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Associations of food preferences and household food availability with dietary intake and quality in youth with type 1 diabetes

LM Lipsky¹, TR Nansel¹, DL Haynie¹, SN Mehta², and LMB Laffel²

¹Prevention Research Branch, Eunice Kennedy Shriver National Institute of Child Health & Human Development, National Institutes of Health, Department of Health and Human Services. 6100 Executive Blvd, Suite 7B13, Bethesda MD 20852

²Section on Genetics and Epidemiology, Pediatric, Adolescent and Young Adult Section, Joslin Diabetes Center, One Joslin Place, Harvard Medical School, Boston MA 02215

Abstract

The objective of this study was to examine associations of food preferences and availability with dietary intake in youth with type 1 diabetes, for whom dietary intake and quality are essential to disease management. Youth ($n=252$, age $13.2\pm2.8y$, diabetes duration $6.3\pm3.4y$) reported preferences and parents reported household availability for 61 food items categorized as fruit, vegetables, whole grains, refined grains and fats/sweets. Youth energy-adjusted daily servings of food groups, Healthy Eating Index-2005 and Nutrient Rich Foods 9.3 scores were calculated from 3-day diet records. Associations of dietary intake and quality variables with preference and availability of all food groups were evaluated by linear regressions adjusted for sociodemographic characteristics. Fruit and whole grain intake were positively related to corresponding preference and availability; whole grain intake and refined grain availability were inversely related. Vegetable, refined grain and fats/sweets intake were unrelated to preference and availability. Diet quality measures were related positively to fruit preference and whole grain availability and inversely to refined grains availability. Findings indicate associations of dietary intake with food preference and availability vary by food group in youth with type 1 diabetes. Measures of overall dietary quality were more consistently associated with food group availability than preferences.

Keywords

Preference; Availability; Dietary intake; Dietary quality; Youth; Type 1 Diabetes

Introduction

In youth with type 1 diabetes, dietary quality is of primary importance for optimizing glycemic control to support normal growth and development while minimizing glycemic excursions and adverse medical complications (American Diabetes Association, 2011; Bantle et al., 2008; Silverstein et al., 2005; Smart, Slander-van, & Waldron, 2009). Dietary guidance for this population is based on that for healthy children and adolescents (Bantle et

Corresponding author: lipskylm@mail.nih.gov [LM Lipsky], Not for publication: Phone: 301.435.6932, Fax: 301-402-2084.

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al., 2008), with a focus on integrating the monitoring of blood glucose and dietary carbohydrate with individualized considerations for aspects of nutritional requirements, meal planning and insulin regimens (Bantle et al., 2008).

Despite the emphasis on nutrition in the management of type 1 diabetes, research suggests suboptimal diet quality in this population that is comparable to, if not poorer than, the general youth population (Rovner & Nansel, 2009). These eating behaviors may contribute to increased cardiovascular risk (Gunther et al., 2009; Liese et al., 2011), and may track into adulthood (Larson et al., 2008; te Velde, Twisk, & Brug, 2007), impacting health outcomes throughout the lifespan. Focus on matching insulin dose with the amount of carbohydrate intake may lead to avoidance of nutrient-rich foods such as fruit, whose carbohydrate content can be difficult to estimate, and preference for packaged, processed foods with nutrition labels or carbohydrate-free food products not requiring insulin administration (Bantle et al., 2008; Gellar, Schrader, & Nansel, 2007; Mehta et al., 2009). Insulin regimen (Mehta et al., 2009), sociodemographic factors (Bortsov et al., 2011) and adherence to diabetes self-management (Mehta, Quinn, Volkening, & Laffel, 2009) have also been associated with dietary behaviors in youth with type 1 diabetes. However, further research is needed to identify modifiable influences on eating behaviors in this population in order to support efforts to improve dietary quality and related health outcomes (Patton, 2011).

Previous research of modifiable influences on eating behaviors in the general youth population has identified food preferences and household availability as important determinants of dietary intake and quality. Studies have consistently demonstrated positive relationships between preferences and intakes of specific foods or food groups (Bere & Klepp, 2004; Brug, Tak, te Velde, Bere, & de, I, 2008; Cullen et al., 2003). Evidence for a similar relationship of food availability and intake is conflicting (Arcan et al., 2007; Befort et al., 2006; Blanchette & Brug, 2005; Brug et al., 2008; Cullen et al., 2003; Gallaway, Jago, Baranowski, Baranowski, & Diamond, 2007; Horst K. et al., 2007; Koui & Jago, 2008; Kristjansdottir et al., 2006; McClain, Chappuis, Nguyen-Rodriguez, Yarocho, & Spruijt-Metz, 2009), suggesting that in the context of an abundant food environment, household availability may be a relatively unimportant influence on eating behavior.

