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Can families eat better without spending more? Improving diet quality does not increase diet cost in a randomized clinical trial among youth with type 1 diabetes and their parents

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Abstract

Background—Although cost is a frequently cited barrier to healthful eating, limited prospective data exist.

Objective—This study examined the association of diet cost with diet quality change.

Design—An 18-month randomized clinical trial evaluated a dietary intervention.

Participants/setting—Youth with type 1 diabetes duration ≥ 1 year, age 8.0 to 16.9 years ($N=136$), receiving care at an outpatient tertiary diabetes center in Boston, Massachusetts participated along with a parent from 2010 to 2013. Eighty-two percent of participants were from middle to upper income households.

Intervention—The family-based behavioral intervention targeted intake of whole plant foods.

Main outcome measures—Diet quality as indicated by the Healthy Eating Index-2005 (HEI-2005, measures conformance to 2005 Dietary Guidelines for Americans) and whole plant food density (WPDF, cup/oz equivalents per 1000 kcal of target food groups) were calculated from three-day food records of youth and parent dietary intake at six and four time points, respectively. Food prices were obtained from two online supermarkets common to the study location; daily diet cost was calculated by summing prices of reported foods.

Statistical analyses performed—Random effects models estimated treatment group differences in time-varying diet cost. Separate models for youth and parent adjusted for covariates examined associations of time-varying change in diet quality with change in diet cost.

Results—There was no treatment effect on time-varying diet cost for either youth [β (95%CI) = -0.49 ($-1.07, 0.08$), $p=.10$] or parents [$\beta=0.24$ ($-1.61, 2.08$) $p=.80$]. Additionally, time-varying change in diet quality indicators was not associated with time-varying change in diet cost for youth. Among parents, a 1 cup/oz-equivalent increase in whole plant food density was associated with a \$.63/day lower diet cost [$\beta=-0.63$ ($-1.20, -0.05$), $p=0.03$].

Conclusions—Improved diet quality was not accompanied by greater cost for youth with type 1 diabetes and their parents participating in a randomized clinical trial. Findings challenge the prevailing assumption that improving diet quality necessitates greater cost.

Keywords

diet quality; diet cost; type 1 diabetes; intervention; families

BACKGROUND

Poor diet is the largest contributor to early death globally ¹, and is especially concerning in youth with type 1 diabetes, given the several-fold increased risk of diet-related chronic disease in this population ² and suboptimal adherence to dietary guidelines ³. A prevailing supposition exists that a healthful diet is necessarily more expensive than an unhealthful one ^{4,5}. In light of the many medical conditions for which diet plays a role in prevention or treatment, this perception represents a serious impediment to the implementation of health care recommendations. It is well-established that the US food supply is characterized by ready access to inexpensive, energy-dense, nutrient-poor food ⁶. If healthful diet change

necessitates substantially greater expense, then educational and behavioral approaches to dietary change are likely to be ineffective until the cost of healthful food is reduced. Despite this, limited research has examined whether initiating healthful dietary changes leads to increased food spending. Consequently, it is unclear to what extent cost represents a real versus a perceived barrier to dietary change.

Findings from the body of research to date addressing the association of diet cost with diet quality are conflicting; however, these studies vary in terms of how the outcome of food cost is defined. Research defining food cost as energy cost; that is, cost per kilocalorie or energy-adjusted cost, has typically shown a positive association of diet cost with quality ^{7–11}. However, the cost per kilocalorie metric refers only to the price of the food's energy content, and does not provide information on the price of other important attributes, notably micronutrients ¹². Further, there is little evidence to suggest that consumers employ this metric in food purchasing decisions ¹³. Adjusting for total energy intake when evaluating the relationship between individual's dietary quality or energy density and food expenditures disregards the positive association between total daily intake and spending ¹³, and represents overadjustment ¹⁴ given data showing a positive association between dietary energy density and total energy intake ¹⁵. Research based on alternative metrics such as cost per meal, cost per day, or cost per food weight has demonstrated weak positive, null, or inverse associations between diet cost and quality ^{12, 16–19}, including one cross-sectional analysis among youth with type 1 diabetes in which there was no significant association between diet cost and diet quality¹⁹. Cross-sectional, nationally representative data from the National Health and Nutrition Examination Survey and the Center for Nutrition Policy and Promotion Food Prices Database demonstrated considerable variation in diet quality across all food spending levels ¹⁷, suggesting that healthful eating may not require additional cost. A recent meta-analysis reviewed 27 studies from 10 different countries and concluded that results were largely mixed depending on how food cost was defined. Overall, a statically significant association of higher diet cost with greater diet quality was observed; however the effect size was modest, with a cost difference between the lowest and highest dietary healthfulness quintile of \$1.48 per day ²⁰.

