Multiple Indicators of Poor Diet Quality in Children and Adolescents with Type 1 Diabetes Are Associated with Higher Body Mass Index Percentile but not Glycemic Control

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ABSTRACT

Background Diet is a cornerstone of type 1 diabetes treatment, and poor diet quality may affect glycemic control and other health outcomes. Yet diet quality in children and adolescents with type 1 diabetes remains understudied.

Objective To evaluate multiple indicators of diet quality in children and adolescents with type 1 diabetes and their associations with hemoglobin A1c and body mass index percentile.

Design In this cross-sectional study, participants completed 3-day diet records, and data were abstracted from participants' medical records. Diet quality indicators included servings of fruit, vegetables, and whole grains; Healthy Eating Index-2005 (HEI-2005) score; Nutrient Rich Foods 9.3 score (NRF 9.3); and glycemic index.

Participants/setting Children and adolescents with type 1 diabetes ≥1 year, aged 8 to 18 years, were recruited at routine clinic visits. Of 291 families enrolled, 252 provided diet data.

Statistical analyses Associations of diet quality indicators to HbA1c and body mass index percentile were examined using analysis of covariance and multiple linear regression.

Results Participants demonstrated low adherence to dietary guidelines; mean HEI-2005 score was 53.4±11.0 (range=26.7 to 81.2). Intake of fruit, vegetables, and whole grains was less than half the recommended amount. Almost half of the participants' daily energy intake was derived from refined-grain products, desserts, chips, and sweetened beverages. Higher fruit (P=0.04) and whole-grain (P=0.03) intake were associated with lower HbA1c in unadjusted, but not adjusted analyses; vegetable intake, HEI-2005 score, NRF 9.3 score, and glycemic index were not associated with HbA1c. Higher fruit (P=0.01) and whole-grain (P=0.04) intake and NRF 9.3 score (P=0.02), but not other diet quality indicators, were associated with lower body mass index percentile in adjusted analyses.

Conclusions Data demonstrate poor diet quality in youth with type 1 diabetes and provide support for the importance of diet quality for weight management. Future research on determinants of dietary intake and methods to promote improved diet quality would be useful to inform clinical care.
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NUTRITION GUIDELINES FOR CHILDREN WITH TYPE 1 diabetes are similar to those for the general population, and nutrition education for families of children with type 1 diabetes includes recommendations for general healthful eating and efforts to achieve and maintain optimal weight for height.[1,2] A primary component of medical nutrition therapy in type 1 diabetes is carbohydrate estimation, especially in the current era emphasizing physiologic insulin replacement, because carbohydrates are the principal macronutrient affecting glycemic excursions.[1] As such, the first priority of medical nutrition therapy is developing individualized meal plans that integrate the insulin regimen and carbohydrate estimation into the family's lifestyle, conforming to preferred meal routines, food choices, and physical activity patterns.[1]

Previous research suggests the need for greater attention to diet quality in children and adolescents with type 1 diabetes.[3,4] Data from the Search for Diabetes in Youth study provided the largest assessment of dietary intake in US persons aged <20 years with type 1 or 2 diabetes. Usual dietary intake was measured using a modified food frequency questionnaire in 1,511 participants aged 10 to 22 years.[5] Participants consumed inadequate amounts of fruit, vegetables, and whole grains, as well as excessive saturated fat. Although these findings are important, they are limited in that food frequency data are useful for ranking subjects rather than for determining absolute amounts of foods consumed.[6] Several small studies (samples sizes ranging from 28 to 132)[7-10] used food records or recalls to assess dietary intake and found that young people consumed inadequate fiber and excessive total and saturated fat. However, dietary assessment in these studies addressed only intake of specific nutrients. Current directions in nutrition research indicate the importance of a food-based approach to dietary analysis, evaluating food groups, diet patterns, or diet quality as opposed to a focus on individual micronutrients or macronutrients.[11,12] Such an approach aligns with food as consumed, thereby having functional utility for health messages,[13] and recognizes concepts of food synergy.[14]