Research on the role of food preferences and availability has primarily focused on these characteristics for fruit and vegetables, and their impact on intake of corresponding food groups. However, dietary choices may result from selecting preferred foods from among all available foods, and as such, may lead to unhealthy food choices if preferences for available nutrient-poor foods are higher than preferences for healthier alternatives. Scant research has examined the relationship of whole grain, fruit and vegetable intake with preference and availability of refined foods, such as refined grains, snacks and sweets; one previous study in the general youth population showed an inverse relationship between fruit and vegetable intake and home availability of unhealthy foods (Cutler, Flood, Hannan, & Neumark-Sztainer, 2011). Moreover, the influence of child food preferences and home food availability on measures of overall dietary quality has not been previously examined. Such measures of dietary exposure provide a more realistic reflection of the nutritional characteristics of the diet as a whole, and may better represent interrelationships among dietary components (Arvaniti & Panagiotakos, 2008; Messina et al., 2001).

The primary objective of this paper is to examine the associations of food preference and availability with dietary intake and quality in a sample of youth with type 1 diabetes. This study extends previous findings by assessing preference and availability of a broader range of food groups including refined foods, and exploring whether food group preference and home availability are associated with intakes of both corresponding and non-corresponding

food groups. The study further investigates the associations of food preferences and availability with measures of overall diet quality.

Methods

Subjects and setting

Subjects were recruited in a cross-sectional study of diet and diabetes-related health outcomes from a pediatric diabetes center in Boston, MA. Families with eligible participants age 8 to 18 years inclusive, with a type 1 diabetes diagnosis for at least 1 year were approached. Of the 455 eligible subjects, 302 (66%) enrolled in the study. Eleven subjects were eliminated due to having a sibling enrolled in the study with longer diabetes duration or more complete data. Of the remaining 291 subjects, 252 with diet records comprise the sample for analysis in this study. The primary reason given for non-participation was time constraints. Child age did not differ according to participation status.

Data collection

Child age, sex, height, weight, and insulin regimen were extracted from medical records. Age- and sex-adjusted BMI percentile were calculated. Household income and size were obtained from parent surveys, and used to calculate the income-to-poverty ratio, a measure of income relative to the poverty level adjusted for inflation and household size (higher ratio corresponds to higher income relative to the poverty threshold) (Bishaw & Macartney, 2010; US Census, 2011).

Child food preferences and parent-reported availability were assessed in surveys administered separately to children and parents based on measures with demonstrated reliability and validity (Cullen K.W. et al., 2000; Cullen et al., 2001; Hearn M.D. et al., 1998; Marsh, Cullen, & Baranowski, 2003). Youth reported preference ratings for each of 61 food items they reported as having tried (0 = do not like/1= like a little/2= like a lot) (Cullen K.W. et al., 2000). Parents reported household availability (yes/no) of each food item over the past 7 days, a measure with demonstrated correlation to observed household food group availability (Marsh et al., 2003; Marsh et al., 2003). Food items on the questionnaires were expanded to include additional fruit and vegetable items as well as whole grains, refined grains and fats/sweets. Responses for food items were grouped by fruit (18 items), vegetables (26 items), whole grains (8 items), refined grains (4 items) and fats/sweets (5 items). Food items and groups are given in Table 1. For each food group, preference reflects the mean preference rating for all eaten foods within each food group, and availability reflects the total number of foods within each food group available in the home over the past 7 days.

Dietary intake was assessed using three-day diet records completed within approximately 1 week after survey administration. Research assistants reviewed instructions, including a sample diet record, with families. Families were instructed to keep records on 3 consecutive days in one week, including 2 weekdays and 1 weekend day, and were asked to use measuring utensils (cups, spoons, food scales) at home if available or, if unavailable, to provide their best estimate of portion size. Families were reminded to provide all specific details for each food item, including names of brands or restaurants, whether the item was labeled as low fat/low sugar/1% milk/etc, and to leave no blank fields on the form.

Nutrition Data System for Research (NDS-R, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) was used to analyze food records for calculating mean daily servings for fruit, vegetables, whole grains, refined grains, and fats/sweets standardized per 4184 kJ in order to simplify comparability of intake across all food groups and to account for differences in total energy requirements. Overall dietary quality was assessed by

