Dietary Adherence and Mealtime Behaviors in Young Children with Type 1 Diabetes on Intensive Insulin Therapy

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ABSTRACT

Diet is an important component of diabetes treatment and integral to successful management. While intensive insulin therapy can allow patients to eat more freely, it is not known how the rapid uptake of intensive therapy in young children with type 1 diabetes has impacted their diet and if diet and healthful eating in young children correlates with mealtime behaviors and glycemic control. This study examined diet, mealtime behaviors, and glucose control in a sample of 39 young children on intensive therapy. This was a one-sample, cross-sectional study. Children had a mean age of 5.1±1.1 years. Children's 3-day diet diaries were assessed using a deviation scale (measure of adherence) and a healthy eating index. Mealtime behaviors were assessed using the Behavioral Pediatric Feeding Assessment Scale. Children's glucose control was measured using continuous glucose monitoring. Children's mean carbohydrate intake was 72%±24% of the recommended levels based on their age, sex, size, and activity level, and children exceeded national guidelines for percentage of calories from fat and saturated fat. A more healthful diet correlated with fewer child mealtime behavior problems, but better dietary adherence correlated with more parent mealtime behavior problems. Even in the context of intensive management, diet can be problematic for young children with type 1 diabetes. Parent-reported problems with mealtime behaviors seem to correlate with healthy eating and dietary adherence.
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DIETARY RECOMMENDATIONS FOR TYPE 1 DIABETES advocate consumption of a healthy diet and maintenance of a balance between carbohydrate intake and insulin levels to achieve near-normal blood glucose levels.[1] In addition, the recommendations seek to reduce youths' risk for overweight and diabetes-related comorbidities, including dyslipidemia and cardiovascular disease.[2] Although achieving these two goals can be challenging for all youth with type 1 diabetes, the available research suggests that parents of young children (age <7 years) with type 1 diabetes perceive diet and mealtimes as the most problematic component of diabetes care.[3] Specifically, research demonstrates that these parents report problems with mealtime behaviors at a level that exceeds the report of parents of young children without type 1 diabetes.[4] In addition, research demonstrates that young children with type 1 diabetes experience problems with dietary adherence and do not consume a healthful diet.[5] However, a notable limitation of these studies is that they were conducted in young children on conventional insulin therapy, which is no longer the gold standard for type 1 diabetes. The gold standard is now intensive insulin therapy, which has been shown to be superior to conventional therapy in achieving better glycemic control.[2] From a dietary perspective, intensive therapy may also be superior to conventional therapy because it allows greater flexibility in the timing, amount, and type of foods children consume, which may lead to better dietary adherence and healthful eating because youth no longer have to consume carbohydrates to match their insulin levels.[1] In young children with type 1 diabetes, dietary adherence and a measure of healthful eating have not been reported for an intensively managed sample. In addition, it is not known whether these dietary measures relate to mealtime behavior problems and glycemic control in young children who are intensively managed. Thus, the purpose of this study was to examine dietary adherence and healthful eating, and to relate these variables to mealtime behavior and glycemic control in a sample of intensively managed young children with type 1 diabetes. The hypotheses were that intensively managed young children would achieve better dietary adherence rates than published rates for conventionally managed children[5] and that problems with mealtime behavior and glycemic control would correlate negatively with measures of dietary adherence and healthful eating.

METHODS

Participants

Thirty-nine families of young children with type 1 diabetes were recruited to complete a project involving videotaping

home meals, continuous glucose monitoring, and diet recording for at least 3 days. Children were eligible to participate if they were younger than 7 years old, had been diagnosed with type 1 diabetes for at least 1 year, were prescribed an intensive insulin regimen (eg, rapid and nonpeaking insulin or rapid-acting insulin only), and were from a family that spoke English in the home. The larger project had a recruitment rate of 51%. Families who refused to participate cited concerns about the videotaping of home meals and the continuous glucose monitor as their reasons.