An important limitation of the current body of research is the predominance of cross-sectional study designs, which are susceptible to confounding and reverse causality, and cannot address the temporality of observed associations. Data from cross-sectional studies have shown a positive association between socioeconomic status and diet quality ^{7, 21}, which may be mediated by diet cost ²². However, several potential alternative explanations for these associations cannot be ruled out, including socioeconomic differences in access to healthful food ²³, education and knowledge about health and nutrition ^{24, 25}, sociocultural norms about diet ^{26, 27}, time and competing demands ²⁸, and food reinforcement value ²⁹. Intervention studies are needed in order to inform the causality of the associations shown in observational research. Relatively fewer prospective studies suggest that while participants may initially anticipate cost to be a barrier ³⁰ improvements in diet can occur without incurring additional costs ^{31–35}. However, these studies are limited by small sample size ^{33, 35}, lack of a control group ^{33, 35}, and relatively short follow-up ³³. The purpose of the current study was to examine the effect of changing diet quality on diet cost in youth with type 1 diabetes and parents participating in an 18-month randomized clinical trial of a

family-based behavioral nutrition intervention previously shown to improve youth diet quality (ClinicalTrials.gov identifier: NCT00999375; registered 20 October 2009) ³⁶.

MATERIALS & METHODS

Design & Study Sample

Parent-youth dyads (N=136) participated in a randomized clinical trial of a family-based behavioral nutrition intervention designed to increase intake of whole plant foods among youth with type 1 diabetes. The study was conducted at an outpatient, free-standing, multidisciplinary tertiary diabetes center in Boston, Massachusetts. Eligibility criteria for youth included age 8.0 to 16.9 years, diagnosis of type 1 diabetes ≥ 1 year, daily insulin dose ≥ 0.5 units per kilogram, most recent hemoglobin A1c $\geq 6.5\%$ and $\leq 10.0\%$, intensive insulin therapy with either an insulin regimen of ≥ 3 injections daily or insulin pump, at least one clinic visit in the past year, and ability to communicate in English. Exclusion criteria included daily use of premixed insulin, transition to insulin pump therapy in the last three months, real-time continuous glucose monitoring use in the last three months, participation in another intervention study in the last six months, and presence of gastrointestinal disease such as celiac disease, multiple food allergies, use of medications that interfere significantly with glucose metabolism, or significant mental illness. Sample size was based on detecting meaningful differences in dietary intake and glycemic control between intervention and control conditions, and has been reported in detail previously ³⁶.

Procedures

The study was conducted from August 2010 through May 2013. Participants were recruited by research staff at regular clinic visits and were enrolled in the study for 18 months. All youth provided assent; parents and youth turning 18 years old during the trial provided written informed consent. Participants were recruited without bias across sex and race/ethnicity. Study procedures were approved by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Institutional Review Board and the Joslin Diabetes Center Committee on Human Subjects. Randomization, which was conducted by the data coordinating center, was stratified by age (<13 years and ≥ 13 years), hemoglobin A1c ($<8.5\%$ and $\geq 8.5\%$), and insulin regimen (injection and insulin pump), with a permuted block randomization scheme. Twenty-four percent of those approached consented to participate; subject retention through study completion was 92%. Study visits were completed in the clinic; diet records were completed by youth and parents following study visits.

Intervention procedures have been described in detail previously ³⁶. In brief, participants randomized to the intervention condition participated in six core and three booster individual sessions delivered to the youth and parent together targeting increased intake of whole plant foods, defined as whole fruits, vegetables, whole grains, legumes, nuts, and seeds. Sessions integrated a motivational interviewing style of interaction and active learning to facilitate skill-building and engagement with the educational information followed by goal-setting using problem-solving to facilitate goal-directed behavior and self-regulation skills. Sessions

did not specifically address diet cost; however, the information included in the recipe book included two pages providing cost estimates of example recipes.