calculating the Healthy Eating Index-2005 (HEI-2005) (Guenther, Reedy, & Krebs-Smith, 2008), as well as the Nutrient Rich Foods 9.3 score (NRF 9.3) (Fulgoni, III, Keast, & Drewnowski, 2009). The HEI-2005 is a measure that reflects adherence to 2005 Dietary Guidelines for Americans, and is comprised of 12 component scores for total fruit, whole fruit, total vegetables, dark green/orange vegetables and legumes, total grains, whole grains, milk, meat and beans, oils, saturated fat, sodium, and solid fat/alcohol/added sugars, corresponding to recommendations for specified food groups and nutrient intakes. Component scores are truncated once intakes exceed minimum (e.g., for grains, fruit, vegetables, meat and beans) and maximum (e.g., for saturated fat, sodium, and solid fat/alcohol/added sugar) guidelines. Scores for the HEI-2005 range from 0 to 100, where a score of 100 reflects adherence to the guidelines for all 12 components. Since the optimal component scores on the HEI-2005 may be satisfied by consuming foods of varying nutritional value, the NRF 9.3 score was also used as a complementary measure of overall dietary quality. The NRF 9.3 score reflects the nutrient density of all foods consumed, and is calculated as the ratio of nutrients to encourage (protein, fiber, vitamins A, C, E, calcium, iron, magnesium and potassium) to nutrients to limit (saturated fat, added sugar and sodium). While there is no standard for an optimal range for the NRF 9.3 score, mean NRF 9.3 scores observed in the US population in NHANES 1999–2002 was 13.3, while scores of individual foods range from –56 (sweetened soft drinks) to 695 (spinach) (Fulgoni, III et al., 2009).

Statistical analysis

Descriptive statistics were calculated for sociodemographic characteristics, insulin regimen, body mass index (BMI) percentile, food group preference and availability, energy-adjusted intakes, and diet quality measures. Multivariate test of means was used to test the hypothesis that mean daily intakes and preferences were equal across all food groups.

Associations between food group intakes and diet quality measures were assessed using Spearman rank analysis. Correlations with two-sided $p < 0.0024$ were considered statistically significant to achieve a Sidak-adjusted family-wise $\alpha = 0.05$ (Abdi, 2007).

Adjusted relationships of preferences and availability with food group intakes and diet quality measures were evaluated using multiple linear regression analysis, with separate models predicting each of the five food group intake variables and two diet quality measures. Independent variables in the models included all food group preferences and availability variables. All independent and dependent variables (except sex) were standardized prior to regression in order to give standardized coefficient estimates. Models were adjusted for youth age, sex and household income. STATA version 11.2 (STATA Corp, College Station, TX) was used for all data analyses.

Results

The sample was 48% female, predominantly White (92%), and representing a wide income range (min/max PIR = 0.3/11.7). Over two-thirds of the sample reported insulin pump use. Mean BMI percentile was within the normal range, with 34% of the sample having a BMI at or exceeding the 85th percentile adjusted for sex and age. The average HEI-2005 of 53.4 reflects a diet that falls short of recommendations (Table 2).

Mean preference ratings were moderately higher for refined grains (1.6 ± 0.4) and fats/sweets (1.6 ± 0.4) than for fruit (1.4 ± 0.4), whole grains (1.2 ± 0.5) and vegetables (1.1 ± 0.4) ($p < 0.0001$ for multivariate test of equality of means). Parents reported past-week home availability of a majority of food items in the refined grains and fats/sweets groups, and approximately half of the food items in the fruit, vegetables and whole grains groups. On a

per-4184 kJ basis, youth reported consuming two to six times the number of servings of refined grains and fats/sweets than of fruit, vegetables and whole grains ($p < 0.0001$ for multivariate test of equality of means) (Table 3).

Positive associations were found between fruit and vegetable intake, as well as between fats/sweets intake and intake of vegetables and refined grains. Intakes of refined grains and whole grains were inversely related. Diet quality measures were positively related to each other, and were each related positively to intake of fruit, vegetables and whole grains, and inversely to refined grain intake (Table 4).

Models predicting food group intakes from food group preferences and availability indicated positive relations of fruit and whole grain intake with corresponding preference and availability. Whole grain intake was also inversely related to availability of refined grains. Effect sizes were similar for statistically significant relationships. There were no statistically significant coefficient estimates for independent variables in models predicting intake of vegetables, refined grains or fats/sweets. Coefficients of determination (R^2) were low for models predicting intakes of vegetables, refined grains and fats/sweets, reflecting the lack of significant relationships with the independent variables. Youth diet quality measures were each related positively to fruit preference and parent-reported home availability of whole grains and inversely to availability of refined grains. In addition, HEI-2005 was related inversely to vegetable availability, while NRF 9.3 was related inversely to fats/sweets preference and positively to fruit availability (Table 5).

Discussion

To our knowledge, associations of youth-reported food group preference and parent-reported household availability with dietary intake and quality have not been examined previously in youth with type 1 diabetes. We found positive associations of preferences and availability with food group intakes for fruit and whole grains, but no significant associations with intake of vegetables, refined grains or fats/sweets. Measures of overall dietary quality (HEI-2005 and NRF 9.3) were related positively to fruit preferences and whole grain availability, and inversely to availability of refined grains, but were unrelated to most other food group preference ratings.

