Longitudinal Associations Between Home Food Environment and Diet Quality in Children

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Abstract

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and Diet Quality in Children

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Background: Child and adolescent diets in the United States are high in fat and sodium and low in vegetables, fruits, whole grains, and dairy foods. Parental practices and foods provided in the home greatly influence children's food related behaviors. This impact may change as children progress through adolescence and other factors begin to play a role, such as peers, media, and convenience of food.

Objective: This study aimed to investigate longitudinal relationships between parenting around food/eating, foods available in the home, and future child diet quality in younger versus older children.

Methods: The National Impact on Kids (NIK) Study was a prospective cohort study with two time points, baseline and 2-year follow-up. Parental surveys were used to collect data on home food environment and 24-hour food recalls were used to collect child dietary intake. Child diet quality indicators include DASH score, fruit and vegetable intake, and high-energy beverage intake. In this secondary data analysis, participants were dichotomized in to two groups:

younger (ages 6-8.99) versus older (ages 9-12.5) at study initiation. Hierarchical linear regression models were used to assess the association between initial parenting around food/eating and foods available in the home and future child diet quality indicators.

Results: Participants were 50.7% female and predominantly Non-Hispanic White (70.2%). A significant overall change in DASH scores ($p=.053$), total fruit and vegetable intake ($p=.017$), and high-energy beverage consumption ($p<.001$) was seen. There was a significant effect of age on parental permissiveness ($p<.001$), as well as rules around food ($p=.003$), however, no significant differences in diet quality were seen between groups. For younger children, initially more parental rules around food was positively related to children's subsequent DASH scores ($p=.028$); and initial availability of non-nutritious foods in the home was positively related to future high-energy beverage intake ($p=.003$). For older children, being Non-Hispanic White ($p=.023$), and initial parental pressure to eat ($p=.035$), permissiveness ($p=.046$), and rules around food ($p=.019$) were positively related to future child DASH scores; initial parental encouragement ($p=.009$) and permissiveness ($p=.015$) were positively related to children's future fruit and vegetable intake; and initial home availability of non-nutritious foods ($p=.023$) and parental restrictiveness ($p=.037$) was related to higher future high-energy beverage intake.

Conclusions: A greater number of longitudinal relationships existed between the home food environment and child diet quality in older as compared to younger children, suggesting that changes in development broadly affect parental influence on child food-related behaviors.

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Introduction

Childhood Obesity and Diet Quality

Childhood obesity is a major public health concern in the United States (US). In 2009-2010, the prevalence of obesity in children and adolescents was 17%.[1-3] Furthermore, it is estimated that 33% of 6-11 year old children were either obese or overweight in 2009-2010.[2] Obese children are at risk of becoming obese adults and suffering from chronic physical and mental health problems such as type 2 diabetes, heart disease, sleep problems, and internalizing and externalizing disorders.[4,5] The high likelihood of these detrimental health conditions persisting into adulthood demonstrates the importance of prevention and treatment of childhood obesity, as well as the ability to intervene as early as possible to prevent the onset of life-long disease.

Poor diet quality contributes to the development of childhood obesity. Compared to recommendations for a healthy diet, child and adolescent diets in the US are high in fat and sodium, and low in vegetables, fruits, whole grains and dairy foods.[6,7] In 2009-2010, children 6-11 years of age ate about 0.79 cups of vegetables (approximately 40% of recommended amounts) and 35.5 grams (more than 150% over recommended amounts) of solid fats per day.[7] Nutrient intake throughout childhood and adolescence is important for growth, health promotion, and the development of lifelong eating behaviors.[8] Although public health efforts to improve adolescent dietary patterns have been associated with self-reported increases in fruit and vegetable consumption and decreases in sweets and soft drink consumption[9], dramatic under-consumption of healthful foods and over-consumption of discretionary calories remains high[10,11] amongst children 6-11 years of age.[9]

Parental Influence on Child Weight Status and Diet Quality

While many factors play a role in childhood obesity, there is evidence that parents and caregivers influence their children's food intake through foods provided in the home, role modeling, and parental feeding practices.[12-18] Availability and accessibility of fruits and vegetables in the home have been negatively associated with childhood obesity[15] and positively associated with intake of these foods by children.[14-16,18] Multiple studies have also found a negative relationship between availability of unhealthful food in the home and child consumption of fruits and vegetables.[14,19]

Children's milk and fruit and vegetable intake has been found to be positively associated with parental milk[12] and fruit and vegetable intake.[13] Our own data confirm these findings by demonstrating that in children 6-11 years of age, fruit and vegetable consumption is positively related to parental encouragement/modeling to eat these foods.[19]

