In, Maojia Wang, hereby submit this original work as part of the requirements for the degree of Master of Science in Nutrition.

It is entitled:
The Predictive Validity of a Home Food Environment Questionnaire for Assessing Diet Quality in Adolescents with Elevated Blood Pressure

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This work and its defense approved by:

Committee chair: Sarah Couch, Ph.D.

Committee member: Seung-Yeon Lee, Ph.D.
The Predictive Validity of a Home Food Environment Questionnaire for Assessing Diet Quality in Adolescents with Elevated Blood Pressure

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 2016

by

Maojia Wang
B.S., University of Cincinnati 2014

Committee Chair:
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ABSTRACT

Objective: To evaluate the predictive validity of a home food environment (HFE) questionnaire to assess overall diet quality as measured by DASH score and fruit and vegetable intake in adolescents with elevated blood pressure.

Method: A total of 96 adolescents aged 11-18 years with a diagnosis of pre-hypertension or stage 1 hypertension, newly enrolled in the Cincinnati Children’s Hypertension Treatment Center were enrolled in this study. All participants were given a HFE questionnaire, which consisted of five scales that assessed psychosocial and physical aspects of the home environment related to eating. These scales were derived from previously published scales that were used to assess fruit and vegetable intake in healthy adolescents. All scales were scored with a 5 point Likert scale ranging from 1 (low/never) to 5 (high/frequently), except parent rules related to eating which were summed and averaged, with a higher score indicating a greater use of food rules in the home. Weight and height were measured at the Center using standard procedures. Demographics were self-reported. Dietary intake data were collected with three random 24-hour dietary recalls by trained registered dietitians and then analyzed using the Minnesota Nutrient Data System for Research software. Multiple regression models were run to assess the associations between HFE scales and diet quality.

Results: The study sample was 65.6 % male and 98.9 % non-Hispanic white; the prevalence of overweight/obesity (BMI ≥85th percentile for age and gender) was 83.3%. Scale scores for healthy home food availability, parenting rules around eating, and frequency of eating family meal together were positively associated with participants’ DASH score when adjusted for age, gender, race, BMI z-score, and energy intake (p<0.05). Scale scores for healthy home food availability and parenting rules around eating were also positively associated with participants’
fruit intake when adjusted for age, gender, and race (p<0.05). Frequency of fast food/carry-out was negatively associated with participants’ DASH score and fruit intake when adjusted for age, gender, race, BMI z-score, and energy intake (p<0.05). Family food insecurity was not associated with diet quality indexes. There was no significant association between HFE scales and vegetable intake servings.

**Conclusion:** Several scales on the HFE questionnaire used in this study had good predictive validity to assess fruit intake and DASH score among adolescents with elevated blood pressure. Specifically, scales for healthy home food availability, parenting rules around eating, frequency of eating family meals together, and frequency of fast food/take out predicted DASH score and/or fruit intake, which confirms the validity of these scales in this population. More research is needed to determine factors within the home food environment that predict vegetable consumption in this at risk population.
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REVIEW OF LITERATURE

Prevalence of Elevated blood pressure in adolescents

In 2004, the National High Blood Pressure (BP) Education Program published the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, which included new guidelines on the classification of elevated blood pressure in children.¹ According to the report, hypertension in children is defined as an average systolic blood pressure (SBP) or diastolic blood pressure (DBP) that is >95th percentile for gender, age and height on three separate occasions. Pre-hypertension (pre-HTN) was classified for the first time in the Fourth Report as an average SBP or DBP level ≥90th percentile but <95th percentile for age, gender and height. This classification was determined based on evidence that pre-HTN tracks into adulthood.¹ Individuals with pre-HTN are at greater risk for developing hypertension and therefore early intervention with diet and lifestyle management is warranted.¹ Based on these classifications, the prevalence of hypertension in adolescents is reported to range from three to eight percent of the population.²⁻⁴ Fifteen to thirty-six percent of adolescents are reported to have pre-HTN.³, ⁴

Fruit and vegetable intakes in adolescents

Eating more fruits and vegetables is recommended in the 2015 Dietary Guidelines for Americans to reduce the risk of some chronic diseases including HTN.⁵ One of the recommended approaches to meeting the dietary guidelines for fruits and vegetables is consuming a dietary pattern that resembles the Dietary Approach to Stop Hypertension (DASH) diet, which emphasizes 7-10 servings for fruits and vegetables. This is a lofty goal considering current intakes in adolescents are much below DASH diet levels. Specifically in 2007-2010, the National Data on Food Intakes study, which analyzed dietary data from the National Health and
Nutrition Examination Surveys (NHANES), reported that among children (ages 1-18 years), sixty percent had usual fruit intakes below U.S. Department of Agriculture (USDA) food pattern fruit intake recommendations, and ninety-three percent did not meet the USDA recommended vegetable intake levels. DASH dietary pattern recommendations for fruit and vegetable intake are comparable to those of the USDA food pattern.

A more recent Centers for Disease Control (CDC) report in 2014 analyzed NHANES data collected in 2003-2004 and 2009-2010 to described trends in fruit and vegetable intakes in children over this time period. The report found that total fruit intake among children increased from 0.55 cup-equivalents per 1,000 calories (CEPC) in 2003-2004 to 0.62 in 2009-2010; this increase was attributed to the significant increases in whole fruit intake (0.24 to 0.40 CEPC), while fruit juice intake decreased from 0.31 to 0.22 CEPC. Total vegetable intake did not change significantly during this period. The report suggested that increased attention to the home and school food environments of children might be useful intervention targets to further improve fruit intake and increase vegetable intakes in youth.

