

The A1C Test and Diabetes

National Diabetes Information Clearinghouse



U.S. Department
of Health and
Human Services

NATIONAL
INSTITUTES
OF HEALTH



What is the A1C test?

The A1C test is a blood test that provides information about a person's average levels of blood glucose, also called blood sugar, over the past 3 months. The A1C test is sometimes called the hemoglobin A1c, HbA1c, or glycohemoglobin test. The A1C test is the primary test used for diabetes management and diabetes research.

How does the A1C test work?

The A1C test is based on the attachment of glucose to hemoglobin, the protein in red blood cells that carries oxygen. In the body, red blood cells are constantly forming and dying, but typically they live for about 3 months. Thus, the A1C test reflects the average of a person's blood glucose levels over the past 3 months. The A1C test result is reported as a percentage. The higher the percentage, the higher a person's blood glucose levels have been. A normal A1C level is below 5.7 percent.

Can the A1C test be used to diagnose type 2 diabetes and prediabetes?

Yes. In 2009, an international expert committee recommended the A1C test as one of the tests available to help diagnose type 2 diabetes and prediabetes.¹ Previously, only the traditional blood glucose tests were used to diagnose diabetes and prediabetes.

¹The International Expert Committee. International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes. *Diabetes Care*. 2009;32(7):1327–1334.

Because the A1C test does not require fasting and blood can be drawn for the test at any time of day, experts are hoping its convenience will allow more people to get tested—thus, decreasing the number of people with undiagnosed diabetes. However, some medical organizations continue to recommend using blood glucose tests for diagnosis.

Why should a person be tested for diabetes?

Testing is especially important because early in the disease diabetes has no symptoms. Although no test is perfect, the A1C and blood glucose tests are the best tools available to diagnose diabetes—a serious and lifelong disease.

Testing enables health care providers to find and treat diabetes before complications occur and to find and treat prediabetes, which can delay or prevent type 2 diabetes from developing.

Has the A1C test improved?

Yes. A1C laboratory tests are now standardized. In the past, the A1C test was not recommended for diagnosis of type 2 diabetes and prediabetes because the many different types of A1C tests could give varied results. The accuracy has been improved by the National Glycohemoglobin Standardization Program (NGSP), which developed standards for the A1C tests.

The NGSP certifies that manufacturers of A1C tests provide tests that are consistent with those used in a major diabetes study. The study established current A1C goals for blood glucose control that can reduce the occurrence of diabetes complications, such as blindness and blood vessel disease.²

How is the A1C test used to diagnose type 2 diabetes and prediabetes?

The A1C test can be used to diagnose type 2 diabetes and prediabetes alone or in combination with other diabetes tests. When the A1C test is used for diagnosis, the blood sample must be sent to a laboratory that uses an NGSP-certified method for analysis to ensure the results are standardized.

Blood samples analyzed in a health care provider's office, known as point-of-care (POC) tests, are not standardized for diagnosing diabetes. The following table provides the percentages that indicate diagnoses of normal, diabetes, and prediabetes according to A1C levels.

Diagnosis*	A1C Level
Normal	below 5.7 percent
Diabetes	6.5 percent or above
Prediabetes	5.7 to 6.4 percent

*Any test for diagnosis of diabetes requires confirmation with a second measurement unless there are clear symptoms of diabetes.

Having prediabetes is a risk factor for getting type 2 diabetes. People with prediabetes may be retested each year. Within the prediabetes A1C range of 5.7 to 6.4 percent, the higher the A1C, the greater the risk of diabetes. Those with prediabetes are likely to develop type 2 diabetes within 10 years, but they can take steps to prevent or delay diabetes.

²Nathan DM, Genuth S, Lachin J, et al. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *The New England Journal of Medicine*. 1993;329(14):977-986.

Is the A1C test used during pregnancy?

The A1C test may be used at the first visit to the health care provider during pregnancy to see if women with risk factors had undiagnosed diabetes before becoming pregnant. After that, the oral glucose tolerance test (OGTT) is used to test for diabetes that develops during pregnancy—known as gestational diabetes. After delivery, women who had gestational diabetes should be tested for persistent diabetes. Blood glucose tests, rather than the A1C test, should be used for testing within 12 weeks of delivery.