Intake of refined grains and fats/sweets in this sample were high relative to intake of fruit, vegetables and whole grains, consistent with previous research of diet quality in the general US youth population as well as in other samples of children with diabetes (Fungwe, Guenther, Juan, Hiza, & Lino, 2009; Reedy & Krebs-Smith, 2010; Rovner et al., 2009). On average, children consumed nearly three daily servings of refined grains and fats/sweets per 4184 kJ, but only 0.5–1.2 servings of fruit, whole grains and vegetables. Similarly, mean preference ratings for refined grains and fats/sweets (marginally higher than the midpoint between “like a little” and “like a lot”) were somewhat higher than those for fruit, whole grains and vegetables (closer to “like a little”).

We found positive relationships between fruit and whole grain intakes with preference and availability of corresponding food groups, comparable to research in the general youth population (Bere et al., 2004; Brug et al., 2008; Cullen et al., 2003; Neumark-Sztainer, Wall, Perry, & Story, 2003; Rasmussen et al., 2006; Resnicow et al., 1997; Bere et al., 2004; Brug et al., 2008; Cullen et al., 2003; McClain et al., 2009; Neumark-Sztainer et al., 2003; Rasmussen et al., 2006; Resnicow et al., 1997). The observed lack of association between intakes and home availability of fats/sweets replicates limited previous research in the general adolescent population (Befort et al., 2006), although this finding is in contrast with previous research documenting the direct influence of the school food environment on

adolescent food choice (Kubik, Lytle, Hannan, Perry, & Story, 2003; Rovner et al., 2009). Our finding regarding a lack of a significant association of vegetable intake with vegetable preference and availability conflicts with prior research in the general population (McClain et al., 2009; Rasmussen et al., 2006). These results indicate that there were generally few differences in relationships of food intake, preference and availability in youth with type 1 diabetes as compared with findings in the general population, despite differential dietary considerations for diabetes management, such as ease of carbohydrate estimation or preference for foods requiring no insulin administration (Mehta et al., 2009).

For the most part, food group preference and availability in this sample were unrelated to intake of non-corresponding food groups. However, inverse relationships between whole grain intake and refined grain availability, taken together with the inverse relationship shown between whole grain and refined grain intakes, suggest that these foods may compete with each other in the diet. Increasing intakes of whole grains may therefore require increasing availability of these foods as well as decreasing access to refined alternatives, echoing findings from focus group research in which youth with type 1 diabetes noted the excessive availability of unhealthy, high-fat foods in the school and home environment as a primary barrier to healthy eating (Gellar et al., 2007). This hypothesis is further supported by evidence from an experimental study at a pediatric diabetes camp, where consumption of low glycemic index foods (including whole grains, fruit, vegetables and legumes) was similar to that of refined alternatives (including refined grains and dairy products) when each were presented as the only food selection on separate eating occasions, despite modestly higher satisfaction ratings for some refined foods (Nansel, Gellar, & Zeitsoff, 2006).

These findings extend previous research relating food preference and availability to intake of individual food groups by additionally examining associations of preference and availability with measures of overall dietary quality. Models predicting diet quality measures demonstrated significant associations of diet quality measures with availability of whole and refined grains as well as fruit preferences, reflecting associations observed in models predicting intakes of individual food groups. Fruit availability, though significantly associated with fruit intake, was related only to NRF 9.3 but not HEI-2005 scores. Similarly, fats/sweets preference was inversely related to NRF 9.3 but not HEI-2005 scores. These differences are likely attributed to differences in the calculation of the two measures, such as the relative prominence of nutrients contained in fruit in the NRF 9.3, and the truncation of HEI-2005 scores above thresholds of intakes of nutrients contained in fats and sweets. Most relationships of food group preference and availability with diet quality measures were in the expected direction. The inverse relationships between HEI-2005 and availability of vegetables and refined grains are in the unexpected direction since intake of these food groups is positively counted in the calculation of the HEI-2005. However, the positive bivariate relationship observed between vegetable intake and HEI-2005 and the lack of a significant association between vegetable availability and vegetable intake suggest that the inverse relationship between vegetable availability and HEI-2005 may reflect either type 1 error or a spurious relationship due to unobserved factors, such as vegetables being consumed together with other dietary components (e.g., salad dressing, butter, cheese, salt) that negatively contribute to HEI-2005 scores. The inverse relationship with refined grains may reflect the positive bivariate relationship observed between intake of refined grains and fats/sweets, the latter of which generally contribute to lower scores on diet quality measures (Fulgoni, III et al., 2009).

Coefficients of determination for models predicting food group intake were low, particularly for fats/sweets, despite controlling for age, sex, and household income, suggesting that these variables do not account for a substantial proportion of the variation in food group intake.

Adjusted R^2 for models predicting overall diet quality measures were somewhat higher ($R^2=0.14$ and $R^2=0.17$ for HEI-2005 and NRF 9.3, respectively), which may be attributed to a greater ability to detect relations with these measures of overall intake as opposed to individual foods (Hu, 2002).