**Fruit and vegetable intake in relation to blood pressure management**

There is an emerging body of evidence to suggest that increasing intake of fruits and vegetables and dietary patterns based on these food groups are effective dietary approaches to lowering blood pressure among adults and youth. For example, several large cohort studies in western countries found an inverse relationship between fruit and vegetable intake and elevated BP. The Coronary Artery Risk Development in Young Adults (CARDIA) Study recruited 4304 young black and white adults aged 18-30 years at baseline and found that plant food intake was inversely related to incident hypertension at 15 year follow-up after adjustment for relevant confounding factors. The French SU.VI.MAX study found that higher fruit and vegetable
consumption was associated with lower BP in 4652 participants aged 35-63 years in both cross-sectional and longitudinal analysis with a median follow-up of 5.4 years.\textsuperscript{12} The Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) Study reported that a 100 g higher fruit and vegetable intake during adolescence was prospectively related to a 0.9 mmHg lower SBP in young adult females. The length of follow-up in the DONALD study was a median of 10 years.\textsuperscript{13}

Several randomized controlled trials of dietary interventions emphasizing plant-based dietary patterns also reported significantly lowered participant BP among those who consumed more fruits and vegetables.\textsuperscript{14-18} The original Dietary Approaches to Stop Hypertension (DASH) study in 1997 reported that an intervention group provided with meals that were rich in fruits and vegetables but otherwise similar to a control group fed a typical Westernized diet for eight weeks reduced SBP by 2.8 mm Hg more (\(P<0.001\)) than the control group. In this same study, a second intervention group provided with meals that were rich in fruits and vegetables, low-fat dairy products and that were reduced in saturated and total fats (a DASH dietary pattern) lowered BP more significantly than the high fruit and vegetable intervention group and the control group.\textsuperscript{14} Several studies since this original publication of the DASH controlled feeding study have confirmed the success of a DASH diet as a means to reduce BP.\textsuperscript{15-18} A systematic review and meta-analysis was conducted in 2013 to evaluate the effectiveness of DASH diet on blood pressure lowering.\textsuperscript{17} The meta-analysis included twenty articles reporting data for 1917 participants and found that both SBP and DBP were significantly decreased as a result of DASH diet intervention; BP changes were even greater in participants with higher baseline BP. Moreover, the DASH diet was shown to reduce BP in children and adolescents.\textsuperscript{16,18} Couch et al conducted a randomized controlled trial in fifty-seven adolescents with elevated BP and found

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that the DASH intervention group that received a behavioral nutrition intervention program emphasizing the DASH dietary pattern had a greater decrease in SBP compared to a control group receiving usual hospital-based nutrition care to moderate BP.\textsuperscript{18}

In conclusion, there is consistent and convincing evidence in the current literature regarding the favorable BP-lowering effect of fruits and vegetables and the DASH dietary pattern. Based on this evidence, the DASH dietary pattern is being advocated as one of the lifestyle measures to reduce BP in adults and children with pre-hypertension and hypertension by the European Society of Hypertension.\textsuperscript{9} Furthermore, the American Heart Association now recognizes the DASH diet as an effective non-pharmacological approach to lowering BP in adults.\textsuperscript{10}

**Determinants of fruit and vegetable intake in adolescents**

A large proportion of the pediatric population doesn’t meet their daily fruit and vegetable recommendations despite recent public health efforts to encourage intake of these food groups for preventing chronic disease. It is important to identify and understand the determinants of fruit and vegetable intake in adolescents in order to increase the consumption of these foods. Many epidemiological studies have been done to examine the determinants of fruit and vegetable intake in adolescents. Factors examined have included socioeconomic and personal characteristics, the home food environment (HFE), and the school food environment. Among socio-demographic factors considered, socioeconomic position has been found to have positive association with fruit and vegetable intake; furthermore, the evidence is consistent for a positive association between family income, social class, and highest level of parent education and fruit and vegetable intake.\textsuperscript{19-24} Personal preferences have been studied extensively and are consistently reported to be a facilitator of fruit and vegetable intake in adolescents.\textsuperscript{19,21,22} Positive attitudes
towards eating fruits and vegetables, for example being confident in one’s ability to prepare and eat these foods, has been observed to have positive association with fruit and vegetable intake.\textsuperscript{22, 25}

Regarding the HFE and influence on fruit and vegetable intake, parent intake of these foods,\textsuperscript{26-27} frequency of family meals together,\textsuperscript{22, 23, 29} and parental support for healthy eating\textsuperscript{22, 28} were found to be positively associated with fruit and vegetable intake in adolescents. The school food environment has also been reported as a predictor of fruits and vegetable intake of children. For example, epidemiological evidence supports a negative association between availability of unhealthy foods at school and fruit and vegetable intake.\textsuperscript{19, 30, 31} Current evidence related to an association between fruit and vegetable intake and gender, age, nutritional knowledge, outcome expectations, parenting style, and home availability is inconsistent.\textsuperscript{32}

**HFE in relation to fruit and vegetable intake in adolescents**

An adolescent’s eating behavior develops within the home environment, and as the adolescent ages, this environment continues to have a significant impact on their food selection and intake. Among the home determinants of fruit and vegetable intakes in this population, parental support for healthy eating fruits and vegetables, family meals, and home availability/accessibility of healthy foods have been amply studied. Several different assessment tools have been used to study these factors.\textsuperscript{33-38} Pinard et al developed a Comprehensive Home Environment Survey (CHES) including two domains to assess HFE as it relates to child dietary behaviors and childhood weight status: food physical environment (availability/accessibility/kitchen appliance & utensils) and food social environment (role modeling/policies around eating/parent feeding styles).\textsuperscript{33} The CHES food-related subscales were found to have high test-retest reliability ($r \geq 0.73$, $p < 0.01$) and the subscales were significantly
correlated with dietary behavioral measures (r = .20 - .55, p < .05; predictive validity). Among the subscales, parent role modeling of a healthy diet was positively associated with child fruit and vegetable intake (p < .05). Another similar home environment survey was given to 219 overweight children aged eight to thirteen years. Home availability of fruits and vegetables, home accessibility of fruits and vegetables, parent role modeling of fruit and vegetable intake, and parenting rules related to eating were found to be positively associated with their child’s fruit and vegetable intake.

