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A contrast between children and adolescents with excellent and poor control: the T1D exchange clinic registry experience

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Abstract

Objectives—Optimizing glycemic control in pediatric type 1 diabetes (T1D) is essential to minimizing long-term risk of complications. We used the T1D Exchange database from 58 US diabetes clinics to identify differences in diabetes management characteristics among children categorized as having excellent vs. poor glycemic control.

Methods—Among registry participants 6–17 yr old with diabetes duration ≥2 yr, those with excellent control [(A1c <7%)(53 mmol/mol) (N= 588)] were compared with those with poor control [(A1c ≥9%) (75 mmol/mol) (N = 2684)] using logistic regression.

Results—The excellent and poor control groups differed substantially in diabetes management ($p < 0.001$ for all) with more of the excellent control group using insulin pumps, performing blood glucose monitoring ≥5×/d, missing fewer boluses, bolusing before meals rather than at the time of or after a meal, using meal-specific insulin:carbohydrate ratios, checking their blood glucose prior

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†A list of the T1D exchange clinic network sites are given in the Supporting Information, Appendix S1.

Conflict of interest

M. S. C., V. C., J. C. W., A. S., J. S., E. C., L. M. L., K. M. M., and M. J. H. have nothing to declare.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Participant characteristics in the excellent HbA1c vs. poor HbA1c cohort by age group

Table S2. Comparison of diabetes management characteristics in the excellent control and poor control groups by age group

Table S3. Comparison of diabetes management characteristics in the excellent control and poor control groups by insulin delivery method

Appendix S1. A list of the T1D exchange clinic network sites

to giving meal time insulin, giving insulin for daytime snacks, giving more bolus insulin, and using a lower mean total daily insulin dose than those in poor control. After adjusting for demographic and socioeconomic factors, diabetes management characteristics were still strongly associated with good vs. poor control. Notably, frequency of severe hypoglycemia was similar between the groups while DKA was more common in the poorly controlled group.

Conclusions—Children with excellent glycemic control tend to exhibit markedly different diabetes self-management techniques than those with poor control. This knowledge may further inform diabetes care providers and patients about specific characteristics and behaviors that can be augmented to potentially improve glycemic control.

Keywords

blood glucose self-monitoring; diabetes mellitus; insulin; pediatric; type 1 diabetes mellitus

The Diabetes Control and Complications Trial (DCCT) and its follow-up Epidemiology of Diabetes Interventions and Complications (EDIC) study established that lower hemoglobin A1c (A1c) serves as an excellent biomarker for the delay and prevention of long-term complications of type 1 diabetes (1, 2). In recognition of the DCCT/EDIC findings, the American Diabetes Association (ADA) recommends target A1c levels <7.0% (53 mmol/mol) in adults with type 1 diabetes, <7.5% (58 mmol/mol) for those 13–17 yr old, <8% (64 mmol/mol) for those 6–12 yr old, and <8.5% (69 mmol/mol) for children 0–6 yr old (though guidelines promote the lowest possible A1c that can be achieved while avoiding recurrent hypoglycemia). The International Society for Pediatric and Adolescent Diabetes (ISPAD) recommends a target of <7.5% (58 mmol/mol) in children and adolescents (3, 4). Following the assimilation of intensive diabetes management as the standard of care and the introduction of improved glucose monitoring devices, insulin pumps, and insulin analogs, patients with type 1 diabetes are increasingly capable of achieving target A1c levels.

Despite this progress, too many children and adolescents fail to achieve optimal control of their type 1 diabetes (5). Indeed, we have recently shown that mean A1c level was 8.8% (73 mmol/mol) in the 6229 teens (13–18 yr old) and 8.4% (68 mmol/mol) in the 6862 pre-teens (6–13 yr) enrolled in the type 1 diabetes (T1D) Exchange Clinic Registry (6). Improving our understanding of the factors underlying varying degrees of glycemic control in children and adolescents with type 1 diabetes is a critical first step forward in our efforts to optimize treatment outcomes.We used the T1D Exchange Clinic Registry database to compare differences in patient characteristics and in diabetes management techniques in patients with excellent glycemic control (defined as A1c <7.0%)(53 mmol/mol) vs. poor glycemic control (A1c ≥9.0%)(75 mmol/mol).