More information about diagnosing and treating gestational diabetes is available in the National Diabetes Information Clearinghouse's (NDIC's) publication *What I need to know about Gestational Diabetes*, available at www.diabetes.niddk.nih.gov or by calling 1-800-860-8747.

Can blood glucose tests still be used for diagnosing type 2 diabetes and prediabetes?

Yes. The standard blood glucose tests used for diagnosing type 2 diabetes and prediabetes—the fasting plasma glucose (FPG) test and the OGTT—are still recommended. The random plasma glucose test, also called the casual glucose test, may be used for diagnosing diabetes when symptoms of diabetes are present. In some cases, the A1C test is used to help health care providers confirm the results of a blood glucose test.

Can the A1C test result in a different diagnosis than the blood glucose tests?

Yes. In some people, a blood glucose test may indicate a diagnosis of diabetes while an A1C test does not. The reverse can also occur—an A1C test may indicate a diagnosis of diabetes even though a blood glucose test does not. Because of these variations in test results, health care providers repeat tests before making a diagnosis.

People with differing test results may be in an early stage of the disease, where blood glucose levels have not risen high enough to show on every test. Sometimes, making simple changes in lifestyle—losing a small amount of weight and increasing physical activity—can help people in this early stage reverse diabetes or delay its onset.

More information about diagnosing diabetes and prediabetes is available in the NDIC's fact sheet *Diagnosis of Diabetes*, available at www.diabetes.niddk.nih.gov or by calling 1-800-860-8747.

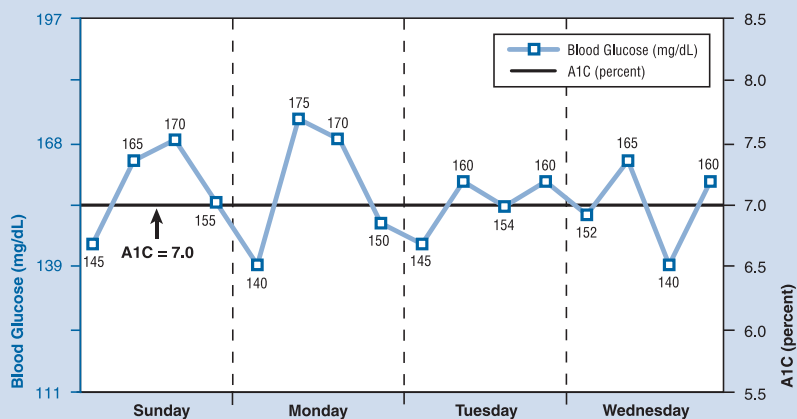
Are diabetes blood test results always accurate?

All laboratory test results can vary from day to day and from test to test. Results can vary

- **within the person being tested.** A person's blood glucose levels normally move up and down depending on meals, exercise, sickness, and stress.
- **between different tests.** Each test measures blood glucose levels in a different way. For example, the FPG test measures glucose that is floating free in the blood after fasting and only shows the blood glucose level at the time of the test. Repeated blood glucose tests, such as self-monitoring several times a day with a home meter, can record the natural variations of blood glucose levels during the day. The A1C test represents the amount of glucose attached to hemoglobin, so it reflects an average of all the blood glucose levels a person may experience over 3 months. The A1C test will not show day-to-day changes.

The following chart shows how multiple blood glucose measurements over 4 days compare with an A1C measurement.

Blood Glucose Measurements Compared with A1C Measurements Over 4 Days



Note: Blood glucose (mg/dL) measurements were taken four times per day (fasting or pre-breakfast, pre-lunch, pre-dinner, and bedtime).

The straight black line indicates an A1C measurement of 7.0 percent. The blue line shows blood glucose test results from self-monitoring four times a day over a 4-day period.

- **within the same test.** Even when the same blood sample is repeatedly measured in the same laboratory, the results may vary due to small changes in temperature, equipment, or sample handling.

