



METABOLIC BASICS | ULTIMATE GUIDE

# The 7 factors that significantly impact your blood sugar

Certain key factors directly impact your blood glucose levels and your metabolic health. Here are the seven to pay attention to.



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Glucose is the body's main source of energy and a critical component of metabolic health. While some glucose comes from the food you eat, your body can also tap into it in the form of glycogen, which is a type of sugar that's stored in your muscles or liver. When glycogen stores are depleted, the body can also produce glucose through a process called gluconeogenesis.

When you need energy, your cells will first attempt to pull glucose from your bloodstream. For metabolic health, you want to achieve low glycemic variability, meaning that your glucose levels remain fairly steady. Optimally,

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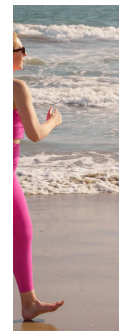
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glucose levels should stay somewhere between 72 mg/dL and 110 mg/dL at all times; your post-meal glucose shouldn't be more than 30 mg/dL higher from your pre-meal level. (Per the American Diabetes Association, anything below 140 mg/dL is normal.)

Chronically high blood glucose can damage your health in several ways. It can lead to insulin resistance—a condition in which your cells stop responding to insulin, the hormone that helps shuttle glucose into the cells for energy. Advanced insulin resistance can ultimately become prediabetes or Type 2 diabetes. But it can also contribute to processes such as inflammation, oxidative stress and glycation, which underlie many other chronic diseases, including Alzheimer's and cancer.

But keeping blood sugar from spiking and then plummeting is important, too: While consistently high blood sugar is well known to be dangerous, research shows that major fluctuations might also be damaging: Scientists from the UK found that people whose blood sugar fluctuated more every six hours had higher levels of oxidative stress and endothelial dysfunction (blood vessel damage) compared to those whose glucose levels stayed steadier throughout the day, and even those who had high but steady glucose.

Meanwhile, other studies have linked wide glucose variability to a higher risk of heart disease and Type 2 diabetes. That's likely because large swings in blood sugar, over time, pave the way for insulin resistance. And, in the short-term, they can make you feel lousy by being associated with feelings of anxiety, fatigue, irritability and increased cravings.

So how do you keep your blood sugar at optimal levels? Start by paying close attention to these factors, all of which have a major impact on glucose and your metabolic health.

## 4 Significant Blood Glucose Levers

### Diet

Your unique genetic makeup and microbiome composition can influence how a particular food impacts your body. That means there's no single diet that's best for everyone in terms of weight maintenance, digestion, or maintaining glucose control. One study of 800 participants found that many had extremely different blood glucose levels after eating the exact same meals. For example, the average postprandial glucose response (PPGR) to bread across 795 people was 44 mg/dl, with the bottom 10% of people exhibiting an average PPGR below 15 mg/dl. The type of meal that induced the highest PPGR differed from person to person, and in some cases different people had opposite PPGRs to pairs of different standardized meals.

That said, there are some universal truths when it comes to how food affects blood sugar. When you consume a food that contains carbohydrates, your



is worth measuring



The top terms in metabolic health, explained

digestive tract breaks it down into sugars including glucose that can be used for energy. Simple carbohydrates, like sugar and refined flours, get processed easily, so glucose reaches your bloodstream quickly; more complex ones, like those found in whole-grain foods or produce, take longer to be digested. Although they eventually are broken down into sugar that enters the bloodstream, this happens more slowly, hence, leading to a more stable blood glucose level.

Other macronutrients also play a role. Fiber, which moves through your body mostly intact (without getting digested), slows the absorption of glucose. And protein and fat prompt the release of compounds such as cholecystokinin, which keep food in your stomach longer and prevent your bloodstream from getting quickly flooded with glucose.

For these reasons, a diet that's composed mostly of whole (unprocessed) foods, including plenty of non-starchy vegetables like leafy greens, is least likely to spike your blood sugar. Foods with added sugar and refined carbohydrates like white bread, pasta, and rice, are more likely to lead to blood sugar spikes.