Measures

Dietary intake—Participants (youth and a parent) completed three-day diet records for youth intake at baseline and 3, 6, 9, 12 and 18 months follow-up and for parent intake at baseline and every six months thereafter. They were instructed on accurately measuring and reporting food and beverage intake and given a sample diet record. Participants were asked to use measuring utensils when at home, and if away from home, to provide their best estimate of portion size. They were reminded to provide all specific details for each food item, including names of brands or restaurants and specific item labeling (e.g., low fat, 1% milk). Recording began on the day of the study visit and continued for the next three full days. Research staff reviewed the completed records upon receipt from the family to ensure completeness, and solicited missing information (e.g., brand names) from the family as needed. For visits in which a participant did not complete a diet record, two non-consecutive 24-hour dietary recalls were obtained by telephone by a registered dietitian using the NDSR multiple pass method³⁷ (1.7% of youth dietary assessments and 4.0% of parent dietary assessments). Diet records were entered by two registered dietitians and verified for consistency and accuracy. Nutrition Data System for Research software (NDSR 2012; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) was used to analyze the records and assess nutrient intake and food group servings. Records of partial days were excluded; 68% of youth records and 66% of parent records included three full days. Of those having fewer than three days, the majority provided only a partial record on the final record day.

Diet quality—Overall diet quality was assessed using the Healthy Eating Index-2005 (HEI-2005) and the Whole Plant Food Density (WPDF) measures. The HEI-2005 score measures conformance to the 2005 Dietary Guidelines for Americans, and is comprised of 12 component scores corresponding to dietary guidelines for intake of 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 energy from solid fat, alcohol and added sugars^{38, 39}. The maximum component score is assigned if intake meets recommended intake levels. Recommendations and scores are expressed on a per-1000 kilocalorie basis to enable comparability and applicability to individuals with varying total energy requirements. Component scores are summed to obtain the total score, with a maximum possible score of 100, which would indicate meeting intake recommendations for all dietary components. The WPDF is a continuous measure representing the proportion of the diet allocated to whole grains, whole fruit, vegetables, legumes, nuts, and seeds, calculated as the total number of cup or ounce equivalents of these foods per 1000 kcal of food consumed⁴⁰.

Diet cost—Diet cost was estimated using methods consistent with previous research^{32–35}. Price information from two online national supermarkets common to the study location was recorded and averaged for each food component reported (approximately 1600 items), except that prices for items reported from a named store or restaurant were obtained from these retail outlets. The lowest non-sale unit price for each item was selected. Costs were

estimated for food as purchased. 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 obtained from a supermarket. Daily diet cost was calculated as the sum of the price of all foods consumed divided by the number of days of recorded intake.

Clinical and demographic data—Youth biomedical data were collected through medical record review. Measured height and weight obtained during routine clinical exams using electronic scales and stadiometers (calibrated daily) were abstracted from the medical record for youth; parents were measured by study staff using the same equipment at the baseline visit (other than three parents who provided self-reported height and weight, and two who provided self-reported height). For youth, frequency and duration of moderate and vigorous physical activity was assessed using questions from the Behavioral Risk Factor Surveillance System ⁴¹. A single continuous variable was calculated by counting each minute of vigorous activity as equivalent to two minutes of moderate activity ⁴². Parents reported information on race/ethnicity, education level, household income and number of people in the home at baseline. The income to poverty ratio was calculated as the ratio of reported household income divided by the 2008 US Census poverty threshold for household size and composition adjusted for inflation ⁴³. This measure accounts for household size and composition when evaluating income, with a higher value indicating greater income relative to the poverty threshold.

Statistical Analysis

Baseline participant demographics, disease-related characteristics, diet quality, and diet cost were summarized with means and standard deviations for continuous variables and frequencies for categorical variables. Family income level was categorized into lower, middle, and upper using cutoffs from the Pew Research Center⁴⁴. Differences in diet cost by income category were tested using Kruskal Wallis non-parametric test, as variance was unequal across income groups. Baseline differences between intervention and control groups were tested using independent t-tests for continuous variables and Pearson chi-square tests for categorical variables. Treatment group differences in youth and parent diet cost at each time point were compared using t-tests. Random effects models estimated treatment group differences in diet cost across the study duration. Change from baseline in diet cost and in each diet quality indicator was calculated for each subsequent assessment period. Separate models estimated associations of time-varying change in youth and parent diet quality indicators with change in diet cost. Youth models controlled for age, height, body mass index (BMI, kg/m²), sex, physical activity, income, parent education, race/ethnicity, and treatment assignment. Parent models controlled for height, BMI, sex, income, education, race/ethnicity, and treatment assignment. Analyses were conducted in 2015 using Stata (version 12, 2012, StataCorp LP).

