



Prediabetes & Insulin Resistance

What is insulin?

Insulin is a hormone made in the pancreas, an organ located behind the stomach. The pancreas contains clusters of cells called islets. Beta cells within the islets make insulin and release it into the blood.

Insulin plays a major role in metabolism—the way the body uses digested food for energy. The digestive tract breaks down carbohydrates—sugars and starches found in many foods—into glucose. Glucose is a form of sugar that enters the bloodstream. With the help of insulin, cells throughout the body absorb glucose and use it for energy.

Insulin's Role in Blood Glucose Control

When blood glucose levels rise after a meal, the pancreas releases insulin into the blood. Insulin and glucose then travel in the blood to cells throughout the body.

- Insulin helps muscle, fat, and liver cells absorb glucose from the bloodstream, lowering blood glucose levels.
- Insulin stimulates the liver and muscle tissue to store excess glucose. The stored form of glucose is called glycogen.
- Insulin also lowers blood glucose levels by reducing glucose production in the liver.

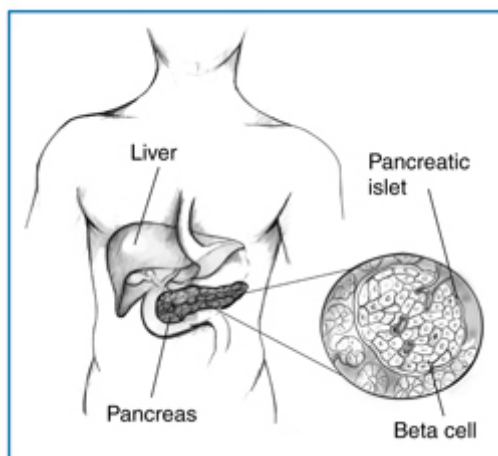
In a healthy person, these functions allow blood glucose and insulin levels to remain in the normal range.

What happens with insulin resistance?

In insulin resistance, muscle, fat, and liver cells do not respond properly to insulin and thus cannot easily absorb glucose from the bloodstream. As a result, the body needs higher levels of insulin to help glucose enter cells.

The beta cells in the pancreas try to keep up with this increased demand for insulin by producing more. As long as the beta cells are able to produce enough insulin to overcome the insulin resistance, blood glucose levels stay in the healthy range.

Over time, insulin resistance can lead to type 2 diabetes and prediabetes because the beta cells fail to keep up with the body's increased need for insulin. Without enough insulin, excess glucose builds up in the bloodstream, leading to diabetes, prediabetes, and other serious health disorders.



The pancreas contains clusters of cells called islets. Beta cells within the islets make insulin and release it into the blood.

What causes insulin resistance?

Although the exact causes of insulin resistance are not completely understood, scientists think the major contributors to insulin resistance are excess weight and physical inactivity.

Excess Weight

Some experts believe obesity, especially excess fat around the waist, is a primary cause of insulin resistance. Scientists used to think that fat tissue functioned solely as energy storage. However, studies have shown that belly fat produces hormones and other substances that can cause serious health problems such as insulin resistance, high blood pressure, imbalanced cholesterol, and cardiovascular disease (CVD).

Belly fat plays a part in developing chronic, or long-lasting, inflammation in the body. Chronic inflammation can damage the body over time, without any signs or symptoms. Scientists have found that complex interactions in fat tissue draw immune cells to the area and trigger low-level chronic inflammation. This inflammation can contribute to the development of insulin resistance, type 2 diabetes, and CVD. Studies show that losing the weight can reduce insulin resistance and prevent or delay type 2 diabetes.

Physical Inactivity

Many studies have shown that physical inactivity is associated with insulin resistance, often leading to type 2 diabetes. In the body, more glucose is used by muscle than other tissues. Normally, active muscles burn their stored glucose for energy and refill their reserves with glucose taken from the bloodstream, keeping blood glucose levels in balance.

Studies show that after exercising, muscles become more sensitive to insulin, reversing insulin resistance and lowering blood glucose levels. Exercise also helps muscles absorb more glucose without the need for insulin. The more muscle a body has, the more glucose it can burn to control blood glucose levels.


Other Causes

Other causes of insulin resistance may include ethnicity; certain diseases; hormones; steroid use; some medications; older age; sleep problems, especially sleep apnea; and cigarette smoking.

Does sleep matter?

