

# Frequency of self-monitoring of blood glucose in relation to weight loss and A1C during intensive multidisciplinary weight management in patients with type 2 diabetes and obesity

Shaheen Tomah,<sup>1</sup> Noor Mahmoud,<sup>1</sup> Adham Mottalib,<sup>1,2</sup> David M Pober,<sup>1</sup> Mhd Wael Tasabehji,<sup>1</sup> Sahar Ashrafzadeh,<sup>1</sup> Osama Hamdy<sup>1</sup>

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<sup>1</sup>Section on Clinical, Behavioral and Outcomes Research, Joslin Diabetes Center, Harvard Medical School, Boston, Massachusetts, USA

<sup>2</sup>Department of Medicine, Lahey Hospital and Medical Center, Burlington, Massachusetts, USA

## Correspondence to

Dr Shaheen Tomah;  
shaheen.tomah@joslin.harvard.edu

## ABSTRACT

**Objective** We evaluated the relationship between frequency of self-monitoring of blood glucose (SMBG) and body weight, A1C, and cardiovascular risk factors in patients with type 2 diabetes (T2D) and obesity enrolled in a 12-week intensive multidisciplinary weight management (IMWM) program.

**Research design and methods** We conducted a retrospective analysis of 42 patients who electronically uploaded their SMBG data over 12 weeks of an IMWM program and divided them into tertiles based on their average frequency of SMBG per day. Mean (range) SMBG frequencies were 2.3 (1.1–2.9) times/day, 3.4 (3–3.9) times/day, and 5 (4–7.7) times/day in the lowest, middle, and highest tertiles, respectively. Anthropometric and metabolic parameters were measured at baseline and after 12 weeks of intervention.

**Results** Participants in the highest tertile achieved a median change (IQR) in body weight of –10.4 kg (–7.6 to –14.4 kg) compared with –8.3 kg (–5.2 to –12.2 kg), and –6.9 kg (–4.2 to –8.9 kg) in the middle and lowest tertiles, respectively ( $p=0.018$  for trend). Participants in the highest tertile had a median change (IQR) in A1C of –1.25% (–0.6 to –3.1%) compared with –0.8% (–0.3% to –2%) and –0.5% (–0.2% to –1.2%) in the middle and lowest tertiles, respectively ( $p=0.048$  for trend). The association between change in body weight and SMBG frequency remained significant after adjusting for age, sex, baseline body mass index, diabetes duration, and use of insulin therapy.

**Conclusions** Increased frequency of SMBG during IMWM is associated with significantly better weight loss and improvement of A1C in patients with T2D and obesity. These findings may suggest future clinical recommendations aimed at increasing SMBG frequency to achieve the most favorable outcomes.

## INTRODUCTION

Diabetes prevalence continues to rise globally for all age groups as researchers projected the number of patients with diabetes to double from 171 to 366 million between the years 2000 and 2030.<sup>1</sup> The parallel rapid increase in prevalence of obesity in Western societies

## Significance of this study

### What is already known about this subject?

- ▶ Self-monitoring of blood glucose (SMBG) is helpful in providing biofeedback to assess real-time effects of lifestyle changes.
- ▶ The optimal frequency of SMBG in patients with type 2 diabetes (T2D) and obesity has been debated.

### What are the new findings?

- ▶ Increased SMBG frequency in patients with T2D and obesity during intensive weight management is associated with significantly better weight loss and A1C improvement

### How might these results change the focus of research or clinical practice?

- ▶ Increasing SMBG frequency in patients with T2D and obesity during intensive weight management should be considered in future recommendations.

further complicates the situation where nearly 87.5% of patients with type 2 diabetes (T2D) are either overweight or obese.<sup>2</sup> Interventional studies in patients with combined T2D and obesity have shown that dietary intervention and increased physical activity can lead to weight reduction and significant improvements in glycemic control. Currently, lifestyle modifications and nutrition therapy are recommended as the first-line treatment for T2D.<sup>3,4</sup> However, patient adherence to lifestyle changes is a major challenge in real-world clinical practice. Lifestyle modifications are particularly difficult to achieve in many patients without accompanying real-time biofeedback to keep them motivated. Self-monitoring of blood glucose (SMBG) was introduced in 1971 and has been a valuable tool for providing feedback on glycemic control.<sup>5</sup> SMBG revolutionized diabetes

