Glycemic Control and Awareness of Insulin Therapy

Yegor Pashchenko, MS-4[1], Daniel H. Clausing, MS-4[1],
Elizabeth Ablah, Ph.D., MPH[1,2], Hayrettin Okut, Ph.D.[1,2,3],
Georges C. Elhomsy, M.D., FACP, FACE[1,4,5]
[1]University of Kansas School of Medicine-Wichita, Wichita, KS
[2]Department of Population Health
[3]Office of Research
[4]Department of Internal Medicine
[5]Wichita Diabetes and Endocrinology, Wichita, KS

ABSTRACT

Introduction. Glycemic control is associated with better health outcomes among patients with diabetes. No previous research has examined the relationship between knowledge of one's insulin dose and glycemic control. This study sought to determine if patients who accurately recalled their insulin dose achieved better glycemic control than patients who could not remember their dose.

Methods. Interviews were conducted with 106 patients. Data were collected during patients' appointments at two endocrinology clinics in Wichita, Kansas from May 29, 2018 to February 15, 2019. Adequate glycemic control was defined as an HbA1c of less than 7.5%. A multiple logistic regression model was developed to identify factors associated with glycemic control.

Results. Of the 109 patients asked to participate, 105 agreed to participate in the study. About half (45%, n = 48) were male. Patients' mean age was 50 years (SD = 17). Seventy-seven percent (n = 81) were overweight (body mass index (BMI) of 25 to 29.9) or obese (BMI >30). Patients who correctly stated their insulin dose had a mean Hemoglobin A1c (HbA1c) of 6.9% (SD = 0.98), whereas those who incorrectly stated their dose had a mean HbA1c of 9.5% (SD = 1.9; p <0.0001).

Conclusions. There was a significant relationship between knowledge of one's insulin dose and adequate glycemic control.

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INTRODUCTION

Poor glycemic control is the leading cause of hospital admissions among patients with diabetes in the United States.[1] Adequate outpatient management could decrease the morbidity of the disease substantially. Previous work by Rohlfing et al.[2] established glycated hemoglobin (HbA1c) as an ideal marker of glycemic control among patients with diabetes. HbA1c became the gold-standard for glycemic monitoring because it has been correlated with adverse outcomes, especially microvascular complications.[3] Although the relationship between adverse health complications and elevated HbA1c is well-documented, and treatment protocols to maintain a normal blood glucose level are similarly well known, patients struggle to maintain adequate glycemic control.[4]

Although adequate glycemic control is elusive for many patients, improved glycemic control can occur when patients with diabetes receive information on the benefits of exercise, glucose monitoring, and a proper diet.[5] Greater patient knowledge about diabetes management can lead to better health outcomes.[6] Yet, no studies to date have documented whether knowledge of one's insulin dose was associated with one's glycemic control. The objective of this study was to determine if patients with insulin-dependent diabetes who could recall their insulin dose accurately achieve better glycemic control than patients who could not recall their dose.

METHODS

This study was approved by the University of Kansas Medical Center's Institutional Review Board.

Participants. Adults (18 years or older) with diagnosed insulin-dependent diabetes who agreed to participate in the study were interviewed at one of two endocrinology clinics in Wichita, Kansas. All participants were taking basal-bolus insulin for glucose control. The medical team consisted of one endocrinologist and two physician assistants. Patients were interviewed from May 29, 2018 through February 15, 2019. Patients who were non-verbal or missed their appointment were not eligible to participate in the study.

Instruments. A survey was administered via semi-structured, face-to-face interview. The 25-item interview tool included variables that can be associated with poor glycemic control, such as weekly time spent performing moderate physical activity,[7] body mass index (BMI),[8] depression diagnosis,[9] frequency of blood glucose checks,[10] and type of insurance.[11] Basic demographic information also was requested, including age, sex, race, ethnicity, and educational status. In addition to the interview, patient health information was abstracted from medical records. Abstracted data included number of missed clinic appointments in the last 12 months, number of other medications currently prescribed,[12] duration of insulin treatment, and their most recent HbA1c value.

Procedures. At the beginning of each appointment, eligible patients were asked if they were interested in participating. After obtaining consent, one researcher administered the interview. Each patient was interviewed in a private exam room. During the interview, the patient's responses were entered into a database. After the interview, the chart data were abstracted. The patient's prescribed insulin dose was abstracted from the chart and compared to the dose reported by the patient. If the self-reported and medical chart doses were the same, the patient was identified as having reported the insulin dose accurately.