Little data are available on the relationship between diet quality and hemoglobin A1c (HbA1c). Overall dietary adherence has been found to be associated with better glycemic control.[15-18] However, assessment of dietary adherence is typically focused on a variety of relevant factors, including carbohydrate estimation, quantity of food in relation to insulin dose, and meal timing, rather than diet quality per se. Two previous studies have examined the association of dietary intake with glycemic control in young people with type 1 diabetes. Higher fiber intake[19] was associated with better glycemic control; no associations were found for any macronutrients.[20]

The obesity epidemic, which contributes to cardiovascular disease risk as well as other adverse outcomes, presents an emerging challenge in type 1 diabetes management.[21,22] Consistent with trends in the US general population, overweight and obesity rates in children and adolescents with type 1 diabetes have increased dramatically.[23] In a multistate sample of 3,953 youth assessed between 2001 and 2004, 22.1% of youth with type 1 diabetes were overweight and 12.6% were obese.[24] Although the relative contribution of poor diet, sedentary lifestyle, and other factors to current obesity rates in the general population is a subject of debate, excessive energy intake, in particular excessive consumption of nutrient-poor foods, is an important contributor.[25] Considering previous findings that intensive insulin therapy was associated with weight gain,[26] it would be useful to determine whether better diet quality is associated with lower body mass index (BMI) among children and adolescents with type 1 diabetes.

The purpose of our study was to provide a detailed examination of the diet quality of a sample of US children and adolescents aged 18 years and younger with type 1 diabetes and to examine the associations of diet quality with HbA1c and BMI percentile. The dietary constructs evaluated include three food groups that are known to be under-represented in the US diet: fruits, vegetables, and whole grains, as well as two indicators of overall diet quality—the Healthy Eating Index-2005 (HEI-2005) and the Nutrient Rich Food 9.3 score (NRF 9.3). The HEI-2005[27] is calculated to reflect conformance to the 2005 Dietary Guidelines for Americans (DGA)[28] and, therefore, is also consistent with dietary recommendations for youth with type 1 diabetes.[1,2] Because requirements for several food groups within the calculation of the HEI-2005 may be met through consumption of less or more optimal choices (eg, fried potatoes vs other vegetables for total vegetables, refined vs whole grains for total grains), the NRF 9.3, a measure of dietary nutrient density[29] was also utilized. The concept of nutrient density has been applied to both individual foods and across the total diet, and represents nutritive value relative to total energy.[30-32] Dietary glycemic index (GI) was also evaluated based on findings from recent feeding studies demonstrating an association between lower dietary GI and improved glycemic control.[33-36] By examining multiple indicators of diet quality, we aimed to provide a more comprehensive analysis of the dietary intake of children and adolescents with type 1 diabetes and to assess associations of diet quality with both glycemic control and weight status of young people.

METHODS

Design, Sample, and Procedures

Cross-sectional data were obtained from children and adolescents with type 1 diabetes and their parents receiving care at a pediatric diabetes center in Boston, MA, from July 2008 through February 2009. Eligibility criteria included age 8 to 18 years, diagnosis of type 1 diabetes ≥1 year, daily insulin dose ≥0.5 units/kg, absence of any gastrointestinal disease such as celiac disease or use of medications that interfere significantly with diabetes management or glucose metabolism, and ability to communicate in English. Medical record data were screened to identify eligible patients who were recruited to participate during a clinic visit by trained research staff. Participants aged 18 years and parents provided informed consent; children younger than age 18 years provided assent. Survey measures were completed at the time of the clinic visit; diet records were completed by families following the clinic visit. Families received $40 compensation for their participation. The institutional review board approved the protocol. Of 455 eligible youth and their parents invited to participate, 302 youth from 291 families enrolled in the study. In families with multiple siblings enrolled data from the sibling with the longest diabetes duration were retained. Of 291 families, 252 completed diet records and comprise the sample for this analysis.