Four main parenting styles (authoritarian, authoritative, permissive, and uninvolved) are often discussed in the literature with mixed results on which style is most beneficial to child diet quality. Recent systematic reviews state that authoritative parenting, known for being assertive with rules and structure, yet responsive and supportive of child self-regulation[20], is most frequently related to healthier child eating habits, lower child Body Mass Index (BMI) levels, and higher rates of physical activity compared to children raised in other parenting styles.[21,22] The remaining parenting styles have shown to be related to poor health outcomes, however, inconsistent results are frequently reported and some researchers suggest that specific parental feeding practices are most consistently and directly related to child diet quality and weight status.[22] Parental feeding practices are behaviors that strive to influence the amount or types of food a child eats. These include monitoring intake (keeping track of what a child eats),

restrictive feeding (regulating the type and amount of food a child eats), controlled feeding (deciding where, when, and what a child eats), pressure to eat (pushing a child to eat certain foods or finish their food), instrumental feeding (using food as a reward), and emotional feeding (attempting to use food for emotional regulation).[23]

Use of restrictive food-related parenting practices, such as disallowing high-fat or high-sugar foods in the home, have been shown to be higher among parents of overweight and obese adolescents compared to normal weight adolescents.[17] However, pressure to eat (example: forcing a child to finish their dinner before they may leave the table) has been shown to be significantly higher in normal weight adolescents compared to obese and overweight adolescents.[17] Others have found a negative association between parental pressure to eat fruits and vegetables and child intake of these foods.[13]

We previously demonstrated a negative relationship between parental permissiveness around food (example: allowing a child to eat meals and snacks while watching television) and child fruit and vegetable intake.[19] We also demonstrated a positive relationship between parental rules around food (example: requiring a child to eat dinner with the family) and child fruit and vegetable intake[19], which appears to support the literature around authoritative parenting styles. Although informative, causal inference cannot be drawn from most of the available data on parenting and children's dietary quality because most of the evidence is cross-sectional.

Very few longitudinal studies have examined prospective associations between parenting around food and eating and children's change in or future food intake. Of the available evidence, increases in child BMI z-scores after one-year follow-up have been predicted by parental instrumental feeding practices in children approximately two years old.[23] A recent meta-analysis concluded that parental feeding restrictions were longitudinally associated with increases in child

eating and weight status.[24] In addition, emotional feeding, encouragement to eat, weight-based restriction, and fat restriction have been predictive of the development of obesogenic eating behaviors (i.e., emotional eating and overeating) in children.[23]

Changes in parental Influence on Child Diet Quality During Transition to Adolescence

The strong influence of caregivers and parents on children's food related behaviors may change as children progress through adolescence and other factors begin to play a role in dietary intake. During the transition from childhood to adolescence, the brain and decision making processes are rapidly changing.[25] Adolescents demonstrate a lack of a sense of urgency regarding the effect of immediate decisions on their future health, which may influence their food-related behaviors.[26] In addition, peers, media, body image, mood, convenience of food, taste, and habit are all factors that have shown to influence adolescent diet quality.[26]

Very little is known about the variation in predictability of home food environment in younger children versus children entering adolescence, however, it is likely that developmental changes and influencers on child diet quality differ. One study found parental feeding restrictions at baseline to be negatively related to child BMI z-scores in children ages 5-6, but not children ages 10-12 after three-year follow-up.[27] In addition, a study that analyzed level of parental encouragement over 5 years found that encouragement to eat healthy foods and diet to control weight decreased between early and middle adolescence.[28]

This study aimed to expand on the available literature by investigating longitudinal relationships between the home food environment at one point and child diet quality 2 years later in younger (age 6-8.99 at time one) versus older children (age 9-12.50 at time one). Specifically, we measured the accessibility and availability of healthful foods in the home food environment, as well as parental practices around food, over a two-year time frame in relation to child diet

quality. We hypothesized that low accessibility and availability of healthful foods in the home food environment at time 1 would negatively predict child diet quality at time 2, even after controlling for time 1 diet quality. In addition, we hypothesized that higher parental permissiveness and restrictive rules around food at time 1 would negatively predict child diet quality at time 2. We expected that accessibility and availability of healthful foods would decrease more and that permissiveness would increase more in older children than in younger children.

Methods

Study design, setting and subjects

Participants were part of the Neighborhood Impact on Kids (NIK) Study[29], an NIH funded longitudinal, observational cohort study of children aged 6 to 12.5 at time 1 and their parents in Seattle/King County, WA and San Diego County, CA. NIK was designed to evaluate the association of neighborhood and home environmental factors with children and parent's weight status and weight-related behaviors. Children who lived in neighborhoods that varied in their physical activity environment (e.g., walkability and availability of high quality parks), and nutrition environment (e.g., availability of healthy food choices) were studied. Neighborhood characteristics were assessed by observation and existing land use and other collected spatial data and put into a Geographic Information System to identify eligible block groups, which defined neighborhoods. All procedures involving human subjects/patients were approved by the Institutional Review Boards at Seattle Children's Hospital (WA) and San Diego State University. Parents provided written informed consent and children provided assent prior to study participation.