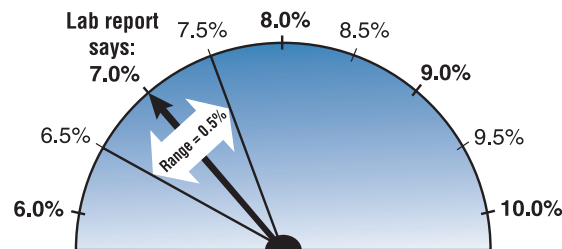
Health care providers take these variations into account when considering test results and repeat laboratory tests for confirmation. Diabetes develops over time, so even with variations in test results, health care providers can tell when overall blood glucose levels are becoming too high.

Comparing test results from different laboratories can be misleading. People should consider requesting new laboratory tests when they change health care providers, or if their health care provider's office changes the laboratory or clinic it uses for blood testing.

How accurate is the A1C test?

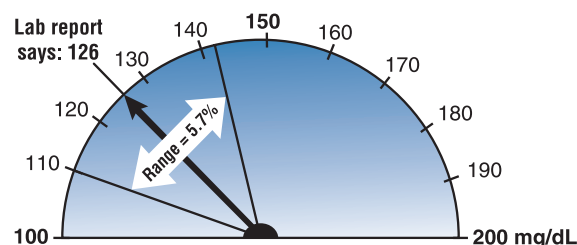
The A1C test result can be up to 0.5 percent higher or lower than the actual percentage. This means an A1C measured as 7.0 percent could indicate a true A1C anywhere in the range from 6.5 to 7.5 percent. Health care providers can visit www.ngsp.org to find information about the accuracy of the A1C test used by their laboratory.

The drawing below shows the range of variation that can occur when an A1C is 7.0 percent on the lab report.



Courtesy of David Aron, M.D., Louis Stokes Department of Veterans Affairs Medical Center

To put the A1C test into perspective, an FPG test result of 126 mg/dL could indicate a true FPG anywhere in the range from 110 to 142 mg/dL. This variation will be even greater if the blood sample is not processed promptly or is not put on ice, causing blood glucose levels in the sample to decrease. The drawing below shows the range of variation that can occur when the FPG is 126 mg/dL.



Courtesy of David Aron, M.D., Louis Stokes Department of Veterans Affairs Medical Center

Can the A1C test give false results?

Yes, for some people. The A1C test can be unreliable for diagnosing or monitoring diabetes in people with certain conditions that are known to interfere with the results. Interference should be suspected when A1C results seem very different from the results of a blood glucose test.

People of African, Mediterranean, or Southeast Asian descent, or people with family members with sickle cell anemia or a thalassemia are particularly at risk of interference. People in these groups may have a less common type of hemoglobin, known as a hemoglobin variant, that can interfere with some A1C tests. Most people with a hemoglobin variant have no symptoms and may not know that they carry this type of hemoglobin.

Not all of the A1C tests are unreliable for people with a hemoglobin variant. People with false results from one type of A1C test may need a different type of A1C test for measuring their average blood glucose level. The NGSP provides information for health care providers about which A1C tests are appropriate to use for specific hemoglobin variants at www.ngsp.org.

More information about problems with the A1C test and different forms of sickle cell anemia is available in the following NDIC publications:

- *For People of African, Mediterranean, or Southeast Asian Heritage: Important Information about Diabetes Blood Tests*
- *Sickle Cell Trait and Other Hemoglobinopathies and Diabetes: Important Information for Physicians*

These publications are available at www.diabetes.niddk.nih.gov or by calling 1-800-860-8747.

False A1C results may also occur in people with other problems that affect their blood or hemoglobin. For example, a falsely low A1C result can occur in people with

- anemia
- heavy bleeding

A falsely elevated A1C result can occur in people who

- are very low in iron, for example, those with iron deficiency anemia

Other causes of false A1C results include

- kidney failure
- liver disease

How is the A1C test used after diagnosis of diabetes?

Health care providers can use the A1C test to monitor blood glucose levels in people with type 1 or type 2 diabetes. The A1C test is not used to monitor gestational diabetes.

The American Diabetes Association recommends that people with diabetes who are meeting treatment goals and have stable blood glucose levels have the A1C test twice a year. Health care providers may repeat the A1C test as often as four times a year until blood glucose levels reach recommended levels.

