood pressure management.

The DASH intervention was based on the SCT and emphasized changing dietary behavior by modifying one’s environment to include more fruits, vegetables, low fat dairy, and less sodium and fat. Emphasized in the program were healthful grocery shopping skills, cooking skills, menu planning, and creating a home environment that was conducive to following a DASH dietary pattern. Food tracking was also central to the DASH intervention where participants tracked their servings of fruits, vegetables, and foods high in sodium and fat. Findings from this study suggest that the DASH intervention was more effective in modifying dietary behavior to be more “DASH-like” compared to usual hospital-based nutrition care among adolescents with hypertension.

The frequency of sitting together at meals was positively related (trend) to change in overall DASH score and DASH sodium component score. This finding confirms the results of others who showed that when parents consume meals with their children, their eating habits tend
to favorably impact those of their children. For example, in a study by Downs et al. (2007), parent modeling at mealtime and parental intake of fruits and vegetables were positively associated with children’s fruit, fruit juice, and vegetable intake. Additionally, Downs et al. (2007) showed that families that ate together more frequently had higher nutritional quality of the food served compared to those who ate out more frequently. Research also showed a positive association between what parents serve at meals, what they consume at meals, and children’s dietary quality (Pearson et al., 2011). Findings from the present study add to the literature as this is the first study to show that the more families sit down together at meals, the less sodium adolescents tended to eat and the greater their compliance to a therapeutic diet to help lower their blood pressure.

In the present study, the DASH vegetable component score was the one DASH component score that did not significantly change post-treatment as compared to the Usual Care group. This finding could reflect the fact that both intervention groups had a modest increase in this food group from baseline to post-treatment or the fact that this food group tends to be one of the most difficult to achieve in terms of recommended number of servings among adolescents in the United States. Kimmons et al. (2009) observed that fewer than 1 in 10 youth in the US met their calorie-specific MyPyramid vegetable serving recommendation in 2008. These researchers also noted that potatoes dominated vegetable consumption among adolescents, in whom fried potatoes increased the median vegetable intake by about 3 fold per day and dark green and orange vegetables and legumes accounted for only a small portion of vegetable intake. Nevertheless, in this study a higher DASH vegetable component score was associated with greater home availability and accessibility of healthy foods including fruits and vegetables. Boutelle et al. (2005) also showed a relationship between home availability of healthy foods and
overall diet quality. These researchers found that having more healthy foods available in the home such as milk and vegetables was related to decreased frequency of eating out, and a lower intake of sodium and fat among adolescents. Conversely these researchers also found that having a greater amount of unhealthy food choices in the home such as soda and chips was related to a greater frequency of eating out and a lower overall diet quality among teens. This research and our findings support the importance of creating a healthy home environment with vegetables and fruits that are not only available but easy to access to improve the diet quality of teens.

Another finding of this study was that a greater change in the DASH vegetable component score was related to having vegetables served at meals. This finding suggests that family meal time may be the primary time during the day when adolescents are exposed to vegetables. Others have found regular family mealtimes to be associated with higher dietary quality and vegetable intake in particular in both school-aged children and adolescents (Gillman et al., 2000; Neumark-Sztainer et al. 2003). Nutritional benefits of a family meal may relate to simply making the food available, and therefore more likely to be eaten by the teen. In addition, there may be psychosocial influences that take place at the meal that may impact the teen’s consumption of more healthful foods. For example, when vegetables are served at family meals, parents tend to also consume these foods, and therefore model healthful eating behaviors to their teens. Pearson et al. (2007) observed that parental modeling, parental encouragement to eat vegetables, and parental intake were positively associated with vegetable consumption among teenagers. In a review of parenting practices around eating, researchers showed that in general parent’s use of modeling, positive encouragement and creating a home environment with healthful foods available were factors related to high diet quality and vegetable consumption.
among children and adolescents (Ventura and Birch, 2008). These findings highlight the importance of family mealtime as an opportunity to serve healthful foods, and in particular vegetables, that the teen may not be getting during the day otherwise, and for parents to model and encourage healthful eating behaviors to their teens. In the present study, the finding that having fast food more frequently pre-intervention was associated with a greater change in the DASH sodium component score was unexpected. This finding may relate to the fact that those who ate a greater amount of fast food/take-out at the start of the intervention likely had higher sodium intake before treatment and were able to experience a greater benefit in terms of improving sodium intake level compared to those who had a lower sodium intake to start. Studies have shown that the majority of sodium in the teenage diet comes from foods eaten out of the home (Drewnowski and Rehm, 2013). A major component of the DASH intervention was how to eat out healthfully and reduce take out / fast food consumption. This concept was emphasized in print material, meal planning activities, phone counseling and food tracking reviews by the study dietitians. Given the heavy focus on reducing fast food and take out consumption to lower fat and sodium in the diet, it stands to reason that reducing fast food intake may have contributed to a greater improvement in sodium intake among DASH participants compared to adolescents in usual care. Our results that the DASH participants experienced a significant decrease in the DASH sodium component score compared to the usual care participants supports this.

There were several strengths of the study including the home food environment questionnaire which was developed based on published validated scales. The 3 day dietary recall data was collected in a rigorous fashion by trained registered dietitians experienced in the multi-pass method, which has been shown to be associated with lower measurement error. Regression
models were adjusted for important factors known to influence diet quality and dietary compliance among adolescents such as age, gender, race, and BMI. The fact that this was an intervention study rather than a cross-sectional study in which dietary intake was measured at multiple times is a major study strength. The study is not without limitations. The sample size for the study was small and may not have been powered appropriately to detect significant difference between groups where they existed. This study was also based on a completer analysis and did not consider all of the participants that received intervention, primarily because we did not have any follow-up dietary data on these individuals. Another weakness of the study was the results were based on self-report of the adolescents; therefore, if the adolescents were not truthful then the results could be biased. Finally, this study did not consider that change in home food environment could have occurred over the course of the intervention. Home food environment was measured at baseline only and then associated with change in dietary measures. Future research should measure change in the family food environment in response to interventions developed based on the SCT as change in these factors may also be related to how well adolescents adhere to a diet intervention.

Different aspects of the home food environment may impact an adolescents’ adherence to the DASH diet. Findings from this study suggest that DASH dietary adherence may be related to sitting down for meals as a family. Vegetable consumption may be increased by this same practice as well as having more of these foods in the home within easy reach. Consuming less takeout/fast food and eating more meals together at home may help adolescent’s lower sodium intake. The DASH-4-Teens intervention as opposed to the Usual care intervention when provided to adolescents with elevated blood pressure may be related to a greater adherence to the DASH diet. This study has identified important family environment factors that should be
emphasized as part of the intervention program to improve the potential for successful dietary change.
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