

Diet of Adolescents With and Without Diabetes

Trading candy for potato chips?

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OBJECTIVE — To compare the dietary intake of adolescents with type 1 diabetes with that of adolescents without diabetes matched on age, sex, and year in school and to compare the diets of both groups with recommendations.

RESEARCH DESIGN AND METHODS — Participants were 132 adolescents with type 1 diabetes, recruited from Children's Hospital of Pittsburgh, and 131 adolescents without diabetes ranging in age from 10.70 to 14.21 years. Dietary intake was assessed with three 24-h recall interviews with each participant and one parent. Percentage of calories from protein, carbohydrates, and total fat; amount of each type of fat; and amount of cholesterol, fiber, and sugar were calculated as averages across 3 days.

RESULTS — Adolescents with diabetes took in less total energy than recommended. The percentage of calories from carbohydrates and protein were within recommendations for adolescents with and without diabetes, but adolescents with diabetes exceeded the recommended fat intake. The diet of adolescents with diabetes consisted of a greater percentage of fat and protein and a smaller percentage of carbohydrates relative to adolescents without diabetes. Adolescents without diabetes consumed more sugar, while adolescents with diabetes took in more of all components of fat than adolescents without diabetes. Male subjects with diabetes had an especially high intake of saturated fat.

CONCLUSIONS — Adolescents with type 1 diabetes consume fewer calories from carbohydrates but more calories from fat than adolescents without diabetes and exceed the recommended levels of fat intake. These findings are of concern given the risk that type 1 diabetes poses for cardiovascular disease.

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There have been drastic changes over the last 3 decades with regard to the dietary recommendations for people with diabetes. Before 1994, nutrition recommendations were set forth for all people with diabetes with little regard to the individual's lifestyle. After 1994 and consistent with the 2002 American Diabetes Association (ADA) evidence-based guidelines, the emphasis shifted from a strict focus on dietary components to a focus on

maintaining target blood glucose levels and a lipid profile and blood pressure that reduce the risk of chronic disease (1,2). The current ADA nutrition recommendations for children and adolescents with type 1 diabetes share these goals and also focus on adequate nutrient intake for growth and development (1). These recommendations are based on the requirements for nondiabetic children and adolescents that are collected in the Dietary Reference

Intakes (3), which update and expand the recommended dietary allowances (RDAs) (4).

Only a few studies have examined the diets of children with type 1 diabetes, and even fewer have compared those diets with children without diabetes. In terms of energy intake, two studies (5,6) of children with type 1 diabetes found that energy intake was lower than recommended; one study (7) found that children met the RDA, and a fourth study (8) found that male subjects met the RDA but female subjects had energy levels below the RDA. Two studies compared the energy intake of children with diabetes with that of matched control subjects. One study (5) found that the intake of children with diabetes fell below that of control subjects who met the RDA, and the other study (9), based solely on girls, found no difference between children with diabetes and control subjects in energy intake, with both groups reporting lower intake than predicted by energy expenditure.

Studies have also examined the components of dietary intake. Carbohydrates are an important consideration in the diets of children with type 1 diabetes, as they are the principal source of energy but require appropriate amounts of insulin to be utilized by the body. Four studies (6–9) found that children met carbohydrate requirements, and one study (5) found that children had a lower carbohydrate intake than recommended. In the two studies that included a comparison group (5,9), children with diabetes had a lower carbohydrate intake than age- and sex-matched control subjects.

Excessive protein intake could be a concern for children with diabetes, as some research has linked high protein intake with the development of renal problems (2). However, the ADA and a recent literature review concluded that children with diabetes should consume the same amount of protein recommended for children without diabetes if their renal function is normal (1,2). Three studies (5,8,9) of children with type 1 diabetes found that protein intake exceeded recommendations, one study (7) met recommenda-

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Abbreviations: ADA, American Diabetes Association; RDA, recommended dietary allowance.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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tions, and one study (6) found that intake fell below the RDA. In the study that found levels within the RDA (7), the intake of the majority of children was at the upper limit of recommendations. Two studies (5,9) included a comparison group and found that protein made up a significantly higher proportion of energy intake for children with diabetes compared with age- and sex-matched control subjects.