Limitations should be considered when interpreting these findings. First, these results may not be representative of all US children with type 1 diabetes since subjects were recruited from a single clinic (albeit with a large catchment area). These findings may not generalize to the general population despite common dietary recommendations for all youth. Further, causality cannot be determined by results from this cross-sectional study design. As well, self-report assessments may be susceptible to social desirability bias or inaccuracies related to cognitive ability or developmental stage (Brenner, Billy, & Grady, 2003). The use of parent-reported, rather than youth-reported, home availability and the absence of a measure of food accessibility in addition to availability may further have limited our ability to detect associations in cases of discrepancies between parent and youth awareness of home food availability. The limited number of food items in some food groups may have further decreased our ability to detect significant relationships. However, the internal validity of these findings is strengthened by the large sample size for a study of a pediatric population with type 1 diabetes, as well as the use of preference and availability measures based on those that have been previously validated in youth populations, and of 3-day dietary records, which provide comparatively valid data on dietary intake.

These findings suggest fruit and whole grain intakes are positively related to preferences and availability of corresponding food groups in this sample of youth with type 1 diabetes. Similarly, positive associations were found of overall dietary quality with fruit and whole grain preference and availability. However, we found no associations of food group preferences and availability with intakes of vegetables, refined grains or fats/sweets, suggesting intakes of these foods are explained by factors external to the models. Intakes of refined grains and fats/sweets were high relative to fruit, vegetables and whole grains despite a lack of significant relationships with preferences and availability. Importantly, inverse associations between intakes of refined grains and whole grains and between whole grain intake and availability of refined grains suggest that these foods may compete with each other within the diet. This indicates that efforts to increase intakes of nutrient-dense foods, such as fruit, vegetables and whole grains in children with type 1 diabetes may require both making nutritionally preferred options available as well as removing less nutrient-dense alternatives from the environment.

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Reference List

- Abdi, H. The Bonferroni and Sidak corrections for multiple comparisons. In: Salkind, Neil, editor. *Encyclopedia of Measurement and Statistics*. Thousand Oaks (CA): Sage; 2007.
- American Diabetes Association. Standards of medical care in diabetes--2011. *Diabetes Care*. 2011; 34(Suppl 1):S11–S61. [PubMed: 21193625]
- Arcan C, Neumark-Sztainer D, Hannan P, van den BP, Story M, Larson N. Parental eating behaviours, home food environment and adolescent intakes of fruits, vegetables and dairy foods: longitudinal findings from Project EAT. *Public Health Nutr*. 2007; 10:1257–1265. [PubMed: 17391551]
- Arvaniti F, Panagiotakos DB. Healthy indexes in public health practice and research: a review. *Crit Rev Food Sci Nutr*. 2008; 48:317–327. [PubMed: 18409114]