management, particularly in patients treated with intensive insulin therapy (IIT), requiring them to test 6–10 (or more) times per day.<sup>6–9</sup> Such high frequency of SMBG in patients with type 1 diabetes on IIT was shown to be associated with a greater reduction in A1C and lower incidence of complications.<sup>4 6 10</sup> While the American Diabetes Association emphasizes the importance of frequent SMBG in patients on IIT, it clearly states the lack of evidence on clinical utility of specific SMBG frequency in patients with T2D treated with oral antihyperglycemic agents and/or basal insulins.<sup>8</sup>

Several randomized controlled trials (RCT) debated the utility of frequent SMBG in non-insulin-treated patients with T2D. It was suggested that integrating feedback from SMBG into clinical and lifestyle decisions may help in achieving glycemic targets in these patients.<sup>8</sup> A meta-analysis of 15 RCTs showed that in non-insulin-treated patients with T2D, the use of SMBG was associated with greater reduction in A1C compared with non-SMBG.<sup>11</sup> Bosi *et al* found that use of a structured SMBG plan led to improved glycemic control among non-insulin-treated patients with T2D compared with patients who did not follow a structured SMBG plan.<sup>12</sup> A more recent meta-analysis concluded that using structured SMBG data to adjust diabetes medications was tied to greater A1C reduction in non-insulin-treated patients with T2D.<sup>13</sup> Although Martin *et al* showed that use of SMBG was associated with lower event rates of stroke and myocardial infarction among patients with T2D compared with non-SMBG users, blood pressure and lipid profile were not different in SMBG users compared with non-SMBG users.<sup>14</sup> Therefore, data are lacking on whether more frequent SMBG has any impact on body weight, glycemic control, and cardiovascular disease (CVD) risk factors during short-term intensive multidisciplinary weight management (IMWM) programs in real-world clinical practice among patients with T2D and obesity.<sup>8 15–19</sup>

We aimed to investigate the relationship between frequency of SMBG and changes in body weight, glycemic control, and CVD risk factors in patients with T2D and obesity enrolled in an IMWM program.

## METHODS

### The IMWM program

The Weight Achievement and Intensive Treatment (Why WAIT) is a 12-week IMWM program designed for patients with diabetes and obesity in real-world clinical practice. It was created in 2005 and has been delivered since then at a tertiary medical center in Boston, MA. Participants enrolled in the program should have a body mass index (BMI) of 30–45 kg/m<sup>2</sup> and be able to exercise. Qualified patients are enrolled in groups of 12–15 participants. Interventions are conducted weekly at the center in 2-hour group sessions over 12 consecutive weeks. All services provided in the Why WAIT program are classified as reimbursable and participation in the

program is covered by most insurance plans. A detailed description of the program was previously published.<sup>20–22</sup> We will briefly outline the four essential components of the program.

### Medication adjustments

Weight gain-promoting medications were substituted, whenever possible, with weight neutral or weight loss-promoting medications.<sup>23</sup> Insulin therapy was used by 45% of past participants. At the beginning of the program, insulin doses were reduced by 20%–30% for patients with A1C <7.5% but remained the same for patients with A1C ≥7.5% then adjusted during the program on a weekly basis after careful reviewing of SMBG, food, and exercise logs. Patients who were unable to follow the medication adjustments plan were excluded to avoid the risk of severe hypoglycemia during weight reduction. Patients were medically evaluated for 30 min at weeks 4 and 8 by a nurse practitioner and at week 12 by a diabetologist.

### Structured medical nutrition therapy

A registered dietitian provided participants with hypocaloric meal plans based on their age, sex, typical caloric intake, and physical activity. Carbohydrates made up ~40%–45% of daily calories, fat <35% with saturated fat <10%, 1–1.5 g/kg of adjusted body weight from protein, and 14g of fiber per 1000 calories.

### Exercise intervention

An exercise physiologist (EP) created individualized exercise plans based on each participant's health status and exercise capacity in addition to a weekly 60 min group exercise sessions under EP supervision. During the program, participants were instructed to increase their exercise duration and frequency from 20 min 4 days/week to 60 min 5–6 days/week.