Higher intakes of saturated fat and cholesterol have been shown to be related to higher total and LDL cholesterol concentrations, both contributors to cardiovascular disease (3). Because adolescents with diabetes have been shown to have mildly disturbed cardiovascular risk profiles compared with nondiabetic siblings (10), limiting saturated fat and dietary cholesterol intakes to recommended levels is especially important. Three of five studies (5–7) showed that children with diabetes exceeded the RDA for total fat intake. This problem is not unique to diabetes, however, as one study (5) showed similar levels of fat intake for children with and without diabetes—levels that exceeded recommendations for both groups. Two studies (8,9) reported total fat levels within recommendations, one study (9) of which found no difference in fat intake between female subjects with diabetes and matched control subjects. Saturated fat was specifically examined in three studies. One study (7) reported intake above the upper limit of 10% of energy, one study (8) found levels that met the RDA, and one study (5) reported that children with diabetes consumed high levels of saturated fat without defining “high.” When cholesterol was examined in the same three studies, two studies (7,8) found that cholesterol intake was within the RDA. The other study (5) did not compare cholesterol with RDA but did find it to be significantly greater in children with diabetes than in age- and sex-matched control subjects.

Some studies (11,12) suggest that high levels of dietary fiber, especially soluble fiber, may decrease the glycemic response to food intake in children with type 1 diabetes. The ADA, however, has not found sufficient evidence to advise that people with diabetes consume a greater amount of fiber than recommended by dietary reference intakes (1). Of two studies that examined fiber intake, one study (7) found that children ate less fiber than recommended, and the other study (9), which had an all-female sam-

ple, found that female subjects with diabetes met fiber recommendations and had a higher fiber intake than nondiabetic control subjects.

In summary, the reported dietary intake of children and adolescents with type 1 diabetes is not consistent across studies. Some of the inconsistency may be due to the different methods used to assess dietary intake. One study (9) evaluated diet with 7-day food diaries, one study (6) evaluated food consumption records in medical charts, two studies (5,8) used a single 24-h recall, and one study (7) used three 24-h recalls. In addition, the age-groups examined are heterogeneous across some of the studies. One study (7) examined children aged 4–9 years, one study (9) examined adolescents aged 12–19 years, and one study's (5) sample ranged from children as young as 3 to adults aged 27 years. Only two studies (5,9) included a comparison group of children without diabetes, and one of these was limited to female subjects. Sample sizes have been relatively small, ranging from 26 to 66 children with type 1 diabetes.

The goal of the current study is to compare the dietary intake of adolescents with type 1 diabetes with that of adolescents without diabetes matched on age, sex, and year in school. The study also examines the extent to which the dietary intake of both groups meets current recommendations. Our sample size is much larger than those of previous studies, and we used three 24-h recall interviews to assess dietary intake. The study focuses on an adolescent population because the increased independence associated with adolescence offers more opportunities for adolescents to make choices about their food intake.

RESEARCH DESIGN AND METHODS

The study was approved by the institutional review boards of Carnegie Mellon University and Children's Hospital of Pittsburgh. Adolescents with diabetes were recruited from the Children's Hospital of Pittsburgh. To be eligible, adolescents had to be in fifth, sixth, or seventh grade; had to have had type 1 diabetes for at least 1 year; and could not have another major chronic illness (e.g., cancer, rheumatoid arthritis). Of 171 adolescents with diabetes contacted about the study and determined to be eligible, 39 refused and 132 agreed, resulting in a 77% response rate. Adolescents without diabetes were recruited

from two sources. First, we solicited 60 volunteers from three area mall health fairs. Second, a local pediatric network of physicians randomly selected families from their database within our age range and sent them letters describing the study. Of 93 families we were able to reach and determine that they were eligible, 61 (66%) agreed to the study.