Yes. Studies show that untreated sleep problems, especially sleep apnea, can increase the risk of obesity, insulin resistance, and type 2 diabetes. Night shift workers may also be at increased risk for these problems. Sleep apnea is a common disorder in which a person's breathing is interrupted during sleep. People may often move out of deep sleep and into light sleep when their breathing pauses or becomes shallow. This results in poor sleep quality that causes problem sleepiness, or excessive tiredness, during the day.

Many people aren't aware of their symptoms and aren't diagnosed. People who think they might have sleep problems should talk with their health care provider.

More information about sleep problems is available from the National Heart, Lung, and Blood Institute at <http://www.nhlbi.nih.gov/health/resources/sleep> .

What is Prediabetes?

Prediabetes is a condition in which blood glucose or A1C levels—which reflect average blood glucose levels—are higher than normal but not high enough for a diagnosis of diabetes.

Prediabetes is becoming more common in the United States. The U.S. Department of Health and Human Services estimates that at least 86 million U.S. adults ages 20 or older had prediabetes in 2012.¹ People with prediabetes are at increased risk of developing type 2 diabetes and CVD, which can lead to heart attack or stroke.

²National diabetes statistics report, 2014. Centers for Disease Control and Prevention website.

<http://www.cdc.gov/diabetes/data/statistics/2014statisticsreport.html> . Updated June 13, 2014. Accessed June 16, 2014.

How does insulin resistance relate to type 2 diabetes and prediabetes?

Insulin resistance increases the risk of developing type 2 diabetes and prediabetes. Prediabetes usually occurs in people who already have insulin resistance. Although insulin resistance alone does not cause type 2 diabetes, it often sets the stage for the disease by placing a high demand on the insulin-producing beta cells. In prediabetes, the beta cells can no longer produce enough insulin to overcome insulin resistance, causing blood glucose levels to rise above the normal range.

Once a person has prediabetes, continued loss of beta cell function usually leads to type 2 diabetes. People with type 2 diabetes have high blood glucose. Over time, high blood glucose damages nerves and blood vessels, leading to complications such as heart disease, stroke, blindness, kidney failure, and lower-limb amputations.

Studies have shown that most people with prediabetes develop type 2 diabetes within 10 years, unless they change their lifestyle. Lifestyle changes include losing 5 to 7 percent of their body weight—10 to 14 pounds for people who weigh 200 pounds—by making changes in their diet and level of physical activity.



What are the symptoms of insulin resistance and prediabetes?

Insulin resistance and prediabetes usually have no symptoms. People may have one or both conditions for several years without knowing they have them. Even without symptoms, health care providers can identify people at high risk by their physical characteristics, also known as risk factors. The section "[Who should be tested for prediabetes?](#)" lists these risk factors.

People with a severe form of insulin resistance may have dark patches of skin, usually on the back of the neck. Sometimes people have a dark ring around their neck. Dark patches may also appear on elbows, knees, knuckles, and armpits. This condition is called acanthosis nigricans.

Who should be tested for prediabetes?

The American Diabetes Association (ADA) recommends that testing to detect prediabetes be considered in adults who are overweight or obese and have one or more additional risk factors for diabetes. The section "[Body Mass Index \(BMI\)](#)" explains how to determine if a person is overweight or obese. However, not everyone who is overweight will get type 2 diabetes. People without these risk factors should begin testing at age 45.

Risk factors for prediabetes—in addition to being overweight or obese or being age 45 or older—include the following:

- being physically inactive
- having a parent or sibling with diabetes
- having a family background that is African American, Alaska Native, American Indian, Asian American, Hispanic/Latino, or Pacific Islander American
- giving birth to a baby weighing more than 9 pounds
- being diagnosed with gestational diabetes—diabetes that develops only during pregnancy
- having high blood pressure—140/90 mmHg or above—or being treated for high blood pressure
- HDL cholesterol level below 35 mg/dL or a triglyceride level above 250 mg/dL
- having polycystic ovary syndrome (PCOS)
- having prediabetes, impaired fasting glucose (IFG), or impaired glucose tolerance (IGT) on an earlier testing
- having other conditions associated with insulin resistance, such as obesity or acanthosis nigricans
- having CVD

If test results are normal, testing should be repeated at least every 3 years. Testing is important for early diagnosis. Catching prediabetes early gives people time to change their lifestyle and prevent type 2 diabetes and CVD. Health care providers may recommend more frequent testing depending on initial results and risk status.

