Examine®

Diabetes & Blood Sugar Supplement Guide

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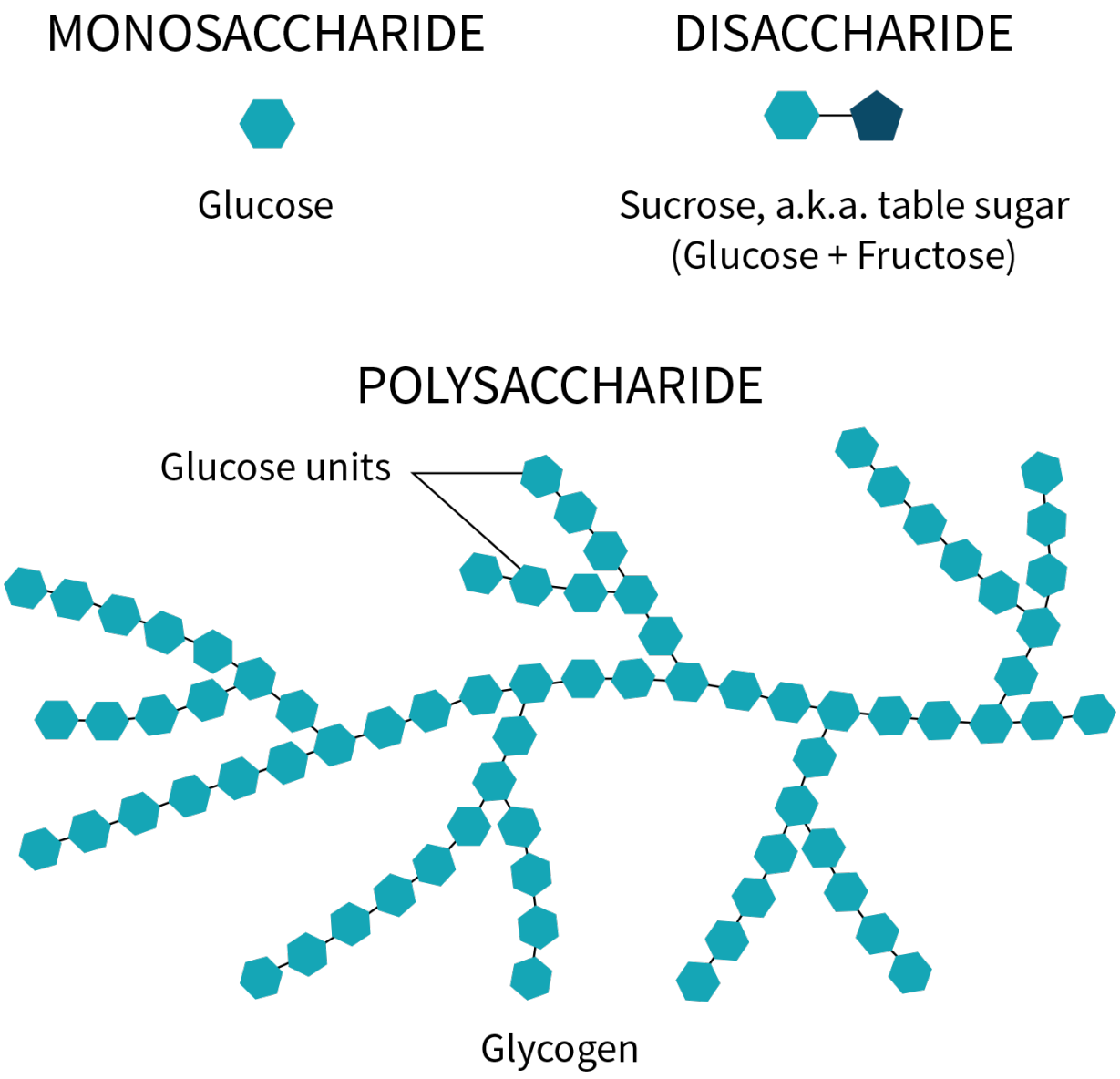
Introduction

Any carbs you ingest, your body breaks down into glucose, also known as *blood sugar* (since it travels through your bloodstream). In this introduction, we'll see how blood sugar (aka blood glucose) and insulin can be measured; but first, we'll review some background information about glucose and its relation to diabetes mellitus (better known as simply *diabetes*).

Glucose is a simple sugar. More precisely, it's a *mono*saccharide (*mono-* meaning "single" and *saccharide* meaning "sugar"). To store glucose molecules, your body combines them into a *poly*saccharide (*poly-* meaning "several"): glycogen.

