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Overall diet quality is not associated with diet cost among youth with type 1 diabetes

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Abstract

The purpose of this study was to examine the association of diet quality with diet cost in a sample of youth with type 1 diabetes, for whom diet is an important component of medical management. Differences in food group spending by diet quality were also examined to identify potential budgetary reallocation to improve overall diet quality. Families of 252 youth with type 1 diabetes ages 8–18 years completed 3-day youth diet records. Cost of each food reported was calculated based on the average price obtained from two online grocery stores. Diet cost was estimated as average daily cost of foods consumed. The Healthy Eating Index 2005 (HEI2005), Nutrient Rich

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Foods Index 9.3 (NRF9.3), and Whole Plant Food Density (WPFD) scores were evaluated. Differences in mean daily diet cost across tertiles of HEI2005, NRF9.3, and WPFD were modest, with none reaching statistical significance. Those in the upper tertile of HEI-2005 spent more on whole fruit, whole grains, lean meat, and low-fat dairy, and less on high-fat meat and high-fat dairy compared to those in the lower tertiles. Higher quality diets can be obtained at comparable costs to lesser quality diets, suggesting that cost need not be an insurmountable barrier to more healthful eating. Reallocation of spending may increase overall quality without substantially increasing overall spending. Findings suggest potential strategies for assisting families of youth with type 1 diabetes in identifying cost-effective ways to achieve a more healthful diet.

Introduction

Although attention to diet is a fundamental health tenet for all persons, it is especially important for those with type 1 diabetes (T1D) as a component of disease management and to reduce long-term risk for cardiovascular complications[1, 2]. Medical nutrition therapy for T1D includes counseling in carbohydrate estimation and recommendations for healthful eating[3, 4]. Dietary intake in this population falls short of dietary guidelines[5], including excess saturated fat and inadequate whole plant foods[6,7]. These findings indicate the need for efforts to improve dietary quality in this population. However, a potentially important barrier to the adoption of a more healthful diet is a widespread perception that doing so is prohibitively expensive[8–15].

Previous research on the association between diet quality and cost has yielded conflicting conclusions. Studies evaluating energy-adjusted diet cost (cost per calorie) consistently find an inverse association with energy-density of individual foods or of the total diet [16–20]. However, the use of energy-adjusted diet costs has been questioned for both mathematical[21, 22] and conceptual[22, 23] reasons, and findings indicate nutrient-rich foods with low energy content are less expensive than nutrient-poor energy-dense foods when evaluated on the basis of edible weight or portion size.[21, 22] Additionally, daily food expenditures, which are dependent on total amount of food consumed, may be increased when accounting for the effect of energy density on increasing daily energy intake.[24] A growing body of research suggests that improving diet quality may not require an increase in food expenditure. In intervention studies among children and adults, improvement in diet quality was not associated with increased cost[25–27]. Additionally, evaluation of cost for recommended dietary changes in a childhood obesity clinic indicated that the recommended diet could be achieved at the same cost, higher cost, or lower cost depending on the type of supermarket used[28].

Various strategies may be employed to improve diet quality while maintaining diet cost, such as choosing from among the less expensive healthful foods or reallocating spending from less to more healthful foods. Several studies note the wide variation in cost of whole plant foods[29, 30], providing support that a healthful diet may be obtainable across a wide range of costs. There is modest research on how consumers partition their spending across food groups. Lower income households purchased significantly less produce and dairy than higher income groups, but did not differ in spending for meats and grain products[31].

Understanding allocation of the food budget to different food groups may offer insights into cost-effective strategies for improving diet quality.

Given the importance of healthful eating in youth with T1D and the overall increase in medical expenditures associated with diabetes management[32], understanding the associations of cost with diet quality may offer clinical and research utility. The purpose of this study was to examine the associations of diet quality with diet cost in a sample of youth with T1D. Additionally, differences in spending on food groups by level of diet quality are examined to identify areas where spending could be reallocated to achieve improvement in dietary intake.