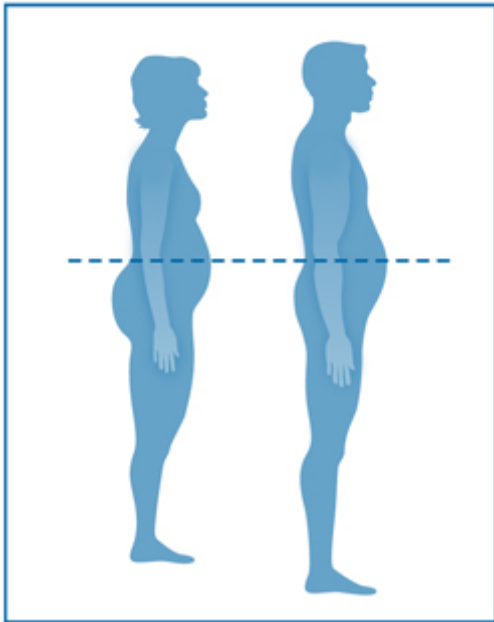
In addition to weight, the location of excess fat on the body can be important. A waist measurement of 40 inches or more for men and 35 inches or more for women is linked to insulin resistance and increases a person's risk for type 2 diabetes. This is true even if a person's BMI falls within the normal range.

How to Measure the Waist

To measure the waist, a person should

- place a tape measure around the bare abdomen just above the hip bone
- make sure the tape is snug but isn't digging into the skin and is parallel to the floor

- relax, exhale, and measure



Source: Adapted from www.cdc.gov

Body Mass Index Table

For a printer-friendly version of this table, use the [PDF Version](#) (51 KB)

Body Mass Index Table 1 of 2

	Normal						Overweight					Obese
BMI	19	20	21	22	23	24	25	26	27	28	29	30
Height (inches)	Body Weight (pounds)											
58	91	96	100	105	110	115	119	124	129	134	138	143
59	94	99	104	109	114	119	124	128	133	138	143	148
60	97	102	107	112	118	123	128	133	138	143	148	153
61	100	106	111	116	122	127	132	137	143	148	153	158
62	104	109	115	120	126	131	136	142	147	153	158	164
63	107	113	118	124	130	135	141	146	152	158	163	169
64	110	116	122	128	134	140	145	151	157	163	169	174
65	114	120	126	132	138	144	150	156	162	168	174	180
66	118	124	130	136	142	148	155	161	167	173	179	186
67	121	127	134	140	146	153	159	166	172	178	185	191
68	125	131	138	144	151	158	164	171	177	184	190	197
69	128	135	142	149	155	162	169	176	182	189	196	203

	Normal						Overweight					Obese
BMI	19	20	21	22	23	24	25	26	27	28	29	30
Height (inches)	Body Weight (pounds)											
70	132	139	146	153	160	167	174	181	188	195	202	209
71	136	143	150	157	165	172	179	186	193	200	208	215
72	140	147	154	162	169	177	184	191	199	206	213	221
73	144	151	159	166	174	182	189	197	204	212	219	227
74	148	155	163	171	179	186	194	202	210	218	225	233
75	152	160	168	176	184	192	200	208	216	224	232	240
76	156	164	172	180	189	197	205	213	221	230	238	246

Body Mass Index Table 2 of 2

	Obese				Extreme Obesity							
BMI	36	37	38	39	40	41	42	43	44	45	46	47
Height (inches)	Body Weight (pounds)											
58	172	177	181	186	191	196	201	205	210	215	220	225
59	178	183	188	193	198	203	208	212	217	222	227	232
60	184	189	194	199	204	209	215	220	225	230	235	240
61	190	195	201	206	211	217	222	227	232	238	243	248
62	196	202	207	213	218	224	229	235	240	246	251	256
63	203	208	214	220	225	231	237	242	248	254	259	264
64	209	215	221	227	232	238	244	250	256	262	267	272
65	216	222	228	234	240	246	252	258	264	270	276	281
66	223	229	235	241	247	253	260	266	272	278	284	289
67	230	236	242	249	255	261	268	274	280	287	293	299
68	236	243	249	256	262	269	276	282	289	295	302	308
69	243	250	257	263	270	277	284	291	297	304	311	317
70	250	257	264	271	278	285	292	299	306	313	320	326
71	257	265	272	279	286	293	301	308	315	322	329	335
72	265	272	279	287	294	302	309	316	324	331	338	344
73	272	280	288	295	302	310	318	325	333	340	348	354
74	280	287	295	303	311	319	326	334	342	350	358	364
75	287	295	303	311	319	327	335	343	351	359	367	374

	Obese				Extreme Obesity							
BMI	36	37	38	39	40	41	42	43	44	45	46	47
Height (inches)	Body Weight (pounds)											
76	295	304	312	320	328	336	344	353	361	369	377	385

Source: Adapted from Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report. National Institutes of Health, 1998.