- Bantle JP, Wylie-Rosett J, Albright AL, Apovian CM, Clark NG, Franz MJ, et al. Nutrition recommendations and interventions for diabetes: a position statement of the American Diabetes Association. *Diabetes Care*. 2008; 31(Suppl 1):S61–S78. [PubMed: 18165339]
- Befort C, Kaur H, Nollen N, Sullivan DK, Nazir N, Choi WS, et al. Fruit, vegetable, and fat intake among non-Hispanic black and non-Hispanic white adolescents: associations with home availability and food consumption settings. *J Am Diet Assoc*. 2006; 106:367–373. [PubMed: 16503225]
- Bere E, Klepp KI. Correlates of fruit and vegetable intake among Norwegian schoolchildren: parental and self-reports. *Public Health Nutr*. 2004; 7:991–998. [PubMed: 15548337]
- Bishaw, A.; Macartney, S. American Community Survey Briefs. U.S. Census Bureau; 2010. Poverty: 2008 and 2009.
- Blanchette L, Brug J. Determinants of fruit and vegetable consumption among 6–12-year-old children and effective interventions to increase consumption. *J Hum Nutr Diet*. 2005; 18:431–443. [PubMed: 16351702]
- Bortsov A, Liese AD, Bell RA, Dabelea D, D'Agostino RB Jr, Hamman RF, et al. Correlates of dietary intake in youth with diabetes: results from the SEARCH for diabetes in youth study. *J Nutr Educ Behav*. 2011; 43:123–129. [PubMed: 21276755]
- Brener ND, Billy JO, Grady WR. Assessment of factors affecting the validity of self-reported health-risk behavior among adolescents: evidence from the scientific literature. *J Adolesc Health*. 2003; 33:436–457. [PubMed: 14642706]
- Brug J, Tak NI, te Velde SJ, Bere E, de BI. Taste preferences, liking and other factors related to fruit and vegetable intakes among schoolchildren: results from observational studies. *Brit J Nutr*. 2008; 99(Suppl 1):S7–S14. S7–S14. [PubMed: 18257952]
- Cullen KW, Baranowski T, Rittenberry L, Cosart C, Owens E, Hebert D, et al. Socioenvironmental influences on children's fruit, juice and vegetable consumption as reported by parents: reliability and validity of measures. *Public Health Nutr*. 2000; 3:345–356. [PubMed: 10979154]
- Cullen KW, Baranowski T, Owens E, Marsh T, Rittenberry L, de Moor C. Availability, accessibility, and preferences for fruit, 100% fruit juice, and vegetables influence children's dietary behavior. *Health Educ Behav*. 2003; 30:615–626. [PubMed: 14582601]
- Cullen KW, Baranowski T, Rittenberry L, Cosart C, Hebert D, de MC. Child-reported family and peer influences on fruit, juice and vegetable consumption: reliability and validity of measures. *Health Educ Res*. 2001; 16:187–200. [PubMed: 11345661]
- Cutler GJ, Flood A, Hannan P, Neumark-Sztainer D. Multiple sociodemographic and socioenvironmental characteristics are correlated with major patterns of dietary intake in adolescents. *J Am Diet Assoc*. 2011; 111:230–240. [PubMed: 21272697]
- Fulgoni VL III, Keast DR, Drewnowski A. Development and validation of the nutrient-rich foods index: a tool to measure nutritional quality of foods. *J Nutr*. 2009; 139:1549–1554. [PubMed: 19549759]
- Fungwe, T.; Guenther, PM.; Juan, W.; Hiza, H.; Lino, M. The quality of children's diets in 2003–04 as measured by the Healthy Eating Index-2005 (Rep No 43). U.S. Department of Agriculture Center for Nutrition Policy and Promotion; 2009.
- Gallaway MS, Jago R, Baranowski T, Baranowski JC, Diamond PM. Psychosocial and demographic predictors of fruit, juice and vegetable consumption among 11–14-year-old Boy Scouts. *Public Health Nutr*. 2007; 10:1508–1514. [PubMed: 17686203]
- Gellar LA, Schrader K, Nansel TR. Healthy eating practices: perceptions, facilitators, and barriers among youth with diabetes. *Diabetes Educ*. 2007; 33:671–679. [PubMed: 17684168]
- Guenther PM, Reedy J, Krebs-Smith SM. Development of the Healthy Eating Index-2005. *J Am Diet Assoc*. 2008; 108:1896–1901. [PubMed: 18954580]
- Gunther AL, Liese AD, Bell RA, Dabelea D, Lawrence JM, Rodriguez BL, et al. Association between the dietary approaches to hypertension diet and hypertension in youth with diabetes mellitus. *Hypertension*. 2009; 53:6–12. [PubMed: 19029488]
- Hearn MD, Baranowski T, Baranowski J, Doyle C, Smith M, Lin LS, et al. Environmental influences on dietary behavior among children: availability and accessibility of fruits and vegetables enable consumption. *J Health Educ*. 1998; 29:26–32.

- Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, van Lenthe F, et al. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. *Health Educ Res.* 2007; 22:203–226. [PubMed: 16861362]
- Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol.* 2002; 13:3–9. [PubMed: 11790957]
- Koui E, Jago R. Associations between self-reported fruit and vegetable consumption and home availability of fruit and vegetables among Greek primary-school children. *Public Health Nutr.* 2008; 11:1142–1148. [PubMed: 18167168]
- Kristjansdottir AG, Thorsdottir I, de BI, Due P, Wind M, Klepp KI. Determinants of fruit and vegetable intake among 11-year-old schoolchildren in a country of traditionally low fruit and vegetable consumption. *Int J Behav Nutr Phys Act.* 2006; 3:41. [PubMed: 17125507]
- Kubik MY, Lytle LA, Hannan PJ, Perry CL, Story M. The association of the school food environment with dietary behaviors of young adolescents. *Am J Public Health.* 2003; 93:1168–1173. [PubMed: 12835204]
- Larson NI, Neumark-Sztainer DR, Story MT, Wall MM, Harnack LJ, Eisenberg ME. Fast food intake: longitudinal trends during the transition to young adulthood and correlates of intake. *J Adolesc Health.* 2008; 43:79–86. [PubMed: 18565441]
- Liese AD, Bortsov A, Gunther AL, Dabelea D, Reynolds K, Standiford DA, et al. Association of DASH diet with cardiovascular risk factors in youth with diabetes mellitus: the SEARCH for Diabetes in Youth study. *Circulation.* 2011; 123:1410–1417. [PubMed: 21422385]
- Marsh T, Cullen KW, Baranowski T. Validation of a fruit, juice, and vegetable availability questionnaire. *J Nutr Educ Behav.* 2003; 35:93–97. [PubMed: 12725715]
- McClain AD, Chappuis C, Nguyen-Rodriguez ST, Yaroch AL, Spruijt-Metz D. Psychosocial correlates of eating behavior in children and adolescents: a review. *Int J Behav Nutr Phys Act.* 2009; 6:54. [PubMed: 19674467]
- Mehta SN, Haynie DL, Higgins LA, Bucey NN, Rovner AJ, Volkening LK, et al. Emphasis on carbohydrates may negatively influence dietary patterns in youth with type 1 diabetes. *Diabetes Care.* 2009; 32:2174–2176. [PubMed: 19741186]
- Mehta SN, Quinn N, Volkening LK, Laffel LM. Impact of carbohydrate counting on glycemic control in children with type 1 diabetes. *Diabetes Care.* 2009; 32:1014–1016. [PubMed: 19244089]
- Messina M, Lampe JW, Birt DF, Appel LJ, Pivonka E, Berry B, et al. Reductionism and the narrowing nutrition perspective: time for reevaluation and emphasis on food synergy. *J Am Diet Assoc.* 2001; 101:1416–1419. [PubMed: 11762736]
- Nansel TR, Gellar L, Zeitsoff L. Acceptability of lower glycemic index foods in the diabetes camp setting. *J Nutr Educ Behav.* 2006; 38:143–150. [PubMed: 16731448]
- Neumark-Sztainer D, Wall M, Perry C, Story M. Correlates of fruit and vegetable intake among adolescents. Findings from Project EAT. *Prev Med.* 2003; 37:198–208. [PubMed: 12914825]
- Patton SR. Adherence to diet in youth with type 1 diabetes. *J Am Diet Assoc.* 2011; 111:550–555. [PubMed: 21443987]
- Rasmussen M, Krolner R, Klepp KI, Lytle L, Brug J, Bere E, et al. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: Quantitative studies. *Int J Behav Nutr Phys Act.* 2006; 3:22. [PubMed: 16904006]
- Reedy J, Krebs-Smith SM. Dietary sources of energy, solid fats, and added sugars among children and adolescents in the United States. *J Am Diet Assoc.* 2010; 110:1477–1484. [PubMed: 20869486]
- Resnicow K, Davis-Hearn M, Smith M, Baranowski T, Lin LS, Baranowski J, et al. Social-cognitive predictors of fruit and vegetable intake in children. *Health Psychol.* 1997; 16:272–276. [PubMed: 9152706]
- Rovner AJ, Nansel TR. Are children with type 1 diabetes consuming a healthful diet? : a review of the current evidence and strategies for dietary change. *Diabetes Educ.* 2009; 35:97–107. [PubMed: 19244565]
- Silverstein J, Klingensmith G, Copeland K, Plotnick L, Kaufman F, Laffel L, et al. Care of children and adolescents with type 1 diabetes: a statement of the American Diabetes Association. *Diabetes Care.* 2005; 28:186–212. [PubMed: 15616254]

- Smart C, Slander-van VE, Waldron S. Nutritional management in children and adolescents with diabetes. *Pediatr Diabetes*. 2009; 10(Suppl 12):100–117. [PubMed: 19754622]
- te Velde SJ, Twisk JW, Brug J. Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight. *Brit J Nutr*. 2007; 98:431–438. [PubMed: 17433126]
- US Census. [accessed September 2011.] Poverty thresholds 2008. 2011.
<http://www.census.gov/hhes/www/poverty/data/threshld/thresh08.html>

HIGHLIGHTS

- Youth with type 1 diabetes exhibit suboptimal dietary intake.
- Food availability and preferences are associated with dietary intake and quality.
- Availability of unhealthy preferred foods may impact intake of healthier choices.

Table 1

List of food items in exposure, preference, and availability questions.

Food groups	Items (#)	Foods
Fruit	18	apples, pears, bananas, cherries, strawberries, blueberries, other berries, grapes, peaches/nectarines, plums, apricots (fresh), oranges, grapefruit, pineapple, other tropical fruit, melons, dried fruit, fruit salad
Vegetables	26	tomatoes, asparagus, beets, broccoli, cauliflower, green peas, green beans, corn, carrots, celery, lettuce, spinach, greens, cabbage, onions, sweet pepper, cucumber, zucchini, winter squash, eggplant, mixed vegetables, okra, fries, potatoes (not fried), sweet potatoes, beans
Whole grains	8	brown/wild rice, wheat pasta, instant oatmeal, old-fashioned oatmeal, steel cut oats, whole grain bread, whole grain crackers, barley/quinoa
Refined grains	4	white rice, white pasta, white bread, crackers (not whole grain)
Fats/sweets	5	chips, popcorn, cakes, cookies, candy

Table 2Subject characteristics (*n*=252)^a

Characteristic	Mean or n	SD or %
Mean age (y)	13.2	2.8
Sex (n, %)		
Male	130	52
Female	122	48
Mean income-to-poverty ratio	4.9	2.8
Mean diabetes duration (y)	6.3	3.4
Mean glycated hemoglobin (%)	8.5	1.3
Insulin regimen (n, %)		
Injections	79	31
Pump	173	69
Mean Body Mass Index percentile	70.4	23.0
Mean Healthy Eating Index-2005 ^b	53.4	11.0
Mean Nutrient Rich Foods score version 9.3 ^c	20.8	10.4

^aData are presented as means and SD except for sex and insulin regimen^bMeasure of adherence to the 2005 US Dietary Guidelines; scores range from 0 (no adherence) to 100 (perfect adherence).^cMeasure of dietary nutrient density, calculated as ratio of nutrients to encourage (protein, fiber, vitamins A, C, E, calcium, iron, magnesium, potassium) to nutrients to limit (saturated fat, added sugar, sodium).