In a study by Ding et al, a questionnaire focusing on both home and community food environment was developed and given to 171 adolescents and 116 children to assess the relation between food environment and healthy food intake. The HFE section of the questionnaire was comprised of questions asking “How often are the following food items available in your home?” Sixteen food items, which were categorized into either healthful foods or unhealthful foods, were included related to this question. The study found that fruit and vegetable intake in adolescents was negatively associated with availability of unhealthful foods at home, but positively associated with availability of healthful foods and the ratio of healthful/unhealthful foods at home. In a more recent study by Couch et al, a HFE questionnaire was used to assess the relationship between the sociocultural and physical environment in the home and child fruit and vegetable intake and weight status. Aspects of the sociocultural environment that were examined included family food rules, restrictive parent feeding strategies, parent-enforced pressure to eat, and parent encouragement/modeling for healthy eating. Aspects of the physical environment that were examined included availability and accessibility of healthy versus unhealthy foods. It was noted that encouragement/ modeling related to healthy eating was positively related to child fruit
and vegetable intake, while availability of high-calorie/nutrient-poor foods was negatively related to child fruit and vegetable intake.

Two other studies used focus groups to identify the HFE factors influencing adolescents’ fruit and vegetable intake. Accessibility to healthful foods, specifically cost was expressed as a barrier by numerous families. Time constraints such as a busy schedule of both children and parents was indicated as a barrier in both studies. The developmental status of teens was indicated as a challenge to healthful eating for adolescents compared to younger children because adolescents have a tendency to resist authority and act counter to their parents encouragement. Family meals and parent modeling were suggested to be important elements in helping families to eat more healthful foods. Findings from these studies confirmed the importance of the HFE on healthful eating behavior in adolescents.

Gaps addressed by the current study

While there has been some research examining the association between the HFE and diet quality in adolescents, little has been done to evaluate the HFE as a target for intervention to remediate chronic disease risk factors in adolescents. One major reason for the paucity of literature in this area is that there is no established validated HFE assessment tool to predict diet quality and fruit and vegetable intake in a population of adolescents with chronic disease risk factors. The current study is designed to address this gap. Specifically, this study will examine the predictive validity of several measures of the HFE including healthy home food availability, family food insecurity, parenting rules around eating, frequency of fast food/carry-out, and frequency of family meals together to assess diet quality and fruit and vegetable intake in adolescents with elevated BP. Should these scales show good predictive validity for adolescents’ healthy eating behavior, this HFE tool may be useful to health care professionals in identifying
important targets for lifestyle intervention to modify BP in youth.
Research Question: Do previously published scales for healthy home food availability, family food insecurity, parenting rules around eating, frequency of fast food/carry-out, and frequency of family meals together at home have good predictive validity to assess diet quality as measured by DASH score and fruit and vegetable intake among adolescents with elevated blood pressure?
METHODS

Participants

Participants for this thesis included 96 adolescents aged 11 to 18 years recruited from the Cincinnati Children’s Hypertension Center (CCHC) for the DASH-4-Teens randomized clinical trial between February 2008 and September 2012. The participants were newly admitted to the CCHC with diagnosed prehypertension or stage 1 hypertension according to the classification established in the Fourth Pediatric Report on Hypertension. All participants included in this study completed a HFE questionnaire and a three day dietary recall at their baseline visit in the DASH-4-Teens trial.

Adolescents with stage 2 hypertension, secondary hypertension, who were using antihypertensive medications, had prior exposure to formal dietary therapy to manage BP, had diagnosed target organ damage, were diagnosed with type 1 or 2 diabetes or an eating disorder, and/or had any psychological or medical condition that would prevent full participation in the study were excluded from the study. Participants were also excluded if they were unwilling to stop the use of vitamins, minerals, and certain antacids. Eligible participants had to speak English and have full medical clearance from a physician to participate. Informed assent or consent (dependent on age of adolescent) and parental permission were obtained by adolescents and parents prior to participation in the study. The Cincinnati Children’s Hospital Medical Center (CCHMC) Institutional Review Board and University of Cincinnati Institutional Review Board approved the study.

Measures:

Demographic and Anthropometric
At baseline, adolescents self-reported date of birth, gender and ethnicity. Height and weight were measured by trained nursing personnel twice at CCHC. A third reading was taken if measurements varied by more than 2%. A wall-mounted stadiometer was used to measure height in meters and a calibrated triple-beam balance scale was used to measure weight in kg. Body mass index (BMI) was calculated as the average of 2 readings for weight in kg divided by the square of the average of 2 readings for height in meters. Centers for Disease Control growth charts and age-specific medians and standard deviations were used to calculate BMI z-scores\textsuperscript{39}.

**Dietary**

Three random 24-hour dietary recalls were performed by trained research dietitians from the Cincinnati Center for Nutrition Research at CCHMC via telephone interviews with the adolescents over a two-week time period prior to the participants’ baseline visit to the CCHC. Prior to the recalls, participants were sent a 2 dimensional food model with instructions and were called to provide training on how to use this tool to estimate portion sizes of foods eaten. Once collected, dietary intake data were analyzed using the Minnesota Nutrient Data Systems for Research (NDSR) software (2010).