### Behavioral intervention

Clinical psychologists and behavioral therapists used validated cognitive-behavioral therapeutic methods for weight management during once-weekly group behavioral support sessions.<sup>24 25</sup> This included: behavioral goal setting, self-monitoring of food intake and exercise, stimulus control techniques, and relapse prevention.<sup>24 25</sup>

Didactic group education sessions were conducted weekly for 30 min and were led by a diabetologist, an EP, a registered dietitian, or clinical psychologist during the 12-week IMWM program. Each session discussed a different topic related to weight and diabetes management.

### Self-monitoring of blood glucose

Irrespective of insulin use, participants in the Why WAIT program were encouraged to self-monitor their blood glucose using a personal glucometer on a daily basis before each meal, at bed time, before and after exercise, occasionally 2–3 hours after meals, and when they feel their blood glucose is low or high. Each week, participants were asked to bring their personal glucometers to the

medical center. SMBG data from the glucometers were synced to a cloud-based diabetes management system at an in-office kiosk (Glooko, Mountain View, CA, USA). Glooko is a telemonitoring system that allows patients to upload their SMBG data to the cloud and share it with their diabetes care team. SMBG data were transferred to an endocrinologist-accessed web cloud (population tracker) and were used by the program providers to make weekly informed therapeutic decisions in adjusting participants' antihyperglycemic medications as deemed necessary.

### Study subjects and design

Due to the retrospective nature of this study, a waiver of the consent process was granted by the Committee on Human Studies (CHS) at the Joslin Diabetes Center (CHS waiver number 2018-01). We retrospectively evaluated 63

adult patients with T2D and obesity who were enrolled in the IMWM program between May 2016 and April 2018. Twenty-one patients did not upload or had incomplete SMBG data during the 12-week program and were excluded from the study. A total of 42 patients (67%) transmitted complete SMBG data for the 12 weeks' duration of the program and were included in the analysis (mean age  $57\pm 9$  years, females 50%, diabetes duration  $10\pm 8$  years, body weight of  $107.5\pm 21$  kg, BMI  $36\pm 6$  kg/m<sup>2</sup>, A1C  $7.8\%\pm 1.4\%$ , and 45% were treated with insulin). We divided participants in ordered distribution into tertiles based on average frequency of SMBG over 12 weeks with each tertile containing 14 participants. Demographic and clinical data at baseline, during the program, and at 12 weeks were collected from electronic medical records. Table 1 shows the baseline characteristics of study tertiles.

**Table 1** Demographic and baseline characteristics of study tertiles

	Lowest tertile (n=14)	Middle tertile (n=14)	Highest tertile (n=14)	P value*
Age (years)	58.7 (9)	56 (9)	55.5 (8.5)	0.6
Female sex (%)	42.8	42.8	64.3	0.4
Race/ethnicity (%)				
Non-Hispanic White	42.8	71.4	35.7	0.1
African-American	7.2	7.2	7.2	1
Asian	0	0	0	–
Hispanic	0	0	0	–
Other/not reported	50	21.4	57.1	0.1
Diabetes duration (years)	11.5 (8)	11 (9)	9 (7.3)	0.6
Weight (kg)	107.6 (20.3)	107.4 (19.2)	107.4 (24)	0.9
Body mass index (kg/m <sup>2</sup> )	36.5 (6.5)	34.5 (4.5)	37.4 (5.9)	0.4
A1C (%)	7.5 (1.0)	8.0 (1.5)	8.0 (1.6)	0.6
Use of insulin therapy (%)	42.9	35.7	57.1	0.5
Weight-adjusted insulin dose (units/kg/day)†	0.49 (0.3)	0.85 (0.4)	0.44 (0.3)	0.1
Other diabetes medications (%)				
Metformin	93	64	86	0.1
SFUs	21	7	14	0.5
DPP-4 inhibitors	0	0	14	0.1
SGLT-2 inhibitors	50	79	57	0.3
GLP-1 analogs	64	57	50	0.7
Systolic blood pressure (mm Hg)	129 (15)	129 (15)	134 (17)	0.6
Diastolic blood pressure (mm Hg)	77 (8)	77 (7)	79 (6)	0.6
Total cholesterol (mg/dL)	144 (21)	164 (34)	173 (40)	0.08
LDL-cholesterol (mg/dL)	74 (17)	88 (33)	88 (26)	0.3
HDL-cholesterol (mg/dL)	48 (12)	46 (11)	56 (16)	0.1
Triglycerides (mg/dL)	113 (30)	188 (226)	150 (82)	0.4

Data are mean (SD) or %.