Methods

Study Population

Youth and their parents were recruited from an outpatient, free-standing, multidisciplinary tertiary diabetes center during routine clinic visits from July 2008 to February 2009 for a cross-sectional study on diabetes and dietary behaviors. Eligibility criteria included age 8 to 18 years, diagnosis of T1D ≥1 year, daily insulin dose ≥0.5 units/kg, no chronic illness (particularly any GI disease such as celiac disease) or medication that interferes significantly with diabetes management or glucose metabolism, and ability to communicate in English. Study procedures were approved by the Joslin Diabetes Center Committee on Human Studies with a *Eunice Kennedy Shriver* National Institute of Child Health and Human Development reliance agreement. Participants 18 years or older provided written informed consent; children younger than 18 years provided assent. Of 455 eligible youth approached, 302 were enrolled (66%); eleven participants were siblings with diabetes of shorter duration and were eliminated. Of the 291 families, 252 completed youth diet records.

Measures

Dietary intake—Parents and children jointly completed three-day youth diet records. They were instructed to record all foods consumed on three consecutive days including one weekend day, including product names and quantities, and were encouraged to use scales and measures for portion size estimation. Research staff made follow-up calls to clarify items that were unclear or incomplete. Diet records were analyzed using the Nutrition Data System for Research (version 2009; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN)[33, 34], which yields micronutrients, macronutrients, and food group servings. Three indicators of diet quality were evaluated. The Healthy Eating Index 2005 (HEI2005)[35] measures compliance with the 2005 USDA Dietary Guidelines for Americans[36], and was selected as the primary measure of diet quality and calculated using published methods[37]. Possible values range from 0–100; a score of 100 indicates all recommendations were met. Because previous literature addressing diet cost and quality has primarily focused on the cost of fruit and vegetables, we included two measures that are more strongly influenced by fruit and vegetable intake. The Nutrient Rich Foods Index 9.3 (NRF9.3) was calculated as the sum of the percent consumed of the reference daily value of 9 nutrients to encourage (protein, fiber, vitamin A, vitamin C, vitamin E, calcium, iron, magnesium, and potassium) subtracted by the sum of the percent consumed of the reference daily value of 3 nutrients to limit (saturated fat, added sugar, and sodium), expressed per 100 kcal[38]. NRF9.3 values of individual foods range, for example, from −56 for regular soft drinks to 695 for spinach. The third indicator, Whole Plant Food Density (WPFD) is calculated as the number of cup or ounce equivalents of whole plant foods (whole grains, whole fruit, vegetables, legumes, nuts, and seeds) per 1000 kcal consumed[39].

Diet cost—Price information from two online national supermarkets (common to the study location) was recorded and averaged for each food component (approximately 1600 foods) with the exception of those items from a named store or restaurant. For these, prices were obtained from regional stores/restaurants. The lowest non-sale unit price for each item was selected. Food group-specific refuse amounts from the USDA National Nutrient Database for Standard Reference, Release 26 (Beltsville MD, 2013), were used to account for the inedible portions (e.g., bone, seeds, skin) of foods as purchased. Except for foods specified as obtained from a specific restaurant, food cost was estimated as if all foods were purchased from a supermarket. Daily diet cost was calculated as the sum of the price of all foods consumed divided by the number of food record days (99% completed three days). Daily diet cost was used as the outcome variable in order to prevent over-adjustment for energy intake, which could obscure an overall positive relationship between energy density and daily spending.

Clinical and demographic data—Biomedical data were collected through medical record review. Measured height and weight were obtained at clinical exams. Frequency and duration of moderate and vigorous physical activity was assessed using questions from the Behavioral Risk Factor Surveillance System[40]. A single continuous variable was calculated by counting each minute of vigorous activity as equivalent to two minutes of moderate activity[41]. Parents reported information on household income and size. The poverty income ratio was calculated as the ratio of reported household income divided by the 2008 US Census poverty threshold for household size adjusted for inflation;[42] higher values indicate greater income.

Analyses

Bivariate associations of demographic variables with diet cost and quality were examined using t-tests and analysis of variance. The relationship between diet quality and cost was examined by evaluating mean differences in diet cost by tertiles of each diet quality indicator as estimated using analysis of covariance adjusting for age, sex, height, weight, and physical activity to account for individual differences in energy need. Allocation of spending across food groups by HEI2005 tertiles was examined using analysis of covariance with the same covariates. Statistical significance was adjusted for multiple comparisons using the Sidak method. Analyses were conducted using Stata version 12 (2011, College Station, TX: StataCorp LP).