Baseline participants were recruited between September 2007 and September 2008 in San Diego and between November 2007 and January 2009 in Seattle. The Time 2 data was scheduled to collect data approximately 2 years after each participant's Time 1 data collection. NIK contacted a total of 8,616 households of which 4,975 were screened for interest and eligibility, and 944 agreed to participate. Among families agreeing to participate, 756 consented and had a measurement visit for the baseline data. Of these families, 670 consented and had a measurement visit for follow-up data (11% attrition). Fifty-five participants were excluded from this present analysis due to missing survey data, resulting in a total of 615 subjects included in the data analyses.

Measures

Demographic information: At Time 1 and 2, parents completed a survey (online or paper) that included items about household, parent and child demographics. The full survey is available online at: http://www.seattlechildrens.org/research/child-health-behavior-and-development/saelens-lab/measures-and-protocols/. Individual–level demographics included child and parent age, sex, race and ethnicity. Household-level characteristics included highest level of adult education achieved in the household (categorized as ≤high school, completed college, and completed graduate degree). Baseline survey forms were completed by 725 parents (95.9% of the enrolled parents); child information was complete on all forms. Table 1 provides sample demographics.

Parental Practices: Parents also completed several measures derived from previously published scales to assess their style and parenting around child feeding practices, including "Encouragement" (3 items on a scale of 0="never" to 5="always") and "Modeling" (4 items on a scale of 0="never" to 5="always") that included items about parent's use of encouragement to

eat nutrient dense foods and modeling positive eating behaviors[30,31]; a “Pressure to Eat” scale (4 items on a scale of 0=“never” to 5=“always”) that included items about feeding strategies to get a child to eat[32]; a “Restrictive Food Practices” scale (2 items on a scale of 0=“never” to 5=“always”) that included items about use of food restriction to control a child’s food intake[33]; a “Permissive Food Practices” scale (3 items on a scale of 0=“never” to 5=“always”) that included items about eating without limits[33]; and a “Household Food Rules” scale (12 items with the response options of 0= “no” or 1= “yes”) that included items about rules enforced in the home related to child’s eating[34]. Two scales assessed home food availability related to high calorie /nutrient poor foods (8 items on a scale of 0=“never” to 5=“always”) and lower calorie/more nutrient dense foods (4 items on a scale of 0=“never” to 5=“always”).[35] Summary scores were created by calculating the mean score for each parental practice construct and both availability of nutritious foods and non-nutritious foods in the home.

Dietary Intake: A trained research dietitian assessed children’s dietary intake using up to three random 24-hour diet recalls over a two-week period with the multiple-pass method.[36] Prior to the recalls, during measurement visits, children and their parents were trained in the use of a 2-dimensional food portion size model to assist with estimation of portion sizes of foods eaten (Nutrition Consulting Enterprises; Framingham, MA). Telephone interviews were conducted with parents alone for children below the age of 8 using the consensus recall approach.[37] Children at or over the age of 8 were interviewed for dietary recall information with their parents present.[38-40]

Food recalls were analyzed for average daily caloric intake, nutrient content and food serving counts using the Minnesota Nutrient Data Systems for Research (NDSR) software, version 2.92 (2010). Given the association between energy density and nutrient quality, two

additional food groupings were created that reflected low nutrient quality foods: high energy, non-dairy beverages (e.g., sweetened soft drinks, fruit drinks) and non-nutritious snack foods (e.g., snack chips and crackers, cookies). A third additional food grouping was created of nutritious foods (high nutrient quality) consisting of all forms of fruits and vegetables (e.g., whole, juices) except savory snacks and fried types.

DASH score[41] is a weighted score from daily servings of 8 food groups - grains, vegetables, fruits, dairy, meat/poultry/fish/eggs, nuts/seeds/legumes, fats/oils, and sweets. Goals of intake for each food group were based on recommendations specified by the Dietary Guidelines for Americans[10], the DASH Collaborative Research Group[41], and on calorie levels specific for age, gender, and sedentary activity level.[42] A maximum score of 10 was achieved within each food group when a child's intake met the food group recommendation, whereas less healthy intakes were scored proportionately lower. 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. 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 a possible range between 0 and 80, with a higher score indicating a higher diet quality. A separate variable of total fruit and vegetable intake was calculated from mean daily servings of reported fruit and vegetables consumed.

Statistical Analyses: Data was analyzed using SPSS 21.0. Paired t-tests were used to assess overall and within group change in diet quality indicators. Associations among parental practice scales were previously assessed using Pearson correlations.[19] To avoid multi-collinearity in

regression models, annual household income was used rather than two demographic scales (annual household income and parental education) with correlations of 0.48. Parental practice scales were previously examined for internal consistency using Cronbach's alphas; those items with values $\geq$0.5 (moderate to high) were retained.

