

About Glucose Monitoring

Glucose monitoring is a method of self-testing glucose (blood sugar) levels for the management of diabetes. It usually involves pricking the finger for a sample of blood and placing that sample on a test strip. The strip is then analyzed by a glucose meter. The meter digitally displays the glucose level as a number in milligrams per deciliter (mg/dL). Some glucose meters allow alternate site testing, such as the forearm or thigh.

Other methods of glucose monitoring exist, including *visually read* blood and urine strips and home glycohemoglobin tests. However the glucose meter is considered the most accurate at-home method for measuring day-to-day glucose control.

People with diabetes should work to keep their glucose levels as close to normal as possible to avoid the immediate symptoms of hypoglycemia and hyperglycemia, and to feel their best. Controlling glucose levels can prevent or delay the development of short-term complications (e.g., unconsciousness) and long-term complications (e.g., diseases of the eyes, kidneys, nerves and blood vessels). People with diabetes can control their glucose levels with methods that may include diet, exercise, insulin and anti-diabetic agents, as prescribed by their physician.

Self-monitoring of blood glucose allows patients to record test results and, according to their physician-prescribed treatment plan, make healthy decisions about diet, exercise and medication dosage. Monitoring glucose provides important knowledge for the management of diabetes. Without monitoring, the patient is not informed of the balance between insulin and glucose levels. People with diabetes and their physicians can examine patterns in glucose test results and judge if the diabetes management plan is working, or if changes need to be made.

All people with diabetes can benefit from glucose monitoring. The American Diabetes Association (ADA) recommends glucose checks for people with diabetes who are:

- Taking insulin or other diabetes medications
- On intensive insulin therapy
- Pregnant
- Having difficulty controlling glucose levels
- Having **Error! Hyperlink reference not valid.** in urine from high blood glucose levels
- Having low glucose without the normal warning signs

Steps to effective glucose monitoring include:

Know the target glucose range. For people with diabetes, the ADA recommends a glucose range of 80 to 120 mg/dL before meals and 100 to 140 mg/dL at bedtime for whole blood readings and 90 to 130 mg/dL before meals and 110 to 150 mg/dL at bedtime for plasma blood readings. At Diabetic Consultants of Alaska, we prefer a pre-meal or fasting glucose of 80-95 and a 2 hr post-prandial (after eating) glucose reading of 100-140.

However, this range is not appropriate for everyone. The target glucose range is a personalized number given by a physician. It is usually based on factors such as age, presence of diabetic complications or other medical conditions, and whether there is a tendency to have hypoglycemia unawareness. Patients should aim to keep their blood glucose levels within their personalized range.

Learn how to check glucose. Ask a physician or certified diabetes educator for a demonstration.

Decide on a testing schedule. Some people with diabetes need to check their glucose more often than others, depending on the type of diabetes, medications and glucose levels. Ask a physician for advice on how often and at what times to test.

Keep a record of results. Patients should record test results in a log book along with medication dose. Changes in food, activity, illness, stress and medication should also be noted. Some glucose meters store test results in memory or connect to computers where results can be downloaded. Once on the computer, results can be printed for physician review or turned into simple graphs and charts.

Look for glucose patterns. Review blood glucose records for trends in hyperglycemia or hypoglycemia. Take note if levels are too high or too low several days in a row at about the same time. Glucose readings that are persistently above or below target range may mean that the diabetes management plan is not working and needs to be revised.

Investigate what causes changes in blood glucose levels. Review the log book for fluctuations and try to connect them with their triggers. Blood glucose levels can be affected by:

<i>Factor</i>	<i>Possible effect on blood glucose levels</i>
Food	Increase
Insulin	Decrease
Non-diabetes	Increase or decrease

medications	
Exercise	Decrease
Illness	Increase
Stress	Increase
Alcohol	Increase

Decide how to get glucose levels back to target range. Patients should review their log book records with their physician and decide what changes are necessary in diet, exercise or medication.

Recent research suggests that half or more of diabetes patients have poor glycemic control and that many admit not checking their glucose enough. However, regular glucose monitoring is essential in avoiding serious consequences such as diabetic retinopathy and diabetic coma.

Scientists are trying to make glucose monitoring more convenient, comfortable and accurate. Available advances include:

Continuous glucose monitoring (CGM) techniques. The U.S. Food and Drug Administration has approved several of these systems, including a wristwatch-like device, and researchers are developing others. Built-in glucose meters featured in some models of insulin pumps

Methods of glucose monitoring

The glucose meter is the most popular method of glucose monitoring. Although other methods exist, the glucose meter is considered the most accurate home method for measuring day-to-day control of glucose (blood sugar).