RESULTS

Participant flow from recruitment through follow-up is reported in Figure 1. Of those invited, 24% provided informed consent and 22% completed baseline. Subject retention through study completion was 92%. All subjects who withdrew had been randomized to the intervention group. One subject withdrew after baseline but before being informed of treatment assignment, 2 withdrew within the first 3 study months; 3 between months 3 and 6, 1 between months 6 and 9, 3 between months 9 and 12, and 1 after month 12. Reasons for withdrawal were primarily lack of time to participate. No study-related adverse events were reported.

Baseline characteristics, daily diet cost, and diet quality were well-balanced between groups (Table 1). Approximately half of the sample (47%) was classified as middle income; 35 percent as upper income, and 18% as lower income. Eight percent of the sample was below the poverty level; 10% had income levels qualifying for Supplemental Nutrition Assistance Program, and 15% had income levels that would qualify for the Special Supplemental Nutrition Program for Women, Infants, and Children. Estimated youth daily diet costs (mean $\pm$ SD) by income category were \$4.66 $\pm$ 1.24 for lower income, \$5.57 $\pm$ 1.61 for middle income, and 5.77 $\pm$ 1.96 for upper income ($p=.03$).

There were no statistically significant differences between treatment groups in youth or parent diet cost at any time point cross-sectionally (Figure 2), although a higher cost for the intervention group among youth of \$1.74/day at 3 months approached statistical significance ($p=.08$) (data not shown). In longitudinal models, there was no treatment effect on time-varying diet cost for either youth [β (95%CI) = -0.49 ($-1.07, 0.08$), $p=.10$] or parents [$\beta=0.24$ ($-1.61, 2.08$) $p=.80$]. Descriptive data on change in diet quality indicators and diet cost across assessment periods is provided in online Supplementary Table 1. Time-varying change in HEI-2005 and WPF was not significantly associated with time-varying change in diet cost for youth (Table 2). Among parents, a 1 cup/oz-equivalent increase in whole plant food density was associated with a \$.63/day lower diet cost ($p=0.03$).

DISCUSSION

Improved diet quality was not accompanied by greater expense in youth with type 1 diabetes and parents participating in a randomized clinical trial, suggesting that persons who choose to improve their diets may be able to do so without increasing their food expenditures. As reported previously, at 18-months follow-up, youth in the intervention group had a mean HEI-2005 score more than 7 points higher and consumed half a cup or ounce equivalent per 1000 kilocalorie more whole plant foods than youth in the control group³⁶. Findings from this study indicate that this improvement in diet quality was not associated with increased diet cost as compared with participants in the control group. Additionally, across treatment groups, time-varying change in youth diet quality, measured both as overall adherence to dietary guidelines and as intake of whole plant food, was not associated with time-varying change in youth diet cost. Taken together, these findings challenge the prevailing assumption that improving diet quality necessitates greater diet cost. Previous support for a positive association of diet quality and cost has come from cross-sectional research, much of which

assesses energy cost rather than daily diet cost, and for which the overall effect attributable to diet quality is small²⁰. Only a small body of intervention research has examined the effect on cost of changes in diet quality^{32–35}; these studies and the current analysis all find no increase in diet cost in association with improved diet quality. Additionally, we observed an inverse association of change in diet cost with change in WPDF among parents. While unexpected, these findings are consistent with results from a diet and physical activity intervention in Finnish adults at high risk for diabetes in which an association of increased fiber intake with decreased diet cost was observed³².

While price does influence food purchasing decisions,⁴⁵ analyses of supermarket food costs for more versus less healthy foods,⁴⁶ for more versus less healthy diets,⁴⁷ and for meeting fruit and vegetable intake guidelines⁴⁸ indicate the feasibility of making more healthful choices without spending more. Additionally, previous research has shown that spending on nuts, beans, and whole grains provide great value for cost-effective improvement in diet quality⁸. Determining acceptable cost-effective healthful choices may initially require additional effort in terms of label reading, learning about and trying new products. In this study, there was a trend toward increased diet cost among youth in the intervention group at three months, followed by a decrease in cost at subsequent assessments. This finding may be spurious or may reflect shifts in purchasing as families experiment with changes in food choices and determine those that fit within their budget. Thus, in light of consumer concerns about the affordability of healthful eating, education on how to access, identify, and choose low-cost, healthful options remains an important component of dietary interventions. As it is well-established that educational approaches alone are typically insufficient to achieve behavior change, such education needs to be provided in conjunction with behavioral approaches such as increasing intrinsic motivation, skills development, problem-solving, self-monitoring, and changing implicit attitudes^{49, 50}.