The sample consisted of 132 adolescents with diabetes and 131 adolescents without diabetes. Demographic characteristics are shown in Table 1. There were no differences between the two groups on sex, race, ethnicity, household structure, or age. However, there were group differences on BMI [$t(261) = 2.64, P < 0.01$], such that adolescents with diabetes had a higher BMI than adolescents without diabetes. BMI was computed from height and weight obtained from medical records for adolescents with diabetes by our staff with a digital scale and stadiometer for adolescents without diabetes. Similar percentages of adolescents with and without diabetes were overweight, defined as exceeding the 95th percentile of BMI for age using the Centers for Disease Control and Prevention growth charts (13).

There was a group difference in Tanner stage [$t(257) = 2.97, P < 0.01$], such that adolescents with diabetes had a higher Tanner stage than adolescents without diabetes. Tanner stage was determined by having parents complete the parental version of Carskadon and Acebo's (14) self-report of pubertal status, which is based on the Pubertal Development Scale (15). Carskadon and Acebo showed that parent ratings were strongly correlated with child and pediatrician ratings of Tanner stages (14). There were missing data on this measure for four adolescents without diabetes and five adolescents with diabetes, as those parents did not complete that portion of the questionnaire. For the adolescents with diabetes, we substituted the physician rating of Tanner stage. Because BMI was correlated with Tanner stage ($r = 0.38, P < 0.001$), we examined whether the group difference in BMI accounted for the group difference in pubertal development. BMI accounted for a portion of the Tanner stage difference but not all of it.

There was also a group difference on social status [$t(261) = 2.94, P < 0.01$], as measured with the four-factor Hollingshead Index (A.B. Hollingshead, Yale University, unpublished manuscript), such that adolescents with diabetes were from

Table 1—Demographic characteristics of the sample

	Diabetes	Nondiabetes
<i>n</i>	132	131
Sex		
Male	47	49
Female	53	51
Race		
White	93	91
Black	2	5
Asian	1	1
American Indian	1	0
More than one race	3	3
Ethnicity		
Non-Hispanic	95	95
Hispanic	2	3
Unknown	3	2
Live with biological mother and father	74	73
Overweight	18.2	16.0
BMI (kg/m ²)	22.05 ± 4.36	20.63 ± 4.37
Age (years)	12.10 ± 0.77	12.07 ± 0.69
Tanner stage	2.77 ± 0.99	2.39 ± 1.11
Social status	41.97 ± 11.05	46.40 ± 13.31

Data are means ± SD or percent.

lower-status families. Social status was associated with a lower BMI ($r = -0.22$, $P < 0.001$) but was unrelated to Tanner stage. The group difference in BMI was reduced but remained significant when controlling for social status.

Adolescents with diabetes had the illness between 1 and 13 years, with an average of (means ± SD) 4.91 ± 2.98 years. The average HbA_{1c} of adolescents with diabetes was 8.04 ± 1.31 . Nonfasting lipid profiles fell in the normal range for the vast majority of adolescents with diabetes. The average total cholesterol was 162 ± 37.20 ; 90% were <200 , and only 2% were >250 .

We met participants with diabetes immediately before or after a routine clinic appointment. We met adolescents without diabetes in their homes. At that time, we obtained informed consent from parents and adolescents and conducted baseline psychosocial interviews. We obtained agreement to contact adolescents and their parents by phone three times over the next 3 months to complete the 24-h dietary recall interviews. Our goal was to contact participants and one parent once a month for the next 3 months, with the first and third interviews being conducted for a weekday and the second interview being conducted for a weekend. Scheduling conflicts did not always permit us to keep this order, but we made

sure that two interviews reflected a weekday and one reflected a weekend day. In the end, we conducted three 24-h recalls with 235 (89%) participants and 214 (81%) parents, two 24-h recalls with 16 (6%) participants and 14 (5%) parents, one 24-h recall with 6 (2%) participants and 2 (1%) parents, and no 24-h recalls with 6 (2%) participants and 33 (13%) parents. Thus, 24-h recall data were available for 257 adolescents and 230 parents.

