Does Blood Glucose Monitoring Increase Prior to Clinic Visits in Children With Type 1 Diabetes?

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OBJECTIVE—To assess the occurrence of white coat adherence in families with children who have type 1 diabetes.

RESEARCH DESIGN AND METHODS—Blood glucose data were downloaded from meters of 72 children, aged 2–11 years, with type 1 diabetes at four consecutive clinic visits. Generalized estimating equations were used to analyze patterns of blood glucose monitoring (BGM) during the 28 days before each clinic visit.

RESULTS—More frequent BGM was associated with better glycemic control. Evidence of a white coat adherence effect, with BGM frequency increasing before a clinic visit, was found only among children with low A1C levels.

CONCLUSIONS—Highly motivated families who frequently monitor their child's blood glucose increased the frequency of BGM before the child's clinic visit. The additional monitoring may benefit the child by providing the physician with a wealth of blood glucose information to guide recommendations.

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Although more frequent blood glucose monitoring (BGM) has been associated with better glycemic control in children and adults with type 1 diabetes (1–3), to our knowledge, no studies have examined whether BGM frequency increases before a visit to the physician. There is a literature on "white coat adherence" (also referred to as white coat compliance and the "toothbrush effect") (4,5)—a term used to connote an improvement in treatment adherence before the clinic appointment. Existing studies of white coat adherence have been conducted with adult epilepsy, HIV, and dermatology populations (6–8) and in pediatric epilepsy and dermatology populations (7,9). Adult patients increased their use of oral and topical medications for a short period before and after a clinic or physician appointment (10). This same pattern of white coat adherence was found in pediatric dermatology patients (7) but not in children with newly diagnosed epilepsy (9). However, no studies evaluating the occurrence of white coat adherence in pediatric patients with type 1 diabetes have been published to date. Therefore, the primary aim of this study was to use data downloaded from blood glucose meters at four consecutive clinic visits to determine if white coat adherence occurred in a sample of pediatric patients.

White coat adherence could have significant implications for type 1 diabetes treatment recommendations. Patients might increase BGM before a clinic visit to please the physician by appearing highly adherent or to provide as much information as possible to guide treatment recommendations. In either case, increased BGM before a clinic visit does not represent the patient's usual pattern of BGM and may mislead the physician into believing the patient's BGM is more frequent than is actually the case.

RESEARCH DESIGN AND METHODS

Data for this study were obtained from the HANDling Diabetes project (11), which recruited children aged <12 years old with diabetes duration >6 months and their parents at two pediatric diabetes clinics. All children who met the age and disease-duration criteria were invited to participate; 95% agreed to do so. Participants' routine care included pediatric diabetes clinic visits every 3 months where data from their blood glucose meters were downloaded. The current study included 72 children whose meters had storage capacity of ≥28 days. To assess the stability of any white coat adherence effect, we examined downloaded data across four consecutive clinic visits. The HANDling Diabetes project was approved by the Florida State University and University of Florida institutional review boards.

Glycemic control

Hemoglobin A_{1c} (A1C), representing the average glucose level during the past 2.5 to 3 months (12), was obtained at each clinic visit using a Siemens Healthcare Diagnostics DCA Vantage (reference range 4.2–6.5%), which is certified by the National Glycohemoglobin Standardization Program (NGSP) as having documented traceability to the Diabetes Control and Complications Trial (DCCT) Reference Method. A1C was temporally aligned with blood glucose meter downloads; A1C represented the same period of time as the blood glucose meter reading downloads.

Blood glucose meter readings

Blood glucose readings and their corresponding dates and times were downloaded from each patient's meter during the clinic visit. At the time this study was conducted (2000–2007), many blood glucose meters had limited data downloading and storage capacity. Therefore, patients' blood glucose meter data were included for analysis only if the patient's meter

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had a storage capacity of ≥28 days. We further restricted our data selection to those downloaded records with sufficient data for analysis defined as *1*) containing at least 20 days of blood glucose readings and *2*) at least one reading within 5 days of the clinic visit at which the meter was downloaded.

Statistical analysis

Descriptive statistics, including means, SDs, and ranges were conducted for demographic and BGM variables. Demographic differences between participants who were and were not included in the analyses were determined by *t* tests. The dependent variable was the average number of blood glucose readings performed per day. Generalized estimating equations (GEE) (13) were used to evaluate predictors of daily BGM frequency downloaded at four consecutive clinic visits. GEE adjusts within-subject dependence in repeated-measures and longitudinal designs in which data from the same subject are intra-individually related, resulting in violation of the assumption of independence in multiple regression (14). Stata SE 9.0 software (StataCorp, College Station, TX) was used for all analyses.