Measures

A child's usual dietary intake was estimated using 3-day food records. Children and parents were jointly provided with detailed instructions on how to accurately measure and report food and beverage intake and were given a sample diet record. Families were instructed to keep records on 3 consecutive days in 1 week, including 2 weekdays and 1 weekend day selected by the family, and were asked to use measuring utensils at home, or if away from home, 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 and specific item labeling (eg, low fat, 1% milk) and to leave no blank fields on the form. Research staff reviewed the completed records upon receipt from the family to ensure completeness, and solicited missing information (eg, brand names) from the family as needed. Nutrition Data System for Research software (Nutrition Coordinating Center, University of Minnesota)[37] was used to analyze the records and assess nutrient intake, food group servings, and GI. Based on the distribution of responses, food group servings were categorized as <1, 1 to <2, and 2 or more (too few subjects consumed three or more servings to classify separately). Two summary indexes of diet quality were calculated. The HEI-2005[27] measures conformance to the 2005 DGA. Possible scores range from zero to 100; a score of 100 would indicate that all dietary guidelines were met. A score $>$80 is considered "good," scores of 51 to 80 indicate "needs improvement," and scores $<$51 are considered "poor."[27] Dietary nutrient density was measured using the NRF 9.3, which is based on nine nutrients to encourage (ie, protein, fiber, vitamin A, vitamin C, vitamin E, calcium, iron, magnesium, and potassium) and three nutrients to limit (ie, saturated fat, added sugar, and sodium), and calculated for intake from food (not including dietary supplements) relative to energy intake.[29]

HbA1c (reference range=4% to 6%) (Tosoh 2.2 device, Tosoh Corporation), height, weight, Tanner stage, insulin regimen, and frequency of blood glucose monitoring were extracted from the medical records. BMI was calculated and compared with the Centers for Disease Control and Prevention 2000 reference standards[38] to determine BMI percentiles according to age and sex. Demographic characteristics were assessed by parent self-report. Frequency and duration of moderate and vigorous physical activity was assessed by interviewing child and parent together using questions from the Behavioral Risk Factor Surveillance System,[39] which have previously been validated against activity logs and accelerometers.[40] A single continuous variable was calculated by counting each minute of vigorous activity as equivalent to 2 minutes of moderate activity.[41]

Analyses

Descriptive statistics were used to summarize sample characteristics, dietary intake, and measures of diet quality. Differences in dietary intake by age, sex, and insulin regimen were examined using *t* tests. Percentage of energy intake from food groups was calculated and summarized descriptively. Analyses examining the percent of the 2005 DGA met for fruits and vegetables included juice and potatoes, respectively, in these groups to allow for comparisons with previously reported intake in the general population. In analyses examining associations of food group intake with HbA1c and BMI percentile, servings of fruit intake excluded juice and servings of vegetables excluded potatoes.

Analysis of variance and analysis of covariance (ANCOVA) were used to explore associations of food group intake (servings/day categorized as $<$1, 1 to $<$2, and $\geq$2) with HbA1c and BMI percentile. Polynomial contrasts were used for assessment of linear trend across food group intake categories. ANCOVA models for HbA1c included age, Tanner stage, insulin regimen, and frequency of blood glucose monitoring as covariates; models for BMI percentile included Tanner stage, physical activity, and energy intake as covariates. Associations of HEI-2005 score, NRF 9.3 score, and GI with HbA1c and BMI percentile were analyzed using multiple linear regression, including the covariates indicated above. To facilitate interpretability of findings, ANCOVA models by tertile of diet quality, including the same covariates, were also conducted if a significant linear relationship was found.

To further explore relationships between diet quality and BMI percentile, a series of regression analyses[42] were used to determine whether the relationship of diet quality with BMI percentile was mediated by energy intake. Regression models assessed the association of diet quality with energy intake, the association of energy intake with BMI percentile, the association of diet quality with BMI percentile, and the association of diet quality with BMI percentile controlling for energy intake. To account for differences in energy need, models controlled for age, sex, Tanner stage, and physical activity. Analyses were conducted using SPSS Statistics version 17.0 (2008, IBM Corp).

RESULTS

Dietary Intake

Demographic and diabetes-related characteristics and dietary intake of the participants are presented in Table 1. The mean HEI-2005 score was 53.4±11.0 (range=26.7 to 81.2), indicating that children were meeting few of the recommendations for overall dietary intake in terms of food groups, fat sources, sodium, and added sugars. Only 0.4% scored in the "good" range; 55.2% "needed improvement" and 44.4% were considered "poor" (data not shown). The mean GI was 59.8±4.0; mean NRF 9.3 score was 20.8±10.3.