Hierarchical linear regression models were used to assess the association between parenting food/eating practices and home food environment scales at time one and diet quality indicators at time two. In order to assess differences between younger and older children, participants were split in to two groups: younger (ages 6-8.99 years old) and older (ages 9-12.5 years old). Three diet quality models were used for each age group to investigate DASH Scores, total fruit and vegetable intake, and total high-energy beverage intake. A priori covariates included diet quality, sex, race, and annual household income at time one. P values <0.05 were considered statistically significant. The first step included the diet quality indicator at time one. Demographic variables (sex, race, annual household income) were entered in the second step. The third and fourth step allowed us to test for whether parent food/eating practices and home food environment scales at time one were related to diet quality at time two after controlling for initial diet quality and demographic factors. Nutritious and non-nutritious food availability in the home were entered in the third step and parental practices around eating/food were entered in the fourth step.

Power analyses were conducted with GPower 3,[43] evaluating the *a priori* sample size required to detect a medium-sized effect (f = .25).[44] Assuming two-tailed alpha = .05 with approximately 12 predictors, adequate power (.80) to detect a medium-sized effect (f = .25) would be achieved with a total sample size of 81. Given the sample size of 615, observed power is more than adequate (>.99).

This secondary data analysis was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Institutional Review Boards at Seattle Children's Hospital.

Results

Sample Characteristics

The sample for this analysis included 615 children ages 6-12 years old at time one that were recruited for the NIK study and had data collected for both time one and time two. The sample was predominantly Non-Hispanic White (70.2%) and 50.7% female. Table 1 provides a complete comparison of the two age groups based on time one demographic characteristics. Using independent t-tests and chi-square analyses, it was found that the time one and time two groups did not significantly differ on any measures at time one.

Changes in Diet Quality and Home Food Environment

Overall child diet quality was poor at time one with a DASH Score of 42.17 and 41.03, total fruit and vegetable intake per day of 3.33 and 3.55, and total high-energy beverage intake per day 0.50 and 0.63 for younger and older children, respectively. There was a significant overall decrease in child DASH Scores (M=-0.62, SD=7.85, p=0.053), increase in fruit and vegetable intake (M=-0.21, SD 2.14, p=0.017), and increase in high-energy beverage intake (M=-0.15, SD=.75, p<.001) in all of the children from time one to time two. Significant differences over time were noted in total fruit and vegetable consumption and total high-energy beverage intake for the younger group (see Table 2) and total high-energy beverage intake for the older group (see Table 3). Mean values of home food environment factors, availability of nutritious and non-nutritious foods in the home and parental feeding practices, and child diet

quality indicators are shown for time one and time two in Table 2 (younger group) and Table 3 (older group). Although statistically significant, absolute change in child dietary intake from time one to time two was minimal, with a mean change in DASH Score of -0.50 and -0.74, total fruit and vegetable intake per day of 0.26 and 0.15, and total high-energy beverage intake per day 0.13 and 0.17 for younger and older children, respectively.

Despite very little overall change in home food environment factors from time one to time two, univariate analyses controlling for time one home food environment measures revealed that there was a significant longitudinal effect of child age on permissiveness ($F(1,611)= 18.43$, $p<0.001$). Both groups had an increase in permissiveness, but parents of older children became more permissive (Mean Change=0.22) than parents of younger children (Mean Change=0.07) from time one to time two. There was also a significant effect of age on parental rules around food from time one to time two ($F(1,611)= 8.83$, $p=0.003$). Parents of older children showed a decrease in rules around food (Mean Change=-0.03), while parents of younger children showed no change (Mean Change=0.00). There were no other significant effects of age on home food environment factors from time one to time two.

Longitudinal Determinants of Child DASH Scores

A multiple regression analysis assessing the relationship of home food environment factors with child diet quality indicated that the predictors accounted for 23% of the variance in DASH Score in younger children ($R^2=0.230$, $F(12, 281)= 6.98$, $p<0.001$) and 23.5% and of the variance in DASH Score in older children ($R^2=0.235$, $F(12, 286)= 7.30$, $p<0.001$) (see Table 4 (younger children) and Table 5 (older children)) for all model parameters. Availability of nutritious and non-nutritious foods in the home contributed significant predictability to the model

for younger children (Δ R^2=.025, Δ F(2, 287)= 4.48, p=.012). Parental practices contributed significant predictability to the model for older children (Δ R^2=.040, ΔF(6,286)= 2.48, p=.024).

For both younger and older children, there was a significant main effect of DASH Score at time one (β=0.32, p<0.001; β=0.38, p<0.001, respectively). In addition, parental rules around food at time one positively predicted DASH Score at time two for both groups (β=0.16, p=0.028; β=0.15, p=0.019, respectively). Parental pressure to eat at time one negatively predicted DASH Score at time two (β=-0.12, p=0.035) for older children. Parental permissiveness at time one also significantly predicted DASH Score at time two (β=0.12, p=0.046), showing that higher parental permissiveness at time one was associated with a greater DASH Score at time two. In the older children, results indicated that race significantly predicted DASH Score at time two (β=-0.13, p=0.023), with being non-white or Hispanic associated with a lower DASH Score at time two.