Table 1—*A1C and blood glucose meter data downloads at four clinic visits*

Variable	Mean ± SD	Range
Time 1 (*n* = 59)		
A1C (%)	8.32 ± 1.16	5.9–11.2
Blood glucose (mg/dL)	202.05 ± 52.27	116.16–363.21
Blood glucose readings (*n*)		
Per day	4.57 ± 1.67	0.86–9.57
28 Days before clinic visit	4.36 ± 2.22	1–12
1 Day before clinic visit	4.75 ± 2.19	1–11
Time 2 (*n* = 61)		
A1C (%)	8.28 ± 0.88	5.9–10.5
Blood glucose (mg/dL)	209.1 ± 39.38	113.62–277.09
Blood glucose readings (*n*)		
Per day	4.51 ± 1.40	1.25–10.68
28 Days before clinic visit	3.82 ± 1.78	1–10
1 Day before clinic visit	4.48 ± 1.87	0–11
Time 3 (*n* = 67)		
A1C (%)	8.40 ± 1.07	5.9–11
Blood glucose (mg/dL)	210.65 ± 44.21	125.03–321.96
Blood glucose readings (*n*)		
Per day	4.52 ± 1.97	1.07–11.89
28 Days before clinic visit	4.24 ± 2.25	1–12
1 Day before clinic visit	4.72 ± 2.76	0–13
Time 4 (*n* = 56)		
A1C (%)	8.30 ± 1.13	6.4–13.7
Blood glucose (mg/dL)	206.99 ± 43.79	124.07–312.29
Blood glucose readings (*n*)		
Per day	4.53 ± 1.46	1.57–8.57
28 Days before clinic visit	4.29 ± 2.25	1–10
1 Day before clinic visit	4.38 + 2.26	0–11

RESULTS—The 72 patients (41 girls, 31 boys) whose downloaded BGM data were used for this study were aged 2 to 11 years (mean 8.0 [SD 2.6]) with a disease duration of 0.7 to 11.0 years (4.0 [2.6]). We examined whether the 72 children whose data were used differed from the 36 children from the HANDling Diabetes project whose blood glucose meter data were insufficient for inclusion; no significant differences in A1C, child sex, age, or disease duration emerged. Table 1 provides A1C results and data obtained from downloaded meters at each of four consecutive clinic visits. The number of children whose data were used varied across clinic visits due to failure to bring a meter to the clinic or to technical difficulties with downloading the data. Although these children's mean A1C values across the four clinic visits were in the target range for this age group (i.e., 8.0 for children aged 6 to 12 years; 8.5 for children aged <6 years) (15), there was great variability, with A1C values as low as 5.9 and as high as 13.7. Similarly, although mean BGM frequency was >4 readings performed per day across the four clinic visits, daily BGM frequency also exhibited great variability, ranging from <1 reading per day to >11 readings per day.

GEE regression models were used to test linear and nonlinear models of BGM frequency in the 28 days before each clinic visit; a linear model provided the best fit with the data. The best model was the same at each clinic visit. The number of days before the clinic visit, child A1C, and A1C × day interaction significantly predicted the number of blood glucose readings performed per day (Table 2). There was a trend toward younger age being associated with more frequent BGM. Figure 1 illustrates the A1C main effect; at all four clinic visits, children with lower A1Cs showed higher BGM frequency regardless of the number of days before the clinic visit. Figure 1 also illustrates the interaction between A1C and the number of days before the clinic visit. On three of the four clinic visits, children with low A1Cs (i.e., A1C = 6) showed an increase in BGM as the date of the clinic visit approached, from less than five readings per day to more than seven readings per day. In contrast, patients with A1Cs in the target range (i.e., A1C = 8.0) and those with high A1Cs (i.e., A1C = 10) showed a flat or slightly declining BGM pattern of approximately three or four readings per day. As a consequence, the largest differences in BGM frequency between children with low and high A1Cs occurred in the days immediately preceding the clinic visit. Only clinic visit 3 failed to display this pattern; at this visit the main effect for A1C is most apparent—children with low A1Cs averaged more than six BGM readings per day throughout the 28-day window.