Consumption of fruits, vegetables, and whole grains was well below recommended amounts (fruit: three servings for all girls and for boys $<$14 years, four servings for boys $\geq$14 years; vegetables: four servings for girls $<$14 years, five servings for girls $\geq$14 years and for boys $<$14 years, six servings for boys $\geq$14 years; and whole grains: three servings for all girls and for boys $<$14 years, 3.5 servings for boys $\geq$14 years). Classifying food group intake consistent with the 2005 DGA (ie, with fruit juice included in fruit servings and potatoes included in vegetable servings), 12.3%, 3.2%, and 11.5% of the youth with type 1 diabetes met guidelines for fruit, vegetable, and whole-grain intake respectively. On average, children consumed 45% of the recommended amount of fruit (including juice), 40.6% of the recommended amount of vegetables (including potatoes), and 47.3% of the recommended amount of whole grains. Girls consumed a greater percentage of the recommended vegetable intake than boys (45.7% vs 35.8%; P=0.007). Children aged 8 to 12 years consumed a greater percentage of the recommended fruit (55.8% vs 35.9%; $P<$0.001) and whole-grain (54.2% vs 41.3%; P=0.04) servings compared with adolescents. There were no differences in dietary intake by insulin regimen (pump vs injection-based therapy) (data not shown).

Intake of food groups as percentage of total energy intake is depicted in the Figure. Notably, 48.4% of energy intake was from highly processed foods, including refined-grain products, desserts, chips, and sweetened beverages (not including milk or juice), whereas only 17.1% was from whole-plant foods (eg, vegetables, fruit, whole grains, nuts, and seeds).

Associations of Dietary Intake with Glycemic Control

The relationships of fruit, vegetable, and whole-grain intake with HbA1c are summarized in Table 2. In unadjusted analyses, higher fruit (P=0.04) and whole-grain intake (P=0.03) were associated with lower HbA1c. These associations were not significant after adjusting for covariates. Vegetable intake was not associated with HbA1c.

In regression analyses, neither the HEI-2005 score, NRF 9.3 score, nor GI was associated with HbA1c (data not shown).

Table 1. Demographic and diabetes-related characteristics and dietary intake of the sample of US children and adolescents with type 1 diabetes (n=252)

Characteristic	Amount represented
Demographics	
	Mean±standard deviaton
Age (y)	13.2±2.8
	n (%)
Sex	
Female	122 (48.4)
Male	130 (51.6)
Race/ethnicity	
White, not Hispanic	231 (91.7)
Hispanic	9 (3.6)
Black	6 (2.4)
Other	6 (2.4)
Highest parent education level	
High school or equivalent	22 (8.7)
Junior college, technical, or some college	43 (17.1)
College degree	112 (44.4)
Graduate education	75 (29.8)
Family income ($)	
<30,000	22 (8.8)
30,000-49,999	17 (6.8)
50,000-69,999	31 (12.3)
70,000-99,999	52 (20.6)
100,000-149,000	57 (22.6)
>150,000	66 (26.2)
No response	7 (2.8)
Diabetes and health-related characteristics	
Insulin regimen	
Multiple daily injections	79 (31.3)
Pump	173 (68.7)
	Mean±standard deviaton
Duration of diabetes (y)	6.3±3.4
Blood glucose monitoring frequency (times/d)	5.44±2.2
Hemoglobin A1c (%)	8.5±1.3
Body mass index percentile	70.4±23.0

(continued)

Table 1. (*continued*)

Characteristic	Amount represented
Food group intake (servings/d)	
Fruit (not including juice)	1.0±1.1
Fruit (including juice)	1.4±1.3
Vegetable (not including potatoes)	1.4±1.2
Vegetable (including potatoes)	2.0±1.4
Whole grains	1.3±1.5
Energy and macronutrients	
Energy intake (kcal/d)	1,993.1±525.4
Carbohydrate (% kcal)	49.0±6.3
Protein (% kcal)	16.1±3.0
Fat (% kcal)	35.0±5.5
Saturated fat (% kcal)	12.4±2.6
Dietary fiber (grams)	16.2±5.9
Diet quality	
Healthy Eating Index 2005 score	53.4±11.0
Nutrient Rich Foods 9.3 score	20.8±10.3
Glycemic Index score	59.8±4.0

Associations of Dietary Intake with BMI Percentile

Associations of food group consumption with BMI percentile are also summarized in Table 2. Children consuming a greater number of daily fruit servings had a lower mean BMI percentile in both unadjusted (P=0.01) and adjusted (P=0.01) analyses. Greater whole-grain intake was significantly associated with lower BMI percentile after adjustment for covariates (P=0.04).