A limitation of this study is the relatively small number of very low income families. Eight percent of the sample was below the poverty level, compared to 10.7% for the state of Massachusetts and 15.1% nationally (2010–2011 average)⁵¹. The number of middle income families in the sample was similar to estimates in the US population (47% in this sample versus 50% nationally); however there were fewer lower income families (18% versus 29%) and a greater number of higher income families (35% versus 21%) than national estimates⁴⁴. While the mean daily diet cost for youth of \$5.41/day observed in this study is near to the estimated cost of the United States Department of Agriculture thrifty and low-cost food plans for children in this age range⁵², families in extreme poverty may spend even less for food, as suggested by the lower mean diet cost among those in the lowest income group in this sample. This study is unable to examine the association of diet quality with cost specifically among families with the most restricted resources due to the small sample size of this group. Comprehensive approaches to improve diet quality for these families need to address an array of barriers, including availability, marketing, policies, and optimal allocation of public assistance^{53–58}.

Additional study limitations that may impact interpretation of findings include the limited geographic area from which the sample was drawn (a single diabetes clinic in the Northeast with a limited number of racial/ethnic minority families). 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 type 1 diabetes ³ and US youth in general ⁵⁹, indicating the bias in estimated intake may be minimal relative to previous studies. Due to pairing of the diet record completion with clinic visits, it was not possible to standardize the number of weekday and weekend days assessed. Additionally, only 68% of youth and 66% of parent records included three full days. Consistent with dietary intake in the US general population, the study included few persons consuming a diet nearing dietary recommendations. As such, it cannot be determined whether the relationship between diet quality and cost would differ for those meeting or exceeding recommendations. Data on parent age and physical activity were not available; thus, analyses of parent diet costs do not control for differences in energy requirements associated with these variables.

Strengths of the study include the use of diet records at multiple time points across 18 months and the evaluation of diet cost in the context of a behavioral intervention with demonstrated improvement in youth diet quality. Food cost was estimated from the lowest non-sale price at two grocery stores with online information, consistent with previous methods of determining diet cost ^{32–35}. Thus, estimates are not confounded by differences in price due to purchasing practices, such as buying foods on sale or “boutique” brands, purchasing from alternative food retail outlets (e.g., corner stores, farmers markets), or eating at restaurants other than those specified within NDSR. Many different name brands are represented in the NDSR database and were priced as such, and the grocery stores used were major food outlets in the geographic area. An advantage of this method is that it provides a homogenous source for pricing that eliminates variation unrelated to nutrient composition of the product. Daily diet cost estimates in this study were within the range of average costs of the USDA food plans⁵².

CONCLUSIONS

In the context of this randomized clinical trial, improved diet quality was not associated with increased diet cost, either between or across treatment groups. These findings do not negate the importance and usefulness of policies and programs to increase access to and affordability of healthful foods. However, they do provide evidence that even in the context of the current food environment, many families could achieve greater diet quality within their current food budget allocation. These findings represent an encouraging message for health professionals and families that for many, cost need not be a barrier to improving dietary intake.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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PRACTICE IMPLICATIONS

What is the current knowledge on this topic?

A prevailing supposition is that a healthful diet is necessarily more expensive than an unhealthful one; however cross-sectional research to date is conflicting and there are few longitudinal studies.

How does this research add to knowledge on this topic?

Improvements in diet quality did not result in increased diet cost among youth with type 1 diabetes in predominantly middle and upper income families, challenging the prevailing assumption that improving diet quality necessitates greater diet cost.

How might this knowledge impact current dietetics practice?

Greater diet quality may be achieved within many families' existing food budget allocation; thus cost may not need to be a barrier to improving dietary intake.

Figure 1.

Participant flow through a randomized clinical trial of a behavioral nutrition intervention in youth with type 1 diabetes (participants are youth-parent dyads)

^aLongitudinal analyses include all available data from each subject through withdrawal or study completion

Adapted with permission from: Nansel TR, Laffel L, Haynie D, Mehta S, Lipsky L, Volkening L, Butler D, Higgins L, Liu A. Improving dietary quality in youth with type 1 diabetes: randomized clinical trial of a family-based behavioral intervention. *International Journal of Behavioral Nutrition and Physical Activity* 2015; 12:58.

Figure 2.
Effect of a behavioral nutrition intervention on diet cost in 136 youth with type 1 diabetes and parents participating in a behavioral nutrition efficacy trial^a
^aBars represent 95% confidence intervals.