The A1C test helps health care providers adjust medication to reduce the risk of long-term diabetes complications. Studies have demonstrated substantial reductions in long-term complications with the lowering of A1C levels.

When the A1C test is used for monitoring blood glucose levels in a person with diabetes, the blood sample can be analyzed in a health care provider's office using a POC test to give immediate results. However, POC tests are less reliable and not as accurate as most laboratory tests.

How does the A1C relate to estimated average glucose?

Estimated average glucose (eAG) is calculated from the A1C. Some laboratories report eAG with the A1C test results. The eAG number helps people with diabetes relate their A1C to daily glucose monitoring levels. The eAG calculation converts the A1C percentage to the same units used by home glucose meters—milligrams per deciliter (mg/dL).

The eAG number will not match daily glucose readings because it is a long-term average rather than the blood glucose level at a single time, as measured with the home glucose meter. The following table shows the relationship between the A1C and the eAG.

Relationship between A1C and eAG

A1C	eAG
Percent	mg/dL
6	126
7	154
8	183
9	212
10	240
11	269
12	298

Source: Adapted from American Diabetes Association. Standards of medical care in diabetes—2011. *Diabetes Care*. 2011;34(Supp 1):S11–S61, table 9.

What A1C target should people have?

People will have different A1C targets depending on their diabetes history and their general health. People should discuss their A1C target with their health care provider. Studies have shown that people with diabetes can reduce the risk of diabetes complications by keeping A1C levels below 7 percent.

Maintaining good blood glucose control will benefit those with new-onset diabetes for many years to come. However, an A1C level that is safe for one person may not be safe for another. For example, keeping an A1C level below 7 percent may not be safe if it leads to problems with hypoglycemia, also called low blood glucose.

Less strict blood glucose control, or an A1C between 7 and 8 percent—or even higher in some circumstances—may be appropriate in people who have

- limited life-expectancy
- long-standing diabetes and difficulty attaining a lower goal
- severe hypoglycemia
- advanced diabetes complications such as chronic kidney disease, nerve problems, or cardiovascular disease

Will the A1C test show changes in blood glucose levels?

Large changes in a person's blood glucose levels over the past month will show up in their A1C test result, but the A1C does not show sudden, temporary increases or decreases in blood glucose levels. Even though the A1C represents a long-term average, blood glucose levels within the past 30 days have a greater effect on the A1C reading than those in previous months.

Points to Remember

- The A1C test is a blood test that provides information about a person's average levels of blood glucose, also called blood sugar, over the past 3 months.
- The A1C test is based on the attachment of glucose to hemoglobin, the protein in red blood cells that carries oxygen. Thus, the A1C test reflects the average of a person's blood glucose levels over the past 3 months.
- In 2009, an international expert committee recommended the A1C test be used as one of the tests available to help diagnose type 2 diabetes and prediabetes.
- Because the A1C test does not require fasting and blood can be drawn for the test at any time of day, experts are hoping its convenience will allow more people to get tested—thus, decreasing the number of people with undiagnosed diabetes.
- In the past, the A1C test was not recommended for diagnosis of type 2 diabetes and prediabetes because the many different types of A1C tests could give varied results. The accuracy has been improved by the National Glycohemoglobin Standardization Program (NGSP), which developed standards for the A1C tests. Blood samples analyzed in a health care provider's office, known as point-of-care (POC) tests, are not standardized for use in diagnosing diabetes.
- The A1C test may be used at the first visit to the health care provider during pregnancy to see if women with risk factors had undiagnosed diabetes before becoming pregnant. After that, the oral glucose tolerance test (OGTT) is used to test for diabetes that develops during pregnancy—known as gestational diabetes.
- The standard blood glucose tests used for diagnosing type 2 diabetes and prediabetes—the fasting plasma glucose (FPG) test and the OGTT—are still recommended. The random plasma glucose test may be used for diagnosing diabetes when symptoms of diabetes are present.
- The A1C test can be unreliable for diagnosing or monitoring diabetes in people with certain conditions that are known to interfere with the results.
- The American Diabetes Association recommends that people with diabetes who are meeting treatment goals and have stable blood glucose levels have the A1C test twice a year.
- Estimated average glucose (eAG) is calculated from the A1C to help people with diabetes relate their A1C to daily glucose monitoring levels.
- People will have different A1C targets depending on their diabetes history and their general health. People should discuss their A1C target with their health care provider.