Depiction of glycogen



Glycogen gets stored in your liver and muscles. If, through prolonged fasting or intense exercise, you deplete your glycogen stores, your body resorts to *gluconeogenesis* — the making (*-genesis*) of new (*-neo-*) glucose (*gluco-*).[1][2]

🔍 *Digging deeper:* Gluconeogenesis

Ketones can *partly* replace glucose as brain fuel.[3][4] More precisely, if you're keto-adapted, ketones can fulfill as much as 70% of your brain's caloric needs.[5] It follows that glucose must still fulfill the last 30%, even when you don't eat carbs. How does your body manage this feat?

Your body can make new glucose out of amino acids (obtained through protein breakdown), glycerol and ketones (both obtained through fat breakdown), and recycled lactate and pyruvate (both produced notably during exercise).[6][2][7]

This process of making new glucose is called *gluconeogenesis*.

After extensive glycogen-depleting exercise, small amounts of gluconeogenesis occur in the absence of any nutrition (i.e., during continued fasting).[8] This glucose can serve to *feed your brain* and slowly *replenish your glycogen stores*.

In people who fast for several weeks (obese individuals under medical supervision), gluconeogenesis amounts to about 80 grams per day: 35–40 grams from recycled lactate and pyruvate, 20 grams from glycerol, 15–20 grams from amino acids, and 10 grams from ketones.[6][7]

Glycogen storage and gluconeogenesis ensure that your body always has enough glucose, whereas insulin ensures that your blood never has too much. Insulin (a hormone produced in your pancreas) rises when blood glucose[9] rises; it lowers blood glucose by telling various cells to absorb it (for storage in your liver or muscles, or for immediate use) and your liver to stop producing it.[10]

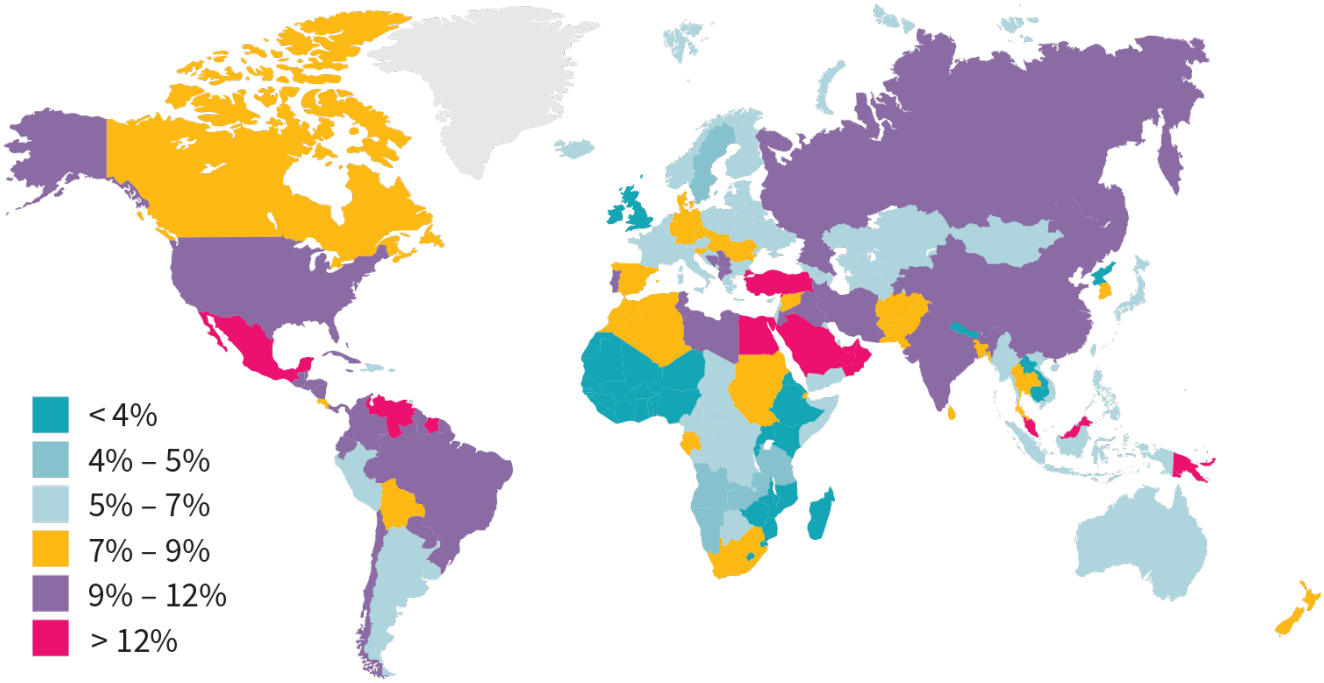
The ability of cells to absorb glucose in response to insulin is called insulin sensitivity, and low insulin sensitivity is called *insulin resistance* — the more sensitive, the less resistant, and vice versa. It is also possible for you to produce too little insulin, if you have type 1 diabetes or are in the late stages of type 2 diabetes, in which case you suffer from *insulin deficiency*. In either case, glucose can't be removed efficiently from your blood, causing *hyperglycemia* (overly high glucose levels).[11]