24-h recall interview

We used the 24-h recall method developed by Johnson et al. (16) to assess dietary intake. This method uses multiple informants and multiple occasions. Its validity has been supported by numerous studies (16–19), which include high levels of parent-child agreement. It has been determined to be valid for children ages 10 years and older (16).

With this method, trained interviewers prompted the adolescent and parent to recall the day's events in chronological order to facilitate accurate recollection and minimize the chance of leaving out activities that were not part of the adolescent's usual routine. The interviewer began by asking the adolescent or parent to recall the time the adolescent woke up and followed this prompt by asking, "What was the first thing you (or your child) did after you (or he/she) woke up?"

Throughout the recall, the interviewer prompted the adolescent or parent to recall the next activity by asking, "What did you (or your child) do next?" When meals or snacks were mentioned, interviewers prompted for specific details about food intake, such as portion size, brand names, recipes, and food preparation. At the end of the recall, the interviewer repeated the recall back to the adolescent or parent and asked him or her to add anything that may have been missed. The interviewer also prompted for missing information about food intake ("Did you have any other meals or snacks, or did you eat or drink anything else yesterday?"), activities, and diabetes behaviors. Adolescents and parents were interviewed independently. Parents were asked to recall only the events they witnessed and were discouraged from guessing or simply recalling the adolescent's typical routine.

Dietary intakes were analyzed for nutritional content with the Food Processor Nutrition Analysis Software (20). The percentage of calories from protein, carbohydrates, total fat, and saturated fat were calculated for each day. Within the category of total fat, we calculated grams of saturated, polyunsaturated, monounsaturated, and *trans* fat. We also calculated grams of cholesterol, fiber, and sugar. We averaged across the 3 (or however many were available) days of assessment.

Overview of analysis

First, we examine the extent to which adolescent and parent reports of diet are related. Second, we provide descriptive information on the nutritional intake of both groups and compare these with recommended levels. Then, we examine whether there are group and sex differences in each aspect of diet with ANCOVA. We controlled for BMI, Tanner stage, and social status in all of these analyses. (Because Tanner stage was missing for four adolescents without diabetes, they were excluded from all analyses.) We conducted a group-by-sex ANCOVA on the total number of calories consumed. We conducted multivariate group-by-sex ANCOVA on the three sources of calories (protein, carbohydrates, and fat), the four kinds of fat (saturated, monounsaturated, polyunsaturated, and *trans* fat), and the three other nutrients (cholesterol, fiber, and sugar). We used multivariate analyses to help control for conducting multiple comparison tests. We only examined univariate effects if the multivariate effect was

Table 2—Dietary intake for adolescents with and without type 1 diabetes

	<i>P</i>	Diabetic		Nondiabetic		Recommended intake*	
		Male subjects	Female subjects	Male subjects	Female subjects	Male subjects	Female subjects
<i>n</i>		59	67	64	63		
Nutrients							
Energy (kcal)	NS	1,969.59 ± 452.55	1,701.96 ± 488.75	1,882.92 ± 631.80	1,701.25 ± 686.38	2,100	1,900
Protein (% kcal)	<0.001	15.87 ± 2.78	16.31 ± 3.06	14.10 ± 3.38	13.43 ± 2.66	10–30	10–30
Carbohydrate (% kcal)	<0.001	48.75 ± 6.21	49.50 ± 7.04	56.12 ± 7.19	56.53 ± 6.43	45–65	45–65
Total fat (% kcal)	<0.001	36.63 ± 4.86	35.09 ± 6.08	30.96 ± 5.83	31.52 ± 5.58	25–35	25–35
Saturated fat (% kcal)	<0.001	13.26 ± 2.47	12.46 ± 2.72	11.21 ± 2.91	11.20 ± 2.60	<10†	<10†
Saturated fat (g)	<0.001	29.16 ± 8.87	23.48 ± 7.98	23.15 ± 8.32	21.27 ± 10.01		
Monounsaturated fat (g)	<0.05	18.93 ± 8.49	16.44 ± 7.63	16.83 ± 8.69	13.29 ± 7.14		
Polyunsaturated fat (g)	<0.05	8.83 ± 5.42	6.90 ± 3.42	6.97 ± 4.09	6.33 ± 4.08		
<i>Trans</i> fatty acids (g)	<0.05	2.54 ± 2.29	2.18 ± 2.53	1.85 ± 2.68	1.49 ± 2.06		
Cholesterol (mg)	<0.08	222.41 ± 120.72	185.80 ± 85.67	196.93 ± 126.00	162.59 ± 97.54	<300†	<300†
Sugar (g)	<0.001	89.07 ± 32.37	79.63 ± 37.24	121.88 ± 53.28	109.84 ± 56.55		
Fiber (g)	NS	13.62 ± 5.60	11.83 ± 5.49	12.00 ± 5.80	11.28 ± 5.75	31	26