Longitudinal Determinants of Child Fruit and Vegetable Intake

A multiple regression analysis assessing the relationship of home food environment factors with child diet quality indicated that the predictors accounted for 26.9% of the variance in total fruit and vegetable intake in younger children (R^2=0.269, F(12, 281)= 8.61, p<0.001) and 24.6% and of the variance in total fruit and vegetable intake in older children (R^2=0.246, F(12, 286)= 7.76, p<0.001) (see Table 6 (younger children) and Table 7 (older children) for all model parameters). Neither availability of nutritious/non-nutritious foods in the home nor parental practices added significant predictability to the model for younger children. Parental practices contributed significant predictability to the model for older children (Δ R^2=.036, ΔF(6,286)= 2.28, p=.037).

For both younger and older children, there was a significant main effect of total fruit and vegetable intake at time one (β=0.46, p<0.001; β=0.44, p<0.001, respectively). There were no other significant effects on total fruit and vegetable intake at time two in the model for younger children. However in older children, parental encouragement and parental permissiveness around food at time one both positively predicted total fruit and vegetable intake at time two (β =0.19, p=0.009; β=0.15, p=0.015, respectively).

Longitudinal Determinants of High-Energy Beverage Intake

A multiple regression analysis assessing the relationship of home food environment factors with child diet quality indicated that the predictors accounted for 17.2% of the variance in total high-energy beverage intake in younger children (R^2=0.172, F(12, 281)= 4.85, p<0.001) and 29.6% and of the variance in total high-energy beverage intake in older children (R^2=0.296, F(12, 286)=10.03, p<0.001) (see Table 8 (younger children) and Table 9 (older children) for all model parameters). Availability of nutritious and non-nutritious foods in the home contributed significant predictability to the model for younger children (ΔR^2=.031, ΔF(2,287)= 5.35, p=.005). Parental practices contributed significant variability to the model for older children (ΔR^2=.040, ΔF(6,286)= 2.48, p=.024). Neither availability of nutritious/non-nutritious foods in the home nor parental practices added significant predictability to the model for older children.

For both younger and older children, there was a significant main effect of total high-energy beverage intake at time one (β=0.31, p<0.001; β=0.47, p<0.001, respectively). Additionally, availability of non-nutritious foods at time one positively predicted total high-energy beverage intake at time two for both younger and older children(β=0.20, p=0.003; β =0.14, p=0.023, respectively). In the older children, results also indicated that parental

restrictiveness around food significantly predicted total high-energy beverage intake at time two (β=-0.11, p=0.037), with higher parental restrictiveness at time one associated with a lower total high-energy beverage intake at time two.

Discussion

The present analyses demonstrated that the home food environment contributes significant predictability to numerous child diet quality indicators. This suggests that targeting parental practices around food and foods available in the home may be effective intervention approaches. This study also brings light to various changes in the home food environment that may affect the future diet quality of children. As hypothesized, parents of older children became more permissive than parents of younger children over time. Parents of older children also showed a decrease in rules around food over time whereas parents of younger children did not. The accessibility and availability of healthful foods in the home did not change differently between younger and older children.

When investigating the predictability of home food environment on the diet quality of children transitioning from early- to mid-childhood versus children transitioning from early- to mid-adolescence, differences were seen in the relationships between parental practices and child diet quality. More associations existed between parental practices around food at baseline and child diet quality at follow-up in older children versus younger children.

Results indicate a positive relationship in older children between higher parental permissiveness at baseline and future child DASH Score, as well as total fruit and vegetable intake. This relationship did not exist amongst the younger children, which provides evidence that parental strategies to support independence in children approaching adolescence may be beneficial to child diet quality. In addition, higher parental pressure to eat at baseline was

negatively associated with DASH Score at follow-up in older children, but not younger children at follow-up. This appears to be consistent with the relationships found in permissiveness and continues to support parental practices that foster independence in children entering adolescence, rather than parental practices that represent a more authoritarian parenting style.

There is increasing evidence that use of controlling food-related parental practices is detrimental to the food-related behaviors of adolescents supports this concept. Food restriction has been found to be related to overweight and obese adolescents[17]. Research has demonstrated that adolescents portray increased autonomy[45] and increased conflict around parental direction around food related behaviors[46]. The items used in this study to measure permissiveness predominantly examined the child's tendency to eat while watching television or in their own bedroom. Children approaching adolescence may seek out this behavior more often or for different reasons than younger children. It is possible that some intentional permissiveness around food may be a parental strategy that benefits child diet quality during adolescence.