**The DASH Score**

A DASH score was calculated from 3 day diet recall food serving averages and mean sodium intake values from the NDSR output files according to the methods from Guenther et al.\textsuperscript{40} NDSR food subgroup codes were used to create 8 food groups and one nutrient group (sodium) that were used to derive the 9 component scores of the DASH score index. The score ranged between 0 and 90, with a higher DASH score indicating a higher diet quality. The 9 food component scores were derived for number of servings of total and whole grains, vegetables, fruits, total and low fat dairy, meat/poultry/fish/eggs, nuts/seeds/legumes, fats/oils, sweets and
sodium. To determine the 9 DASH component scores, actual intake of servings from the nine food/nutrient groups were compared against DASH recommendations \(^{41}\) (calculated with consideration given to calorie targets for age and gender). If the adolescent’s dietary intake of the food group/nutrient met the servings recommendation a maximum score of 10 for the food/nutrient group was assigned. Otherwise lower intakes were scored proportionately. \(^{41-43}\)

For the meats, fats and sodium groups, lower intakes were recommended; therefore, reverse scoring was applied and intakes >200% of the recommended upper level were assigned a score of 0.

**HFE Questionnaire**

HFE questionnaires were completed by all participants prior to their baseline assessment visit in the DASH-4-Teens randomized clinical trial. All questionnaire items were derived from previously published scales and tested for internal consistency in different population. The healthy home food availability scale included 8 items (Cronbach’s \(\alpha = 0.77\) ) from the Girls Health Enrichment Multisite Study\(^ {20}\), and was used to assess fruit, vegetable and low-fat food availability at home. The food insecurity scale consisted of 4 items (Cronbach’s \(\alpha = 0.84\) ) from the Radimer/Cornell Measures of Hunger and Food Insecurity\(^ {44}\) to assess family food security. The parent food rules scale from the Active Where? Parent-Child Survey\(^ {45}\) (6 items; Cronbach’s \(\alpha = 0.60\) ) related to parenting rules around eating and screen time and included rules about dessert, TV during meal times, snacks before dinner, fast food intake, high fat snacks intake, and daily screen time. A frequency of fast food scale related to the number of times per week that the participant consumed a fast food/carry-out meal (1 item); this scale was derived from Gillis et al.\(^ {46}\) A frequency of family meals together scale was a single item that related to the number of times per week that meals were eaten together as a family.\(^ {47}\) The home food availability scale,
the frequency of fast food scale, and the frequency of family meals together scale were scored using a five point Likert scale ranging from 1 (strongly disagree or never) to 5 (strongly agree, every day, or always). Responses were summed when more than one item were included in the scale and average scores were generated. The average was then used as the scale score. Items of the food insecurity scale were scored using a five point Likert scale ranging from 1 (never) to 5 (a lot). Again, responses were summed and average scores were generated. The average was then used as the scale score. Parenting rules were scored as 1 (yes or sometimes) and 0 (no) and the scale score was calculated as the sum of these responses.

**Statistical Analysis**

Data were analyzed using SAS 9.4.1. Means and standard deviations were calculated for continuous variables, while frequencies were derived for categorical variables. Distributions of the residuals were checked for normality assumptions and based on these findings, DASH scores, fruit intake servings, and vegetable intake servings were found to be normally distributed. All assumptions for simple linear regression and multiple regression analyses were met. Three sets of linear regression models were run in which DASH score, fruit intake servings, and vegetable intake servings were the dependent variables. In these models, HFE scale scores (healthy food availability, family food insecurity, frequency of family meal together, and frequency of fast food/carry-out) were independent variables of interest. For each set of linear regression models, four models were built to include different covariates: Model 1 was unadjusted; Model 2 was adjusted for age, gender, and race; Model 3 was adjusted for the covariates in Model 2 plus BMI z-scores and energy intake; Model 4 was adjusted for the covariates in Model 3 plus income. P values <0.05 were considered significant.
RESULTS

Participant Characteristics

As shown in Table 1, the participants were adolescents 11-18 years of age. There were ~ twice as many males as female participants. The majority of participants were non-Hispanic and over 60% were Caucasians. The prevalence of overweight/obesity (BMI ≥85th percentile) among the participants in this sample was higher than national pediatric data, which speaks to overweight/obesity as a risk factor for elevated BP in youth. On average, the participants consumed ~ one serving of fruit and one and a half servings of vegetables daily, which were far lower than DASH recommendations of 7-10 servings daily of fruits and vegetables. Mean energy intake was comparable with DASH diet recommendation. The average DASH score was about 46% of the total possible score.

Descriptive results of HFE scales in participants

Table 2 lists all of the HFE scales and scale items. Internal consistencies of the scales, as measured by Cronbach’s alpha, were consistent with previously published values (reported in Methods). Mean HFE scores indicate a high perceived availability of fruits/vegetables/low-fat dairy in the home, a high-perceived use of food rules around eating in the home, and a low perceived food insecurity level. On average, participants reportedly ate fast food 1-2 days per week (based on a Likert scale score where a mean of 2 = 1-2 days per week) and ate meals together as a family 3-4 times per week (based on a Likert scale where a mean of 3 = 3-4 times per week).
### Table 1: Characteristics of Study Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Definition</th>
<th>n</th>
<th>%</th>
<th>Mean ± standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>11-18</td>
<td>96</td>
<td>100</td>
<td>14.6±2.1</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>63a</td>
<td>65.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>33</td>
<td>34.4</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>Caucasian</td>
<td>63</td>
<td>65.6</td>
<td></td>
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<tr>
<td></td>
<td>African American</td>
<td>31</td>
<td>32.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>2</td>
<td>2.1</td>
<td></td>
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<tr>
<td>Ethnicity</td>
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<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Hispanic</td>
<td>95</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>&lt;$20,000</td>
<td>21</td>
<td>21.9</td>
<td></td>
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<tr>
<td></td>
<td>$20,000 to 50,000</td>
<td>37</td>
<td>38.5</td>
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<td>$50,000 to 80,000</td>
<td>21</td>
<td>21.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>=&gt;$80,000</td>
<td>15</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>BMIZ score</td>
<td></td>
<td></td>
<td></td>
<td>1.88±0.81</td>
</tr>
<tr>
<td>BMI percentile</td>
<td>&lt;85th percentile</td>
<td>16</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>85th to &lt;95th percentile</td>
<td>7</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥95th percentile</td>
<td>73</td>
<td>76.0</td>
<td></td>
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<tr>
<td>Dietary intake</td>
<td>Energy, kcal/d</td>
<td></td>
<td></td>
<td>1673.8±571.9</td>
</tr>
<tr>
<td></td>
<td>Fruits, servings/d</td>
<td></td>
<td></td>
<td>1.0±1.0</td>
</tr>
<tr>
<td></td>
<td>Vegetables, servings/d</td>
<td></td>
<td></td>
<td>1.5±1.1</td>
</tr>
<tr>
<td></td>
<td>DASH score</td>
<td></td>
<td></td>
<td>41.6±8.4</td>
</tr>
</tbody>
</table>