\*One-way analysis of variance (ANOVA) or Pearson's  $\chi^2$  test.

†For insulin-treated subjects.

DPP, dipeptidyl peptidase; GLP, glucagon-like-peptide; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SFU, sulfonylurea; SGLT, sodium-glucose transport proteins.

### Statistical analysis

Demographic and baseline characteristics were evaluated using descriptive statistics. Continuous variables are reported as mean±SD or median (IQR) as appropriate for their distribution as determined by Shapiro-Wilk test. Categorical variables are presented as percentages. The descriptive characteristics of the three tertiles were compared using one-way analysis of variance for continuous variables, and Pearson's  $\chi^2$  test for categorical variables. The study outcomes were calculated as end of IMWM program minus baseline values. A non-parametric test for trend across ordered tertiles, an extension of the Wilcoxon rank-sum test, was used to explore the relationship between the tertile of SMBG frequency and change in metabolic outcomes. Univariate and multivariable linear regressions were used to investigate the association between SMBG frequency and changes in body weight and A1C. A two-sided p value <0.05 was considered statistically significant. Statistical analysis was conducted using STATA Special Edition V.15.0 for Windows (StataCorp, College Station, Texas, USA, 2017).

## RESULTS

### Characteristics of study tertiles

At baseline, mean body weight was 107.6±20.3 kg in the lowest tertile of SMBG frequency, 107.4±19.2 kg in the middle tertile, and 107.4±24 kg in the highest tertile. A1C was 7.5%±1.0%, 8.0%±1.5%, and 8.0%±1.6%, respectively. At baseline, there were no significant differences among the three tertiles in age, sex, race, duration of diabetes, insulin use, A1C, body weight, or BMI. Nine patients (64.3%) in the lowest tertile, 11 (78.6%) in the middle tertile, and 10 (71.4%) in the highest tertile attended 11–12 sessions (92%–100%) of the IMWM program. The remaining patients attended 8–10 sessions (p=0.7 between tertiles).

### Frequency of SMBG in study tertiles

Mean (range) SMBG frequency was 2.3 (1.1–2.9) times per day in the lowest tertile, 3.4 (3–3.9) times per day in the middle tertile, and 5 (4–7.7) times per day in the highest tertile. Only one participant in the highest tertile performed SMBG on average >7 times per day.

### Changes from baseline to 12 weeks in SMBG frequency tertiles

#### Frequency of SMBG and change in body weight

After 12 weeks, higher frequency of SMBG was associated with significantly higher magnitude of weight loss in comparison to lower frequency of testing (table 2). Participants in the highest tertile achieved a median change (IQR) in body weight of -10.4 kg (-7.6 to -14.4 kg) compared with -8.3 kg (-5.2 to -12.2 kg), and -6.9 kg (-4.2 to -8.9 kg) in the middle and lowest tertiles, respectively (p=0.018 for linear trend across tertiles). This translated to a BMI change of -3.9 kg/m<sup>2</sup> (-2.8 to -4.9 kg/m<sup>2</sup>), -2.7 kg/m<sup>2</sup> (-1.6 to -3.9 kg/m<sup>2</sup>), and -2.5 kg/m<sup>2</sup> (-1.5 to -3.3 kg/m<sup>2</sup>), respectively (p=0.012 for linear trend across tertiles).

To confirm these findings, we examined the association between SMBG frequency and the main outcome measure of change in body weight in the total cohort (n=42). Linear regression analyses revealed a significant association between SMBG frequency and change in body weight over 12 weeks (table 3). In multivariable analyses, this association remained significant after adjusting for age, sex, and baseline BMI (model 1). After adjusting for age, sex, baseline BMI, and diabetes duration, the results were similar to the unadjusted model (model 2). Furthermore, the association remained significant after adjusting for age, sex, baseline BMI, diabetes duration, and use of insulin therapy (model 3).