Procedure

Institutional Review Board approval was obtained from the participating hospitals: Cincinnati Children's Hospital and C.S. Mott Children's Hospital. Parents who agreed to participate scheduled a home visit to complete the informed consent, study questionnaires, and to learn how to record their children's food and beverage intake. Families were instructed to record their child's food and beverage intake for up to 3 days (including 1 weekend day) according to a standardized protocol.[5,6] In addition, children's weight and height were measured according to a standardized protocol using portable equipment, and a continuous glucose monitor was placed to measure their daily glycemic control.[5,7] Families who completed the study received remuneration for their time ($70.00). Families' diet records were reviewed by a research dietitian and analyzed using Nutrition Data System for Research software version 2009 (NDSR), developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis. As an additional sample descriptive, young children's most recent (within 3 months) glycated hemoglobin A1c (HbA1c) level was collected from the medical records. Children's HbA1c tests had been completed using the DCA 2000+ Analyzer (Bayer Corp; reference ranges 4.3% to 5.7%; 23 to 39 mmol/mol).

Measures

Dietary Deviation Scale. To remain consistent with previous research,[5] a modified version of Dietary Deviation Scale[8] was used. This adherence measure examines how closely youth achieve recommendations for daily food intake based on their individualized diet plan. Two adherence scores were calculated: caloric deviation score, which was the ratio of actual energy intake to children's recommended intake, and carbohydrate deviation score, which was the ratio of actual carbohydrate intake to children's recommended intake. Recommended intakes for energy and carbohydrates were determined based on the Harris-Benedict equation, (accounting for children's age, sex, size, and activity level). Although not part of the Dietary Deviation Scale, children's percentages of calories from total and saturated fat were also evaluated because of recommendations from the American Diabetes Association (ADA) that youth with type 1 diabetes reduce their intake of these macronutrients.[2]

Healthy Eating Index 2005 (HEI-2005). The HEI-2005 is a standardized tool that was used to measure the quality of children's diets.[9] The HEI-2005 provides a measure of healthful eating based on 12 component scores reflecting intake of foods from different food groups. Published methodology was used to calculate children's HEI-2005 scores based on NDSR data.[10] First, children's NDSR Serving Count Food Files were modified based on appropriate serving size guidelines for young children 2 to 7 years old. Then, HEI-2005 scores were calculated based on children's intake of total fruit, whole fruit, total vegetables, dark green/orange vegetables and legumes, total grains, whole grains, milk, and meat and beans, and reduced intake of oils, saturated fat, sodium, and percentage calories from solid fat/added sugars. Total scores for HEI-2005 can range from 0 to 100, with 100 reflecting more healthful eating.[9] In addition, the HEI-2005 can be scored for individual food group intake. For fruit, vegetable, and grain intake, scores are based on a 0 to 5 scale, with a score of 5 reflecting greater intake. For percentage calories from solid fat/added sugar intake, scores are based on a 0 to 20 scale, with a score of 20 reflecting intake of less than 20% of total calories. The HEI-2005 has been used previously in youth with type 1 diabetes.[11] In this study, HEI-2005 total score and scores for whole fruit, total vegetable, whole grains, and percentage calories from solid fat/added sugar are presented.

Behavioral Pediatric Feeding Assessment Scale (BPFAS). The BPFAS is a 35-item questionnaire that was used to assess family mealtime behaviors.[12] The BPFAS includes 25 items specific to child behaviors and 10 items specific to parent behaviors. Individual items for the BPFAS are scored according to a 5-point Likert Scale (1-5, 5=most likely) based on the frequency of occurrence of each behavior. In addition, items are scored using a dichotomous scale (yes or no) to identify the specific items parents perceived to be problematic. The BPFAS yields four component scales: child frequency and parent frequency, which reflect the sum of the Likert scale scores for child and parent items, respectively, and child problem and parent problem, which reflect the sum of the dichotomous scale scores for child and parent items, respectively. Across all of the BPFAS component scales, higher scores reflect more problematic behavior. The BPFAS is valid and reliable for young children with type 1 diabetes.[13] For the current study, all four component scales are presented.

Glycemic Control. Children wore a retrospective continuous glucose monitor to measure their mean daily glucose and their parents recorded chilren's food intake. Children's mean hours of use for the monitor was 56±18.6, and they had an average of 275±43 (range, 83-288) separate glucose measurements per 24 hours of sensing. Data lost from the sensors were primarily due to sensor or user error. Children's diet records were paired to their monitor data so that only full days of each were retained for the final analyses.