Data are means ± SD. *Recommended intakes are based on the dietary reference intakes (3) unless otherwise noted. †Recommended intakes are based on the ADA guidelines (1).

significant. To facilitate comparisons to dietary recommendations and to other studies, we report the unadjusted means for all dietary components for male and female subjects with and without diabetes in Table 2.

RESULTS

Correspondence between adolescent and parent reports

Parent and adolescent reports of total calories consumed were correlated for both adolescents with diabetes ($r = 0.34$, $P < 0.001$) and adolescents without diabetes ($r = 0.50$, $P < 0.001$). Parent and adolescent percentage of calories from protein, carbohydrates, and fat also were highly correlated for adolescents with diabetes ($r = 0.52$, 0.54 , and 0.60 , respectively; all $P < 0.001$) and adolescents without diabetes ($r = 0.50$, 0.35 , and 0.30 , respectively; all $P < 0.001$). However, there were significant differences in the number of calories that parents and adolescents reported [$t(250) = 10.31$, $P < 0.001$], such that adolescents reported that they consumed more calories ($1,808 \pm 584$) than parents reported ($1,401 \pm 603$). In fact, adolescents reported higher levels of intake of all aspects of diet compared with parents. This discrepancy was the same for adolescents with and without diabetes. We were not surprised by this finding because our experience during the interviews was that parents were not always around for meals and did not always know what adolescents ate. Thus, rather

than averaging across parent and adolescent reports, we relied on adolescent reports for data analysis.

Comparison to recommendations

As shown in Table 2, the total number of calories consumed by male and female subjects with and without diabetes was below recommendations. However, the percentage of calories from carbohydrates and protein fell within the level of recommendations for both groups of adolescents. Only adolescents with diabetes exceeded the recommended levels of total fat intake. Both groups of adolescents exceeded recommendations for saturated fat.

Group and sex comparisons

There were no effects of group or sex on the total number of calories consumed. There was a significant multivariate effect of group on the three sources of calories [$F(3,244) = 23.70$, $P < 0.001$] but no effect for sex or group-by-sex interaction. Univariate analyses revealed main effects of group on all aspects of diet: protein [$F(1,246) = 37.76$, $P < 0.001$], carbohydrates [$F(1,246) = 65.05$, $P < 0.001$], and fat [$F(1,246) = 36.68$, $P < 0.001$]. As shown in Table 2, the diet of adolescents with diabetes consists of a greater percentage of fat and protein and a smaller percentage of carbohydrates relative to adolescents without diabetes. When grams of protein, carbohydrates, and fat were examined, the same group differences emerged. Thus, it is not only that

adolescents with diabetes consumed a greater proportion of calories from protein and fat than adolescents without diabetes, but they also consumed more grams of protein and fat than adolescents without diabetes.