In parallel with increased permissiveness, parents of older children also demonstrated a decrease in rules around food from baseline to follow-up. Although very little overall change occurred in this study, it is possible that a large decrease in rules around food may negatively influence the diet quality of children entering adolescence. A higher amount of parental rules around food at baseline was positively correlated with DASH Score at follow-up in both younger and older children. This is consistent with our own data[19] and may elucidate longitudinal benefits of increased parental rules around food. Also consistent with our previous cross-sectional findings, higher parental restrictiveness around food at baseline was associated with lower intake of high-energy beverages at follow-up in older children.[19]

It is likely that there is a proper balance between allowing a child more independence as they enter adolescence while continuing to provide structure around food behaviors that benefit children of all ages. Though this data shows benefits to parental permissiveness in older children, our previous cross-sectional findings revealed a positive relationship between parental permissiveness and child BMI z-scores.[19] We also previously reported consistent positive cross-sectional relationships between availability of nutritious foods in the home and child diet quality indicators, yet no such relationship existed in this longitudinal study. On the contrary, we have consistently found that rules around food seem to benefit child diet quality both cross-sectionally[19] and longitudinally.

This constellation of parenting practices appears to be supportive of authoritative parenting styles, where rules and guidelines exist, yet flexibility and support of autonomy still occurs.[20] Others have found promotion of authoritative parenting to be an effective intervention style to preventing and managing childhood obesity.[47] Performing longitudinal analyses and dichotomizing the participating children by age may have revealed new relationships and the importance of allowing older children the ability to establish their own sense of choice around food, while providing them with structured environments.

Results also indicate that being a part of an ethnic minority was negatively associated with DASH score in older children. Previous studies have demonstrated differences in diet quality of adolescents when comparing minorities to Non-Hispanic Whites.[48-51] There is evidence that cultural values, familial support of fruit and vegetable intake, as well as taste preferences are key contributors to food choices of minority adolescents[50], yet little is known about differences seen between younger and older children. More research is needed around diet quality and ethnicity in children of various ages.

Parental encouragement at baseline was positively related to total fruit and vegetable intake at follow-up in older children, but not younger children. These relationships may be due to developmental differences and the strong influence of other factors as children begin to enter adolescence. Studies have shown that providing a positive environment around nutritious foods and food behaviors, such as promoting family meals and encouraging fruits and vegetables, benefits the diet quality of adolescents.[19,48,49]

Despite minimal relationships seen between the availability of healthful foods at baseline and child diet quality at follow-up, there was a positive relationship seen in both age groups between the availability of unhealthful foods in the home at baseline and consumption of high-energy beverages at follow-up. This is consistent with previous cross-sectional findings from the NIK study[19] and provides additional support for policies removing sugar-sweetened beverages and non-nutritious foods from the immediate environments of children, including home, school, and childcare programs.

Limitations

This study had a prospective cohort design. No causal inferences can be drawn from these data, however, the longitudinal design provides strong evidence for the influence of the home food environment (HFE) predictors on future child diet quality indicators. In addition, self-report surveys for measurement of home food availability and parenting practices around child eating/food and 24-hour diet recalls were used. This form of data has historically shown to have accuracy errors and possible self-report biases.[52] Expert professionals were used to collect the recalls however and multiple diet recalls (up to three days) were completed for each participant.

The demographic characteristics (i.e. high income and higher educational attainment) of individuals recruited into this study from the larger population presents a challenge to the generalizability of the results. Future research focusing on populations of lower SES is needed to determine the relationship between HFE and child diet quality.

The authors acknowledge that despite detection of statistically significant relationships, limited overall change was seen in diet quality indicators over time. It is possible that two years was not enough time to see dramatic changes in child diet quality and/or the home food environment. Future studies should continue to track changes in diet for longer amounts of time in order to verify these results. On the other hand, research has shown that children who were overweight in early childhood were more likely to be obese during adolescence, which suggests that health behaviors are established in early childhood.[3] There is also evidence that child dietary preferences and patterns begin developing during the first year of life.[53] Future investigations around parenting practices and diet quality may need to begin as early as infancy in order to better detect changes over time.

Finally, although HFE contributed significant predictability to models investigating child diet quality over time, other predictors likely play a significant role. There is evidence that number of children in the household, as well as number of adults in the household influence child diet quality.[54] Future research to investigate the influence of other factors on child diet quality is needed.

Table 1

Baseline demographic characteristics of participants by age

	Age group		
	Younger (n = 301)	Older (n = 314)	Total (N = 615)
	N (%)	N (%)	N (%)
Sex			
Male	146 (48.5)	157 (50.0)	303 (49.3)
Female	155 (51.5)	157 (50.0)	312 (50.7)
Ethnicity/Race			
Non-Hispanic White	215 (71.4)	217 (69.1)	432 (70.2)
Other ethnicity	86 (28.6)	97 (30.9)	183 (29.8)
Parent Education			
No college degree	66 (22.1)	76 (24.4)	142 (23.3)
Completed college only	120 (40.1)	123 (39.5)	243 (39.8)
Completed graduate	113 (37.8)	112 (36.0)	225 (36.9)
Household Income			
<50 K	34 (11.4)	41 (13.4)	75 (12.4)
50-100K	106 (35.7)	121 (39.5)	227 (37.6)
>100K	157 (52.9)	144 (47.1)	301 (49.9)

NOTE. Younger= age 6-8.99 at time one; Older= age 9-12.50 at time one. Participant characteristic of the entire sample. Values are expressed as total N (%) for all categorical variables. Total of 5(0.8%) missing for parent education, total of 12(1.9%) missing for household income.