*BMI = body mass index. BMI was calculated as weight (kg)/height (m²), with BMIZ scores and weight status cut points defined as per CDC criteria.

**Fruits and vegetables included whole and 100% juice in salads, soups, stews, stir-fry, and similar mixed dishes and excluded fried fruits and vegetables; serving sizes were calculated according to the DASH dietary pattern.

***DASH score was calculated according to Guenther and colleagues; possible score ranged from 0 to 90 with higher score=higher diet quality

### Table 2: Items, Internal Consistency, Mean ± standard deviation, Range of Home Food Environment scales

<table>
<thead>
<tr>
<th>Home Food Environment Scales (No. of Items)</th>
<th>Items</th>
<th>Internal Consistency</th>
<th>Mean ± standard deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home food availability (8)</td>
<td>1. How many days did family members provide fruits or vegetables to you as part of a meal?</td>
<td>0.80</td>
<td>3.88±0.65</td>
<td>1 to 5a</td>
</tr>
<tr>
<td></td>
<td>2. How many days did family members provide low-fat dairy foods to you as part of a meal?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Food insecurity (4)

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. During the past month, did you worry that food at home would run out before your family got money to buy more?</td>
<td>0.86</td>
<td>1 to 5</td>
</tr>
<tr>
<td>2. During the past month, did the food that your family bought run out, and you didn’t have money to get more?</td>
<td>1.44 ± 0.67</td>
<td>1 to 5</td>
</tr>
<tr>
<td>3. During the past month, did you have to eat less because your family didn’t have enough money to buy food?</td>
<td>1.44 ± 0.67</td>
<td>1 to 5</td>
</tr>
<tr>
<td>4. During the past month, did you have to skip a meal because your family didn’t have enough money for food?</td>
<td>1.44 ± 0.67</td>
<td>1 to 5</td>
</tr>
</tbody>
</table>

### Parent food rules (6)

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A rule at home is that there is no dessert until my plate is cleaned.</td>
<td>0.64</td>
<td>0 to 6</td>
</tr>
<tr>
<td>2. A rule at home is that there is no TV during meal times.</td>
<td>3.07 ± 1.76</td>
<td>0 to 6</td>
</tr>
<tr>
<td>3. A rule at home is that there are no snacks before dinner.</td>
<td>3.07 ± 1.76</td>
<td>0 to 6</td>
</tr>
<tr>
<td>4. A rule at home is that there are no high-fat snacks (e.g. potato chips, ice-cream).</td>
<td>3.07 ± 1.76</td>
<td>0 to 6</td>
</tr>
<tr>
<td>5. A rule at home is that there is limited fast food.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. A rule at home is that I am only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
allowed to spend two hours at most watching TV, playing video games, and using the computer every day.

| Frequency of fast food (1) | 1. How many days did you eat something from a fast-food or take-out restaurant? | N/A | 1.93 ± 0.74 | 1 to 5
| Frequency of family meals together (1) | 1. How many times did all or most of your family eat a meal together? | N/A | 3.36 ± 1.27 | 1 to 5

*Items of home food availability were scored using a Likert scale ranging from 1 (never/strongly disagree/) to 5 (everyday/strongly agree). The higher the score was, the higher the home food availability was.

*Items of food insecurity were scored using a Likert scale ranging from 1 (never) to 5 (a lot). The higher the score was, the higher the level of food insecurity was.

*Items of parent food rules were scored as 1 (yes) and 0 (no) responses. The scale score was the sum of the responses ranging from 0 to 6. The higher the score was, the more food rules were used in the home.

*Frequency of fast food per week were scored as 1= never, 2= 1-2 days per week, 3 = 2-3 days per week, 4 = 4-5 days per week, 5 = everyday.

*Frequency of family meals together were scored as 1=never, 2= 1-2 times per week, 3 = 2-3 times per week, 4 = 4-5 times per week; 5 = >6 times per week.

**Home Food Environment Scales in Relation to Diet Quality**

The results in Table 3 shows that home food availability was positively associated with participants’ DASH score in unadjusted model 1 and adjusted model 3 at the p<0.05 level, but the association became attenuated in adjusted model 2 and 4. Food insecurity was not associated with DASH score in any of the models. Parent food rules was positively associated with DASH score in unadjusted model 1 at p<0.01 level and when adjusted for covariates the associations remained significant in model 2, and 3 at p<0.05 level. Frequency of fast food was negatively associated with DASH score in all models. Frequency of family meals together was positively associated with DASH score in model 1, 2, and 3 at p<0.05 level, but was attenuated when adding income as a covariate in model 4.
Table 3: Estimate associations between home food environment and DASH score of adolescents aged 11 to 18 years in multivariate regression models