CONCLUSIONS—This study clearly replicates the link between BGM frequency and A1C across four clinic visits in a sample of children with type 1 diabetes. Surprisingly few published studies exist demonstrating a link between BGM frequency from downloaded meters and glycemic control (1,16,17); most have used nonobjective methods of assessing BGM adherence (e.g., physician notes, patient self-report, logbooks) (18,19). Our findings are consistent with two other recent studies that found a significant association between downloaded blood glucose meter data and glycemic control (17,20). Importantly, the data in the current

Table 2—*Significant predictors of BGM frequency modeled for blood glucose meter data downloaded at four clinic visits*

Variable	β Coefficient ± SE	95% CI	*P*	Wald χ^2
Clinic visit 1 (*n* = 59)				60.26*
Day before clinic visit	−0.0352 ± 0.0083	−0.0514 to −0.0191	0.001	
Child's age	−0.0255 ± 0.0157	−0.0563 to 0.0053	0.104	
Child's A1C	−0.1475 ± 0.0359	−0.2179 to −0.0771	0.001	
A1C × day	0.0035 ± 0.0010	0.0016–0.0054	0.001	
Clinic visit 2 (*n* = 61)				37.57*
Day before clinic visit	−0.0547 ± 0.0110	−0.0763 to −0.0331	0.001	
Child's age	−0.0255 ± 0.0140	−0.0530 to 0.0020	0.069	
Child's A1C	−0.2075 ± 0.0457	−0.2970 to −0.1180	0.001	
A1C × day	0.0065 ± 0.0013	0.0039–0.0091	0.001	
Clinic visit 3 (*n* = 67)				48.01*
Day before clinic visit	0.0228 ± 0.0079	0.0073–0.0383	0.004	
Child's age	−0.0515 ± 0.0176	−0.0860 to −0.0171	0.003	
Child's A1C	−0.1033 ± 0.0405	−0.1827 to −0.0239	0.011	
A1C × day	−0.0032 ± 0.0010	−0.0051 to −0.0013	0.011	
Clinic visit 4 (*n* = 56)				58.27*
Day before clinic visit	−0.0529 ± 0.0010	−0.0724 to −0.0334	0.001	
Child's age	−0.0304 ± 0.0171	−0.0640 to 0.0032	0.076	
Child's A1C	−0.2019 ± 0.0419	−0.2840 to −0.1198	0.001	
A1C × day	0.0058 ± 0.0012	0.0035–0.0082	0.001	

*$P < 0.0001$.

study highlight the stability of the association between A1C and BGM across four clinic visits occurring within a 12-month period.

Our findings also demonstrated a white coat adherence effect for those families whose children had low A1Cs. These families increased their BGM immediately before the clinic visit. In contrast, children with high A1Cs showed lower, more stable, or even declining BGM across the 28 days before the child's clinic visit. As a consequence, the largest differences in BGM frequency between children with low and high A1Cs occurred immediately before the clinic visit. Families who increased their monitoring before the visit may have benefited from the additional information they were able to provide their child's physician, resulting in a wealth of information on which to base treatment recommendations. Parents of these children appeared to be highly motivated to manage their child's diabetes. They may have viewed the clinic visit as an opportunity to capitalize on the information provided by the physician, or they may have been invested in gaining physician approval. Certainly, the diabetes clinic visit may serve as an opportunity to reinforce families who monitor frequently, and the increased amount of BGM data they provide the physician may result in better clinical recommendations that ultimately lead to better glycemic control.

The pattern of white coat adherence among children with low A1Cs was replicated in three of four clinic visits. Although we found a large main effect for glycemic control at the third clinic visit, BGM frequency was high throughout the 28 days before the clinic visit for children with low A1Cs and increased slightly for those with higher A1Cs. We suspect that a study-wide intervention that occurred at that time may explain this finding. The study protocol required all families to be given a written description of the providers' recommendations—including recommendations regarding BGM frequency. This intervention may have increased and stabilized BGM for this interval; however, the usual pattern of results returned by the subsequent clinic visit.

