Dietary Behaviors Predict Glycemic Control in Youth With Type 1 Diabetes

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OBJECTIVE — To investigate the association between dietary adherence and glycemic control among youth with type 1 diabetes.

RESEARCH DESIGN AND METHODS — We conducted a cross-sectional analysis of 119 youth aged 9–14 years (mean ± SD 12.1 ± 1.6 years) with diabetes duration ≥1 year (5.4 ± 3.1 years). Dietary adherence was assessed using the Diabetes Self-Management Profile diet domain. Higher score defined greater dietary adherence. Glycemic control was determined by A1C.

RESULTS — Dietary adherence score was inversely correlated with A1C ($r = -0.36$, $P < 0.0001$). In a multivariate model ($R^2 = 0.34$, $P < 0.0001$), dietary adherence ($P = 0.004$), pump use ($P = 0.03$), and caregiver education ($P = 0.01$) were associated with A1C. A1C of youth in the lowest (9.0%) tertile of diet score was higher than A1C of youth in the middle (8.1%, $P = 0.004$) and upper (8.4%, $P = 0.06$) tertiles. Dietary adherence uniquely explained 8% of the variance in A1C in the model.

CONCLUSIONS — Greater dietary adherence was associated with lower A1C among youth with type 1 diabetes.

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Data for youth with type 1 diabetes demonstrate a gap between attained glycemic control and age-specific goals (1–3). With intensive insulin therapy, dietary behaviors become central to optimizing glycemic control. Studies have shown that greater dietary adherence improves glycemic control among adults with type 1 diabetes (4,5). In this study, we investigated the relationship between dietary adherence and glycemic control in youth with type 1 diabetes.

RESEARCH DESIGN AND METHODS

Families ($n = 119$) with type 1 diabetes participating in the Family Management of Childhood Diabetes pilot study provided data on dietary adherence. The ethics committees of the participating centers approved the protocol, and participants provided written informed consent.

Eligible youth were aged 9–14 years with type 1 diabetes for ≥1 year, daily insulin dose >0.5 units/kg, and A1C <13%. Demographic and diabetes-specific data included child age, sex, height, weight, blood glucose monitoring (BGM) frequency, and insulin regimen. A1C was measured centrally (reference range 4–6%).

Participants completed the Diabetes Self-Management Profile (DSMP), a 25-item structured interview that assesses adherence to diabetes self-management (6,7). Parents ($n = 119$) and youth ≥11 years old ($n = 81$) completed the DSMP. Adherence to diabetes-specific dietary behaviors was assessed with the six-item DSMP diet subscale. Diet scores could range from 0 to 17 points, with higher scores reflecting greater dietary adherence. A previous study demonstrated a significant inverse relationship between diet score and A1C (6).

Parametric and nonparametric analyses were performed with SAS version 8.2 (SAS Institute, Cary, NC) using $\alpha < 0.05$ to determine significance.

RESULTS

Mean ± SD A1C was 8.4 ± 1.3%; 37% of youth had A1C <8%. Mean parent diet score was 10.8 ± 3.5 (range 2–17). Parent diet score was correlated with A1C ($r = -0.36$, $P < 0.0001$). Youth were grouped into tertiles by parent diet score; youth characteristics by tertile are shown in Table 1. Mean A1C of youth in the lowest tertile was 0.9% higher than that of youth in the upper two tertiles ($P < 0.0001$). BGM frequency was lowest among youth in the lowest tertile of dietary adherence ($P = 0.004$).

Mean youth diet score was 11.3 ± 3.3 (range 4–17), and youth diet score correlated positively with parent diet score ($r = 0.41$, $P < 0.0001$). Youth diet score was not correlated with A1C. However, we identified seven outliers with A1C >10% reporting high dietary adherence whose parents reported low adherence. These youth had high daily insulin doses (1.2 ± 0.4 units/kg) on injection therapy. Excluding these youth, parent ($n = 112$) and child ($n = 74$) diet scores were significantly correlated ($r = 0.44$, $P = 0.0001$), and both parent ($r = -0.24$, $P = 0.04$) and child ($r = -0.36$, $P = 0.002$) diet scores were associated with youth A1C.