Data Analysis. A sample size of 100 patients with diabetes (50 in each knowledge group) was determined to detect a difference of 40% between groups. Data were analyzed with SAS version 9.4 (2018, SAS Int. Inc., Cary, NC). Frequencies, proportions, means, and standard deviation were calculated. Likelihood ratio chi-square and Fisher's exact tests were used to test the significance of the association between two nominal or categorical variables. Prior to the main analyses, the Shapiro-Wilk test was conducted to test for normal distribution of outcomes. Hence, the rank transform approach to nonparametric methods was used as combination of PROC RANK and PROC GLM in SAS. Several longstanding nonparametric tests including Kruskal-Wallis are either exactly equivalent to rank transform tests or are nearly

equivalent to them. Least-squares means (to estimate the marginal means over a balanced population) were used for pairwise comparisons of groups by Tukey test using Kramer adjustment. Mann-Whitney U test and t-test methods were used to test the differences between means of two independent groups. Univariate linear regression models were used to test the association among HbA1c, number of minutes of moderate exercise each week and BMI. All statistical tests at $p \leq 0.05$ were considered significant.

RESULTS

Of the 109 patients who met inclusion criteria, 105 patients agreed to participate in the study (96%). The mean patient age was 50 years (SD = 17; Table 1). Most of the sample (80%, n = 84) reported they were Caucasian, and 53% percent of patients (n = 56) were female. Sixty-two percent of patients (n = 65) reported having completed high school or some college. Fifty-seven percent (n = 60) of patients reported being employed. Approximately three-quarters of patients (78%, n = 82) were overweight (BMI 25 - 29.9) or obese (BMI >30). Forty-five percent of patients (n = 48) had inadequate glycemic control (≥ 7.5%), with a mean HbA1c of 9.5% (SD = 1.9). More than half of patients (55%, n = 58) had adequate glycemic control, with a mean HbA1c of 6.6% (SD = 0.98).

Bivariate analysis suggested that patients who correctly stated their insulin dose had a mean HbA1c of 6.9% (SD = 0.98), whereas those who incorrectly stated their insulin dose had a mean HbA1c of 9.5% (SD = 1.9, $p < 0.0001$). A regression analysis was conducted to determine the association between the insulin dose error (the number of insulin units greater than or less than reported by the patient) and their resultant HbA1c. For every 29.5 units of insulin less than the patient's prescribed dose, the resultant HbA1c increased by one point. There also was a positive correlation between minutes of moderate physical activity per week and HbA1c ($p = 0.02$).

Although a greater insulin dose error and more minutes of exercise were the only variables associated with elevated HbA1c in bivariate analyses, a multivariate model suggested that other factors also contribute to an elevated HbA1c. Specifically, major depressive disorder ($p = 0.03$), elevated BMI ($p = 0.04$), type of insurance ($p < 0.0001$), increased duration of insulin use ($p = 0.01$), a greater number of missed clinic appointments ($p < 0.0001$), fewer glucose checks ($p = 0.026$), and a greater number of prescribed medications ($p = 0.02$) also were associated significantly with elevated HbA1c ($F_{(19,72)} = 7.57$, $p < 0.0001$, $R^2 = 0.666$). Patients who correctly stated their insulin dose, on average, had a 2.6% lower HbA1c value than patients who incorrectly stated their insulin dose, when accounting for these other variables in the model. Additionally, for every 100 minutes of moderate physical activity, patients were likely to have a 0.2% increase in HbA1c ($p = 0.02$).

Table 1. Patient characteristics.

Patient characteristics*	n (%)
Age	
18 - 25	8 (8)
26 - 35	23 (22)
36 - 45	13 (12)
46 - 55	13 (12)
56 - 65	23 (22)
66 - 75	20 (19)
76 or older	6 (6)
Education level	
High school or less	33 (31)
Some college	32 (30)
College degree	29 (28)
Graduate degree	10 (9)
Race and ethnicity	
Caucasian	89 (84)
African American	9 (6)
Hispanic	4 (4)
Asian American	5 (4)
Other or more than one race/ethnicity	3 (3)
Employment status	
Employed	53 (50)
Retired	28 (27)
Disabled	11 (10)
Unemployed	13 (12)
Student	4 (4)
Body Mass Index	
Normal weight	23 (17)
Overweight	27 (23)
Obese	55 (60)
Glycemic control	
Adequate glycemic control (HbA1c less than 7.5%)	59 (55)
Inadequate glycemic control (HbA1c greater than or equal to 7.5%)	47 (45)

*Some categories do not add up to the total number of participants because some patients left a survey question blank or selected multiple options (e.g., they were retired and disabled or Hispanic and African American).