Results and Discussion

The sample had a mean ± SD age of 13.2±2.8 years, mean T1D duration of 6.3±3.4 years, and mean A1c of 8.5±1.3; 69% used insulin pump therapy. Mean estimated daily diet cost was $6.93 (Table 1), which is similar to national estimates[43] and within the range of average costs of the USDA food plans for children age 8–18 years[44,45]. Diet cost was lower for children <12 years of age. Higher household income was associated with greater NRF9.3 and WPFD, but not with HEI2005 or diet cost. Normal weight status was associated with greater NRF9.3.

Differences in adjusted mean daily diet cost across tertiles of HEI2005, NRF9.3, and WPFD were modest, with none reaching statistical significance (p=0.20, 0.09, and 0.09, respectively) (Table 2; Supplementary Table). Our findings differ from those in an examination of diet cost in the general population of adults [46]; these differences may be related to differences in the population or methodology used. HEI2005 was selected as the primary indicator of conformance to dietary guidelines, and as the most comprehensive measure incorporating all key food groups. While the various indicators measure associated constructs, we anticipated that NRF9.3 and WPFD may be more sensitive to costs associated with fruit and vegetable purchase. However, across income levels, US consumers spend only 8% to 12% of their food costs on fruits and vegetables combined [47]. The association of household income with two of the three indicators of diet quality, but not with diet cost, suggests that factors other than diet cost, such as food availability, time, resources, demands, and preferences may relate to socio-economic disparities in diet quality[15, 48–51].

Examination of mean cost for individual food groups showed significant differences in spending allocation across HEI2005 tertiles (Table 3). Those in the highest tertile spent more on whole fruit, vegetables, whole grains, lean meat, and low-fat dairy, and less on high-fat meat and high-fat dairy relative to those in the lowest tertile. The low and middle tertiles differed only in spending on whole fruit and high-fat meat. No differences by HEI2005 tertile were seen for spending on fruit juice, discretionary foods, and beverages. This suggests that those closer to complying with the dietary recommendations are not doing so by limiting foods of minimal nutritional value.

The day-to-day management of T1D poses considerable burden to families, and attention to healthful eating may be perceived as another demand on time, cost, and effort. Our findings that a more healthful diet may be achieved at a cost comparable to a less healthful diet may be of considerable utility for these families and their health care teams. Daily diet costs of those in the highest HEI2005 tertile (mean ± SD HEI2005=65.6±5.7) were $0.68 more than those in the lowest tertile (mean ± SD=41.5±5.0). Those in the highest tertile of NRF9.3 (mean ± SD NRF9.3=32.2±8.1) spent on average $0.87 more than those in the lowest tertile (mean ± SD=10.4±3.8), and those in the highest tertile of WPFD (mean ± SD 3.9±1.0 cup/oz equivalents of whole plant foods per 1000 kcal) spent an average of $0.89 more than those in the lowest tertile (mean ± SD 1.0±0.4 cup/oz equivalents of whole plant foods per 1000 kcal). These data suggest that large differences in intake patterns can be observed within small differences in food spending. Within the context of effective behavior change approaches[52], dietitians may assist families in overcoming concerns about cost as a barrier to healthful eating, highlighting cost in terms of nutrition per dollar spent, and supporting families efforts to reduce spending on discretionary foods, choose low-cost options for whole plant foods (e.g, bananas, carrots, cabbage, brown rice, legumes)[30], and outlets for purchasing healthful foods. An analysis of cost for a wide range of fruits and vegetables demonstrated that fruit and vegetable guidelines may be met within a budget equal to the Thrifty Food Plan[44] allocation to fruits and vegetables[30, 53].

There are several limitations of the study that may impact interpretation of findings. The sample contained youth from a single diabetes clinic in the Northeast. Families choosing to participate may differ from the clinic population in dietary practices, and the task of completing food records may influence reported intake. However, dietary intake in this sample is consistent with previous research in T1D[54] and US youth in general[55]. The sample size, while comparable to dietary assessments of youth with type 1 diabetes, may not have been adequate for detecting small differences in diet cost. The average income of the sample was $80,000, slightly lower than the average income for the metropolitan area at $85,009[56,57]. The sample included a limited number of low-income families. Five percent of the sample was at or below poverty line, 6% were eligible for the Supplemental Nutrition Assistance Program (SNAP, formerly food stamps) and 12% were eligible for WIC benefits and services. It is possible the relations between cost and diet quality may be different for those with the most restricted resources.