Research design and methods

The T1D Exchange clinic network includes 67 US-based pediatric and adult endocrinology practices. A registry of individuals with type 1 diabetes commenced enrollment in September 2010 (6). Each clinic received approval from an institutional review board (IRB). Informed consent was obtained according to IRB requirements from adult participants and parents/guardians of minors; assent from minors was obtained as required. Data were

collected for the registry's central database from the participant's medical record and by having the participant or parent complete a comprehensive questionnaire, as previously described (6).

Excellent glycemic control was arbitrarily defined as past 12-month average HbA1c <7.0% (53 mmol/mol) and poor control was defined as past 12-month average HbA1c ≥9.0% (75 mmol/mol) in order to have a substantial separation between group HbA1c levels. This report includes data on 3272 participants enrolled through 1 August 2012 at 58 clinics who met the following criteria: age ≥6 and <18 yr with duration of T1D ≥2 yr; and an HbA1c level either <7.0% (53 mmol/mol) or ≥9.0% (75 mmol/mol). Participants who were currently using a real-time continuous glucose monitor (N=144, 4% of the cohort) and those for whom data were not available to characterize as either a pump or injection user were excluded.

HbA1c levels, mainly measured with point-of-care devices (81% DCA, 4% other POC, 12% lab, 4% unknown), were obtained from the clinic chart. All other data were self-reported and collected per the T1D Exchange registry questionnaire.

A diabetes management composite score (DMCS) of 0–4 was derived by combining four diabetes management variables:

- **i.** bolusing before meals,
- **ii.** always performing self-monitoring of blood glucose (SMBG) prior to bolusing at time of meal,
- **iii.** missing doses <1×/wk, and (4) SMBG frequency per day ≥5.

Statistical methods

Separate univariate logistic regression models were used to assess differences between the excellent control and poor control groups in demographic, socioeconomic, clinical, and diabetes management characteristics. Then, two multivariate logistic regression models were constructed, with one model including demographic, socioeconomic, and clinical variables and the other including diabetes management variables; for both models variables with $p \leq 0.1$ from respective univariate analyses were assessed and using a backward elimination process, variables with $p \leq 0.01$ were retained. Finally, the variables from both multivariate models with $p \leq 0.01$ were included in a third multivariate model.

Differential results according to age or insulin delivery method (insulin pump vs. injection) were assessed by including interaction terms in the models.

Data analyses were performed using SAS software, Version 9.3 (2011 SAS Institute Inc., Cary, NC, USA). In view of the large sample size and number of variables evaluated, only p values ≤0.01 were considered to be significant and emphasis should be placed on the magnitude of the differences between groups.

Results

Demographics

The analysis included 588 participants with excellent control (A1c <7%/53 mmol/mol) and 2684 with poor control (A1c ≥9%/75 mmol/mol). The characteristics of the participants included in the analyses are shown in Table 1. Repeat analyses in which the good control group was redefined as having 12-month average HbA1c <7.5% (58 mmol/mol) produced similar results for all variables examined (data not shown).

Compared with the poor control group, the excellent control group was slightly younger and more likely to be non-Hispanic white, male, of normal weight, and have shorter T1D duration, higher annual household income, higher parental education level, and private insurance ($p < 0.001$ for each). Comparison of participant characteristics between excellent and poor control groups was further stratified by age.