Even whole grains can be problematic, says Deena Adimoolam, MD, a New Jersey-based specialist in endocrinology and metabolism. "Many people believe that foods like brown rice, whole wheat bread, wheat pasta, and quinoa won't impact blood glucose levels, but it's important to remember that they all still contain carbohydrates, which can lead to high glucose values," she says. "Foods like sweet potatoes can also lead to high glucose values, but not as high as white potatoes." For instance, a medium sweet potato has about 23 grams of carbohydrates (versus about 34 grams for a similarly-sized white potato).

While you may choose to avoid some of these foods, oftentimes the best approach is to pair them with some healthy fat, protein, or fiber, all of which can help blunt the blood sugar spikes caused by carbohydrates, says Krystal Kobasic, RN, MS, CDCES, program coordinator of the Diabetes Teaching Center at UCSF Medical Center.

Foods that combine both fiber and protein—such as bean, legumes, and nuts—may be especially helpful for keeping blood sugar stable, due partly to the fact that fiber slows the rate at which food moves through your GI tract.

Finally, the order in which you eat foods can make a difference in your blood sugar response. Studies show that eating fat and protein before carbs can blunt the glucose rise.

**What You Can Do:** Limit simple carbohydrates and sugars and avoid these five worst foods for metabolic health. Whenever possible choose foods that are unlikely to spike blood sugar and choose whole foods that are rich in micronutrients, fiber, omega-3s, and probiotics.

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## NUTRITION

# 9 Essential elements of metabolically healthy meals

Casey Means, MD

## Exercise

Exercise provides both short-term and long-term metabolic health benefits. In the short-term, it helps move glucose out of your bloodstream and into your cells, which is why doing moderate exercise in the hours after eating can help blunt a blood sugar spike.

When you're active, your muscles need glucose immediately. Although they have access to some stored glucose (in the form of glycogen), they first try to take it from your bloodstream rather than tap into the reserves. Your pancreas then secretes insulin, which enables sugar from the blood to move into the cells. "Insulin is the key that opens up the cells to make them more accepting of the glucose," Kobasic says. Exercise makes your cells more sensitive to insulin and improves the movement of sugar into cells, which is known as the glucose transporter response. Exercise boosts the number of glucose transporters traveling to the lining of cells (GLUT4 channels), so more glucose can enter muscle cells without additional insulin production.

While that helps by lowering your blood sugar right away, some of the beneficial effects of exercise linger. In fact, one study on older adults compared the effects of 15-minute walks after each meal and 45-minute daily walks mid-morning or mid-afternoon and found that both short and long exercise routines resulted in better blood sugar control over a 24 hour period compared to days when participants didn't walk, likely because during that time their cells continued to use insulin more efficiently. (Postmeal walks were particularly effective in lowering glucose in the 3 hours after dinner, likely due to the fact that a walk after dinner uses glucose as fuel, while the glucose benefits of a longer mid-day walk are less pronounced after the next meal.)

In the long-term, regular physical activity helps, in part, because it increases the number of muscle cells, which means more mitochondria to turn glucose into energy. Regular exercise also prompts the liver to metabolize glucose more efficiently and reduce insulin clearance, which can help improve glycemic variability. In other words, your muscles become primed to absorb more glucose.

Being too sedentary has the opposite effect. Several studies have linked sitting too much throughout the day to more inflammation and higher levels of insulin resistance. And while some forms of intense exercise, such as HIIT or weight

lifting, [can lead to transient increases in glucose](#), this effect is short-lived and does not detract from the long-term [metabolic health benefits](#) of exercise.

**What You Can Do:** Aim for a minimum of 30 minutes of moderate-intensity aerobic exercise, five days a week, as recommended by the [World Health Organization](#). If possible, time your movement after meals, as evidence shows that [walking after eating offers significant benefits](#) for curbing postprandial glucose spikes. In addition, consider adding strength training to your routine, as increased muscle mass [increases glucose uptake capacity](#) and improves insulin sensitivity.

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PHYSICAL FITNESS

## More evidence that exercise—even at low intensity—is great for metabolic health

The Levels Team

### Stress

Stress prompts a hormonal response in the body that affects glucose levels. When you're feeling extremely frazzled or panicked, your body readies itself to fight off a threat by leaving ample glucose in your bloodstream for your muscles to use. To increase blood glucose, your body pumps out more [adrenaline and glucagon](#), and consequently your [cells become insulin resistant](#) so that glucose stays in your blood. The result is elevated glucose, as illustrated in research that shows a link between perceived work-related stress and [increased levels of circulating glucose](#).