On average youth demonstrated suboptimal adherence to dietary recommendations as evaluated by the HEI2005. Therefore, it cannot be determined whether the relationship between diet quality and expenditure would differ from what is reported here for those meeting or exceeding recommendations. However, there were wide and overlapping ranges of spending at each diet quality tertile, suggesting that there is great variability in the amount spent across each level of diet quality. Previous research has similarly found a wide range of prices for fruits and vegetables, suggesting that a high quality diet can be obtained across various levels of spending[29, 30].

Food cost was estimated based on the lowest non-sale price at two grocery stores with online information, consistent with previous methods of determining diet cost[25–27]. Thus, estimates would not account for differences in price due to factors such as buying foods on sale, “boutique” brands, different types of grocery stores, foods from farmers markets, or foods from restaurants other than those specified within NDSR. However, many different name brands were represented in the NDSR database and priced as such, and the grocery stores used were major food outlets. An advantage of this method is that it provides a homogenous source for pricing that eliminates variation in prices unrelated to nutrient composition of the product.

This study provides useful and novel information on the relationship between diet quality and diet cost among youth with T1D. Strengths include a relatively large sample of youth with T1D and the use of three-day diet records to assess dietary intake. The attention given to diet as an aspect of diabetes management may facilitate the reporting of dietary intake in families of youth with T1D. Costs were estimated for the overall diet as consumed from an extensive database of foods. Further, current and locally-obtained retail prices linked to dietary data were used to approximate spending on food.

Conclusions

In summary, youth with T1D who demonstrated relatively better diet quality did so at a cost comparable to those with poorer diet quality. The difference in average daily diet cost between the highest and lowest tertiles of each diet quality indicator was modest. Findings may inform dietary counseling in families of youth with T1D, and suggest that it is possible to improve diet quality without undue financial burden.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Mean ± SD daily food cost ($/day) and diet quality by subject characteristics in a sample of youth with type 1 diabetes (n=252)

	Diet cost		Diet quality indicators					
	$/day	***P***	**HEI2005**	***P***	**NRF 9.3**	***P***	**WPF**	***P***
Total Sample	6.93 ± 3.40	-	53.4 ± 11.0	-	20.8 ± 10.4	-	2.4 ± 1.3	-
Age (years)								
< 12 (n=91)	6.30 ± 2.04	0.03	54.1 ± 11.6	0.43	20.4 ± 9.7	0.64	2.5 ± 1.29	0.34
≥ 12 (n=161)	7.28 ± 3.92		52.9 ± 10.6		21.0 ± 10.8		2.3 ± 1.36	
Sex								
Male (n=130)	6.82 ± 2.58	0.61	52.2 ± 10.8	0.09	19.7 ± 7.9	0.09	2.2 ± 1.25	0.05
Female (n=122)	7.04 ± 4.10		54.6 ± 11.0		21.9 ± 12.5		2.5 ± 1.41	
Weight status[a]								
Normal weight (n=166)	6.97 ± 3.57	0.93	53.9 ± 11.1	0.40	21.9 ± 11.0	0.03[b]	2.5 ± 1.4	0.26
Overweight (n=57)	6.66 ± 2.24		51.6 ± 10.6		18.2 ± 7.6		2.1 ± 1.1	
Obese (n=29)	7.24 ± 4.25		53.7 ± 10.7		19.3 ± 10.8		2.1 ± 1.1	
Parent education								
< College degree (n=65)	6.75 ± 2.94	0.88	54.4 ± 11.0	0.69	20.6 ± 10.4	0.99	2.3 ± 1.3	0.80
College degree (n=112)	6.79 ± 3.07		53.1 ± 11.5		20.9 ± 11.4		2.4 ± 1.5	
Graduate degree (n=75)	7.28 ± 4.17		52.9 ± 10.2		20.8 ± 8.9		2.4 ± 1.1	
Household income (PIR tertiles)								
Low (n=85)	6.71 ± 2.78	0.21	51.4 ± 10.5	0.07	18.4 ±8.5	0.01	2.1 ± 1.2	0.03
Middle (n=84)	6.53 ± 3.06		52.9 ± 10.8		20.3 ± 10.4		2.3 ± 1.3	
High (n=75)	7.66 ± 4.35		55.3 ± 11.2		23.2 ± 11.0		2.6 ± 1.4	
HbA1c (%)								
< 8.5 (n=143)	7.22 ± 3.63	0.12	54.0 ± 10.7	0.28	21.5 ± 9.5	0.19	2.5 ± 1.26	0.04
≥ 8.5 (n=109)	6.55 ± 3.04		52.5 ± 11.2		19.8 ± 11.4		2.2 ± 1.40	
Insulin regimen								
Injections (n=79)	7.18 ± 3.98	0.44	54.0 ± 10.6	0.50	20.7 ± 10.7	0.96	2.4 ± 1.3	0.99
Pump (n=171)	6.82 ± 3.10		53.0 ± 11.1		20.8 ± 10.3		2.4 ± 1.4	