Diabetes management characteristics

A number of factors related to diabetes management differed significantly between the excellent and poor control groups (Table 2). Participants in excellent control (HbA1c <7.0%) (53 mmol/mol) more frequently monitored blood glucose, checked their blood glucose prior to giving meal time insulin, gave insulin for daytime snacks, gave insulin in advance of starting a meal, varied insulin:carbohydrate ratios for meals, and used a pump to deliver insulin. The excellent control group on average used a smaller total daily insulin dose, gave more bolus insulin and less frequently missed an insulin dose ($p < 0.001$ for all comparisons). Participants in the excellent control group had a higher average DMCS than participants in the poor control group, 2.8 vs. 1.9 ($p < 0.001$) (Table 2). Of those in the excellent control group, 68% had a composite score ≥3 compared with 35% in the poor control group. In the multivariate analysis, four diabetes management characteristics remained statistically significant ($p \leq 0.01$) (Table 2). The odds of being in the excellent control group were higher for those who (i) reported checking glucose levels more frequently, (ii) used lower daily insulin doses, (iii) missed bolus insulin doses less frequently, or (iv) used a pump to deliver insulin. Each variable remained significant ($p \geq 0.01$) after further adjusting for patient characteristics (last column in Table 2).

Results stratified by age group (6 to <13 and 13 to <18 yr) were similar to the overall analyses, with none of the variable by age interactions showing meaningful differences although there was evidence of a slight statistical interaction for parental education (Supporting Information Tables S1 and S2). In contrast, for the following four diabetes management variables the magnitude of differences comparing the excellent and poor control groups was greater in participants using pump vs. injection (if an association was present, the direction of association was the same): number of SMBG measurements per day, frequency of bolusing for daytime snacks, timing of meal time bolus, and frequency of missing an insulin dose (Table S3). Among pump users, those in the excellent control group had more basal rate changes per day ($p < 0.001$). Mean duration of pump infusion set insertion was similar between groups ($p = 0.2$). Among injection users, the insulin regimen appeared similar comparing the excellent and poor control groups ($p = 0.10$).

Notably, severe hypoglycemic events (seizure or loss of consciousness) within the prior 12 months were reported by 4% in the excellent control group and by 7% in the poor control group, a non-significant difference in favor of excellent control ($p = 0.03$).

Diabetic ketoacidosis was reported by 2% in the excellent control group and by 21% in the poor control group ($p< 0.001$).

Discussion

This study utilized data collected from pediatric patients participating in the T1D Exchange Clinic Registry to document demographic, socioeconomic, clinical, and diabetes management characteristics associated with excellent and poor glycemic control in US children with type 1 diabetes. Those who were younger, male, and non-Hispanic white with highly educated parents and private insurance were most likely to achieve good glycemic control. With respect to diabetes management, we demonstrated that frequency of missed insulin doses, frequency of SMBG, timing of meal boluses, total daily insulin dose differed between the excellent and poor control groups, factors that remained significant after adjusting for significant demographic factors. Nevertheless, demographic characteristics remain undeniably associated with the causal pathway that determines glycemic control. Successful efforts to improve glycemic control in US children with type 1 diabetes will likely encompass individualized or demographic-specific strategies designed to target improvements in diabetes management characteristics.

Many of the factors affecting glycemic control are predictable and have been previously reported in the pediatric diabetes literature. Specifically, the German/Austrian DPV-Wiss-Initiative has reported data from over 26 000 children and adolescents with type 1 diabetes and has confirmed strong associations with A1c and frequency of SMBG after adjusting for age, gender, diabetes duration, BMI, insulin regimen, insulin dose, and center differences (7). In addition, the DPV has shown strong associations with glycemic control and age, duration of diabetes, gender, minority status, season, treatment period, insulin regimen, and center (8). While the size of the pediatric T1D Exchange cohort is somewhat smaller than the DPV experience, the T1D Exchange data similarly provide a unique opportunity to better understand how to apply the limited resources of diabetes providers when attempting to improve glycemic control in US children with type 1 diabetes. That said, our current analyses lack the input of other variables known to be associated with glycemic control. Specifically, patients with concurrent mental health issues and family conflict are more likely to be in poor control (9, 10). Future efforts to characterize depression and familial conflict within the T1D Exchange cohort will undoubtedly provide additional improvements in our understanding of the factors associated with glycemic control.