<table>
<thead>
<tr>
<th>Home food environment scales</th>
<th>Unadjusted Model 1 DASH Score Estimate (p-value)</th>
<th>Adjusted Model 2(^a) DASH Score Estimate (p-value)</th>
<th>Adjusted Model 3(^b) DASH Score Estimate (p-value)</th>
<th>Adjusted Model 4(^c) DASH Score Estimate (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home food availability</td>
<td>2.87 (0.03)*</td>
<td>2.58 (0.06)</td>
<td>3.14 (0.02)*</td>
<td>2.38 (0.093)</td>
</tr>
<tr>
<td>Food insecurity</td>
<td>-0.64 (0.62)</td>
<td>-0.64 (0.65)</td>
<td>-1.39 (0.34)</td>
<td>0.11(0.95)</td>
</tr>
<tr>
<td>Parent food rules</td>
<td>1.15 (0.018) *</td>
<td>1.20 (0.02) *</td>
<td>1.04 (0.038) *</td>
<td>0.81 (0.13)</td>
</tr>
<tr>
<td>Frequency of fast food</td>
<td>-3.32 (0.003)**</td>
<td>-3.16 (0.007)**</td>
<td>-2.65 (0.02) *</td>
<td>-2.4 (0.045)*</td>
</tr>
<tr>
<td>Frequency of family meals</td>
<td>1.35 (0.045)*</td>
<td>1.43 (0.048)*</td>
<td>1.37 (0.05)*</td>
<td>0.75 (0.31)</td>
</tr>
</tbody>
</table>

\(^a\)Model 2 was adjusted for adolescent age, gender, and race.
\(^b\)Model 3 was adjusted for adolescent age, gender, race, BMI z-score, and energy intake.
\(^c\)Model 4 was adjusted for adolescent age, gender, race, BMI z-score, energy intake, and income.

*\(p<0.05\).
**\(p<0.01\).
***\(p<0.001\).

Table 4 shows that home food availability was positively associated with fruit intake among adolescents in model 1 and 2 at \(p<0.05\), but not in model 3 and 4. Food insecurity and family meal together were not associated with fruit intake in any of the four models. Parent food rules was positively associated with fruit intake in all four models at the \(p<0.05\) level. Frequency of weekly fast food was negatively associated with fruit intake in model 3and 4. Frequency of weekly family meals together was not associated with fruit intake in any of the four models.
Table 4: Estimate associations between home food environment and fruit intake servings of adolescents aged 11 to 18 years in multivariate regression models

<table>
<thead>
<tr>
<th>Home food environment scales</th>
<th>Unadjusted Model 1</th>
<th>Adjusted Model 2</th>
<th>Adjusted Model 3</th>
<th>Adjusted Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Intake Estimate (p-value)</td>
<td>Fruit Intake Estimate (p-value)</td>
<td>Fruit Intake Estimate (p-value)</td>
<td>Fruit Intake Estimate (p-value)</td>
<td></td>
</tr>
<tr>
<td>Home food availability</td>
<td>0.37 (0.02) *</td>
<td>0.36 (0.03)*</td>
<td>0.31 (0.07) *</td>
<td>0.31 (0.087)</td>
</tr>
<tr>
<td>Food insecurity</td>
<td>-0.24 (0.12)</td>
<td>-0.22 (0.19)</td>
<td>-0.14 (0.43)</td>
<td>-0.04(0.86)</td>
</tr>
<tr>
<td>Parent food rules</td>
<td>0.13 (0.027)*</td>
<td>0.13 (0.036)*</td>
<td>0.14 (0.024)*</td>
<td>0.17(0.014)*</td>
</tr>
<tr>
<td>Frequency of fast food</td>
<td>-0.22 (0.12)</td>
<td>-0.21 (0.15)</td>
<td>-0.30 (0.03) *</td>
<td>-0.32 (0.038)*</td>
</tr>
<tr>
<td>Frequency of family meals together</td>
<td>0.058 (0.48)</td>
<td>0.054 (0.55)</td>
<td>0.061 (0.48)</td>
<td>0.04(0.68)</td>
</tr>
</tbody>
</table>

*aModel 2 was adjusted for adolescent age, gender, and race.
*bModel 3 was adjusted for adolescent age, gender, race, and BMI z-score, and energy intake.
*cModel 4 was adjusted for adolescent age, gender, race, BMI z-score, energy intake, and income.
*p<0.05.
**p<0.01.
***p<0.001.

Table 5 shows that none of the aspects of HFE were associated with vegetable intake among adolescents in any of the four models.

Table 5: Estimate associations between home food environment and vegetable intake servings of adolescents aged 11 to 18 years in multivariate regression models

<table>
<thead>
<tr>
<th>Home food environment scales</th>
<th>Unadjusted Model 1</th>
<th>Adjusted Model 2</th>
<th>Adjusted Model 3</th>
<th>Adjusted Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable Intake Estimate (p-value)</td>
<td>Vegetable Intake Estimate (p-value)</td>
<td>Vegetable Intake Estimate (p-value)</td>
<td>Vegetable Intake Estimate (p-value)</td>
<td></td>
</tr>
</tbody>
</table>
Table 6: Estimate associations between home food environment and fruit & vegetable intake servings of adolescents aged 11 to 18 years in multivariate regression models