**Table 2** Changes in metabolic parameters at 12 weeks in study tertiles

	Lowest tertile (n=14)	Middle tertile (n=14)	Highest tertile (n=14)	P value†
Body weight (kg)	-6.9 (-4.2 to -8.9)	-8.3 (-5.2 to -12.2)	-10.4 (-7.6 to -14.4)	0.018*
BMI (kg/m <sup>2</sup> )	-2.5 (-1.5 to -3.3)	-2.7 (-1.6 to -3.9)	-3.9 (-2.8 to -4.9)	0.012*
A1C (%)	-0.5 (-0.2 to -1.2)	-0.8 (-0.3 to -2)	-1.25 (-0.6 to -3.1)	0.048*
Systolic blood pressure (mm Hg)	1 (-16 to 6)	-3.5 (-13 to 8)	-12 (-17 to -5)	0.1
Diastolic blood pressure (mm Hg)	0.5 (-4 to 4)	-3.5 (-10 to 0)	-5 (-10 to 0)	0.1
Total cholesterol (mg/dL)	-12 (-18.5 to -4.5)	-16 (-21 to 5)	-19 (-37 to -8)	0.2
LDL-cholesterol (mg/dL)	-11.5 (-15 to 1)	-0.5 (-13 to 13)	-7 (-20 to 5)	0.7
HDL-cholesterol (mg/dL)	2 (0 to 8)	3.5 (-1 to 4)	-2 (-5 to 2)	0.06
Triglycerides (mg/dL)	-12 (-28 to 14)	-31.5 (-55 to -10)	-30 (-75 to -13)	0.08
Weight-adjusted insulin dose (units/kg/day)‡	-0.18 (-0.34 to -0.12)	-0.38 (-0.44 to -0.23)	-0.2 (-0.8 to 0.17)	0.5

Data are median (IQR).

\*P<0.05.

†Non-parametric test for trend across ordered groups, an extension of the Wilcoxon rank-sum test.

‡For insulin-treated subjects.

BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

**Table 3** Association between change in body weight and self-monitoring of blood glucose (SMBG)

	Crude		Model 1		Model 2		Model 3	
	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value
SMBG frequency (times per day)	-1.044 (-2.062 to -0.272)	0.044	-0.972 (-1.934 to -0.011)	0.048	-1.013 (-1.997 to -0.0294)	0.044	-1.117 (-2.158 to -0.0757)	0.036

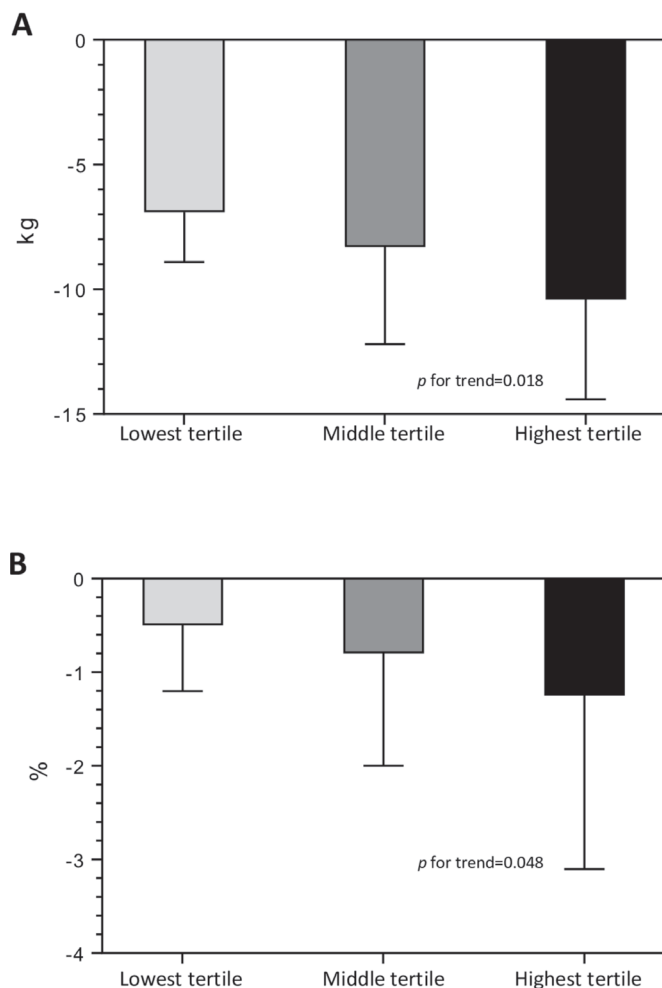
Model 1 is adjusted for age, sex, and baseline body mass index (BMI).