In addition to dietary adherence, more frequent BGM ($P = 0.002$), insulin pump use ($P = 0.0006$), younger age ($P = 0.03$), and higher parent education ($P = 0.005$) were associated with lower A1C. To determine the unique contribution of dietary adherence to glycemic control, we performed a multivariate analysis adjusting for age, sex, BGM frequency, daily insulin dose, pump use, and parent education. In a significant model ($R^2 = 0.34$, $P < 0.0001$), higher parent diet

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Table 1—*Characteristics of youth with type 1 diabetes by level of dietary adherence*

	Lowest	Middle	Highest	Overall
n	41 (34)	39 (33)	39 (33)	119
Age (years)	12.2 ± 1.6	12.4 ± 1.7	11.8 ± 1.5	12.1 ± 1.6
Female sex	24 (59)	14 (36)	21 (54)	59 (50)
BMI (*Z* score)	0.5 ± 0.6	0.8 ± 0.7	0.8 ± 1.0	0.7 ± 0.8
Family structure				
Two-parent household	30 (75)	33 (85)	36 (92)	99 (83)
One-parent household	10 (25)	6 (15)	3 (8)	19 (17)
Race/ethnicity				
White	25 (63)	29 (74)	31 (80)	85 (72)
Black	9 (22)	3 (8)	2 (5)	14 (12)
Hispanic	4 (10)	4 (10)	2 (5)	10 (9)
Other	2 (5)	3 (8)	4 (10)	9 (7)
Annual income				
>$100,000	12 (31)	13 (35)	16 (44)	41 (37)
$50,000 to $100,000	15 (38)	16 (43)	15 (42)	46 (41)
$30,000 to $50,000	3 (8)	3 (8)	5 (14)	11 (10)
<$30,000	9 (23)	5 (14)	0 (0)	14 (12)
Caregiver educational level				
Graduate school	6 (15)	4 (10)	6 (16)	16 (13)
College or associate degree	15 (39)	16 (41)	21 (55)	52 (45)
High school or GED	16 (41)	18 (46)	11 (29)	45 (39)
Less than high school	2 (5)	1 (3)	0 (0)	3 (3)
Insulin dose (units · kg^{-1} · day^{-1})	1.0 ± 0.3	1.0 ± 0.3	1.0 ± 0.3	1.0 ± 0.3
Insulin delivery				
Insulin pump	11 (27)	9 (24)	18 (46)	38 (32)
≥4 injections/day	6 (14)	11 (29)	9 (23)	26 (22)
3 injections/day	11 (27)	14 (37)	7 (18)	32 (27)
≤2 injections/day	13 (32)	4 (10)	5 (13)	22 (19)
BGM frequency*				
>5/day	6 (15)	12 (31)	18 (46)	36 (30)
3–5/day	25 (61)	24 (61)	19 (49)	68 (57)
<3/day	10 (24)	3 (8)	2 (5)	15 (13)
A1C level (%)*				
Unadjusted	9.1 ± 1.4†‡	8.2 ± 1.1†	8.0 ± 1.1‡	8.4 ± 1.3
Adjusted§	9.0 ± 2.0§¶	8.1 ± 2.0§	8.4 ± 2.1¶	—

Data are means ± SD or *n* (%). §Adjusted for age, sex, BGM frequency, daily insulin dose, pump use, parent education. *$P < 0.05$ based on χ^2 (categorical) or ANOVA (continuous), comparing differences across three levels of dietary adherence. †$P = 0.003$; ‡$P = 0.0001$; §$P = 0.004$; ¶$P = 0.06$. GED, General Education Development.

score ($P = 0.004$), insulin pump use ($P = 0.03$), and higher parent education ($P = 0.01$) were significantly associated with lower A1C. Youth in the lowest tertile of parent diet score had higher adjusted mean A1C (9.0%) than youth in the middle (8.1%, $P = 0.004$) and upper (8.4%, $P = 0.06$) tertiles. Dietary adherence uniquely explained 8% of the variance in A1C in this model.

CONCLUSIONS— The DSMP diet domain assesses dietary adherence among youth with type 1 diabetes. Parent report of dietary adherence may be more valid for youth with high A1C. In our sample of youth aged 9–14 years, the A1C of youth in the lowest tertile of parent-reported dietary adherence was 0.6–0.9% higher than the A1C of youth in the upper two tertiles. This suggests that lower A1C values may be achieved in youth with type 1 diabetes whose families attain a threshold of dietary adherence. Indeed, dietary adherence uniquely explained 8% of the variance in A1C in our sample.