In regression analyses controlling for Tanner stage, physical activity, and energy intake, higher NRF 9.3 score was associated with lower BMI percentile (β=−.15; P=0.02). In ANCOVA by NRF 9.3 score tertile, controlling for Tanner stage, physical activity, and energy intake, the mean BMI percentiles of those in the lowest, middle, and highest tertiles were 74.3, 70.9, and 65.8, respectively (P=0.02). The HEI-2005 and GI were not associated with BMI percentile (data not shown).

The association of NRF 9.3 score with BMI percentile was not mediated by energy intake. In a series of regression models controlling for age, sex, Tanner stage, and physical activity, higher NRF 9.3 score was associated with both lower BMI percentile (β=−.15; P=0.02), and lower energy intake (β=−.17; P=0.005). However, the association of NRF 9.3 score with BMI percentile (β=−.15; P=0.02) did not decrease in magnitude when energy intake was added to the model. In fact, energy

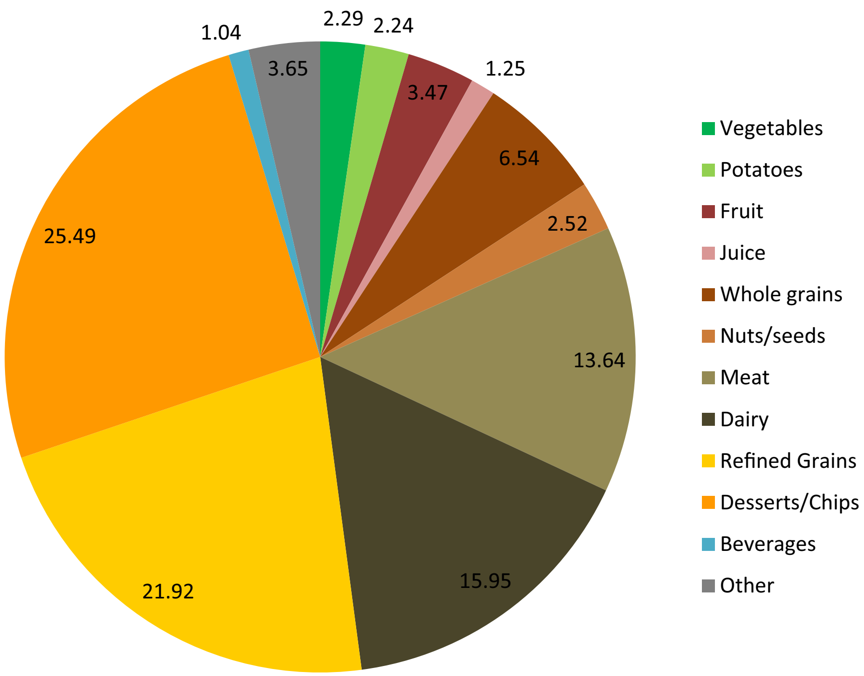

Figure. Percent of energy intake from food groups among children and adolescents with type 1 diabetes. Food groupings based on Nutrition Data Software for Research (Nutrition Coordinating Center, University of Minnesota) food categories. NOTE: Information from this figure is available online at www.andjrnl.org as part of a PowerPoint presentation.

intake was not associated with BMI percentile (β=.001; P=0.99).