Hope through Research

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) conducts and supports research related to the causes, treatment, and prevention of diabetes. Many ongoing research studies use the A1C test to measure and compare the success of different treatments or medications for diabetes care. In addition, researchers continue to improve measurement of A1C.

Participants in clinical trials can play a more active role in their own health care, gain access to new research treatments before they are widely available, and help others by contributing to medical research. For information about current studies, visit www.ClinicalTrials.gov.

For More Information

American Association of Diabetes Educators

200 West Madison Street, Suite 800

Chicago, IL 60606

Phone: 1-800-338-3633 or 312-424-2426

Diabetes Educator Access Line:

1-800-TEAMUP4 (1-800-832-6874)

Fax: 312-424-2427

Email: aade@aadenet.org

Internet: www.diabeteseducator.org

American Diabetes Association

1701 North Beauregard Street

Alexandria, VA 22311

Phone: 1-800-DIABETES (1-800-342-2383)

Fax: 703-549-6995

Email: AskADA@diabetes.org

Internet: www.diabetes.org

JDRF

26 Broadway, 14th Floor

New York, NY 10004

Phone: 1-800-533-CURE (1-800-533-2873)

Fax: 212-785-9595

Email: info@jdrf.org

Internet: www.jdrf.org

Acknowledgments

Publications produced by the Clearinghouse are carefully reviewed by both NIDDK scientists and outside experts. This publication was reviewed by Randie Little, Ph.D., University of Missouri-Columbia; David B. Sacks, M.B., Ch.B., F.R.C.Path., NIH Clinical Center; and Leonard Pogach M.D., M.B.A., F.A.C.P., Medical Service, Veterans Affairs Central Office.

You may also find additional information about this topic by visiting MedlinePlus at www.medlineplus.gov.

This publication may contain information about medications. When prepared, this publication included the most current information available. For updates or for questions about any medications, contact the U.S. Food and Drug Administration toll-free at 1-888-INFO-FDA (1-888-463-6332) or visit www.fda.gov. Consult your health care provider for more information.

The U.S. Government does not endorse or favor any specific commercial product or company. Trade, proprietary, or company names appearing in this document are used only because they are considered necessary in the context of the information provided. If a product is not mentioned, the omission does not mean or imply that the product is unsatisfactory.

National Diabetes Education Program

1 Diabetes Way
Bethesda, MD 20814-9692
Phone: 1-888-693-NDEP
(1-888-693-6337)
TTY: 1-866-569-1162
Fax: 703-738-4929
Email: ndep@mail.nih.gov
Internet: www.ndep.nih.gov
www.yourdiabetesinfo.org

The National Diabetes Education Program is a federally funded program sponsored by the U.S. Department of Health and Human Services' National Institutes of Health and the Centers for Disease Control and Prevention and includes over 200 partners at the federal, state, and local levels, working together to reduce the morbidity and mortality associated with diabetes.

National Diabetes Information Clearinghouse

1 Information Way
Bethesda, MD 20892-3560
Phone: 1-800-860-8747
TTY: 1-866-569-1162
Fax: 703-738-4929
Email: ndic@info.niddk.nih.gov
Internet: www.diabetes.niddk.nih.gov

The National Diabetes Information Clearinghouse (NDIC) is a service of the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The NIDDK is part of the National Institutes of Health of the U.S. Department of Health and Human Services. Established in 1978, the Clearinghouse provides information about diabetes to people with diabetes and to their families, health care professionals, and the public. The NDIC answers inquiries, develops and distributes publications, and works closely with professional and patient organizations and Government agencies to coordinate resources about diabetes.

This publication is not copyrighted. The Clearinghouse encourages users of this publication to duplicate and distribute as many copies as desired.

This publication is available at
www.diabetes.niddk.nih.gov.



U.S. DEPARTMENT OF HEALTH
AND HUMAN SERVICES
National Institutes of Health

NIH Publication No. 11-7816
September 2011



The NIDDK prints on recycled paper with bio-based ink.