While identifying significant associations between factors associated with good and poor control are helpful, clinicians managing children with type 1 diabetes are likely to find additional utility in understanding the relative impact of one factor vs. another factor. We therefore used univariate and multivariate adjusted analyses to generate odds ratios for behaviors associated with excellent or poor controlled. As one example of our findings, we observed the largest odds ratio comparing groups when analyzing the self-reported

frequency of insulin omission. Compared with those omitting insulin 3–4×/wk, participants who reported never missing insulin doses were more than 17 times more likely to be in the excellent control group. Importantly, when the model was adjusted for other diabetes management characteristics and demographic characteristics, those who reported never missing insulin boluses were 24.5 times more likely to be in excellent control. While many of the behaviors investigated are strongly interrelated and prevented us from truly identifying factors that work independently, these data suggest that efforts aimed at a number of specific behaviors (i.e., reducing the frequency of missed insulin doses) could have a dramatic effect on improving glycemic control in children with type 1 diabetes.

Notably, the lack of a difference in severe hypoglycemia rates between children with excellent control and those with poor control supports the notion that tight glycemic control can safely be achieved in children with type 1 diabetes. This finding is consistent with recent studies (11) that refute the association between lower A1c and frequency of severe hypoglycemic episodes. This may be due to improvements in insulin management via the use of short-acting insulin analogs, more widespread use of newer smart insulin pumps, and diabetes education regarding adjustment of insulin doses with mild hypoglycemia (participants in the database were excluded from this analysis if they were using continuous glucose monitoring systems due to the small number). By contrast, rate of DKA was, not surprisingly, higher in the poorly controlled group. Also notable were diabetes management behaviors that remain less than optimal in both the excellent and poorly controlled groups. Specifically, 53% of children in the excellent group and 76% of those in the poor control group failed to always give bolus insulin for daytime snacks. Interventions aimed at improving snack bolusing may provide a mechanism for improving A1c in both children with poor and excellent control.

In an effort to provide further meaning to this study, we divided the pediatric cohorts into subgroups based on age (6 to <13 and 13 to <18). Interestingly, the division of the study subjects into pre-teen and teen age cohorts did not reveal marked differences between the groups and instead emphasized the effect of primary demographic factors and patient management characteristics on A1c across the pediatric age spectrum. Unfortunately, we were unable to formally report the effects of pubertal progression on insulin sensitivity in this analysis. However, when examining the differences in insulin usages amongst children divided by age 6 to <13 and 13 to <18, we did observe the expected trend of increased insulin requirements in the older, presumably pubertal group.

In conclusion, a collection of highly interrelated demographic and diabetes management characteristics differ significantly when comparing US children in excellent vs. poor glycemic control. While this study does not have the capacity to explain all characteristics associated with good vs. poor control, this effort represents one of the largest descriptions of glycemic control and its associated factors in a cohort of children managed by a diverse group of type 1 diabetes clinics across the US. Given that children in poor control outnumber those in excellent control in this study by more than 4:1, policymakers and payers should be reminded that the long-term costs of poorly controlled type 1 diabetes are likely to far outweigh the costs of ensuring patients and providers have adequate tools to optimize diabetes care for a larger percentage of the pediatric type 1 diabetes population.

Future studies should focus on the development of successful strategies to modify diabetes management characteristics in children with poor glycemic control.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