Model 2 is adjusted for age, sex, baseline BMI and diabetes duration.

Model 3 is adjusted for age, sex, baseline BMI, diabetes duration and use of insulin therapy.

### Frequency of SMBG and change in A1C

Similarly, higher frequency of SMBG was associated with significantly lower A1C in comparison to lower frequency of testing. Median change (IQR) of A1C was  $-1.25\%$  ( $-0.6\%$  to  $-3.1\%$ ) in the highest tertile compared with  $-0.8\%$  ( $-0.3\%$  to  $-2\%$ ) and  $-0.5\%$  ( $-0.2\%$  to  $-1.2\%$ ) in the middle and lowest tertiles, respectively ( $p=0.048$  for linear trend across tertiles) (figure 1). In our cohort, changes in A1C at 12 weeks were significantly associated



**Figure 1** Median change (IQR) in (A) body weight and (B) A1C across SMBG tertiles at 12 weeks.  $n=14$  in each tertile. Mean (range) SMBG frequency was 2.3 (1.1 to 2.9) times per day in the lowest tertile, 3.4 (3 to 3.9) times per day in the middle tertile, and 5 (4 to 7.7) times per day in the highest tertile.

with baseline A1C levels ( $R^2=0.76$ ,  $p<0.0001$ ). Although the weak association between SMBG frequency and reduction in A1C did not reach statistical significance in simple linear regression ( $R^2=0.18$ ,  $p=0.06$ ) (table 4), this association was strengthened after adjusting for baseline A1C (adjusted  $R^2=0.77$ ,  $p<0.05$ ) (model 1). Furthermore, this association remained significant after adjusting for baseline A1C, age, sex and diabetes duration (model 2) as well as use of insulin therapy (model 3).

Among insulin-treated patients, 5 (62.5%) in the highest tertile stopped insulin by the end of the 12-week IMWM program compared with 1 (20%) and 1 (16.7%) in the middle and lowest tertiles, respectively ( $p=0.14$  between tertiles).

### Frequency of SMBG and change in CVD risk factors

Changes in blood pressure and lipid profile showed no significant relation to tertile of SMBG frequency (table 2).

## DISCUSSION

To our knowledge, this study is among the first to evaluate the relationship between the frequency of SMBG and body weight, glycemic control, and CVD risk factors in patients with T2D and obesity during an IMWM program. After dividing participants into three tertiles based on the frequency of daily SMBG, we found a significant relationship between SMBG frequency and changes in body weight and A1C over 12 weeks, with reductions in body weight and improvement in A1C being higher in those who frequently monitored their blood glucose irrespective of insulin use. These findings indicate a possible increased benefit by recommending higher frequency of SMBG during IMWM programs. Although attendance of the IMWM program sessions was similar across study tertiles, this might not reflect actual active engagement in the different components of the IMWM program. The results of this study may be attributed to patients' improved exercise behavior and adherence to the recommended dietary plan consequent to real-time feedback from SMBG during IMWM in patients with T2D and obesity.<sup>26</sup> Although participants enrolled in the Why WAIT program were generally testing their blood glucose more frequently than average patients in diabetes clinics, providing them with additional strips and/or justifying the necessity for frequent glucose testing with their

**Table 4** Association between change in A1C and self-monitoring of blood glucose (SMBG)

	Crude		Model 1		Model 2		Model 3	
	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value
SMBG frequency (times per day)	-0.241 (-0.496 to 0.013)	0.06	-0.131 (-0.261 to -0.0007)	0.049	-0.158 (-0.276 to -0.041)	0.009	-0.182 (-0.303 to -0.062)	0.004

Model 1 is adjusted for baseline A1C.

