

# Self-Monitoring of Blood Glucose: The Basics

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**S**elf-monitoring of blood glucose (SMBG) is an important component of modern therapy for diabetes mellitus. SMBG has been recommended for people with diabetes and their health care professionals in order to achieve a specific level of glycemic control and to prevent hypoglycemia. The goal of SMBG is to collect detailed information about blood glucose levels at many time points to enable maintenance of a more constant glucose level by more precise regimens. It can be used to aid in the adjustment of a therapeutic regimen in response to blood glucose values and to help individuals adjust their dietary intake, physical activity, and insulin doses to improve glycemic control on a day-to-day basis.

SMBG can aid in diabetes control by:

- facilitating the development of an individualized blood glucose profile, which can then guide health care professionals in treatment planning for an individualized diabetic regimen;
- giving people with diabetes and their families the ability to make appropriate day-to-day treatment choices in diet and physical activity as well as in insulin or other agents;
- improving patients' recognition of hypoglycemia or severe hyperglycemia; and
- enhancing patient education and patient empowerment regarding the effects of lifestyle and pharmaceutical intervention on glycemic control.

Numerous trials have been carried out to determine the true impact of SMBG on glycemic control. Some, including randomized, controlled trials, have demonstrated the efficacy of

SMBG. Among patients with type 1 diabetes, SMBG has been associated with improved health outcomes.<sup>1</sup> Specifically, increasing frequency of SMBG was linearly correlated with reductions in HbA<sub>1c</sub> among type 1 patients in Scotland. Among patients with type 2 diabetes, a higher frequency of SMBG was associated with better glycemic control among insulin-treated patients who were able to adjust their regimen.<sup>2</sup> Other studies, however, have suggested that SMBG has not achieved its true potential impact as an aid to improving glycemic control.

An article analyzing data from the third National Health and Nutrition Examination Survey (NHANES III) concluded that, for patients with type 2 diabetes, there was little correlation between SMBG frequency and glycemic control.<sup>3</sup> This article sparked considerable controversy, including questions regarding the validity of the NHANES III study design to properly examine the relationship between SMBG and glycemic control. Because the NHANES III was a cross-sectional analysis of patient behavior and glycemic control, a cause-and-effect relationship would be difficult to determine. Prospective study designs need to be employed to better understand the role of SMBG in all patients with diabetes.

Nevertheless, most diabetologists agree that self-management of diabetes needs to incorporate some SMBG data, and that motivated patients can benefit from the increased empowerment that SMBG yields. Diabetes specialists now recommend that patients use SMBG data for day-to-day regimen changes and that health care professionals use SMBG data to guide alterations in medication regimens. The American Diabetes Associa-

tion has sanctioned efforts to teach people with diabetes to use SMBG data actively as part of a patient-centered self-management program.

## SMBG Use and Frequency

SMBG works by having patients perform a number of glucose tests each day or each week. The test most commonly involves pricking a finger with a lancet device to obtain a small blood sample, applying a drop of blood onto a reagent strip, and determining the glucose concentration by inserting the strip into a reflectance photometer for an automated reading. Test results are then recorded in a logbook or stored in the glucose meter's electronic memory. People with diabetes can be taught to use their SMBG results to correct any deviations out of a desired target range by changing their carbohydrate intake, exercising, or using more or less insulin.

The frequency with which patients with diabetes should monitor their blood glucose level varies from person to person. Most experts agree that insulin-treated patients should monitor blood glucose at least four times a day, most commonly fasting, before meals, and before bed. In addition, patients using insulin can benefit by obtaining postprandial blood glucose readings to help them more accurately adjust their insulin regimen. A positive correlation between frequency of SMBG and glycemic control among patients with insulin-treated type 1 or type 2 diabetes has been demonstrated.<sup>1,2</sup> Patients treated with intermediate, short-acting, or rapid-acting insulin may benefit from SMBG data to make adjustments in their regimen.

For patients with type 2 diabetes, optimal SMBG frequency varies

**Table 1. Blood Glucose Meters**

	Weight (oz.)	Sample Size ( $\mu$ L)	Test Time (sec)	Memory (number of readings)	Comments/Special Features
<b>Roche Diagnostics (accu-chek.com)</b>					
Accu-check Simplicity	2	5	25	30	<ul style="list-style-type: none"> <li>English/Spanish instruction</li> </ul>
Accu-check Advantage	3	4	40	100	<ul style="list-style-type: none"> <li>Automatic timing</li> <li>English/Spanish instruction</li> <li>Dataport</li> </ul>
Accu-check Complete	4.4	4	26–40	1,000	<ul style="list-style-type: none"> <li>Offers custom features with trend information graph reports</li> <li>For people who test frequently</li> <li>Readouts in multiple languages</li> </ul>
Accu-check Active	2	1	5–10	200	<ul style="list-style-type: none"> <li>Very small size</li> <li>English/Spanish instruction</li> </ul>
<b>Lifescan (lifescan.com)</b>					
One Touch FastTake	1.6	1.5	15	150	<ul style="list-style-type: none"> <li>Compact meter size</li> <li>Small sample size</li> <li>Alternate site testing</li> </ul>
One Touch Surestep	4.5	10	30	150	<ul style="list-style-type: none"> <li>Simple single-button testing</li> <li>Touchable test strip</li> </ul>
One Touch Profile	4.5	10	45	250	<ul style="list-style-type: none"> <li>Downloadable</li> <li>Data tracking for frequent testers</li> <li>Spanish</li> </ul>
One Touch Basic	3	10	45	75	<ul style="list-style-type: none"> <li>Display in multiple languages</li> </ul>
One Touch Ultra	2	1	5	150	<ul style="list-style-type: none"> <li>Finger or forearm testing</li> </ul>

depending on the pharmaceutical regimen and whether patients are in an adjustment phase or at their target for glycemic control. If a patient is on a stable oral regimen with HbA<sub>1c</sub> concentration within the target range, infrequent SMBG monitoring is appropriate. In such cases, patients can use SMBG data as biofeedback at times of increased stress or changes in diet or physical activity.