Youth in the highest tertile of dietary adherence were twice as likely to use pump therapy than youth in the lower two tertiles. In addition, these youth also monitored blood glucose more frequently. This may relate to the focus on nutrition and BGM during the pump implementation process or the selection of patients for pump therapy who demonstrate adequate adherence (8,9). Alternatively, youth using pumps may be more attentive to dietary and BGM behaviors because they need to administer insulin throughout the day.

We also explored the relationship between injection therapy and dietary adherence. For youth treated with three or fewer injections daily ($n = 55$), dietary adherence was significantly associated with A1C ($P = 0.0002$). In this group, youth in the lowest tertile of dietary adherence had a mean A1C of 9.6% compared with 8.1% for youth in the middle ($P = 0.0009$) and 8.0% for youth in the upper tertile ($P = 0.002$) of dietary adherence. This finding suggests that dietary adherence may be particularly important for youth on fixed insulin regimens, who have less opportunity for insulin adjustment, to manage postprandial glucose excursions.

One limitation to this analysis is its cross-sectional design, which limits our ability to establish causal relationships between dietary adherence and A1C. The study is strengthened by the ethnic and racial diversity of the study sample. Additional studies are needed to replicate the unique contribution of dietary adherence to glycemic control in other pediatric populations. These studies may include broader age ranges, as dietary patterns and family involvement change from childhood to older adolescence.

Dietary adherence may represent an important modifiable factor in the treatment of youth with type 1 diabetes. In this era of intensive management, future interventions aimed at increasing diabetes-specific dietary adherence may improve glycemic control in this population.

References

1. Danne T, Mortensen HB, Hougaard P, Lynggaard H, Aanstoot HJ, Chiarelli F, Daneman D, Dorchy H, Garandeau P, Greene SA, Hoey H, Holl RW, Kaprio EA, Kocova M, Martul P, Matsuura N, Robertson KJ, Schoenle EJ, Søvik O, Swift PG, Tsou RM, Vanelli M, Åman J: Persistent differences among centers over 3 years in glycemic control and hypoglycemia in a study of 3,805 children and adolescents with type 1 diabetes from the Hvidøre Study Group. *Diabetes Care* 24:1342–1347, 2001
2. Svoren BM, Volkening LK, Butler DA, Moreland EC, Anderson BJ, Laffel LMB: Temporal trends in the treatment of pediatric type 1 diabetes and impact on acute outcomes. *J Pediatr* 150:279–285, 2007
3. de Beaufort CE, Swift PG, Skinner CT, Aanstoot HJ, Aman J, Cameron F, Martul P, Chiarelli F, Daneman D, Danne T, Dorchy H, Hoey H, Kaprio EA, Kaufman F, Kocova M, Mortensen HB, Njolstad PR, Phillip M, Robertson KJ, Schoenle EJ, Urakami T, Vanelli M: Continuing stability of center differences in pediatric diabetes care: do advances in diabetes treatment improve outcome? The Hvidoere Study Group on Childhood Diabetes. *Diabetes Care* 30:2245–2250, 2007
4. Delahanty LM, Halford BN: The role of diet behaviors in achieving improved glycemic control in intensively treated patients in the Diabetes Control and Complications Trial. *Diabetes Care* 16:1453–1458, 1993
5. Wolever TM, Hamad S, Chiasson JL, Josse RG, Leiter LA, Rodger NW, Ross SA, Ryan EA: Day-to-day consistency in amount and source of carbohydrate associated with improved blood glucose control in type 1 diabetes. *J Am Coll Nutr* 18:242–247, 1999
6. Harris MA, Wysocki T, Sadler M, Wilkinson K, Harvey LM, Buckloh LM, Mauras N, White NH: Validation of a structured interview for the assessment of diabetes self-management. *Diabetes Care* 23:1301–1304, 2000
7. Iannotti RJ, Nansel TR, Schneider S, Haynie DL, Simons-Morton B, Sobel DO, Zeitzoff L, Plotnick LP, Clark L: Assessing regimen adherence of adolescents with type 1 diabetes. *Diabetes Care* 29:2263–2267, 2006
8. Tamborlane WV, Fredrickson LP, Ahern JH: Insulin pump therapy in childhood diabetes mellitus: guidelines for use. *Treat Endocrinol* 2:11–21, 2003
9. Overby NC, Margeirsdottir HD, Brunborg C, Andersen LF, Dahl-Jorgensen K: The influence of dietary intake and meal pattern on blood glucose control in children and adolescents using intensive insulin treatment. *Diabetologia* 50:2044–2051, 2007