Table 3

Preferences, availability and intake by food group

	Fruit (18 items)		Vegetables (26 items)		Whole grains (8 items)		Refined grains (4 items)		Fats/sweets (5 items)		P-value ^d
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
Mean preference (child report) ^b	1.4	0.4	1.1	0.4	1.2	0.5	1.6	0.4	1.6	0.4	<0.001
Availability (parent report, % of items) ^c	44	16	56	15	51	21	80	25	76	22	n/a
Mean intake (servings per 4184 kJ)	0.5	0.6	1.2	0.8	0.7	0.7	2.5	1.0	2.9	1.1	<0.001

^aMultivariate test of equality of means.

^bRange of preference response ratings is 0 "do not like", 1 "like a little", 2 "like a lot".

^cValue reflects mean percentage of foods available in the home over the last 7 days within each food group.

Spearman correlations between food group intakes (mean daily servings per 4184 kJ) and diet quality measures (HEI-2005 and NRF 9.3)

Table 4

	Fruit		Vegetables		Whole grains		Refined grains		Fats/Sweets		HEI-2005	
	ρ	P-value	ρ	P-value	ρ	P-value	ρ	P-value	ρ	P-value	ρ	P-value
Vegetables	0.23*	0.002	.									
Whole grains	0.22	0.003	0.18	0.003	.							
Refined grains	-0.08	0.18	-0.02	0.76	-0.20*	0.001	.					
Fats/Sweets	0.11	0.08	0.25*	<0.0001	0.07	0.24	0.22*	0.0004	.			
HEI-2005	0.45*	<0.0001	0.42*	<0.0001	0.37*	<0.0001	-0.22*	0.0004	-0.05	0.42	.	
NRF 9.3	0.44*	<0.0001	0.36*	<0.0001	0.37*	<0.0001	-0.29*	<0.0001	-0.10	0.10	0.67*	<0.0001

HEI-2005- Healthy Eating Index-2005, NRF 9.3- Nutrient Rich Foods score version 9.3.

* Spearman correlations are significant at $p < .0024$ (for Sidak-adjusted family $\alpha = 0.05$)

Table 5

Standardized coefficient estimates from adjusted regressions predicting energy-adjusted food group intakes and diet quality measures ^a.

Independent Variables	Model											
	Fruit	Vegetables	Whole Grains	Refined Grains	Fats/Sweets	HEI-2005 ^a	NRF 9.3 ^a					
	β	SE	β	SE	β	SE	β	SE	β	SE	β	SE
Preference												
Fruit	0.26**	0.08	-0.02	0.08	0.04	0.07	-0.03	0.08	0.06	0.08	0.20*	0.07
Vegetables	-0.04	0.08	0.12	0.08	-0.01	0.07	0.05	0.08	0.03	0.08	-0.07	0.07
Whole grains	-0.07	0.08	0.05	0.08	0.14*	0.07	0.006	0.08	-0.07	0.08	0.11	0.07
Refined grains	0.05	0.08	0.10	0.08	-0.05	0.07	0.06	0.08	0.03	0.09	0.11	0.08
Fats/sweets	-0.09	0.07	-0.10	0.08	0.03	0.06	-0.02	0.08	-0.03	0.08	-0.10	0.07
Availability												
Fruit	0.21**	0.07	0.10	0.07	0.07	0.06	0.04	0.07	-0.04	0.08	0.11	0.07
Vegetables	-0.13	0.07	0.07	0.07	-0.04	0.07	-0.09	0.08	0.04	0.08	-0.16*	0.07
Whole grains	-0.02	0.07	0.13	0.07	0.20**	0.06	-0.08	0.07	0.10	0.07	0.20**	0.07
Refined grains	-0.11	0.07	-0.05	0.07	-0.21**	0.06	0.05	0.07	-0.02	0.08	-0.19**	0.07
Fats/sweets	0.08	0.07	0.05	0.07	-0.003	0.06	-0.02	0.07	-0.02	0.08	0.06	0.07
Adjusted R ²	0.10		0.05		0.15		0.04		-0.04		0.14	

^aHEI-2005- Healthy Eating Index-2005; NRF 9.3- Nutrient Rich Food score version 9.3

* p< 0.05,

** p< 0.01,

*** p< 0.001

^aEach column indicates a separate model adjusted for all independent variables as well as youth age (y), sex and household income (income to poverty ratio).