If you are overweight or obese, choose sensible ways to get in shape:

- Avoid crash diets. Instead, eat less of the foods you usually have. Limit the amount of fat you eat.
- Increase your [physical activity](#). Aim for at least 30 minutes of physical activity most days of the week.
- Set a reasonable weight-loss goal, such as losing 1 pound a week. Aim for a long-term goal of losing 5 to 7 percent of your total body weight. To estimate this amount in pounds, find the weight closest to yours on the chart below. Follow the row across to see how many pounds you need to lose.

Your weight in pounds	5 percent loss in pounds	7 percent loss in pounds
150	8	11
175	9	12
200	10	14
225	11	16
250	13	18
275	14	19
300	15	21
325	16	23
350	18	25

To find your exact weight loss goal, multiply .05 by your weight in pounds to find your 5 percent goal; multiply .07 by your weight to find your 7 percent goal.

What is metabolic syndrome?

Metabolic syndrome, also called insulin resistance syndrome, is a group of traits and medical conditions linked to overweight and obesity that puts people at risk for both CVD and type 2 diabetes. Metabolic syndrome is defined* as the presence of any three of the following²:

- **large waist size**—waist measurement of 40 inches or more for men and 35 inches or more for women

- **high triglycerides in the blood**—triglyceride level of 150 milligrams per deciliter (mg/dL) or above, or taking medication for elevated triglyceride level
- **abnormal levels of cholesterol in the blood**—HDL, or good, cholesterol level below 40 mg/dL for men and below 50 mg/dL for women, or taking medication for low HDL
- **high blood pressure**—blood pressure level of 130/85 or above, or taking medication for elevated blood pressure
- **higher than normal blood glucose levels**—fasting blood glucose level of 100 mg/dL or above, or taking medication for elevated blood glucose

In addition to type 2 diabetes, metabolic syndrome has been linked to the following health disorders:

- obesity
- CVD
- PCOS
- nonalcoholic fatty liver disease
- chronic kidney disease

However, not everyone with these disorders has insulin resistance, and some people may have insulin resistance without getting these disorders.

People who are obese or who have metabolic syndrome, insulin resistance, type 2 diabetes, or prediabetes often also have low-level inflammation throughout the body and blood clotting defects that increase the risk of developing blood clots in the arteries. These conditions contribute to increased risk for CVD.

*Similar definitions have been developed by the World Health Organization and the American Association of Clinical Endocrinologists.

²Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation*. 2009;120:1640–1645.

How are insulin resistance and prediabetes diagnosed?

Health care providers use blood tests to determine whether a person has prediabetes, but they do not usually test specifically for insulin resistance. Insulin resistance can be assessed by measuring the level of insulin in the blood.

However, the test that most accurately measures insulin resistance, called the euglycemic clamp, is too costly and complicated to be used in most health care providers' offices. The clamp

is a research tool used by scientists to learn more about glucose metabolism. Research has shown that if blood tests indicate prediabetes, insulin resistance most likely is present.

Blood Tests for Prediabetes

All blood tests involve drawing blood at a health care provider's office or commercial facility and sending the sample to a lab for analysis. Lab analysis of blood is needed to ensure test results are accurate. Glucose measuring devices used in a health care provider's office, such as finger-stick devices, are not accurate enough for diagnosis but may be used as a quick indicator of high blood glucose.

Prediabetes can be detected with one of the following blood tests:

- the A1C test
- the fasting plasma glucose (FPG) test
- the oral glucose tolerance test (OGTT)

A1C test. Sometimes called hemoglobin A1c, HbA1c, or glycohemoglobin test, this test reflects average blood glucose levels over the past 3 months. This test is the most reliable test for prediabetes, but it is not as sensitive as the other tests. In some individuals, it may miss prediabetes that could be caught by glucose tests.