Table 1

Baseline sample characteristics of 136 youth with type 1 diabetes and parents participating in a behavioral nutrition efficacy trial

	All Participants	Treatment (N=66)	Control (N=70)	<i>p</i> ^a
	Mean ± SD or N (%)	Mean ± SD or N (%)	Mean ± SD or N (%)	
Demographics				
Youth age (years)	12.8±2.6	12.6±2.7	13.0±2.5	0.27
Youth sex				
Male	66 (48.5)	35 (53.0)	31 (44.3)	0.31
Female	70 (51.5)	31 (47.0)	39 (55.7)	
Youth race/ethnicity				
White, non-Hispanic	123 (90.4)	58 (87.9)	65 (92.9)	0.17
Hispanic	7 (5.2)	6 (9.1)	1 (1.4)	
Black, non-Hispanic	5 (3.7)	2 (3.0)	3 (4.3)	
Other	1 (0.7)	0 (0.0)	1 (1.4)	
Highest parent education level ^b				
High school or equivalent	8 (5.9)	4 (6.1)	4 (5.7)	0.48
Junior college, technical or some college	27 (19.9)	11 (16.7)	16 (22.9)	
College degree	46 (33.8)	20 (30.3)	26 (37.1)	
Graduate education	55 (40.4)	31 (47.0)	24 (34.3)	
Family income to poverty ratio ^b	5.2±3.1	5.5±3.2	4.9±3.0	0.23
Youth diabetes characteristics				
Duration of diabetes (years)	6.0±3.1	5.6±2.5	6.3±3.6	0.15
Insulin regimen				
Injection only	42 (30.9)	20 (30.3)	22 (31.4)	0.89
Pump	94 (69.1)	46 (69.7)	48 (68.6)	
Frequency of blood glucose monitoring (times/d)	5.7±2.4	5.8±2.4	5.6±2.5	0.60
Hemoglobin A1c (%)	8.1±1.0	8.1±1.1	8.1±1.0	0.95
Youth diet characteristics				
Healthy eating index 2005 ^c	53.3±11.6	53.0±11.9	53.7±11.5	0.72
Whole plant food density ^d	2.0±1.2	2.0±1.2	2.0±1.1	0.84
Diet cost (\$/day)	5.48±1.71	5.54±1.61	5.43±1.81	0.71
Parent diet characteristics				
Healthy eating index 2005 ^c	56.8±12.3	55.8±12.5	57.8±12.2	0.35
Whole plant food density ^d	2.5±1.4	2.5±1.4	2.5±1.4	0.91
Diet cost (\$/day)	9.91±6.45	10.69±7.47	9.16±5.23	0.17

^aComparisons between intervention and control groups using independent *t*-tests for continuous variables or chi-square for categorical variables.

^bMissing data from 1 participant on highest parent education and from 2 participants on family income.

^cRepresents healthy eating index 2005 total score; indicates conformance to 2005 Dietary Guidelines for Americans (max=100, complete conformance).

^dContinuous measure representing the total number of cup or ounce equivalents per 1000 kcal consumed of whole grains, fruit, vegetables, legumes, nuts and seeds.

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Table 2

Association of time-varying change in diet cost with time-varying change in diet quality indicators^a in 136 youth with type 1 diabetes and parents participating in a behavioral nutrition efficacy trial

	Diet cost (\$/day)					
	Youth			Parent		
	β	95% CI	p^b	β	95% CI	p^b
Diet quality indicators						
Healthy eating index 2005 ^c	-0.0005	-0.02, 0.02	0.96	-0.06	-0.13, 0.01	0.11
Whole plant food density ^d	-0.10	-0.27, 0.07	0.26	-0.63	-1.20, -0.05	0.03

^aSeparate random effects models estimating association of change in youth diet cost with change in parent diet cost with change in parent diet quality. Youth models adjusted for age, height, body mass index (BMI, kg/m²), sex, physical activity, income, parent education, race/ethnicity, and treatment assignment. Parent models adjusted for height, BMI, sex, income, education, race, and treatment assignment.

^bBoldface indicates statistical significance (p<.05).

^cRepresents healthy eating index 2005 total score; indicates conformance to 2005 Dietary Guidelines for Americans (max=100, complete conformance).

^dContinuous measure representing the total number of cup or ounce equivalents per 1000 kcal consumed of whole grains, fruit, vegetables, legumes, nuts and seeds.