<table>
<thead>
<tr>
<th>Home food environment scales</th>
<th>Unadjusted Model 1 F&amp;V Intake Estimate (p-value)</th>
<th>Adjusted Model 2 F&amp;V Intake Estimate (p-value)</th>
<th>Adjusted Model 3 F&amp;V Intake Estimate (p-value)</th>
<th>Adjusted Model 4 F&amp;V Intake Estimate (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home food availability</td>
<td>0.31 (0.08)</td>
<td>0.21 (0.26)</td>
<td>0.17 (0.36)</td>
<td>0.13 (0.52)</td>
</tr>
<tr>
<td>Food insecurity</td>
<td>-0.19 (0.26)</td>
<td>-0.23 (0.22)</td>
<td>-0.19 (0.32)</td>
<td>-0.12(0.60)</td>
</tr>
<tr>
<td>Parent food rules</td>
<td>0.09 (0.16)</td>
<td>0.087 (0.22)</td>
<td>0.1 (0.15)</td>
<td>0.1 (0.18)</td>
</tr>
<tr>
<td>Frequency of fast food</td>
<td>-0.17 (0.27)</td>
<td>-0.10 (0.52)</td>
<td>-0.18 (0.28)</td>
<td>-0.15(0.39)</td>
</tr>
<tr>
<td>Frequency of family meals together</td>
<td>0.036 (0.69)</td>
<td>0.02 (0.83)</td>
<td>0.026 (0.79)</td>
<td>0.02 (0.83)</td>
</tr>
</tbody>
</table>

*aModel 2 was adjusted for adolescent age, gender, and race.
*bModel 3 was adjusted for adolescent age, gender, race, and BMI z-score, and energy intake.
*cModel 4 was adjusted for adolescent age, gender, race, BMI z-score, energy intake, and income.
*p<0.05.
**p<0.01.
***p<0.001.

Table 6 shows that when combing fruit and vegetable intake servings together as the dependent variable, home food availability was positively associated with fruit and vegetable intake servings in model 1 and 2. Food insecurity and family meal together were not associated with fruit and vegetable intakes in any of the four models. Parent food rules was positively associated with fruit intake in all four models at the p<0.05 level. Frequency of fast food and frequency of family meals together were not associated with fruit and vegetable intakes in any of the four models.
<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent food rules</td>
<td>0.22 (0.024)*</td>
<td>0.22 (0.036)*</td>
<td>0.26 (0.012)*</td>
<td>0.26 (0.02)*</td>
</tr>
<tr>
<td>Frequency of fast food</td>
<td>-0.39 (0.10)</td>
<td>-0.28 (0.26)</td>
<td>-0.46 (0.06)</td>
<td>-0.47 (0.06)</td>
</tr>
<tr>
<td>Frequency of family meals</td>
<td>0.09 (0.49)</td>
<td>0.02 (0.87)</td>
<td>0.06 (0.67)</td>
<td>0.06 (0.69)</td>
</tr>
<tr>
<td>together</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a Model 2 was adjusted for adolescent age, gender, and race.
*b Model 3 was adjusted for adolescent age, gender, race, and BMI z-score, and energy intake.
*c Model 4 was adjusted for adolescent age, gender, race, BMI z-score, energy intake, and income.
*p<0.05.
**p<0.01.
***p<0.001.

**DISCUSSION**

The predictive validity of five scales of important physical and social factors in the HFE was assessed in the current study. Overall, with the exception of food insecurity, the scales showed good predictive validity for fruit intake and overall diet quality as measured by the DASH score index in our sample of adolescents with elevated BP. In particular, healthy home food availability, frequency of weekly family meals together, and parenting rules around eating, were positively associated with DASH score. Healthy home food availability and parenting rules around eating were also positively related to fruit intake. Adjusting prediction models for income attenuated positive associations between these scales, diet quality and fruit intake suggesting that family income had a significant influence on these relationships. Frequency of fast food was negatively associated with DASH score, and remained significant after adjusting for income. Given that intake of fruit and better adherence to a DASH diet are dietary behaviors conducive to BP lowering in teens with elevated BP, interventions targeting family meals, parenting rules and healthy home food availability may lead to effective BP lowering in youth with hypertension.

Our finding of a positive association between healthy home foods availability, fruit intake, and DASH score in adolescents with hypertension supports the predictive validity of this
HFE scale for these measures of diet quality in this population. Creating a home environment where healthy foods are readily available has been shown by others to be conducive to improving diet quality among adolescents. For example, in a study by Ding et al\textsuperscript{35}, fruit and vegetable intake of adolescents was positively associated with availability of more-healthful food and availability of fruits and vegetables in the home, but not with the number of neighborhood food outlets. Gattshall et al\textsuperscript{34} looked at child’s fruit intake and vegetable intake separately and confirmed that children’s intake of these food groups was positively associated with availability of these foods at home. Findings from the present study support use of the home availability scale for assessing fruit intake and DASH score in teens with elevated BP. This is important, given the empirical evidence demonstrating benefit of fruit and the DASH diet on lowering BP among youth with hypertension.

In the present study, a greater frequency of family meals together predicted greater DASH score; this finding suggests that this HFE scale showed good predictive validity for an index of high diet quality in our population. Similar relationships have been reported by investigators from the Project EAT study, which included 3957 adolescents from 31 middle and high schools in Minnesota. This study found that family meal habits were positively correlated with fruit and vegetable intake as a measure of high diet quality in adolescents.\textsuperscript{22, 29} In this study, the tool to assess family meal habits examined three aspects of family meals: frequency of family meals together, parental presence at meals, and priority given to family meals. Notably, children’s fruit and vegetable intakes was \textasciitilde 1 serving greater in families that had meals together more than seven times per week compared to those never had meals together. In another study of the HFE and diet quality in over 18,000 adolescents, Videon et al showed that parental presence at the evening meal was associated with a lower risk of poor fruit and vegetable intakes and of
There are several reasons why having family meals together might be conducive to improving diet quality in teens. When eating meals together as a family, parents are often able to role model healthy eating practices, reinforce healthy food rules, and positively encourage fruit and vegetable consumptions to increase children’s intake of these food groups. These practices have been related to better diet quality in adolescents\textsuperscript{35-37}. Interestingly, in the present study, frequency of family meals together was not related to intake of vegetables, but was positively related to fruit intake and overall DASH score. Vegetables are usually served at family dinner and often are not consumed by teens at any other time during the day\textsuperscript{23}. Since the HFE items addressed family meals rather than dinner only, this may explain the lack of association between vegetables and this measure in our study.