DISCUSSION

The purpose of this study was to determine if there was an association between knowledge of one's insulin dose and glycemic control. The current study suggested that patients who accurately reported their insulin dose had a lower mean HbA1c than those who inaccurately reported their insulin dose. These findings are consistent with other studies that have examined the association between glycemic control and diabetes knowledge, such as proper diet,[5] diabetes medication awareness,[6] and symptom recognition of hypoglycemia.[13] This might suggest that increasing patient involvement in diabetes management can lead to better glycemic control. It was also possible that this association is a biproduct of healthier patients being more involved in their healthcare.

In the current study, patients who inaccurately reported their insulin dose were more likely to have a higher HbA1c. For every 30 units that patients under-reported their insulin dose, their HbA1c increased by one percentage point. This suggested that the magnitude of a patient's insulin dose error correlated to the amount that their HbA1c was elevated.

In addition to insulin dose error, the current study also suggested that other factors are associated with poor glycemic control: longer duration of insulin use, fewer daily blood glucose checks,[14] certain comorbid medical factors, and social factors. Another factor that varies between individuals with diabetes is the number of times they check their blood sugar every day. This study suggested that patients who check their glucose more often had lower HbA1c values. This was consistent with previous literature.[14]

In addition to diabetes management factors, other medical comorbidities, such as depression and high BMI, also were associated with increased HbA1c values. A study by Lustman et al.[15] suggested that untreated depression was associated with poor diabetes medication adherence. The current study suggested there was not an association between poor glycemic control and having a diagnosis of depression. One potential reason for this discrepancy was that all participants in the current study who reported a diagnosis of depression were being treated for their depression; however due to the limited scope of the survey, the extent, severity, and medication responsiveness of their depression was not taken into account during data analysis. Moreover, Brieler et al.[16] suggested that the use of antidepressants can improve glycemic control among depressed patients with diabetes. This might suggest that recognizing, diagnosing, and treating depression can lead to better glycemic control. Another interpretation might be that patients with good glycemic control are less likely to feel depressed.

The current study suggested that BMI was associated with glycemic control. This was inconsistent with a study by Koga et al.[17] that suggested no correlation with BMI. A 2001 study by Boulé et al.[8] suggested that greater physical activity lead to lower HbA1c levels, whereas the current study suggested an association between more time spent exercising and worse HbA1c values, which was also inconsistent with the findings of Boulé et al.[8] It is unclear why more exercise would be associated with poorer glycemic control. One explanation is that some of the participants in the present study were farmers or other outside laborers who had high levels of physical activity, but who also experienced barriers to accessing their insulin during the workday. Another explanation was that an unmeasured factor was associated with both increased activity and poorer glycemic control (e.g., type of exercise), and this factor was not assessed by the survey. Regardless of the reason for this odd relationship, medical comorbidities like depression status and BMI are important factors to explore in predicting glycemic control.

In addition to considering the role of medical comorbidities when determining the factors that affect glycemic control, the role of concomitant social factors also was important. One such social factor in the current study was missed clinic appointments. The study suggested that patients who miss six or more clinic appointments had higher HbA1c values than patients who missed one or fewer clinic appointments. This supported previous research by Karter et al.,[18] indicating that patients who missed more than 30% of their appointments had higher HbA1c

values, with a mean HbA1c of 8.6%. Another social factor explored in the current study was the association between being a patient on Medicaid and glycemic control. The current study suggested no association, which was inconsistent with a study by Healy et al.[11] where being a Medicaid patient was associated with poor diabetes medication adherence. The lack of association between Medicaid status and poor glycemic control in the current study could be attributed to the small sample size and lack of variability in participants' insurance type.

Limitations. The current study had several potential limitations. As a cross-sectional study, a causal relationship between glycemic control and other factors could not be established. Due to time constraints, only five to ten minutes were dedicated to interviewing each patient; this limited the number of potential factors that could be surveyed regarding glycemic control. For example, it could have been useful to include data about patients' attitudes toward healthcare, literacy,[19] medical knowledge,[20] living situation,[21] relationship status, number of children, diet characteristics,[9] completing a depression screening, and access to transportation.[22] Additionally, the interview only included patients during an eight-month period; this may have resulted in a less representative sample due to seasonal variation. The studies smaller sample size created some oddities in generating a model. For example, individual categories within variables, such as five missed clinic appointments vs. four, were not necessarily correlated with different HbA1c values, but they were considered significant and included in the model if there were at least two distinct groups (e.g., six missed clinic appointments were associated with higher HbA1c than zero missed clinic appointments). Finally, the interview questions could be subject to recall bias and self-reporting bias which should be considered when interpreting the results of this study.

CONCLUSIONS

This study suggested that patients who have adequate knowledge of insulin dose have better glycemic control, when controlling for insulin dose, minutes of exercise, depression status, BMI, and type of insurance. Additionally, patients who reported higher levels of moderate physical activity had higher HbA1c values.

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