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Table 1

Participant characteristics in the excellent HbA1c vs. poor HbA1c cohort

	Excellent HbA1c< 7.0% (53 mmol/mol) (N = 588)	Poor HbA1c≥9.0% (75 mmol/mol) (N = 2684)	Unadjusted odds ratio (99% confidence interval)*	p Value	Adjusted odds ratio (99% confidence interval)†	p Value
Age (yr)						
Mean ± SD	12.9±3.3	13.9±2.8		<0.001‡		<0.001‡
Age group—n (%)						
13 to <18	298 (51%)	1814 (68%)	Ref		Ref	
6 to <13	290 (49%)	870 (32%)	2.0 (1.6, 2.6)		1.9 (1.4, 2.5)	
Gender—n (%)						
Female	259 (44%)	1364 (51%)	Ref	0.003	—	
Male	329 (56%)	1320 (49%)	1.3 (1.0, 1.7)			
Race/Ethnicity—n (%)				<0.001		<0.001
Black Non-Hispanic	13 (2%)	349 (13%)	Ref		Ref	
Hispanic or Latino	55 (9%)	317 (12%)	4.7 (2.1, 10.6)		5.5 (2.3, 13.0)	
Other Race/Ethnicity	34 (6%)	181 (7%)	5.0 (2.1, 12.1)		4.7 (1.8, 11.9)	
White Non-Hispanic	485 (82%)	1820 (68%)	7.2 (3.4, 15.3)		4.4 (2.0, 9.5)	
Duration of T1D (yr)						
Mean ± SD	5.0±3.0	6.5±3.4		<0.001‡		<0.001‡
>10 yr	58 (10%)	550 (20%)	Ref		Ref	
6–9 yr	153 (26%)	909 (34%)	1.6 (1.0, 2.4)		1.5 (0.9, 2.3)	
3–5 yr	221 (38%)	950 (35%)	2.2 (1.5, 3.3)		2.1 (1.3, 3.3)	
1–2 yr	156 (27%)	275 (10%)	5.4 (3.5, 8.3)		5.1 (3.1, 8.4)	
Body weight				<0.001‡		<0.001‡
Mean ± SD (BMI Z score)	0.52 ±0.83	0.75±1.15				
Weight Category—n (%)						
Obese (≥95‰ percentile)	56 (10%)	439 (17%)	Ref		Ref	
Overweight (85th to <95th percentile)	87 (15%)	674 (25%)	1.0 (0.6, 1.6)		0.8 (0.5, 1.4)	
Normal/underweight <85th percentile)	440 (75%)	1533 (58%)	2.3 (1.5, 3.3)		1.7 (1.1, 2.7)	

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	Excellent HbA1c< 7.0% (53 mmol/mol) (N = 588)	Poor HbA1c≥9.0% (75 mmol/mol) (N = 2684)	Unadjusted odds ratio (99% confidence interval)*	p Value	Adjusted odds ratio (99% confidence interval)†	p Value
Household Income§—n (%)				<0.001		<0.001
Less than $25 000	19 (4%)	348 (19%)	Ref		Ref	
$25 000 to <$50 000	41 (10%)	511 (28%)	1.5 (0.7, 3.1)		1.0 (0.5, 2.3)	
$50 000 to <$75 000	59 (14%)	318 (17%)	3.4 (1.7, 6.9)		1.4 (0.6, 3.1)	
≥75 000	312 (72%)	651 (36%)	8.8 (4.7, 16.5)		2.4 (1.1, 5.0)	
Parent's Education¶—n (%)				<0.001		<0.001
Less than a high school diploma	10 (2%)	148 (6%)	Ref		Ref	
High school diploma\GED	99 (18%)	1073 (44%)	1.4 (0.6, 3.3)		1.0 (0.4, 2.6)	
Associate degree	42 (7%)	359 (15%)	1.7 (0.7, 4.4)		1.1 (0.4, 2.9)	
Bachelor degree	181 (33%)	498 (21%)	5.4 (2.3, 12.9)		2.7 (1.0, 6.9)	
Masters, doctorate or professional degree	220 (40%)	339 (14%)	9.6 (4.0, 22.9)		4.3 (1.7, 11.1)	
Insurance Status‖—n (%)				<0.001		<0.001
No insurance	3 (1%)	19 (1%)	Ref		Ref	
Other	70 (13%)	950 (42%)	0.5 (0.1, 2.4)		0.7 (0.1, 4.1)	
Private	459 (86%)	1130 (57%)	2.2 (0.4, 11.1)		1.5 (0.3, 8.6)	

*The odds ratios were derived from the univariate logistic regression modeled for the probability of the excellent control. Odds ratios greater than 1.0 indicate a higher probability of the factor being associated with the excellent control group compared with the poor control group.

†The odds ratios were derived from the multivariate logistic regression, which only included factors with a p value ≤0.01 in the final model.

‡The p values were taken from the model specification where the predictor variable was treated as continuous.

§One hundred and fifty-seven (27%) subjects missing household income data in the excellent group and 856 (32%) in the poor group.

¶Thirty-six (6%) subjects missing education data in the excellent group and 267(10%) in the poor group.