For patients whose diabetes is out of control or for those having medication initiated, however, SMBG data can be helpful in creating or modifying the diabetes management regimen. Persistent fasting hyperglycemia, for example, might indicate excessive hepatic glucose output, and patients experiencing this problem might derive benefit from using metformin (Glucophage), which has

been shown to decrease nocturnal hepatic glucose output. Additionally, patients with persistent postprandial hyperglycemia might derive benefit from taking a short-acting oral agent with meals to either decrease carbohydrate absorption (i.e., an alpha-glucosidase inhibitor such as acarbose [Precose] or miglitol [Glyset]) or stimulate insulin secretion at the time of the meal (i.e., repaglinide [Prandin] or nateglinide [Starlix]).

People with type 2 diabetes who use insulin should perform SMBG at least four times per week, including at least two fasting and two postprandial values. Additional measurements at bedtime and before meals can also be obtained. Thoughtful interpretation of SMBG data will assist patients and health care providers in selecting appropriate pharmaceutical and lifestyle regimens.

### Recommending a Meter

There are now seven manufacturers and more than 20 types of meters available on the market. Meters vary in size, weight, test time, memory capabilities, and special features. Most meters can measure blood glucose with only a one- or two-step process. Most also incorporate no-wipe technology, which means users do not have to wipe off excess blood after applying a blood drop to the reagent strip. In addition, many meters now require only a very small amount of blood, thus decreasing the pain of deep wounds from the lancet.

A few of the newer meters offer the option of obtaining blood samples from alternate sites, such as a forearm instead of a fingertip. This can benefit patients who find constant lancet wounds on their fingers difficult to tolerate.

Table 1. Blood Glucose Meters cont'd

	Weight (oz.)	Sample Size ( $\mu$ L)	Test Time (sec)	Memory (number of readings)	Comments/Special Features
<b>Bayer (glucometer.com)</b>					
Glucometer Elite XL	1.75	2	30	120	<ul style="list-style-type: none"> <li>• Individual foil-wrapped strips</li> <li>• No buttons</li> <li>• Auto on/off</li> <li>• English/Spanish instruction</li> <li>• Dataport</li> </ul>
Glucometer DEX	2.5	4	30	100	<ul style="list-style-type: none"> <li>• No strip handling</li> <li>• 10-strip disc cartridge</li> <li>• Dataport</li> </ul>
Glucometer Elite	1.75	2	30	120	<ul style="list-style-type: none"> <li>• Individual foil-wrapped strips</li> <li>• No buttons</li> <li>• Auto on/off</li> <li>• English/Spanish instruction</li> </ul>
<b>Medisense (medisense.com)</b>					
Precision Xtra	1.6	3	20	450	<ul style="list-style-type: none"> <li>• Uses full words for prompts</li> <li>• Individual foil-wrapped strips</li> <li>• Touchable strip</li> <li>• Dataport</li> <li>• Five languages</li> </ul>
Precision QID	1.5	3	20	10	<ul style="list-style-type: none"> <li>• Uses abbreviations for prompts</li> <li>• Individual foil-wrapped strips</li> <li>• Touchable strip</li> <li>• Dataport</li> </ul>
<b>Therasense (therasense.com)</b>					
FreeStyle	1.5	0.3	15	250	<ul style="list-style-type: none"> <li>• Finger or forearm testing sites</li> <li>• Five languages</li> <li>• Dataport</li> </ul>

Although there has been concern that the accuracy of alternate site testing is inferior to detect hypoglycemia,<sup>4</sup> the judicious use of this alternative may help to improve adherence to an SMBG regimen.

More complex meters have features to aid in identifying trends and to graph reports for more comprehensive data tracking, particularly for patients who test several times a day.

Table 1 provides a summary of the more popular blood glucose meters. Recent reviews of available meters have been published elsewhere.<sup>5,6</sup>

### Summary

SMBG can play an important role in improving metabolic control in patients with diabetes. It is recommended for

patients treated with insulin and is desirable for all patients with diabetes. Judicious use of SMBG data can help to improve glycemic control, select an anti-diabetic regimen, and provide powerful feedback to patients wishing to improve metabolic control.

### REFERENCES

<sup>1</sup>Evans JMM, Newton RW, Ruta DA, MacDonald TM, Stevenson RJ, Morris AD: Frequency of blood glucose monitoring in relation to glycemic control: observational study with diabetes database. *BMJ* 319:83–86, 1999

<sup>2</sup>Franciosi M, Pellegrini F, De Bernardis G, Belfiglio M, Nicolucci A: The impact of blood glucose self-monitoring on metabolic control and quality of life in type 2 diabetic patients. *Diabetes Care* 24:1870–1877, 2001

<sup>3</sup>Harris MI: Frequency of blood glucose monitoring in relation to glycemic control in patients with type 2 diabetes. *Diabetes Care*

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<sup>4</sup>Jungheim K, Koschinsky T: Risky delay of hypoglycemia detection by glucose monitoring at the arm. *Diabetes Care* 24:1303–1304, 2001

<sup>5</sup>Self care of diabetes. *Consumer Rep* Oct. 2001, p. 72–75

<sup>6</sup>Blood Glucose Monitors and Data Management in Buyers Guide 2001. *Diabetes Forecast* Jan. 2001, p.71–88

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