Although some health care providers can quickly measure A1C in their office, that type of measurement—called a point-of-care test—is not considered reliable for diagnosis. For diagnosis of prediabetes, the A1C test should be analyzed in a laboratory using a method that is certified by the NGSP.

The A1C test can be unreliable for diagnosing prediabetes 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.

An A1C of 5.7 to 6.4 percent indicates prediabetes.

More information about the A1C test is provided in the NIDDK health topic, [The A1C Test and Diabetes](#).

Fasting plasma glucose test. This test measures blood glucose in people who have not eaten anything for at least 8 hours. This test is most reliable when done in the morning. Prediabetes found with this test is called IFG.

Fasting glucose levels of 100 to 125 mg/dL indicate prediabetes.

OGTT. This test measures blood glucose after people have not eaten for at least 8 hours and 2 hours after they drink a sweet liquid provided by a health care provider or laboratory. Prediabetes found with this test is called IGT.

A blood glucose level between 140 and 199 mg/dL indicates prediabetes.

The following table lists the blood test levels for a diagnosis of prediabetes.

	A1C (percent)	Fasting Plasma Glucose (mg/dL)	Oral Glucose Tolerance Test (mg/dL)
Diabetes	6.5 or above	126 or above	200 or above
Prediabetes	5.7 to 6.4	100 to 125	140 to 199
Normal	About 5	99 or below	139 or below

Definitions: mg = milligram, dL = deciliter
For all three tests, within the prediabetes range, the higher the test result, the greater the risk of diabetes.

Source: Adapted from American Diabetes Association. Standards of medical care in diabetes—2012. *Diabetes Care*. 2012;35(Supp 1):S12, table 2.

Understanding Test Results

A blood test indicating prediabetes means that insulin resistance has progressed to the point where the beta cells in the pancreas can no longer compensate and a person's blood glucose levels are rising toward type 2 diabetes. The higher the test results, the greater the risk of type 2 diabetes. The level of risk also depends on an individual's other risk factors, which are listed in the section "[Who should be tested for prediabetes?](#)"

Test numbers. For example, people with an A1C below 5.7 percent may still be at risk for diabetes if they have a family history of type 2 diabetes or have gained excess weight around the waist. People with an A1C above 6.0 percent should be considered at very high risk of developing diabetes. A level of 6.5 percent or above means a person has diabetes.

Follow up. People whose test results indicate they have prediabetes may be retested in 1 year and should consider making lifestyle changes to reduce their risk of developing type 2 diabetes.

Varying results. Although all these tests can be used to test for prediabetes, in some people one test will indicate a diagnosis of prediabetes or diabetes when another test does not. 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.

Health care providers repeat laboratory tests to confirm test results. 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.

Can insulin resistance and prediabetes be reversed?

Yes. Physical activity and weight loss help the body respond better to insulin. The Diabetes Prevention Program (DPP) was a federally funded study of 3,234 people at high risk for diabetes.

The DPP and other large studies proved that people with prediabetes can often prevent or delay diabetes if they lose a modest amount of weight by cutting fat and calorie intake and increasing physical activity—for example, walking 30 minutes a day, 5 days a week.

People at High Risk for Diabetes

DPP study participants were overweight and had prediabetes. Many had family members with type 2 diabetes. Prediabetes, obesity, and a family history of diabetes are strong risk factors for type 2 diabetes. About half of the DPP participants were from minority groups with high rates of diabetes, including African Americans, Alaska Natives, American Indians, Asian Americans, Hispanics/Latinos, and Pacific Islander Americans.

DPP participants also included others at high risk for developing type 2 diabetes, such as women with a history of gestational diabetes and people ages 60 and older.


Approaches to Preventing Diabetes

The DPP tested three approaches to preventing diabetes:

- **Making lifestyle changes.** People in the lifestyle change group exercised, usually by walking 5 days a week for about 30 minutes a day, and lowered their intake of fat and calories.
- **Taking the diabetes medication metformin.** Those who took metformin also received information about physical activity and diet.
- **Receiving education about diabetes.** The third group only received information about physical activity and diet and took a placebo—a pill without medication in it.

People in the lifestyle change group showed the best outcomes. However people who took metformin also benefited. The results showed that by losing an average of 15 pounds in the first year of the study, people in the lifestyle change group reduced their risk of developing type 2 diabetes by 58 percent over 3 years.

Lifestyle change was even more effective in those ages 60 and older. People in this group reduced their risk by 71 percent.