Data Analyses. Means and standard deviations were calculated for all variables. To examine the relations among dietary adherence, healthy eating, mealtime behaviors, and glycemic control, Pearson product-moment correlations were used. To adjust for multiple correlations, α=.01 was set a priori for statistical significance.

RESULTS AND DISCUSSION

Table 1 provides descriptive statistics for the 39 families who participated. All of the families counted carbohydrates and had completed at least one diabetes-specific nutrition educa-

Table 1. Child and family characteristics of the families of young children with type 1 diabetes providing adherence and mealtime behavior information

Variable	Mean±standard deviation
Age (y)	5.0 ± 1.5
Hemoglobin A1c (%)	8.6 ± 1.3[a]

Variable	Frequency	%
Sex of child		
Male	20	51
Female	19	49
Race		
White	32	82
Non-white	7	18
Parents' marital status (married)	29	74
Hollingshead Four-Factor Socioeconomic Scale		
I (lowest level)	2	5
II	4	10
III	11	28
IV	14	36
V (highest level)	8	21
Insulin regimen		
Pump	25	64
Multiple daily injections	14	36
Body mass index percentile		
<5th	0	0
6th-49th	4	11
50th-84th	15	38
85th-94th	15	38
>95th	5	13

[a]Hemoglobin A1c=70±9 mmol/mol.

tion class. Fifty-seven percent had completed an advanced carbohydrate counting class.

Dietary Adherence and Healthful Eating. Children consumed a mean of 1,245±365 kcal per day or 71%±20% of their recommended energy intake. Children consumed a mean of 157±52 g of carbohydrates per day or 72%±24% of their recommended carbohydrate intake. Children's mean percentage of calories from fat was 35%±5%, which exceeded daily USDA recommendations,[14] and the daily mean intake of 12%±3% calories from saturated fat exceeded ADA recommendations.[1,2] Children had a mean HEI-2005 score of 64±10, suggesting they consumed a diet that did not meet daily USDA recommendations based on their age. Children's mean HEI-2005 component scores also revealed some dietary deficiencies, with below-guideline intakes of fruits (3.7±1.8), vegetables (2.7±1.9), and whole grains (3.1±1.9), and intake that exceeded the guidelines for percentage calories from solid fat and added sugar (13.4±5.3).

Failure to find support for the hypothesis pertaining to children's dietary adherence suggests that intensive insulin therapy may not confer any advantage in helping young children achieve better dietary adherence. Likewise, intensive therapy did not seem to aid young children in consuming a more healthful diet. Past research in conventionally managed young children has found Calorie and Carbohydrate Deviation Scores that are generally consistent with the current results and suggest daily intakes less than recommendations.[5] Early childhood is a period of rapid growth, and adequate carbohydrate and energy intake is important to fuel this growth. However, excessive intake of these macronutrients can lead to overweight. In this sample, the majority of children exceeded the 85th percentile for body mass index despite energy and carbohydrate intake below recommendations. Thus, the findings suggest that close monitoring of young children's energy and carbohydrate intakes is important to ensure appropriate intake.

Higher-than-recommended intakes of total and saturated fat have been reported previously in two studies recruiting school-age children and adolescents with type 1 diabetes[15,16] and one study recruiting young children,[5] but have not yet been reported in young children on intensive insulin therapy. Research suggests that adolescents with type 1 diabetes may be predisposed to consume more foods relatively high in fat and saturated fat because these foods may also be relatively low in carbohydrates (eg, cheese and bacon).[17,18] However, exceeding daily recommendations for fat and saturated fat can be problematic for youth with type 1 diabetes because they are at an increased risk for cardiovascular disease and dyslipidemia.[2]

Relationship between Measures of Diet, Mealtime Behaviors, and Glucose Control. Results of a series of Pearson product-moment correlations revealed a significant negative relation between children's HEI-2005 scores and the BPFAS Child Problem Score ($r=-0.40$, $P=0.01$). There was a positive relationship between children's carbohydrate deviation score and the BPFAS Parent Problem Score ($r=0.43$, $P=0.01$). Several other relationships approached significance ($P\leq0.05$) and are reported in Table 2.