DISCUSSION

Dietary intake in children and adolescents with type 1 diabetes fell well short of US dietary guidelines, with the mean HEI-2005 score falling at the low end of the "needs improvement" range, and <1% of the sample scoring in the "good" HEI-2005 range. Consumption of fruit, vegetables, and whole grains averaged less than half of the recommended intake, with only 3% to 12% of the sample meeting guidelines for these food groups. Saturated fat intake exceeded guidelines, with intake nearly twice the recommended maximum. Notably, intake of whole plant foods (ie, fruit, vegetables, whole-grain products, and nuts/seeds) was also inadequate, comprising only 17% of energy intake; conversely, almost half of energy intake came from highly processed foods, including refined-grain products, chips, desserts, and beverages. Although data on the NRF 9.3 score of US children and adolescents have not been published, the NRF 9.3 score in our sample was higher than that reported from analyses of National Health and Nutrition Examination Survey data among persons aged 4 years and older (NRF 9.3 score =3.3±0.5),[29] suggesting that the diets of youth in this sample may offer greater nutrient density than that of the US population in a way not reflected in calculation of the HEI-2005.

Medical nutrition therapy is a fundamental component of care for children and adolescents with type 1 diabetes. Medical nutrition therapy focuses on consuming an overall healthful diet to optimize growth, maintain normal weight, reduce risk for cardiovascular disease, and optimize glycemic control through attention to carbohydrate estimation for prandial insulin dosing. Families may find carbohydrate estimation to be more salient and critical for diabetes management. Notably, findings from previous focus groups suggest that families may emphasize carbohydrate quantity and accuracy of carbohydrate estimation at the expense of overall dietary healthfulness.[43] This may, in part, explain why the diets of the young people in our study appear to be no better than those of the general population with respect to meeting dietary guidelines. The mean HEI-2005 score of 53.4 in our sample was similar to that reported in a representative sample of US children and adolescents (54.7 for those aged 6 to 11 years and 54.8 for those aged 12 to 17 years).[44] Children and adolescents with type 1 diabetes in our study, however, consumed less fruit and vegetables than young people in the general population. Study participants consumed 45% of the recommended servings of fruit, compared with 71.5% among US children aged 6 to 11 years and 54.6% among those aged 12 to 18 years.[45] Their intake of vegetables, at 40.6% of recommendation, was lower than the 58.3% consumed by US children and 47.6% consumed by adolescents.[45]

Our dietary intake findings are consistent with those observed in the Search for Diabetes in Youth study,[5] in which US children with diabetes were found to consume inadequate fruit, vegetables, and high-fiber grains based on analyses of data from food frequency questionnaires. Although food frequency questionnaires arguably have the advantage of lower subject burden, they are most useful for ranking respondents, rather than providing precise estimates of intake.[6] Our study extends the Search for Diabetes in Youth study[5] findings by using data from 3-day diet records to provide a more in-depth analysis of dietary intake, including multiple overall diet quality indexes as well as proportion of energy intake from food groups representing the entire diet.

Table 2. Mean hemoglobin A1c (HbA1c) and body mass index (BMI) percentile by categories of fruit, vegetable, and whole-grain intake among US children and adolescents with type 1 diabetes (n=252)

Variable	<1 serving	1 to <2 servings	≥2 servings	*P* for linear trend
Associations with HbA1c[a]				
Fruits				
Unadjusted mean	8.6	8.3	8.1	0.04
Adjusted mean	8.5	8.5	8.3	0.21
Vegetables				
Unadjusted mean	8.4	8.5	8.6	0.47
Adjusted mean	8.4	8.6	8.4	0.80
Whole grains				
Unadjusted mean	8.7	8.3	8.3	0.03
Adjusted mean	8.6	8.4	8.4	0.11
Associations with BMI percentile[b]				
Servings of fruits				
Unadjusted mean	72.1	72.4	61.0	0.01
Adjusted mean	71.9	72.1	61.4	0.01
Servings of vegetables				
Unadjusted mean	68.1	72.3	71.7	0.33
Adjusted mean	68.3	72.4	70.8	0.51
Servings of whole grains				
Unadjusted mean	71.7	74.4	64.6	0.09
Adjusted mean	71.7	74.2	64.3	0.04

[a]Analysis of covariance models for hemoglobin A1c adjusted for age, Tanner stage, insulin regimen, and blood glucose monitoring frequency.
[b]Analysis of covariance models for BMI percentile adjusted for Tanner stage, energy intake, and physical activity.
NOTE: Information from this table is available online at www.andjrnl.org as part of a PowerPoint presentation.