When we examined the four kinds of fat, a significant multivariate effect for group [$F(4,243) = 5.18$, $P = 0.001$] and a significant multivariate group-by-sex interaction [$F(4,243) = 4.62$, $P = 0.001$] appeared. Univariate analyses revealed main effects of group on all four components of fat: saturated [$F(1,246) = 15.10$, $P < 0.001$], monounsaturated [$F(1,246) = 5.82$, $P < 0.05$], polyunsaturated [$F(1,246) = 5.81$, $P < 0.05$], and *trans* fat [$F(1,246) = 3.96$, $P < 0.05$]. None of the univariate group-by-sex interactions was significant, but the interaction for saturated fat approached significance [$F(1,246) = 3.20$, $P = 0.08$]. As shown in Table 2, adolescents with diabetes take in more of all kinds of fat than adolescents without diabetes, and male subjects with diabetes take in substantially more saturated fat than the other groups.

Examination of the three other nutrients revealed a multivariate effect for group [$F(3,244) = 15.19$, $P < 0.001$] (Table 2). Univariate analyses revealed group differences on sugar [$F(1,246) = 23.70$, $P < 0.001$], such that adolescents without diabetes consumed more sugar than adolescents with diabetes, and a marginally significant group difference on cholesterol [$F(1,246) = 3.00$, $P = 0.08$], such that adolescents with diabetes consumed

more cholesterol than adolescents without diabetes. There was no group difference on fiber. There also was a multivariate effect of sex [$F(3,244) = 3.22, P < 0.05$] but no group-by-sex interaction. Univariate analyses revealed that both groups of male subjects consumed more cholesterol [$F(1,246) = 7.53, P < 0.01$] and more fiber [$F(1,246) = 4.03, P < 0.05$] than female subjects.

CONCLUSIONS— When compared with dietary recommendations, both adolescents with and without diabetes consumed fewer calories than recommended. However, validation studies on measures of dietary intake, including the 24-h recall, have shown that such measures are more likely to lead to an underestimate than an overestimate of calories consumed (21). Therefore, we place more emphasis on the distribution of those calories. Our data showed that both groups of adolescents met the dietary requirements for carbohydrates and protein. Adolescents without diabetes also met the dietary requirements for total fat, but adolescents with diabetes exceeded those recommendations. Both groups exceeded the requirements for saturated fat. Given the risk that type 1 diabetes poses for cardiovascular disease, the increased fat intake in adolescents with diabetes is cause for concern.

Adolescents with diabetes also consumed a greater proportion of calories from protein and fat and a smaller proportion of calories from carbohydrates than adolescents without diabetes. The findings for carbohydrates and protein are consistent with two previous case-comparison studies (5,9). However, the finding that adolescents with diabetes take in a larger percentage of calories from fat is new. When examining the different kinds of fat, adolescents with diabetes took in more calories from each kind of fat than adolescents without diabetes, but male subjects with diabetes took in an especially high number of calories from saturated fat. Whereas adolescents without diabetes consumed more grams of sugar, there was a trend for adolescents with diabetes to consume more grams of cholesterol.

There are a number of limitations of this study. Although the 24-h recall is an improvement over other self-report methods of dietary intake, it is not without flaws. A major limitation is that adolescents may not recall everything that

they ate at the end of the day. We regard the finding that adolescents consumed a lower level of calories than recommended as a result of underreports of food intake rather than an actual inadequate calorie intake. Given that we had a greater percentage of overweight adolescents in our study compared with population norms, it is unlikely that adolescents are actually consuming less than the recommended number of calories. As with any self-report instrument, there may be a reporting bias as to what kinds of foods adolescents are willing to tell us that they eat. We countered this problem somewhat by obtaining reports for three separate days and by adolescents' knowledge that we interviewed parents.

We conclude by suggesting that families of adolescents with diabetes may not have kept pace with contemporary dietary recommendations that emphasize consuming nutrients from a variety of foods rather than restricting intake of sugars and other carbohydrates. Instead, families of adolescents with diabetes may still be overly concerned with the added sugar in candy, not recognizing that the blood glucose rise in response to added sugars is equivalent to that caused by other carbohydrates (2). They may be more concerned that the sugar in candy is going to translate into high blood glucose levels today than that the fat in potato chips will translate into cardiovascular disease in 10 years. In an attempt to avoid foods high in sugar, adolescents with diabetes and their families may perceive foods high in fat and cholesterol as more acceptable.

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