Model 2 is adjusted for baseline A1C, age, sex, and diabetes duration.

Model 3 is adjusted for baseline A1C, age, sex, diabetes duration and use of insulin therapy.

insurance plans clearly added further benefits during the intervention.

In this cohort, the findings of a strong trend toward higher magnitude of weight loss and reduction in BMI with more frequent SMBG (table 2) were confirmed in multivariate analyses accounting for important confounders including age, sex, baseline BMI, diabetes duration, and use of insulin therapy (table 3).

It is important to note that participants in the middle and highest tertiles of SMBG frequency had a mean baseline A1C of  $8.0\% \pm 1.5\%$  and  $8.0\% \pm 1.6\%$ , respectively, compared with  $7.5\% \pm 1.0\%$  for peers in the lowest tertile. Although we initially found a weak trend toward better glycemic control with increased frequency of SMBG, the marginal p for trend (0.048) (table 2) mirrored the absence of a statistically significant association in the unadjusted linear regression analysis ( $p=0.06$ ) (table 4). However, after adjusting for baseline A1C, the association between SMBG frequency and reduction in A1C reached statistical significance indicating confounding effect of baseline A1C on the magnitude of improvement in glycemic control over the 12-week IMWM program. This is consistent with findings from a meta-analysis of nine RCTs that evaluated the benefits of SMBG on glycemic control in patients with T2D where A1C significantly improved in the subgroup of patients whose mean baseline A1C was  $\geq 8.0\%$  in contrast to those with baseline A1C  $< 8.0\%$ .<sup>27</sup> Park *et al* showed that perception of time has an effect on glycemic variability in patients with T2D,<sup>28</sup> however, it is unknown if the perception of SMBG values has similar effects on long-term glycemic control.

In this cohort, we did not observe any relationship between tertile of SMBG frequency and changes in blood pressure or lipid profile, which was not a surprise since all participants showed improvement in these cardiovascular risk factors by the end of the 12-week program.

This study has several limitations including its retrospective design, small sample size, the lack of a control group, and being conducted at a single tertiary care center. Retrospective design might help our purpose in reflecting the reality of frequency of testing in real practice when more testing is recommended at the beginning. It also prevents dilution of results if poor adherence non-intentionally plagued the high-testing groups in the prospective design. Increasing the sample size may increase the power of the study and limit the

margin of errors. Having a control group may add some value, but the main purpose of the study is to compare the impact of SMBG frequency within a cohort exposed to the same IMWM program. This IMWM program requires a considerable time commitment and financial resources from its participants which may limit the generalizability of these results. However, study tertiles had similar racial/ethnic distribution. Furthermore, scientifically known confounders were adjusted for in our statistical analyses in a systematic way to help with interpreting the results. Data on physical and mental quality of life and barriers to performing SMBG and/or uploading SMBG data were lacking due to the retrospective design of the study. However, despite these limitations, our study suggests that increased SMBG frequency may be important during IMWM to obtain maximal weight loss and glycemic improvement and may warrant the use of continuous glucose monitors in patients with T2D and obesity during intensive weight reduction irrespective of insulin use. This assumption may need to be confirmed in a randomized clinical study that evaluates the effect of different SMBG frequencies on body weight and glycemic control in patients with T2D and obesity during an IMWM program, and puts into consideration the cost-effectiveness of using a continuous glucose monitor during weight loss. While previous studies compared SMBG with non-SMBG users with T2D and evaluated the change in A1C among patients with T2D who followed a structured compared with a non-structured SMBG plan,<sup>11 12</sup> our study is the first to describe the relationship between ascending frequencies of SMBG and the direction of change in body weight during an IMWM program. The real-world nature of this study helps minimize the discrepancies in effectiveness that are frequently noted between clinical trials and real-world clinical practice.<sup>29</sup>

In conclusion, this study showed that patients with T2D and obesity who engage in more frequent SMBG during a 12-week IMWM program achieve more favorable weight loss outcomes and greater reductions in A1C. This association remained significant after adjusting for age, sex, baseline BMI and A1C, diabetes duration, and use of insulin therapy. These results suggest possible future recommendations for increasing SMBG frequency in patients with T2D during IMWM to reach optimal outcomes.

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