A glucose meter, or glucose monitor, is a small, portable device designed for home use that tests the levels of blood glucose. Testing glucose levels with a typical meter requires a person to place a small sample of blood on a test strip. Test strips are coated in chemicals that combine with glucose. The strip is then analyzed by the meter. Meters measure glucose in different ways. Some measure the amount of electricity that can pass through the blood sample. Others measure how much light reflects from it. The meter digitally displays the glucose level as a number in milligrams per deciliter (mg/dL) that can be recorded for glucose monitoring.

Alternatives to the glucose meter include:

Visually read blood glucose strips. These strips require a blood sample to be applied to a chemically coated test strip. The test pad on the strip then changes color accordingly. The more glucose is present in the blood the greater the color change on the test pad. The user then compares the color on the test pad to a color chart on the side of the vial and estimates their blood glucose level. Visually read blood strips are beneficial when patients forget their meter or when their meter is malfunctioning. They are also easier to use when traveling. However, healthcare experts recommend the use of glucose meters over visually read blood test strips because:

Comparing color patches is not as straightforward as reading a number on a glucose meter.

Visually read blood strips are less accurate than meters because they provide only a range and not an exact number. Although some experienced people can read the strips as accurately as a meter, most people are simply guessing.

Patients must be able to see subtle changes in color to use this test, which may not be possible for someone who is colorblind or has eye diseases such as diabetic retinopathy, glaucoma or cataracts. A meter does not use colors.

Visually read urine strips. Glucose is also present in urine, and there are several urine tests available on the market. Some require the strip to be dipped into a cup of urine, and others need to be passed through a stream of urine. The chemically coated test pad then reacts with the glucose in the sample and changes color accordingly. The test pad is then compared to a color chart on the side of the vial.

Like visually read blood strips, visually read urine strips are beneficial when patients forget their meter or when their meter is malfunctioning. They are also easier to use when traveling. Although urine testing is less intrusive than blood testing, it is less accurate. Urine strips should be used for glucose measuring only when blood testing is not an option. Among the drawbacks of visually read urine strips:

Hypoglycemia is not detected. The strips measure if blood glucose levels are too high but do not detect if levels are too low because at lower levels glucose does not enter the urine.

Results are not current. Urine strips do not report what glucose levels are at the moment, but rather what they were several hours ago. Current readings are necessary for deciding insulin dosage, handling emergencies and evaluating treatment programs.

Results do not provide details. Urine strips do not report when

levels were high or how high they were.

Results are not exact. Urine glucose levels are more of an average value than blood glucose levels.

Many factors can alter results. Urine strip results may be altered by aspirin, fluid intake, vitamin C, dehydration, and failure to fully empty the bladder on the previous trip to the bathroom. Results are easier to misread. Like visual read blood strips, colorblindness or other visual difficulties can interfere with accurate reading, as can reading the strip before it has finished changing color. Comparing color patches is not as straightforward as reading a number from a glucose meter.

Glycohemoglobin test (or A1C test). This test measures a person's average blood glucose level over a two- to three-month period. Hemoglobin is a protein component of red blood cells that transports oxygen to the cells in the body. Hemoglobin combines with blood glucose to make glycosylated hemoglobin. The test shows the amount of glucose that sticks (glycates) to the red blood cells, which is proportional to the amount of glucose in the blood.

Having a glycohemoglobin test at least twice a year is a good way to determine if glucose levels are under control. Patients who are not meeting their treatment goals should have the A1C test four times a year, or as recommended by their physician. Traditionally assessed in a physician's office, glycohemoglobin can now be measured with home testing kits. Most require patients to take their own blood sample and mail it to a lab for results. At least one version allows patients to see an immediate digital reading, but it is a one-time-use test. However, home monitoring cannot replace the regular A1C test performed by a physician.

Although glycohemoglobin testing can provide an idea of how well a patient's diabetes management plan is working, it does not replace daily self-testing of blood glucose levels. Major drawbacks of solely using glycohemoglobin tests include

- Day-to-day glucose control is not measured

- Insulin amounts cannot be adjusted based on A1C test results

- Vitamins C and E, high levels of lipids and diseases of the liver and kidneys may cause inaccurate results

- Anemia and other diseases that affect hemoglobin may cause inaccurate results

Frequency of Glucose Monitoring

People with diabetes and their physicians should decide how often to test glucose (blood sugar) levels. Some patients need to test more often than others. Testing three to four times a day is usually

recommended for people who take insulin, because their glucose levels tend to fluctuate throughout the day. Patients may need to test more often if they are sick or have a change in their normal routine such as an increase in stress or exercise level.