HEI2005 - Health Eating Index-2005. NRF9.3 - Nutrient Rich Foods index (version 9.3). WPFD - Whole Plant Foods Density. PIR - Poverty-Income Ratio.

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[a]Normal weight=Body Mass Index (BMI) percentile <85 (includes 3 with BMI %ile < 5), Overweight = BMI %ile ≥ 85 and <95, Obese=BMI %ile ≥ 95.

[b]Significant pairwise differences in NRF 9.3 were observed between normal weight and overweight (p=0.01), and between normal weight and obese youth (=0.048).

Table 2

Adjusted mean ± SE* diet cost ($/day) by diet quality indicator tertile in a sample of youth with type 1 diabetes (n=252).

	Tertile			
Diet quality indicator	**Low**	**Middle**	**High**	**P-value****
HEI2005	6.67 ± 0.37	6.80 ± 0.36	7.35 ± 0.37	0.20
NRF 9.3	6.50 ± 0.37	6.96 ± 0.37	7.37 ± 0.37	0.09
WPFD	6.49 ± 0.37	6.96 ± 0.36	7.38 ± 0.37	0.09

HEI2005 - Health Eating Index-2005. NRF9.3 - Nutrient Rich Foods index (version 9.3). WPFD - Whole Plant Foods Density.

* Means are adjusted for age, sex, height and weight, and self-reported physical activity.

** P-value for overall trend test

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Table 3

Mean ± SD diet cost ($/day) for individual food groups overall and mean ± SE diet cost by HEI-2005 tertiles in a sample of youth with type 1 diabetes (n=252).

Food Group	Total Sample	HEI-2005 tertiles			
		Low	Middle	High	*P*
Whole fruit	0.56 ± 0.60	0.31 ± 0.06^{a}	0.55 ± 0.06^{b}	0.82 ± 0.06^{c}	<0.001
Fruit juice	0.07 ± 0.12	0.07 ± 0.01	0.07 ± 0.01	0.09 ± 0.02	0.24
Vegetables	0.78 ± 0.63	0.67 ± 0.07^{a}	0.76 ± 0.07^{ab}	0.92 ± 0.07^{b}	0.009
Whole Grains	0.33 ± 0.33	0.24 ± 0.04^{a}	0.33 ± 0.04^{ab}	0.42 ± 0.04^{b}	<0.001
Refined Grains	0.78 ± 0.45	0.83 ± 0.05^{a}	0.83 ± 0.05^{a}	0.71 ± 0.05^{a}	0.09
Lean meat	0.45 ± 0.55	0.36 ± 0.06	0.43 ± 0.06	0.56 ± 0.06	0.02
High-fat meat	0.64 ± 0.57	0.89 ± 0.06^{a}	0.62 ± 0.06^{b}	0.41 ± 0.06^{c}	<0.001
Low-fat dairy	0.33 ± 0.35	0.27 ± 0.04^{a}	0.30 ± 0.04^{a}	0.43 ± 0.04^{b}	0.003
High-fat dairy	0.55 ± 0.38	0.63 ± 0.04^{a}	0.61 ± 0.04^{a}	0.41 ± 0.04^{b}	<0.001
Discretionary foods*	0.90 ± 0.52	0.97 ± 0.06	0.83 ±0.06	0.88 ± 0.06	0.27
Beverages	1.32 ± 2.85	1.28 ± 0.31	1.24 ± 0.31	1.44 ± 0.31	0.72

*Discretionary foods include cakes, cookies, pastries, candies, chips, and added fats.

Different subscripts denote statistically significant differences (p<0.05, adjusted for multiple comparisons). Analysis of covariance models for differences between tertiles were adjusted for age, sex, measured height and weight, and self-reported physical activity.