Associations of dietary intake of fruit and whole grains with glycemic control were modest and not significant in adjusted models. It is possible that the low overall consumption of these foods greatly limited the ability to detect relationships, because even the highest category of intake was well below the recommended amount. Notably, families of children with type 1 diabetes have reported limiting fruit consumption by their child with type 1 diabetes due to concerns about fruit's effect on raising blood glucose levels and potential imprecise estimation of carbohydrate content.[43] Although the relationship of increased fruit intake with better glycemic control was not significant in adjusted analyses, findings indicate no detrimental effect of fruit consumption on HbA1c. This information could allay parental concerns regarding perceived negative influence of fruit consumption on glycemic control, and thereby encourage parents to help their children meet dietary guidelines for fruit intake.

The lack of an association between GI and HbA1c is inconsistent with findings from recent short-term feeding studies assessing the influence of GI on glucose levels[33-36]; however, the small variance in GI observed in our study population, with few subjects consuming a low-GI diet, may have affected the ability to detect a relationship. The low-GI test meals used in the above studies ranged from 34 to 48, whereas only 0.8% of our sample had a dietary GI below 50. Interventions targeting dietary change may be required to achieve a sample in which there are sufficient numbers of persons consuming a low-GI diet for periods beyond acute feeding studies to examine adequately any associations with HbA1c.

Greater fruit and whole-grain intake were associated with lower BMI percentile, as was overall diet quality as assessed by the NRF 9.3. The relationship of diet quality with BMI percentile was not mediated by energy intake because energy intake was not associated with BMI percentile. Indeed, previous studies of children and adolescents have also failed to find a significant relationship between energy intake and adiposity[46]; this may be related in part to possible under-reporting of energy intake among overweight adolescents.[47] Notably, higher diet quality (nutrient density) was associated with lower energy intake, suggesting that a focus on healthful food choices may assist young people in avoiding excessive energy intake. Such an approach may be more effective than attempts to restrict energy per se. Results are consistent with studies in adults linking higher diet quality to improved weight management,[48-51] and lend further support to the importance of encouraging healthful dietary intake, including fruit consumption, to prevent overweight and obesity in children and adolescents with type 1 diabetes. Considering the high prevalence of cardiovascular risk factors observed in young people with diabetes,[52,53] efforts to promote a healthy body weight in this population are warranted.

Our study provides support for the importance of clinical and research attention to diet quality among children and adolescents with type 1 diabetes. Strengths include the use of 3-day diet records and evaluation of key food groups as well as multiple measures of overall diet quality, providing a more in-depth evaluation of dietary intake than available previously. Our findings should be interpreted in light of study limitations, however. The sample was drawn from a single clinic with a limited number of minority and low-income families, with a relatively large number using an insulin pump. Data are cross-sectional, precluding determination of causality. Findings suggest the need for longitudinal research to examine more fully the relationship of diet quality to health outcomes in type 1 diabetes. Although diet records are among the most reliable and valid measures of dietary intake, the task of completing food records may influence intake such that the records may not reflect usual intake. As with all self-report measures of intake, participant self-report may be biased by social desirability. However, food records capture diet with great detail relative to food frequency questionnaires, and are less susceptible to recall bias.[6] Parents and children were trained together in how to complete the diet records to address the developmental and practical realities of this population. Importantly, very few young people were consuming a diet that reflected dietary guidelines; thus, associations could not be examined across the spectrum of diet quality.

CONCLUSIONS

Similar to the general population of US children and adolescents, overall adherence to dietary guidelines among children and adolescents with type 1 diabetes was low. Intake of fruits and vegetables was even lower than that reported in nationally representative data. Almost half of energy intake was from highly processed foods (eg, refined grains, chips, sweets, and beverages). Future research to better understand determinants of dietary intake and methods to promote improved diet quality among this population would be useful to inform clinical care. It is well established that unhealthful diets are pervasive in the US population; furthermore, achieving and maintaining healthful dietary change is challenging.[25,44,54] The clinical care of children and adolescents with type 1 diabetes offers the potential to improve dietary intake in this population. Carbohydrate estimation and individualized meal plans are key components of optimal type 1 diabetes management, along with counseling on overall healthful eating.[1,2] Results from our study suggest the importance of finding strategies to improve healthful eating in the context of medical nutrition therapy for the care of children and adolescents with type 1 diabetes.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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