Overall, these results suggest that parents who perceive more problematic child mealtime behaviors have children with poorer dietary quality, and that achieving better dietary adherence may be associated with more perceived mealtime behavior problems. These results provide partial support for the study hypothesis relating diet to mealtime behavior. The relationships found between adherence and parent-reported mealtime problems are generally consistent with the existing research, which suggests that mealtimes can be problematic for families of young children with type 1 diabetes.[19] Although these associations do not imply causation, teaching strategies to parents to manage mealtime behaviors more effectively may help reduce parent reporting of mealtime problems and improve children's dietary adherence. Specifically, there is good evidence that mealtime management and calorie intake can improve by teach-

Table 2. Correlations between measures of children's dietary adherence, healthy eating, mealtime behaviors, and glucose control in families of young children with type 1 diabetes

Variable	Carbohydrate deviation score	Calorie deviation score	HEI-2005[a] total	Mean daily glucose level	BPFAS[b] parent problem	BPFAS child problem	BPFAS parent frequency	BPFAS child frequency
Carbohydrate Deviation Score	1	0.91**	0.17	0.06	0.43**	0.36*	0.32*	0.07
Calorie Deviation Score		1	0.14	0.12	0.36*	0.35*	0.36*	0.14
HEI-2005 Total			1	−0.34*	−0.28	−0.40**	−0.13	−0.13
Mean Daily Glucose Level				1	0.30	0.47**	0.34*	0.32*
BPFAS Parent Problem					1	0.57**	0.57**	0.49**
BPFAS Child Problem						1	0.45**	0.53**
BPFAS Parent Frequency							1	0.69**
BPFAS Child Frequency								1

[a]HEI-2005=Healthy Eating Index 2005.
[b]BPFAS=Behavioral Pediatric Feeding Assessment Scale.
*$P\leq0.05$.
**$P\leq0.01$.

ing parents behavioral management strategies, including contingent attention, positive reinforcement, shaping, rule-setting, and consequences.[20] The current finding linking better dietary quality to lower mean daily glucose levels ($r=-0.34$, $P<0.05$) suggests that consuming a healthy diet may also be an important determinant of better health outcomes in young children with type 1 diabetes.

There are some limitations to this study. First, the study was conducted in married families who were primarily white and in the middle to upper-middle income classes. Although representative of the available clinic populations and potentially representative of the larger population of young children with type 1 diabetes (who are disproportionately from non-Hispanic white descent),[21] these data may not generalize to families from other ethnic or racial backgrounds. Second, this study had a relatively low recruitment rate. This was primarily due to a component of the larger study that asked families to consent to having at least three meals videotaped in the home. However, because of its recruitment rate, it is possible the study results may not generalize beyond a population of families who are highly motivated to participate in clinical research. Third, the data relied exclusively on parent report of young children's food and beverage intake, which could introduce a bias related to parent reporting. To minimize the likelihood of bias, families were given a digital scale and taught how to weigh and measure foods to improve their accuracy. In addition, research personnel emphasized to parents that they should report what their child actually consumed versus what they believed was optimal. However, in future research, multiple strategies for collecting dietary intake (eg, food-frequency questionnaire, 24-hour recall) may help to judge the validity of parents' reporting as well as capture data specific to young children's diet. Finally, the study design is cross-sectional vs longitudinal. A cross-sectional design is adequate to obtain simple descriptive data, but it cannot reveal the direction of relations among variables.[22] To determine the direction in the relationships between mealtime behavior and dietary intake, a longitudinal design is needed.

CONCLUSIONS

Emerging data demonstrate that whereas intensive insulin therapy may help to simplify dietary management in type 1 diabetes, it does not seem to encourage more healthful eating among youth.[17,18] This study looked exclusively at young children with type 1 diabetes and discovered no advantage for achieving better dietary adherence or healthy eating based on intensive insulin therapy. In addition, behavioral measures suggested that problems with parent–child mealtime behaviors may relate to dietary adherence and dietary quality. The preschool and early school-age period can be a difficult time for parents to negotiate with respect to diet because young children often demonstrate neophobia, transient food preferences, an unpredictable appetite, and food refusal.[23,24] Nevertheless, this is also an important period for establishing healthy eating patterns in children. The study findings suggest that parents of young children with type 1 diabetes may benefit from behavioral nutrition education to teach them effective strategies for mealtime management and how to feed their child a healthy diet that meets daily recommendations for energy, carbohydrate, and fat.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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