The present study found a positive relationship between food rules related to eating, fruit intake and DASH score among participants. These results are in line with recent findings by Couch et al. who used the same food rules scale used in the present study\textsuperscript{36}. These researchers also found a positive association between parent rules related to child’s eating and diet quality as measured by DASH score among 6-9 year old children. These findings suggest that having more food rules in the home related to eating has beneficial effects on diet quality of children and teens. Parent food rules related to eating may contribute to diet quality benefits as they are directed at overall healthy eating habits such as “no TV during meals”. The rules also relate to not filling up on unhealthy foods before dinner and limiting unhealthy snacking and fast food intake. Hypothetically, parents that enforce these rules likely make a point of providing healthy foods at meals and for snacks. Also, parents that enforce less distraction at mealtime in essence are promoting more mindful eating. Researchers have showed that mindfulness may be a factor related to better adherence to healthy diet and exercise programs.\textsuperscript{49} Our findings add to the
literature as this is the first study showed that having parenting rules around eating at home is positively associated with not only overall diet quality but also fruit intake of an adolescent; these positive relationships also support the predictive validity of this HFE scale for DASH score and fruit intake among adolescents with elevated blood pressure.

The present study showed that the family food insecurity scale was not associated with adolescents’ fruit and vegetable intake or diet quality. These findings suggest that the food insecurity scale used in the present study does not have good predictive validity for diet quality as measured by DASH score or fruit and vegetable intake in adolescents. It also may suggest that food insecurity is not related to diet quality in adolescents. This latter hypothesis is in line with recent findings from a systematic review by Hansen et al., who showed no association between food insecurity and diet quality in either adults or children. Reasons for this finding are unclear, however several factors may account for this null association. First, only 1 in 5 participants in our sample were from low-income families (family income less than $20,000) (Table 1). Therefore, we may not have had enough power in our analysis to show significant association between DASH score and food insecurity. Second, the expected association between food insecurity and diet quality may have been weakened by adolescents’ participation in the school meals programs. It could be argued that adolescents who participate in school breakfast and lunch programs would have the opportunity to improve their diet quality at no or reduced cost, even though their meals at home may be negatively impacted by food insecurity. To account for school meal participation in the present study, the average frequency of participation per week in free or reduced price school meals was determined from an individual item on the HFE questionnaire. We added the average response scores of this item as a covariate in the food insecurity models and our results did not change; this suggests that school lunch participation
may be an unlikely explanation for our findings. A third possible explanation for the lack of association between food insecurity and diet quality in this study may relate to parenting practices in regards to teens’ eating. There is evidence to suggest that in food insecure households, the major food preparer often sacrifices his/her own diet quality to meet the nutritional needs of his/her children.\textsuperscript{51} This practice would suggest that in food insecure households, the parent’s diet quality would suffer before that of the child/teen. In this study, we did not collect parent recall data to assess whether this could explain our findings. This hypothesis warrants further investigation.

Frequency of fast food/carry-out was found to have a negative association with adolescents’ fruit intake and DASH score in the present study. This finding supports the predictive validity of this HFE scale to assess these diet quality measures and supports findings from others in the direction of association. Bowman et al examined fast food consumption in 6212 children and adolescents 4 to 19 years old and its relationship with nutrition-related outcomes.\textsuperscript{52} These researchers found that children who ate fast food, compared with those who did not, consumed not only more total energy but also fewer fruits and non-starchy vegetables and concluded that consumption of fast food among children might have an adverse effect on their diet quality. Taveras et al also found that frequency of eating fried food away from home was associated with lower consumption of fruits and vegetables.\textsuperscript{53} Our findings suggest that designing interventions to encourage more home cooking and less consumption of take-out food may be conducive to promoting higher quality diets in line with a DASH-type diet, which would be particularly important for adolescents with elevated blood pressure.

There were several strengths of our study. First, the HFE questionnaire items were derived from published scales that were tested for internal consistency in each of the published
studies from which they were acquired; the internal consistency of the scales in our sample were similar to those previously published indicating that the items still related well-together in our sample of youth. Second, the HFE questionnaire was administered to adolescents and was able to capture their perception of their HFE rather than that of their parents. It would be expected that the association between the adolescent’s perception of their HFE and their diet would be stronger than the association between parent perception of the HFE and adolescent diet intake. No studies have looked at relationships between the HFE and diet quality from the adolescent’s point of view. Third, the dietary recall data were collected using the multi-pass approach by trained registered dietitians to reduce measurement error. Further, 3 day, 24 hour recalls were used to assess diet quality, which is considered a best practice for assessing dietary intake for use with this age group among whom overestimating energy intake and reporting inaccurate portion size were commonly observed.\textsuperscript{54, 55} Fourth, regression models were built by adding important factors known to influence the relationship between HFE and diet quality in a step-wise fashion to assess true correlations, including age, gender, race, BMI, energy intake, and income. This allows one to consider whether variability explained by these covariates had an important influence on the relationships. Income was one factor that was shown to have an influence on several of the relationships between HFE factors and diet quality. Understandably, income may impact a family’s ability to buy fruits and vegetables or their practices of cooking at home versus eating out. Future studies should examine these influences in greater detail. The study is not without limitations. Sample size was fairly small so our ability to generalize our conclusions to all adolescents with elevated blood pressure is limited. Also, adolescents might not be truthful about their HFE resulting in biased self-reporting data.
Collectively, findings from this study suggest that the scales for home food availability, parent food rules around eating, frequency of family meals together, and frequency of fast food per week on the HFE questionnaire have good predictive validity to assess diet quality in terms of DASH score and fruit intakes in adolescents with elevated blood pressure. Further research is needed to determine factors within the HFE that predict vegetable consumption in this at-risk population.
Reference:


