Self-monitoring of Blood Glucose Among Type-2 Diabetic Patients: An Analytical Cross-Sectional Study

Ahmed S. Alzahrani (1)
Rishi K. Bharti (2)
Hassan M. Al-musa (3)
Shweta Chaudhary (4)

(1) Family and Community Medicine specialist, Aseer Health Affairs, Abha, Saudi Arabia
(2) Assistant Professor, Community medicine consultant, Faculty of Medicine,
King Khalid University, Saudi Arabia.
(3) Associate Professor, Family Medicine consultant, Family and Community medicine department,
Faculty of medicine, King Khalid University, Saudi Arabia.
(4) Assistant Professor, Department of Anatomy, Faculty of Medicine, King Khalid University,
Saudi Arabia.

Corresponding author:
Dr. Ahmed Salem Al-zahrani,
Family Medicine specialist, Community Medicine resident
Abha, King Khalid University, Saudi Arabia
Email: ahmedalzahrani122333@gmail.com

Abstract

Background: Diabetes mellitus (DM) is a public health disease needing urgent consideration; it has a great impact on human life in addition to being costly to manage. According to the current recommendations, self-monitoring of blood glucose (SMBG) is important in order to achieve and maintain glycemic control, prevent and identify hypoglycemia, prevent severe hyperglycemia and support lifestyle changes.

Methods: The objective of this study is to explore the effect of using SMBG on glycemic control among type 2 diabetic patients attending the primary health care centers in Abha city in the Kingdom of Saudi Arabia, by comparing those who are monitoring themselves and others who are not. The study design was analytical cross-sectional and conducted through an interviewing questionnaire.

Results: The age of participants was 30-82 years old, with a mean age distribution of 57.4 years old. The percentages of groups doing and not doing SMBG were 43% and 57% respectively. Chi square tests show that the relationship between glycemic control and SMBG is statistically significant according to frequency and time of doing SMBG, since al- most all of the results for the participants who do SMBG are above the target for glycemic control (>=7%). The relationship between glycemic control and compliance according to SMBG shows there is a statistically significant relationship with appointment compliance among the group doing SMBG, and with drug compliance among the other group.

In both groups, almost all the participants were above the target for control (>=7%), which means that there is no relationship between doing SMBG and better glycemic control.

Conclusion: There is not sufficient evidence to show that the self-monitoring of blood glucose is associated with an improvement in glycemic control among type 2 diabetics and it is shown that glycemic control for both groups that are using and not using SMBG is above the target. It is recommended that more well conducted randomized controlled trials should be undertaken to evaluate the relationship between SMBG and glycemic control in type 2 diabetes, at the same time the current guidelines for the use of SMBG among patients with well controlled non-insulin treated type 2 diabetes need to be reviewed.

Key words: Self-monitoring, blood glucose (SMBG), glycemic control, type 2 diabetes, comorbidities.

Introduction

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia that results from defects in insulin secretion, action or both(1).

Diabetes can be classified into type 1 diabetes (B-cell destruction usually leading to absolute insulin deficiency), type 2 diabetes (ranging from being characterized predominantly by insulin resistance with relative insulin deficiency to predominantly an insulin secretory defect with insulin resistance) and other specific types of diabetes (1).

Diabetes and its complications are major causes of death in many countries. Type 2 is the most prevalent type occurring in up to 91% of adults with diabetes in high-income countries. It is estimated that 193 million people with diabetes are undiagnosed and they are more at risk of developing complications (2).

The prevalence of type 2 diabetes in Saudi Arabia is about 32.8%; the predicted prevalence will be 35.37% in 2020; 40.37% in 2025 and 45.36% in the year 2030. The coefficient on time factor indicates that the prevalence rate has increased from 1982-2015 (3).

Saudi Arabia should include preventive measures against diabetes on a war footing basis in its national health policy to minimise the burden of the disease (3).

In patients with type 2 diabetes, SMBG can help to achieve better glycemic control, although there is not sufficient evidence to confirm that strict monitoring in these patients is associated with an improved outcome (4).

The outcome of several clinical studies, especially amongst diabetics on insulin therapy, has shown that SMBG plays a key role in preventing complications in the short, medium and long term.

According to the American Diabetes Association (ADA) and the National Academy of Clinical Biochemistry (NACB), patients and healthcare personnel should be trained on the appropriate use of the device, as well as on the correct interpretation of data (5).

In type 2 diabetes, the efficacy of frequent glucose measurements remains uncertain. The results of studies suggest that SMBG can play an important role in improving metabolic control if it is an integral part of a wider educational strategy (6).

Higher SMBG testing rates were associated with lower HbA1c, only when stratifying the analyses to control for treatment intensification (4).

A significant reduction in HbA1c levels was associated with Asian populations, in a small sample size, and telecare, and with those patients with baseline HbA1c greater than 8.0% (7).

There was no convincing evidence to support a recommendation for routine self- monitoring of all patients and no evidence of improved glycemic control in predefined subgroups of patients(8).

SMBG indications can be used as a measure for acute correction ("primary adjustment"), if blood glucose levels are increased or decreased during intensive insulin therapy, when correction may be made with rapid-acting insulin or administration of carbohydrate (9).

The OneTouch® Select Simple™ glucose meter meets current regulatory expectations for glucose meter performance (10) and consideration of personal aspects of daily living that impact on an individual's ability to achieve their desired glycemic control(11).

Optimal glycemic control will improve long-term outcomes in many patients with diabetes. Tools such as new therapeutics and advanced technology, including highly accurate BGMSs, will help patients, working alongside their diabetes teams, to achieve the goal of improved glucose control (12).

The health burden due to DM in Saudi Arabia is predicted to rise to catastrophic levels, unless a wide-ranging epidemic control program is adopted, with great emphasis on healthy diet, including exercise and active lifestyles, and weight control. To properly manage DM in Saudi Arabia, a multidisciplinary approach is required (13).

SMBG is recommended as an essential part of daily DM management regardless of type and mode of treatment strategy of adjusting medication at monthly intervals based on intensified SMBG data can be adopted in conjunction with HbA1c results to achieve better glycemic control (14). According to one published study, 15.3% of people with type 2 diabetes practice SMBG (15).

Results of a Saudi study conclude that SMBG has a positive impact on glycemic control, expressed as decrease in HbA1c levels with time post referral(19). T2DM patients following SMBG have shown better lifestyle changes and compliance to drug therapy. It could be due to regular monitoring of blood glucose levels thereby patients became motivated and understood the importance of dietary changes, regular exercise and intake of antidiabetic pills in controlling the disease and its associated complications(19). Patients following SMBG have also shown a more positive attitude and awareness about diabetes and risk factors associated with it than patients without SMBG follow-up (19).

According to ADA, the glycemic targets are : HBA1c at target (defined as <7%) and not at target (defined as ≥7) (19). FBS at target (defined as 80-130mg/dl) and not at target (defined as >130mg/dl.) (20). RBG at target (defined as <180 mg/dl.) and not at target (defined as ≥180mg/dl) (20).

This study aimed to explore the effect of using SMBG on glycemic control among type 2 diabetic patients at Abha city's PHCCs.

Materials and methods

This research had an analytical cross-sectional study design to explore the effect of SMBG on glycemic control among type 2 diabetics in Abha city's PHCCs by comparing those who are doing it and others who are not doing it.

Type 2 diabetic patients attending governmental primary health care centres (PHCCs), excluding those with type 1 and gestational diabetes, made up the study population. There are about 10 primary health care centres in Abha city according to Abha sector of Aseer health affairs, serving about 5,000 diabetic patients. The study used STATCALC EPI software and the sample size was 314 calculated. The sample was recruited using systematic random sampling of patients attending the PHC.

The data were collected using a validated questionnaire which was distributed and initiated through an interview with participants. The study was approved by the ethical committee (institutional review board), and permission was granted by Aseer health affairs. Consent was obtained from participants verbally. Data were cleaned, coded, entered and analyzed using SPSS version 21.

Results

Participants were aged between 30 and 82 years old with a mean age distribution of 57.4. Males constituted 47.8% of the sample and females made up 52.2%. The bio-demographic characteristics of type 2 diabetic patients according to their self-monitoring of blood glucose status are shown in Table 1.

Table 1: Bio-demographic characteristics of type 2 diabetic patients according to their self-monitoring of blood glucose status

Bio-demographic characteristics		Doing SMBG in last 6months						P
		Yes		No		Total		
		No	%	No	%	No	%	
Gender	male	65	48.1%	85	47.5%	150	47.8%	.907
	female	70	51.9%	94	52.5%	164	52.2%	
Age in years	30-49	26	19.3%	32	17.9%	58	18.5%	.016*
	50-59	66	48.9%	63	35.2%	129	41.1%	
	60-69	19	14.1%	50	27.9%	69	22.0%	
	70-89	24	17.8%	34	19.0%	58	18.5%	
Nationality	Saudi	135	100.0%	160	89.4%	295	93.9%	.001*
	Not Saudi	0	0.0%	19	10.6%	19	6.1%	
Marital status	Unmarried	10	7.4%	12	6.7%	22	7.0%	.809
	Married	125	92.6%	167	93.3%	292	93.0%	
Occupation	worker	31	23.0%	34	19.0%	65	20.7%	.001*
	retired	44	32.6%	31	17.3%	75	23.9%	
	housewife	37	27.4%	100	55.9%	137	43.6%	
	other	23	17.0%	14	7.8%	37	11.8%	
Educational status	illiterate	38	28.1%	113	63.1%	151	48.1%	.001*
	educated	97	71.9%	66	36.9%	163	51.9%	
Smoking status	ex-smoker	26	19.3%	0	0.0%	26	8.3%	.001*
	non-smoker	86	63.7%	145	81.0%	231	73.6%	
	current smoker	23	17.0%	34	19.0%	57	18.2%	

6 * P < 0.05 (significant)

Table 2 reveals complications of diabetes were present in about 43.9% of the participants (46.7% among the group doing SMBG) with 25.4% Retinopathy (14.3% were doing SMBG and 34.7 were not), Neuropathy is about 51.4% (23.8% were doing SMBG and about 74% were not). About 78.3 % of participants had diabetes for five years or more (87.4% among those doing SMBG), the majority of treatment received was by metformin in about 82.2% of participants: 69.6% were doing SMBG and 91.6% were not; the lowest is glimepiride by 5.1%. Comorbidities of diabetes were present in 51.3% of all participants: hypertension 50%, lipid disorders 26%, obesity 4% and others 20%.

In the group doing SMBG: 46% had comorbidities and 54% had no comorbidities, while in the other group: 55% had comorbidities and 45% had no comorbidities.

Our result shows, causes of not doing SMBG were mainly because of unavailability of strips (36%) and no desire (about 24%).

Table 2: Diabetes data for patients according to their self-monitoring of blood glucose status

Diabetes data		Doing SMBG in last 6months						P
		Yes		No		Total		
		No	%	No	%	No	%	
Duration of DM	0-6 months	0	0.0%	12	6.7%	12	3.8%	
	1-3 years	10	7.4%	7	3.9%	17	5.4%	.001*
	3-5 years	7	5.2%	32	17.9%	39	12.4%	
	5 years or more	118	87.4%	128	71.5%	246	78.3%	
Treatment received #	Glibenclamide	34	25.2%	45	25.1%	79	25.2%	.993
	Gliclazide	22	16.3%	47	26.3%	69	22.0%	.035*
	Metformin	94	69.6%	164	91.6%	258	82.2%	.001*
	Metformin XR	29	21.5%	10	5.6%	39	12.4%	.001*
	Glimepiride	0	0.0%	16	8.9%	16	5.1%	.001*
	Insulin	67	49.6%	52	29.1%	119	37.9%	.001*
	Other Medications	37	27.4%	82	45.8%	119	37.9%	.001*
Complications of diabetes	No	72	53.3%	104	58.1%	176	56.1%	.399
	Yes	63	46.7%	75	41.9%	138	43.9%	
If yes, mention # (n=138)	Retinopathy	9	14.3%	26	34.7%	35	25.4%	.006*
	Nephropathy	9	14.3%	5	6.7%	14	10.1%	.140
	Cardiovascular	37	58.7%	41	54.7%	78	56.5%	.631
	Neuropathy	15	23.8%	56	74.7%	71	51.4%	.001*

#: more than one answer was allowed
* P < 0.05 (significant)

Table 3   shows the number of people doing SMBG three times a day was lowest at 5.2%, and twice a day was highest at 45.9%, and moderately more than once   a week by about 25%. Time of doing SMBG was before meals in 59.3%, feeling of hypoglycemic episode 35.6% and during episode of illness 5.2%.

The scale of was SMBG helpful shows extremely helpful in 28.9%, somewhat helpful in 40.7%, slightly helpful in 11.9% and not at all helpful in 0.7%. For reason for SMBG being helpful if scale was 7 or more it indicated the following: improved diabetes control (70.0%), help during episode of illness (12.7%), better to do physical activity (9.1%) and avoid hypoglycemia (8.   Reason for SMBG being helpful if scale is 4 or less is because it is painful 100%. Good diet compliance constitutes about 28 %, fair 55% and poor 18 percent .

Good drug compliance constitutes about 54 percent, fair 45% and poor about 0.64%. Diet compliance among the group doing SMBG was fair (54.1%), good (40%) and poor (10%). Drug compliance among them was fair (29%), good (70%) and poor (1.5%), Physical activity compliance: fair in 63%, good in 24% and poor in 13% appointment compliance: fair in 38%, good in 61% and poor in 0.7%.

Table 3: Relationship between glycemic control and SMBG among type 2 diabetic patients

SMBG		HBA1C				p
		<7%		>=7%		
		No	%	No	%	
Frequency of SMBG	once a day	5	26.3%	14	73.7%	
	twice a day	0	0.0%	62	100.0%	
	three times a day	0	0.0%	7	100.0%	.001*
	once a week	6	46.2%	7	53.8%	
	more than once a week	0	0.0%	34	100.0%	
Time of doing SMBG	before meals	11	13.8%	69	86.3%	
	during episode of illness	0	0.0%	7	100.0%	.016*
	feeling of hypoglycemic episode	0	0.0%	48	100.0%	
Scale of SMBG being helpful	somewhat unhelpful	0	0.0%	3	100.0%	
	slightly unhelpful	0	0.0%	7	100.0%	
	not at all unhelpful	0	0.0%	14	100.0%	
	not at all helpful	0	0.0%	1	100.0%	.377
	slightly helpful	0	0.0%	16	100.0%	
	somewhat helpful	5	9.1%	50	90.9%	
	extremely helpful	6	15.4%	33	84.6%	

* P < 0.05 (significant)

Table 4 shows the relationship between glycemic control and SMBG:

In relation to glycemic control the frequency of SMBG once daily was in 26% at target, once a week in 46% while twice a day, three times a day and more than once a week all were not at target 100%. Time of doing before meals was at target in 14% while during episode of illness and feeling of hypoglycemic episode was not at target 100%. Not all scales of 'helpful' were at target except extremely helpful 15% and somewhat helpful 9% were at target.

Findings elicit the relationship between glycemic control and compliance according to SMBG:

Among the group doing SMBG: diet compliance was good and at target in 9%, fair and at target in 8% and poor and at target 0% drug compliance: good and at target in 12%, fair, poor and at target in 0%. Physical activity compliance: good and at target in 16%, fair and at target in 7% and 0 in poor, Appointment compliance: good and at target 13%, fair, poor and at target 0%.

Findings show that about 57% were not doing SMBG in last 6 months and only 43% were not doing SMBG in last 6 months and only 43% are doing it.

Table 4: Relation between glycemic control and compliance according to SMBG among type II diabetic patients

SMBG	Compliance		HBA1C laboratory results				P
			<7%		>=7%		
			No	%	No	%	
Yes	diet compliance	good	5	9.3%	49	90.7%	
		fair	6	8.2%	67	91.8%	.671
		poor	0	0.0%	8	100.0%	
	drug compliance	good	11	11.7%	83	88.3%	
		fair	0	0.0%	39	100.0%	.073
		poor	0	0.0%	2	100.0%	
	physical activity compliance	good	5	15.6%	27	84.4%	
		fair	6	7.1%	79	92.9%	.127
		poor	0	0.0%	18	100.0%	
	appointment compliance	good	11	13.3%	72	86.7%	
		fair	0	0.0%	51	100.0%	.023*
		poor	0	0.0%	1	100.0%	
No	diet compliance	good	0	0.0%	33	100.0%	
		fair	5	5.0%	95	95.0%	.336
		poor	1	2.2%	45	97.8%	
	drug compliance	good	0	0.0%	75	100.0%	.034*
		fair	6	5.8%	98	94.2%	
	physical activity compliance	good	0	0.0%	33	100.0%	
		fair	5	7.4%	63	92.6%	.063
		poor	1	1.3%	77	98.7%	
	appointment compliance	good	4	7.5%	49	92.5%	
		fair	1	.9%	110	99.1%	.066
		poor	1	6.7%	14	93.3%	

* P < 0.05 (significant)

Discussion

The age of participants was from 30-82 years old with a mean age distribution of 57.4. Males constituted 47.8% of participants and females made up 52.2%, which is similar to some extent to the results of the Fremantle diabetes study (16).

There was a statistically significant difference (p <0.05) in all bio demographic characteristics according to SMBG, and only gender and marital status were insignificant (p >0.050), and these findings are in accordance with the Fremantle diabetes study(16). In terms of diabetic data, the duration of diabetes shows significant differences between the groups doing SMBG and those who were not (p<0.001) also in concordance with Fremantle diabetes study(16); all types of treatment received show significant differences except glibenclamide (p>0.05). The complications in general show an insignificant difference in terms of who had complications or those who were free of them, but among those who had complications, there is a significant difference with retinopathy and neuropathy groups rather than with nephropathy and cardiovascular complications.

Comorbidities with diabetes were present in 51.3% of all the participants; half of them had hypertension and of the other half, one third had a lipid disorder and one quarter had obesity.

Out of our participants, there were 43% self-monitoring blood glucose, and most of the remaining 57% were not doing this because of unavailability of strips and because they had no motivation to.

In terms of the frequency of doing SMBG, approximately half the participants (46%) did it twice a day, mostly before meals (about 60%), followed by more than once a week (25%) and least frequently three times a day and this is similar to results of the Barnard et al study (17).

About 40% of participants who indicated how helpful SMBG was chose 'somewhat helpful', 30% chose 'extremely helpful' and 10% chose 'not at all helpful'. Among those choosing that SMBG is helpful, 70% of them stated that it was because it improved diabetes control, while of the other group not doing SMBG who chose that it was unhelpful, two thirds of them because it reminded them of their illness and discouraged them from making any changes in their lifestyles, and these findings are in accordance with results from the Barnard et al study(17).

All participants who did SMBG and who chose the option stating it was unhelpful indicated that this was because it is painful, also in accordance with previous study (17).

The diet, drug, physical activity and appointment compliance among both groups show significant differences (p<0.001), with good compliance being more prevalent amongst the group doing SMBG while there was more poor compliance among the other group.

The laboratory results show significant differences between both groups in terms of their FBS and RBS results (p<0.05), but not HBA1C results (p>0.05) and these findings are in accordance with impact of self-monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomized trial (18).

In the group doing SMBG, 89% were above the target of control for FBS and 70% for RBS. The relationship between glycemic control and SMBG is statistically significant according to frequency of and time of doing SMBG, demonstrating that all of the results of the participants who did SMBG were above the target for glycemic control (>=7%). This means that doing SMBG is not currently associated with better glycemic control. The relationship between glycemic control and compliance according to SMBG shows there is a statistically significant relationship with appointment compliance among the group doing SMBG, and with drug compliance among the other group.

In both groups, almost all of them were above the target of control (>=7%), again meaning that, there is no relation between doing SMBG and better glycemic control.

The relevance of these findings will add information similar to that of most of the previous studies that concluded the routine using of SMBG among type 2 diabetic patients may be not recommended or if it is done should be highly individualized.

Conclusion

According to the results of this study, there is not sufficient evidence to show that the self-monitoring of blood glucose is associated with an improvement in glycemic control among type 2 diabetics and it is shown that glycemic control for both groups that are using and not using SMBG is above the target.

It is recommended that more well conducted randomized controlled trials should be undertaken to evaluate the relationship between SMBG and glycemic control in type 2 diabetes; at the same time the current guidelines for the use of SMBG among patients with well controlled non-insulin treated type 2 diabetes need to be reviewed.

References

1. American Diabetes Association. Diagnosis and Classification of Diabetes Mellitus. Diabetes Care. 2004; 27 (Supplement 1): S5–10.
2. Tobergte D.R., Curtis S. IDF 2015. J Chem Inf Model. 2013; 53 (9):1689–99.
3. Meo S.A. Prevalence and future prediction of type 2 diabetes mellitus in the Kingdom of Saudi Arabia: A systematic review of published studies. 2016; (April 2015): 2014–7.

4. Murata G.H., Duckworth W.C., Shah J.H., Wendel C.S., Mohler M.J., Hoffman R.M. Blood glucose monitoring is associated with better glycemic control in type 2 diabetes: A database study. J Gen Intern Med. 2009; 24(1): 48–52.

5. Montagnana M., Caputo M., Giavarina D., Lippi G. Overview on self-monitoring of blood glucose. Clin Chim Acta. 2009; 402(1–2): 7–13.

6. Szymborska-Kajanek A., Psurek A., Hese R., Strojek K. Self-monitoring of blood glucose in treatment of type 2 diabetes. Diabetes Res Clin Pract. 2009; 86 (SUPLL.1).

7. Garg S.K., Hirsch I.B. Self-Monitoring of Blood Glucose. Diabetes Technol Ther. 2016; 18 (S1): S-3-S-9.

8. Clarke S.F., Foster J.R. A history of blood glucose meters and their role in self-monitoring of diabetes mellitus. Br J Biomed Sci. 2012; 69(2): 83–93.

9. Nauck M.A., El-Ouaghlidi A., Vardarli I. Self-monitoring of blood glucose in diabetes mellitus: arguments for an individualized approach. Dtsch Arzteblatt Int. 2009; 106 (37): 587–94.

10. Krouwer J.S. Analysis of the Performance of the OneTouch SelectSimple Blood Glucose Monitoring System: Why Ease of Use Studies Need to Be Part of Accuracy Studies. 2011; 5 (6): 1610–1.

11. Kerr D., Messing R., Resch A. Actionable self-monitoring of blood glucose: redefining the role for patients using multiple daily injection therapy. J Diabetes Sci Technol. 2011; 5 (6): 1584–90.

12. Bernstein R., Parkes J.L., Goldy A., Brown D., Harrison B., Chu A., et al. A new test strip technology platform for self-monitoring of blood glucose. J Diabetes Sci Technol. 2013; 7 (5): 1386–99.

13. Al Dawish M.A., Robert A.A., Braham R., Al Hayek A.A., Al Saeed A., Ahmed R.A., et al. Diabetes Mellitus in Saudi Arabia: A Review of the Recent Literature. Curr Diabetes Rev. 2015;

14. Ba-Essa E.M., Mobarak E.I., Alghamdi A., Al-Daghri N.M. Intensified glucose self-monitoring with education in Saudi DM patients. Int J Clin Exp Med. 2015; 8 (10): 19374–80.

15. Ong W.M., Chua S.S., Ng C.J. Barriers and facilitators to self-monitoring of blood glucose in people with type 2 diabetes using insulin: A qualitative study. Patient Prefer Adherence. 2014; 8: 237–46.

16. Davis WA, Bruce DG, Davis TM. Is self-monitoring of blood glucose appropriate for all type 2 diabetic patients? The Fremantle diabetes study. Diabetes Care. 2006;29 (8):1764–70.

17. Barnard KD, Young AJ, Waugh NR. Self-monitoring of blood glucose - A survey of diabetes UK members with type 2 diabetes who use SMBG. BMC Res Notes. 2010.

18. Farmer A, Wade A, Goyder E, Yudkin P, French D, Craven A, et al. Impact of self monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomised trial. BMJ. 2007.

19. Vijayaraghavalu S et al. / Pharmacie Globale (IJCP) 2015, 03 (01).

20. American Diabetes Association. 6. Glycemic targets: Standards of Medical Care in Diabetes-2018. Diabetes Care 2018; 41(Suppl. 1):S55–S64.