‖Fifty-six (10%) subjects missing insurance status data in the excellent group and 405 (15%) in the poor group.

Table 2

Comparison of diabetes management characteristics in the excellent control and poor control groups

	Excellent HbA1c <7.0% (53 mmol/mol) (N = 588) *	Poor HbA1c ≥9.0% (75 mmol/mol) (N =2684) *	Unadjusted odds ratio (99% confidence interval) †	p Value	Odds ratio adjusted for all significant diabetes management characteristics (99% confidence interval) ‡	p Value	Odds ratio adjusted for all significant diabetes management and patient characteristics (99% confidence interval) §	p Value
Self-reported SMBG Frequency (times per day)—n (%)				<0.001¶		<0.001¶		
0–2	9 (2%)	205 (8%)	Ref		Ref		Ref	<0.001¶
3–4	105 (18%)	1028 (41%)	2.3 (0.9, 5.8)		1.7 (0.6, 4.5)		1.7 (0.7, 3.9)	
5–9	356 (62%)	1197 (47%)	6.8 (2.8, 16.5)		2.8 (1.1, 7.3)		2.3 (1.0, 5.1)	
>10	105 (18%)	96 (4%)	24.9 (9.6, 64.4)		7.5 (2.7, 21.2)		7.0 (2.9, 17.0)	
Frequency of SMBG prior to bolusing at time of meal—n (%)				<0.001				
Never/Rarely	14 (3%)	112 (6%)	Ref		//		//	
Sometimes/Most of the time	106 (25%)	835 (43%)	1.0 (0.5, 2.2)					
Always	309 (72%)	1006 (52%)	2.5 (1.2, 5.2)					
Total daily insulin dose (units/kg/d)				<0.001¶		<0.001¶		<0.001¶
≥1.5	12 (2%)	232 (9%)	Ref		Ref		Ref	
1.0 to <1.5	105 (19%)	703 (29%)	2.9 (1.3, 6.5)		1.9 (0.8, 4.4)		1.9 (0.9, 3.7)	
0.5 to <1.0	354 (64%)	1183 (48%)	5.8 (2.7, 12.6)		3.2 (1.4, 7.3)		2.9 (1.5, 5.7)	
<0.5	85 (15%)	332 (14%)	5.0 (2.2, 11.3)		4.1 (1.7, 10.0)		4.3 (2.1, 8.8)	
Number of boluses on a typical day—n (%)				<0.001¶				
≤2 boluses	33 (6%)	237 (10%)	Ref		//		//	
3–4 boluses	151 (28%)	1091 (46%)	1.0 (0.6, 1.7)					

	Excellent HbA1c <7.0% (53 mmol/mol) (N = 588) *	Poor HbA1c ≥9.0% (75 mmol/mol) (N =2684) *	Unadjusted odds ratio (99% confidence interval) †	p Value	Odds ratio adjusted for all significant diabetes management characteristics (99% confidence interval) ‡	p Value	Odds ratio adjusted for all significant diabetes management and patient characteristics (99% confidence interval) §	p Value
≥5 boluses	363 (66%)	1058 (44%)	2.5 (1.5, 4.1)					
Ratio of bolus to basal insulin—n (%)				0.9¶				
<0.9	125 (24%)	781 (37%)	Ref		//		//	
0.9—<1.5	183 (36%)	672 (32%)	1.7 (1.2, 2.4)					
≥1.5	204 (40%)	641 (31%)	2.0 (1.4, 2.7)					
Bolus given for daytime snacks—n (%)				<0.001				
Never/Rarely	80 (14%)	566 (22%)	Ref		//		//	
Sometimes/Most of the time	215 (39%)	1360 (54%)	1.1 (0.8, 1.6)					
Always	261 (47%)	597 (24%)	3.1 (2.2, 4.4)					
Timing of mealtime insulin bolus—n (%)				<0.001				
Not given regularly	13 (2%)	109 (4%)	Ref		//		//	
During or after meal	130 (23%)	896 (35%)	1.2 (0.6, 2.7)					
Before meal	362 (63%)	1334 (52%)	2.3 (1.1, 4.9)					
Depends on glucose level prior to meal	68 (12%)	238 (9%)	2.4 (1.0, 5.5)					
Insulin:carbohydrate ratios used to determine amount of insulin bolus—n (%)				<0.001				
No/Don't know	64 (12%)	436 (19%)	Ref		//		//	
Yes, all 3 meals the same	216 (40%)	1289 (55%)	1.1 (0.8, 1.7)					
Yes, 3 meals not	263 (48%)	621 (26%)	2.9 (1.9, 4.3)					