Table 2

Summary of variables at time 1 and time 2 for younger children (6-8 at time 1)

	Time	
	Time 1 (*n* = 301)	Time 2 (*n* = 301)
	M (*SD*) [Range]	*M* (*SD*) [Range]
Child DASH Score	42.17 (7.13)	41.67 (7.74)[a]
	[19.78,61.54]	[14.58,65.31]
Child total fruit and veg intake	3.33 (1.80)	3.59 (2.07)[a]*
	[.28,12.00]	[.10,12.31]
Total high energy bev intake	.50 (.57)	.63 (.72)[a]**
	[0,3.58]	[0,4.52]
Nutritious foods in the home	4.28 (.52)	4.27 (.49)
	[1.75,5.00]	[2.75,5.00]
Non-nutritious foods in the home	2.80 (.67)	2.79 (.62)
	[1.38,4.88]	[1.38,4.75]
Parental Modeling	4.00 (.60)	4.01 (.56)
	[1.67,5.00]	[2.33,5.00]
Parental Encouragement	4.39 (.52)	4.34 (.51)
	[2.75,5.00]	[2.75,5.00]
Parental Restrictiveness	3.69 (1.03)	3.61 (1.06)
	[1.00,5.00]	[1.00,5.00]
Parental Pressure	2.27 (.87)	2.13 (.83)
	[1.00,4.75]	[1.00,4.75]
Parental Permissiveness	1.96 (.57)	2.06 (.55)
	[1.00.4.33]	[1.00,4.33]
Parental Rules around food	.46 (.17)	.46 (.19)
	[.00,.92]	[.00,1.00]

Note: T-tests were used compare means of three outcome variables. Predictors were not assessed.
[a] indicates missing values (total n=298)
* indicates statistically significant change ($p \leq 0.05$)
** indicates statistically significant change ($p \leq 0.01$)

Table 3

Summary of variables at time 1 and time 2 for older children (9-12 at time 1)

	Time	
	Time 1 (*n* = 313)	Time 2 (*n* = 314)
	M (*SD*) [Range]	*M* (*SD*) [Range]
Child DASH Score	41.03 (6.80)[a]	40.29 (7.33)[b]
	[20.04,59.05]	[25.00,65.68]
Child total fruit and veg intake	3.55 (2.06)[a]	3.70 (2.31)[b]
	[.19,16.19]	[.30,16.91]
Total high energy bev intake	.63 (.70)	.80 (.78)[b]***
	[0,4.35]	[0,4.63]
Nutritious foods in the home	4.15 (.57)	4.15 (.53)
	[2.00,5.00]	[2.00,5.00]
Non-nutritious foods in the home	2.79 (.64)	2.78 (.60)
	[1.00,4.38]	[1.25,4.63]
Parental Modeling	3.94 (.57)	3.91 (.59)
	[2.33,5.00]	[2.00,5.00]
Parental Encouragement	4.28 (.55)	4.27 (.53)
	[2.00,5.00]	[2.25,5.00]
Parental Restrictiveness	3.70 (1.07)	3.54 (1.11)
	[1.00,5.00]	[1.00,5.00]
Parental Pressure	2.15 (.92)	2.09 (.89)
	[1.00,4.75]	[1.00,5.00]
Parental Permissiveness	2.18 (.63)	2.37 (.64)
	[1.00,4.00]	[1.00,5.00]
Parental Rules around food	.44 (.16)	.41 (.18)
	[.08,.83]	[.00,.92]

Note: T-tests were used to compare means of three outcome variables. Predictors were not assessed.
[a] indicates missing values (total n=312)
[b] indicates missing values (total n=307)
* indicates statistically significant change ($p \leq 0.05$)
** indicates statistically significant change ($p \leq 0.01$)
*** indicates statistically significant change ($p \leq 0.001$)

Table 4

Regression coefficients for DASH score ages 6-8

	B	**SE B**	***β***	***p***
Block 1				
Time 1 DASH Score	.35	.07	.32	<.001
Block 2				
Gender	.52	.87	.03	.552
Race	-1.12	.98	-.07	.255
Household Income	-.06	.18	-.02	.750
Block 3				
Time 1 nutritious food at home	1.49	.86	.10	.083
Time 1 non-nutritious food at home	-1.33	.73	-.12	.068
Block 4				
Time 1 Parent Modeling	-1.44	.81	-.11	.076
Time 1 Parent Encouragement	1.46	.95	.10	.125
Time 1 Parent Restrictiveness	.10	.42	.01	.808
Time 1 Parent Pressure	-.12	.50	-.01	.122
Time 1 Parent Permissive	1.32	.85	.10	.122
Time 1 Parent Rules	7.18	3.24	.16	.028