Although our study was restricted to those families whose meters held at least 28 days of data, we found no evidence that the 72 children whose data were used for this analysis differed from the 36 children who were excluded because their meters had limited data storage capacity. With the advent of meters with even greater storage capacity, an examination of the impact of the clinic visit on BGM frequency after the clinic visit—as well as before the clinic visit—will also be possible. Future studies will need to assess white coat adherence in adolescents and young adults. In this study, age did not interact with day, suggesting that in this 2- to 11-year-old age-group, white coat adherence did not differ by age. This may not be the case in children older than 11 years, especially because responsibility for their diabetes management shifts toward them and away from parents (21). Further, in future studies, a measure of social desirability may prove useful in identifying those parents or patients who are more likely to engage in white coat adherence to please their physicians.

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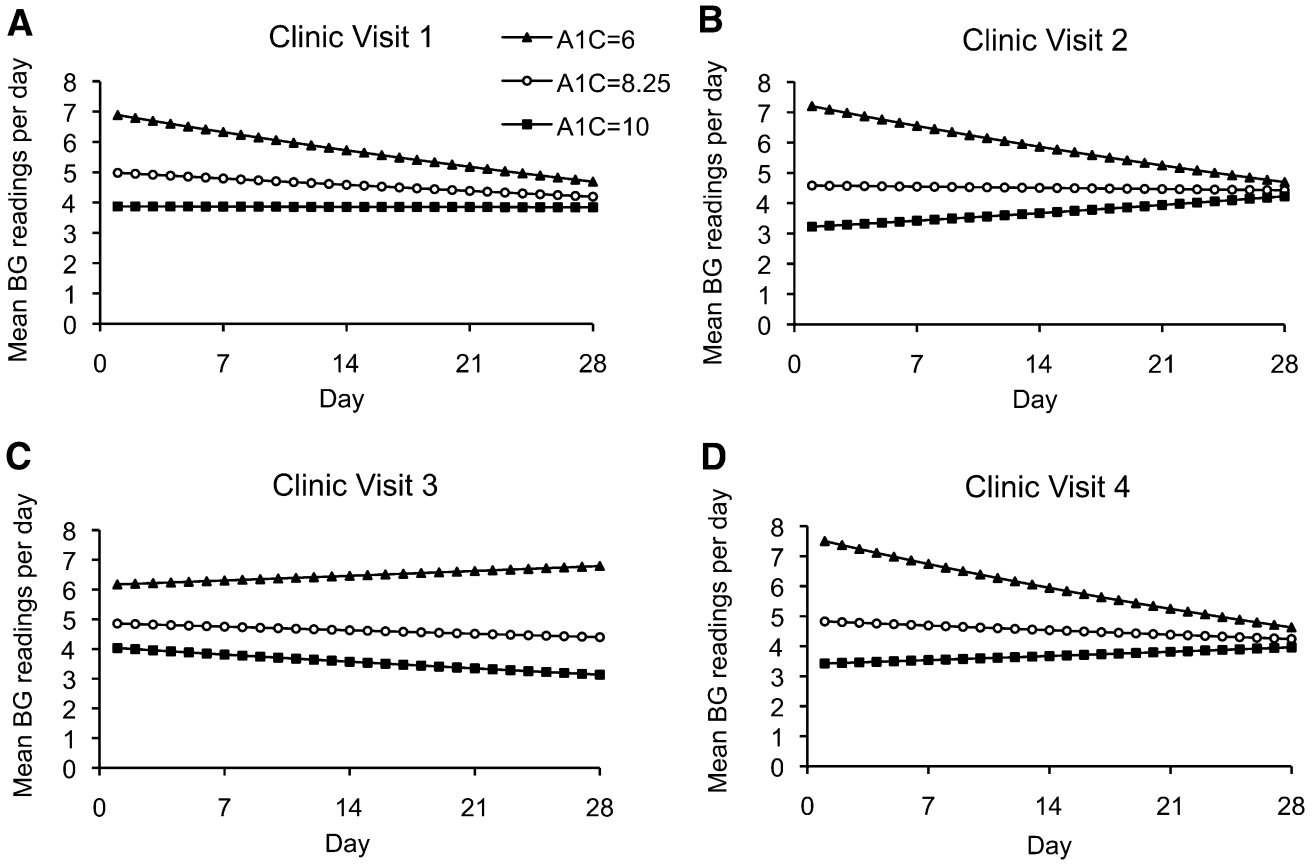

Figure 1—*A1C main effects and interactions with the number of days before clinic visits 1* (A)*, 2* (B)*, 3* (C)*, and 4* (D)*. BG, blood glucose.*

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