	Excellent HbA1c <7.0% (53 mmol/mol) (N = 588) *	Poor HbA1c ≥9.0% (75 mmol/mol) (N =2684) *	Unadjusted odds ratio (99% confidence interval) †	p Value	Odds ratio adjusted for all significant diabetes management characteristics (99% confidence interval) ‡	p Value	Odds ratio adjusted for all significant diabetes management and patient characteristics (99% confidence interval) §	p Value
all the same								
Frequency of missing insulin dose—n (%)				<0.001		<0.001		<0.001
≥3×/wk	16 (3%)	592 (23%)	Ref		Ref		Ref	
1–2×/wk	55 (10%)	647 (25%)	3.1 (1.5, 6.6)		3.1 (1.4, 6.6)		3.3 (1.8, 6.0)	
<1 ×/wk	139 (24%)	560 (22%)	9.2 (4.6, 18.4)		8.6 (4.2, 17.7)		8.7 (4.9, 15.2)	
Never	364 (63%)	780 (30%)	17.3 (8.8, 33.8)		21.5 (10.6, 43.4)		24.5 (14.1, 42.8)	
Frequency of exercise (d/wk)—n (%)				0.01¶				
0 d	12 (3%)	46 (3%)	Ref		//		//	
1–2d	28 (7%)	189 (10%)	0.6 (0.2, 1.5)					
3–5d	185 (45%)	857 (47%)	0.8 (0.4, 2.0)					
6–7d	190 (46%)	744 (41%)	1.0 (0.4, 2.3)					
Insulin delivery method				<0.001		<0.001		<0.001
Injection			Ref		Ref		Ref	
Pump Use	404 (69%)	1099 (41%)	3.2 (2.5, 4.1)		4.5 (3.3, 6.1)		3.1 (2.4, 4.0)	
*Composite of 4 factors** (DMCS)*				<0.001¶				
Mean±SD	2.83 ± 1.02	1.93 ± 1.23						
Factors—n (%)								
0	15 (3%)	373 (14%)	Ref		N/A		N/A	
1	48 (8%)	640 (25%)	1.9 (0.9, 4.1)					
2	124 (21%)	665 (26%)	4.6 (2.2, 9.6)					
3	225 (39%)	601 (23%)	9.3 (4.6, 18.9)					
4	166 (29%)	300 (12%)	13.8 (6.7, 28.3)					

* n ranges between 415 (71%) and 588 in the excellent group and between 1836 (68%) and 2684 in the poor group because of missing data.

† The odds ratios were derived from the univariate logistic regression modeled for the probability of the excellent control. Odds ratios greater than 1.0 indicate a higher probability of the factor being associated with the excellent control group compared with the poor control group.

‡ The odds ratios were derived from the multivariate logistic regression, Multivariate logistic regression was then performed on those diabetes management variables with $p \leq 0.1$ from the univariate analyses. Using backward elimination, only predictors with $p \leq 0.01$ were retained in the final model.

§ The odds ratios were derived from the multivariate logistic model specified in footnote '‡' while adjusting for participant characteristics with a p value ≤ 0.01 (i.e., race/ethnicity, household income, parent's education, insurance, diabetes duration, BMI Z score).

¶ The p values were taken from the model specification where the predictor variable was treated as continuous.

‖ The variable was included initially in the model but removed through backward elimination.

** The composite variable (ranging 0–4) is composed of four dichotomous items (0/1), bolus before meal, always SMBG prior to bolusing at time of meal, miss doses <1 ×/wk, SMBG frequency ≥5. The composite variable was not included in the multivariate model.