Patients aiming for normal or near-normal glucose levels may be advised by their physician to monitor four or more times a day. Studies have shown that when monitoring drops to less than four times a day, glucose control worsens.

People taking anti-diabetic agents will be advised to monitor frequently when their physician is trying to find the right dose or when there is a change in their diabetes care plan, such as an increase in insulin. Once a physician has decided if any changes are needed, recommended monitoring may be reduced to once or twice a day. When diabetes is managed without medications and glucose levels are under control, monitoring might be as little as once or twice a day, or three or four times a week.

Useful times for glucose monitoring include:

Before meals or a big snack (preprandial). Insulin doses can be adjusted based on results.

Two hours after meals or a big snack (postprandial). Results can show the effects of various foods on glucose levels. When a dose of rapid-acting insulin is taken before meal, results can show its effectiveness.

Before bedtime. When the reading is low, steps can be taken immediately to raise blood glucose levels. Insulin doses can be adjusted if results continue to be low.

Early morning (2 or 3 a.m.). When performed once a week, early morning blood glucose tests can provide information on overnight glucose levels. Insulin doses can be adjusted to prevent nighttime hypoglycemia. Immediate action can be taken to raise glucose levels.

Certain circumstances may result in unusual changes in glucose levels. During such time, additional glucose checks may be recommended. These include:

Sick days. Illness can cause blood glucose levels to increase because the body releases hormones to help fight the illness to promote healing. These hormones can cause an increase in blood glucose.

Experiencing symptoms of low blood glucose. Results can confirm symptoms are due to hypoglycemia and not something else.

Immediate steps can be taken to raise glucose levels.

Experiencing symptoms of high blood glucose. Results can confirm symptoms are due to hyperglycemia and not something else. Immediate steps can be taken to lower glucose levels.

Menstruation. The hormone fluctuations during the cycle may influence fluctuations in blood glucose.

Before driving or operating heavy machinery (for patients taking insulin or sulfonylureas). Immediate action can be taken to raise blood glucose levels that are too low.

Increased stress. Stress can cause glucose levels to increase.

Increased physical activity. Exercise can decrease blood glucose levels.

Taking new antidiabetic agents. Many medications may affect patients' blood glucose levels or their ability to recognize low blood glucose warning signs. Patients are encouraged to discuss these possibilities with their physician or pharmacist.

Experiencing frequent insulin reactions overnight or waking up with very high blood glucose levels.

Change in diabetes management program, such as insulin schedule, eating plan or exercise plan.

Weight loss or gain.

Hypoglycemia unawareness.

Pregnancy. A diabetic woman may also be advised by her physician to increase glucose monitoring if she is thinking about becoming pregnant.

Blood glucose levels have been erratic, severely high or low.

Intensive insulin therapy

Benefits and Risks of Glucose Monitoring

All people with diabetes benefit from blood glucose (sugar) monitoring. People with type 1, type 2, gestational diabetes or other forms of diabetes who take insulin or anti-diabetic agents can judge how well insulin and diabetes medications are working.

Monitoring also provides information on how much insulin or oral medication is needed to counter the rise of glucose (blood sugar) after a meal. These medications may put a person at risk for low glucose levels. Monitoring will reveal if levels are too low.

Patients who manage diabetes with a diet and exercise plan can benefit from feedback on how well their exercise and food choices are working. For a pregnant woman, glucose monitoring guides the treatment adjustments necessary to keep herself and her fetus healthy.

Glucose monitoring is an effective way to control blood glucose levels and it offers many possible benefits to diabetes patients. Potential benefits of glucose monitoring include:

Detecting and preventing hypoglycemia (low glucose) and hyperglycemia (high glucose).

Preventing or delaying long-term complications of diabetes, including diseases of the eyes, kidneys, nerves and blood vessels.

Uncovering the effects of food, exercise, stress, illness, insulin and other medications and other factors on glucose levels.

Keeping track of glucose levels over time and determining trends and patterns.

Assisting in making day-to-day decisions for glucose management, including insulin and medication dosage and meal size.

Confirming that suspicions of low or high blood glucose levels are accurate and not the result of something unrelated to diabetes.

Alerting to emergency situations so immediate action can be taken to lower or raise glucose levels.

Determining the need for starting insulin therapy.

Identifying where changes in the diabetes management plan are needed.

Deciding what action is needed when a person is suffering from an illness.

The potential risks associated with glucose monitoring involve use of a glucose meter. A number of factors can make meter readings inaccurate, including machine malfunctions or human error. Before initiating any self monitoring program, please consult with Dr Ross Tanner at Diabetes and Lipid Clinic of Alaska.