While an intense episode of stress is apt to cause this reaction, long-term stress is also problematic, says Kobasic. Chronic stress may lead to prolonged insulin resistance, because your body is constantly coping with elevated levels of cortisol. In addition, many people overeat or choose less-healthy foods when they're stressed, which can further elevate glucose levels.

Taking steps to better manage stress can greatly benefit metabolic health. Research has found, for instance, that regularly practicing [deep breathing](#) might translate to lower blood glucose levels by activating the body's [parasympathetic nervous system](#), aka the "rest and digest" system. [Research](#) has shown that people who participated in 20 sessions of diaphragmatic breathing had significant reductions in their cortisol levels—which, in turn, helps lower blood glucose levels.

**What You Can Do:** While life's challenges can't be avoided, our stress response can be managed with the right tools. Prioritize your psychological



well-being and take steps to manage stress. For example, diaphragmatic breathing exercises can be helpful in managing stress and its metabolic effects. One study of people with Type 2 diabetes showed that a daily 20-minute practice of diaphragmatic breathing led to reductions in fasting blood glucose and post-meal glucose levels in 9 weeks.

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MENTAL HEALTH

## How does stress affect my glucose levels?

The Levels Team

### Sleep

Research shows that sleep quantity and quality are vital for optimal metabolism, insulin sensitivity, and glucose variability. One study on healthy young men offers a compelling glimpse at this connection: After five nights of sleep deprivation—four hours of sleep per night—study participants exhibited metabolic profiles that resembled people with Type 2 diabetes. The men showed signs of impaired metabolism and insulin resistance, and the rate of clearing sugar out of the bloodstream was 40% slower than when they were well-rested.

There is also a large body of evidence that connects sleep loss and poor sleep to the development of obesity and diabetes. Although the exact mechanisms are still being teased out, changes in hormone secretion likely play a major role.

For starters, the stress hormone cortisol tends to dip at night, which helps lower and stabilize blood sugar while you're sleeping. But if you don't get enough rest, cortisol may remain elevated. Plus, you're more apt to feel frazzled during the day. "If you're tossing and turning all night, it can lead to an increase in adrenaline and cortisol," says Kobasic. Higher levels of these hormones precipitates a rise in blood glucose .

When you sleep, your body also produces balanced amounts of ghrelin and leptin, two hormones that impact appetite and satiety. If you don't get enough sleep (or your sleep is poor quality), you may produce too much ghrelin. That can indirectly lead to higher glucose levels by prompting you to overeat. And research has shown that people who are sleep-deprived often crave sweets and starches.

Lack of sleep has also been tied to increased inflammation. Inflammation contributes to insulin resistance, and when your body doesn't use insulin efficiently, blood glucose levels remain elevated. Additionally, research has

shown that lack of sleep increases levels of C-reactive protein, an inflammatory marker in the blood. Other studies have found that sleep deprivation also decreases daytime secretion and normal cycles of IL-6, as well as tumor necrosis factor-alpha (TNF-a), which are inflammatory substances.

**What You Can Do:** Prioritize getting enough quality sleep. How much sleep you need is individual, but research indicates seven to eight hours is optimal for metabolic health. The risk of diabetes increases sharply for every hour lost below seven. The risk also increases above eight hours on average.

Learn more:

SLEEP

## How does sleep affect blood sugar?

Alex Moskov

### 3 Other Levers of Glucose to Know About

While the factors above, especially diet and exercise, have the greatest impact on your blood sugar levels, many other levers also affect it—and early research sheds light on their importance. The most significant of them include:

#### Micronutrients

When you think about what's on your plate, your focus is likely on carbohydrates, fat, and protein, which are macronutrients. But *micronutrients*—which your body needs in smaller amounts—also impact how your body handles glucose.