People in the metformin group also benefited, reducing their risk by 31 percent. More information about the DPP, funded under NIH clinical trial number NCT00004992, is available at www.bsc.gwu.edu/dpp .

Lasting Results

The Diabetes Prevention Program Outcomes Study (DPPOS) has shown that the benefits of weight loss and metformin last for at least 10 years. The DPPOS has continued to follow most DPP participants since the DPP ended in 2001. The DPPOS showed that 10 years after enrolling in the DPP

- people in the lifestyle change group reduced their risk for developing diabetes by 34 percent
- those in the lifestyle change group ages 60 or older had even greater benefit, reducing their risk of developing diabetes by 49 percent
- participants in the lifestyle change group also had fewer heart and blood vessel disease risk factors, including lower blood pressure and triglyceride levels, even though they took fewer medications to control their heart disease risk
- those in the metformin group reduced their risk of developing diabetes by 18 percent

Even though controlling weight with lifestyle changes is challenging, it produces long-term health rewards by lowering the risk for type 2 diabetes, lowering blood glucose levels, and reducing other heart disease risk factors.

More information about the risk of developing diabetes; the DPP, funded under NIH clinical trial number NCT00004992; and the DPPOS, funded under NIH clinical trial number NCT00038727, is provided in the NIDDK health topics:

- [Diabetes Prevention Program](#)
- [Am I at risk for type 2 diabetes? Taking Steps to Lower Your Risk of Getting Diabetes](#)

What steps can help reverse insulin resistance and prediabetes?


By losing weight and being more physically active, people can reverse insulin resistance and prediabetes, thus preventing or delaying type 2 diabetes. People can decrease their risk by

- eating a healthy diet and reaching and maintaining a healthy weight
- increasing physical activity
- not smoking
- taking medication

Eating, Diet, and Nutrition

Adopting healthy eating habits can help people lose a modest amount of weight and reverse insulin resistance. Experts encourage people to slowly adopt healthy eating habits that they can maintain, rather than trying extreme weight-loss solutions. People may need to get help from a dietitian or join a weight-loss program for support.

In general, people should lose weight by choosing healthy foods, controlling portions, eating less fat, and increasing physical activity. People are better able to lose weight and keep it off when they learn how to adapt their favorite foods to a healthy eating plan.

The DASH (Dietary Approaches to Stop Hypertension) eating plan, developed by the NIH, has been shown to be effective in decreasing insulin resistance when combined with weight loss and physical activity. More information on DASH is available at www.nhlbi.nih.gov/health/health-topics/topics/dash NIH .

The U.S. Dietary Guidelines for Americans also offers healthy eating advice and tools for changing eating habits at www.choosemyplate.gov .

Dietary Supplements

Vitamin D studies show a link between people's ability to maintain healthy blood glucose levels and having enough vitamin D in their blood. However, studies to determine the proper vitamin D levels for preventing diabetes are ongoing; no special recommendations have been made about vitamin D levels or supplements for people with prediabetes.

Currently, the Institute of Medicine (IOM), the agency that recommends supplementation levels based on current science, provides the following guidelines for daily vitamin D intake:

- People ages 1 to 70 years may require 600 International Units (IUs).
- People ages 71 and older may require as much as 800 IUs.

The IOM also recommended that no more than 4,000 IUs of vitamin D be taken per day.

To help ensure coordinated and safe care, people should discuss use of complementary and alternative medicine practices, including the use of dietary supplements, with their health care provider.

More information about using dietary supplements to help with diabetes is provided in the NIDDK health topic, [Complementary and Alternative Medical Therapies for Diabetes](#).

Physical Activity

Regular physical activity tackles several risk factors at once. Regular physical activity helps the body use insulin properly.

Regular physical activity also helps a person

- lose weight
- control blood glucose levels
- control blood pressure
- control cholesterol levels

People in the DPP who were physically active for 30 minutes a day, 5 days a week, reduced their risk of type 2 diabetes. Many chose brisk walking as their physical activity.

Most people should aim for at least 30 minutes of exercise most days of the week. For best results, people should do both aerobic activities, which use large muscle groups and make the heart beat faster, and muscle strengthening activities.

Aerobic activities include brisk walking, climbing stairs, swimming, dancing, and other activities that increase the heart rate.

Muscle strengthening activities include lifting weights and doing sit-ups or push-ups.