NOTE: N=294

Table 5

Regression coefficients for DASH Score ages 9-12

	B	**SE B**	***β***	***p***
Block 1				
Time 1 DASH Score	.40	.06	.38	<.001
Block 2				
Gender	-.48	.75	-.03	.519
Race	-1.97	.87	-.13	.023
Household Income	-.03	.15	-.01	.862
Block 3				
Time 1 nutritious food at home	.30	.76	.02	.693
Time 1 non-nutritious food at home	.04	.67	.00	.952
Block 4				
Time 1 Parent Modeling	-.55	.84	-.04	.507
Time 1 Parent Encouragement	1.28	.91	.10	.161
Time 1 Parent Restrictiveness	.29	.36	.04	.427
Time 1 Parent Pressure	-.93	.44	-.12	.035
Time 1 Parent Permissive	1.36	.68	.12	.046
Time 1 Parent Rules	6.63	2.82	.15	.019

NOTE: N=299

Table 6

Regression coefficients for fruit and vegetable intake ages 6-8

	B	SE B	*β*	*p*
Block 1				
Time 1 total fruit and veg intake	.53	.06	.46	<.001
Block 2				
Gender	.16	.22	.04	.482
Race	.31	.26	.07	.223
Household Income	.02	.05	.02	.687
Block 3				
Time 1 nutritious food at home	.00	.22	.00	.999
Time 1 non-nutritious food at home	-.09	.19	-.03	.623
Block 4				
Time 1 Parent Modeling	.14	.21	.04	.498
Time 1 Parent Encouragement	.28	.25	.07	.263
Time 1 Parent Restrictiveness	.02	.11	.01	.865
Time 1 Parent Pressure	.08	.13	.03	.541
Time 1 Parent Permissive	.01	.22	.00	.972
Time 1 Parent Rules	.78	.84	.06	.356

NOTE: N=294

Table 7

Regression coefficients for fruit and vegetable intake ages 9-12

	B	SE B	*β*	*p*
Block 1				
Time 1 total fruit and veg intake	.49	.06	.44	<.001
Block 2				
Gender	.07	.24	.02	.760
Race	-.21	.27	-.04	.453
Household Income	-.05	.05	.06	.295
Block 3				
Time 1 nutritious food at home	.19	.24	.05	.439
Time 1 non-nutritious food at home	.01	.21	.00	.956
Block 4				
Time 1 Parent Modeling	-.38	.27	-.09	.155
Time 1 Parent Encouragement	.77	.29	.19	.009
Time 1 Parent Restrictiveness	.04	.12	.02	.726
Time 1 Parent Pressure	-.08	.14	-.03	.587
Time 1 Parent Permissive	.53	.22	.15	.015
Time 1 Parent Rules	.27	.89	.02	.765

NOTE: N=299

Table 8

Regression coefficients for high-energy beverage intake ages 6-8

	B	SE B	β	p
Block 1				
Time 1 total high-energy bev intake	.38	.07	.31	<.001
Block 2				
Gender	-.11	.08	-.07	.194
Race	.12	.10	.08	.199
Household Income	-.01	.02	-.02	.754
Block 3				
Time 1 nutritious food at home	-.01	.08	-.01	.894
Time 1 non-nutritious food at home	.21	.07	.20	.003
Block 4				
Time 1 Parent Modeling	.06	.08	.05	.473
Time 1 Parent Encouragement	.00	.09	.00	.979
Time 1 Parent Restrictiveness	-.03	.04	-.04	.516
Time 1 Parent Pressure	-.03	.05	-.03	.573
Time 1 Parent Permissive	-.06	.08	-.05	.446
Time 1 Parent Rules	-.11	.31	-.03	.723

NOTE: N=294

Table 9

Regression coefficients for high-energy beverage intake ages 9-12

	B	SE B	β	p
Block 1				
Time 1 total high-energy bev intake	.52	.06	.47	<.001
Block 2				
Gender	-.06	.08	-.04	.453
Race	.10	.09	.06	.283
Household Income	-.02	.02	-.08	.164
Block 3				
Time 1 nutritious food at home	-.05	.08	-.04	.527
Time 1 non-nutritious food at home	.16	.07	.14	.023
Block 4				
Time 1 Parent Modeling	-.05	.09	-.04	.538
Time 1 Parent Encouragement	.07	.10	.05	.442
Time 1 Parent Restrictiveness	-.08	.04	-.11	.037
Time 1 Parent Pressure	.04	.05	.05	.383
Time 1 Parent Permissive	-.03	.07	-.02	.670
Time 1 Parent Rules	.51	.30	.11	.089

NOTE: N=299

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