Several different micronutrients have been linked to better metabolic health. One is magnesium, which may affect glucose metabolism and insulin sensitivity through a process called autophosphorylation: Magnesium enables phosphorus, another mineral, to attach to an insulin receptor and turn it on, which improves insulin sensitivity. Magnesium also seems to help glucose transporter proteins move sugar out of the bloodstream and into the cells.

Several other minerals, including selenium (an antioxidant that helps reduce inflammation) and vitamin B6 (which is involved in numerous cellular reactions that regulate glucose metabolism) also have the potential to impact glucose levels.

**What You Can Do:** Base your diet on whole foods or minimally processed foods. Avoid ultraprocessed foods as those are notoriously devoid of micronutrients, and [use supplements and vitamins](#) if needed. The full landscape of micronutrients—and the health benefits they offer—is very broad. Learn more about what to look for in our [comprehensive guide](#).

Learn more:

#### NUTRITION

## 8 Micronutrients essential for metabolic health

Kaitlin Sullivan

### Microbiome

Another way micronutrients might impact glucose levels is by altering your [gut microbiome](#). Your gut microbiome refers to all the microbes (bacteria, viruses, and fungi) that live in your intestinal tract. This includes bad bugs that have the potential to make you sick as well as health-promoting ones. The balance and composition of your microbiome is extremely important. Emerging research suggests that it plays a [critical role in metabolic health](#).

Scientists are still learning about how the microbiome is connected to glucose regulation, but there are several mechanisms that likely explain it. Your gut produces sensor hormones, called incretins, that detect incoming food and prompt the body to metabolize it. Glucagon-like peptide 1 (GLP-1) is an [incretin that tells the pancreas to release insulin](#), which lowers blood glucose levels.

[Research](#) suggests that gut microbiota interfere with incretin secretion in people with metabolic health problems. For instance, there are significant differences in incretin production between people with Type 2 diabetes or prediabetes and those who don't have either condition.

[Short chain fatty acid \(SCFA\) production](#) also appears to be important. SCFAs are produced in the digestive tract after non-digestible fiber (which isn't broken down by your body) has been fermented by specific gut bacteria, and the amount of fiber and type of bacteria in the gut impact how much of these beneficial fatty acids are produced. Butyrate, for instance, is one type of SCFA that has anti-inflammatory properties. Studies have found that people with Type 2 diabetes don't produce as much [butyrate](#) as metabolically-healthy people. Excessive inflammation may lead to insulin resistance and worse glycemic control.

**What You Can Do:** Optimize your diet for gut health by taking in more [probiotics](#), or "good" bacteria, and prebiotics, which feed these helpful



organisms. Fiber is also crucial for digestive health. Women should aim for 22 to 28g fiber per day, and men should target 28 to 32g per day.

Learn more:

#### NUTRITION

## How your gut microbiome affects your metabolic health

Dr. Orville Kolterman

### Environmental toxins

The chemicals you eat, breathe, and are otherwise exposed to also have the power to impact your metabolic health. While research in this area is still emerging, there is already good reason to take the connection seriously. For example, studies have shown that nicotine from cigarettes directly affects fat cells and alters them in such a way to promote insulin resistance.

Petrochemicals, which are derived from fossil fuels and found in everything from plastics and fertilizers to personal care products, are also likely problematic. Bisphenol A (BPA) is one type of petrochemical that seems to alter or mimic hormones such as estrogen. Research suggests that the estrogenic effect of BPA may cause insulin resistance by increasing insulin release from the pancreas.

Certain additives in processed and ultra-processed foods in the U.S. may also cause potential health problems, including inflammation, that can hurt metabolic health, research shows. Review some of the most problematic ingredients here, including:

- Potassium bromate and azodicarbonamide (ADA) found in bread crackers and baked goods
- Brominated vegetable oil (BVO) in some sodas
- Titanium dioxide in baked goods, dairy products, salad dressing, and chewing gum
- Yellow 5, Yellow 6, and Red 40 food dyes in candies, cookies, cereals, yogurt cups, and cakes

**What You Can Do:** Don't smoke. Watch out for petrochemicals in skincare products and food packaging. Avoid fast food and ultraprocessed foods that

likely contain ingredients harmful to metabolic health.

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#### METABOLIC HEALTH

## How environmental toxins impact metabolic health

The Levels Team

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