People who haven't been physically active recently should talk with their health care provider about which activities are best for them and have a checkup before starting an exercise program.

Not Smoking

Those who smoke should quit. A health care provider can help people find ways to quit smoking. Studies show that people who get help have a better chance of quitting.

For more information about how to reverse insulin resistance and prediabetes with diet and increased physical activity, see the following National Diabetes Education Program publications:

- [Get Real! You Don't Have to Knock Yourself Out to Prevent Diabetes!](#)
- [More Than 50 Ways to Prevent Diabetes](#)
- [Small Steps. Big Rewards. Your Game Plan to Prevent Type 2 Diabetes.](#)

Medication

The medication metformin is recommended for treatment of some individuals at very high risk of developing type 2 diabetes. In the DPP, metformin was shown to be most effective in preventing or delaying the development of type 2 diabetes in younger, heavier people with prediabetes. In general, metformin is recommend for those who are younger than age 60 and have

- combined IGT and IFG
- A1C above 6 percent
- low HDL cholesterol
- elevated triglycerides
- a parent or sibling with diabetes
- a BMI of at least 35

Metformin also lowers the risk of diabetes in women who have had gestational diabetes. People at high risk should ask their health care provider if they should take metformin to prevent type 2 diabetes.

Several medications have been shown to reduce type 2 diabetes risk to varying degrees, but the only medication recommended by the ADA for type 2 diabetes prevention is metformin. Other medications that have delayed diabetes have side effects or haven't shown long-lasting benefits. No medication, including metformin, is approved by the U.S. Food and Drug Administration to treat insulin resistance or prediabetes or to prevent type 2 diabetes.

Points to Remember

- Insulin is a hormone that helps cells throughout the body absorb glucose and use it for energy. Insulin resistance is a condition in which the body produces insulin but does not use it effectively.
- Insulin resistance increases the risk of developing type 2 diabetes and prediabetes.
- The major contributors to insulin resistance are excess weight, especially around the waist, and physical inactivity.
- Prediabetes is a condition in which blood glucose or A1C levels—which reflect average blood glucose levels—are higher than normal but not high enough for a diagnosis of diabetes.
- The Diabetes Prevention Program (DPP) study and its follow-up study, the Diabetes Prevention Program Outcomes Study (DPPOS), confirmed that people with prediabetes can often prevent or delay diabetes if they lose a modest amount of weight by cutting fat and calorie intake and increasing physical activity.
- By losing weight and being more physically active, people can reverse insulin resistance and prediabetes, thus preventing or delaying type 2 diabetes.
- People with insulin resistance and prediabetes can decrease their risk for diabetes by eating a healthy diet and reaching and maintaining a healthy weight, increasing physical activity, not smoking, and taking medication.
- The DPP showed the diabetes medication metformin to be most effective in preventing or delaying the development of type 2 diabetes in younger and heavier people with prediabetes and women who have had gestational diabetes.

Clinical Trials


The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) and other components of the National Institutes of Health (NIH) conduct and support research into many diseases and conditions.

What are clinical trials, and are they right for you?

Clinical trials are part of clinical research and at the heart of all medical advances. Clinical trials look at new ways to prevent, detect, or treat disease. Researchers also use clinical trials to look at other aspects of care, such as improving the quality of life for people with chronic illnesses.

[Find out if clinical trials are right for you](#) [NIH](#) .

What clinical trials are open?

Clinical trials that are currently open and are recruiting can be viewed at www.ClinicalTrials.gov [NIH](#) .



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Alternate Versions

- [PDF Version](#) (678 KB) 

You can also order print versions from our [online catalog](#).

Additional Links

- [Delaying or Preventing Type 2 Diabetes](#)
- [Be Active Your Way: A Guide for Adults](#)  (PDF, 678 KB) 
- [Diabetes Prevention Program](#)
- [The A1C Test and Diabetes](#)
- [National Diabetes Education Program](#)

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George A. Bray, M.D., Pennington Biomedical Research Center, Louisiana State University; Richard F. Hamman, M.D., Dr.P.H., University of Colorado Health Sciences Center

Contact Us

The National Institute of Diabetes and Digestive and Kidney Diseases
Health Information Center



Phone: 1-800-860-8747



Email: healthinfo@niddk.nih.gov



TTY: 1-866-569-1162



Hours: 8:30 a.m. to 5 p.m. eastern time, M-F