Hyperglycemia causes oxidative stress and inflammation and impairs several physiological processes,[12][13][14] thereby damaging your body and increasing the risk of many diseases — cardiovascular diseases, mostly,[15] but probably also cancer, Alzheimer's, and Parkinson's.[16][17][18]

Insulin resistance paves the road to type 2 diabetes, which accounts for 90% to 95% of all diabetes cases and has become a global health issue. In 2016, the World Health Organization (WHO) estimated that the percentage of diabetics in the world population had nearly doubled since the 1980s, for a total of 422 million diabetics. However, while the incidence keeps increasing in some countries, on a worldwide scale it seems to have either leveled off or decreased since the early 2000s.[19]

In 2017, the Centers for Disease Control and Prevention (CDC) reported an important, steady increase in the rate of diabetes in the US over the past 60 years, with 30.3 million Americans (nearly 1 in 10) having diabetes and 84.1 million American adults (approximately 1 in 3) having prediabetes[20] (which is to say, blood glucose levels high enough to be harmful and lead to diabetes[21]). One should note, however, than other sources have reported a decrease in the incidence of diabetes in the US since the early 2000s.[19]

Worldwide diabetes prevalence



Adapted from Cho et al. *IDF Diabetes Atlas*. 2017. ISBN:978-2-930229-81-2

The major cause of type 2 diabetes is excess caloric intake and the resulting obesity. Unsurprisingly, weight loss can help. One review found that weight loss from all kinds of interventions — surgery, appetite-suppressing medicines, lifestyle interventions, or a combination — alleviates diabetes.[22]

Surprisingly, many long-term studies that used only a diet to achieve weight loss reported only modest improvements in diabetes. Why? Probably because few achieved _substantial _long-term weight loss.[23] Moreover, exercise in itself can help reduce the risk and severity of type 2 diabetes.[24][25][26]

Exercising regularly and maintaining a healthy weight are the two major pillars of metabolic health, but insulin resistance can be complex, both mechanistically and causally. As a result, the basics may not always cut it, and what's effective for one individual may not be for another. Unfortunately, researchers are often unable to explore interindividual differences, leaving diabetics to fight their disease through trial and error, based on what's effective for a majority.

Measuring blood glucose

Fasting Plasma Glucose (FPG)

Glycemic control can be tested in several ways, each with its own cutoff values indicating impaired glucose regulation.[27] Of these tests, *fasting blood glucose* is the most common, followed by *HbA1c*.

Methods of glycemic-control measurement

	Acute Methods			Chronic Methods
TEST	 **Random plasma glucose test (RPGT)**	 **Fasting plasma glucose (FPG)**	 **Oral glucose tolerance test (OGTT)**	 **Hemoglobin A1c (HbA1c)**
PROCEDURE	A droplet of blood is assessed with a blood-glucose meter. It can be taken at any time	A droplet of blood is assessed with a blood-glucose meter after a fast of at least 8 hours.	A droplet of blood is assessed with a blood-glucose meter at regular intervals over two hours after drinking a glucose solution.	A single blood test that can measure an average of your blood glucose levels over the past 2–3 months.
RANGES	Variable depending on activity levels and last meal. Above 200 mg/dL at any point is considered abnormal.	**Normal:** < 100 mg/dL **Prediabetes:** 100–125 mg/dL **Diabetes:** ≥ 126 mg/dL	**Normal:** < 140 mg/dL **Prediabetes:** 140–199 mg/dL **Diabetes:** ≥ 200 mg/dL	**Normal:** < 5.7% **Prediabetes:** 5.7–6.4% **Diabetes:** ≥ 6.5%

FPG (aka fasting blood glucose) is simply a measure of how much glucose is floating around in your blood during a fast. After at least 8 hours of not eating (typically in the morning before breakfast), blood is drawn and analyzed for glucose concentration. From 100 to 125 mg/dL (5.6 to 7.0 mmol/L), you are considered prediabetic; above 125 mg/dL, you are considered diabetic.

Two caveats:

- Your fasting blood glucose may be normal even if you have insulin resistance, since an increase in insulin resistance can be countered — for a time — by an increase in insulin production.
- The amount and composition of your food affect your blood glucose levels, which is why the test is performed after an 8-hour fast. However, fasting blood glucose levels _can _vary from day to day, and so a single test may not be entirely reliable.[28][29]

Hemoglobin A1c (HbA1c)

HbA1c (glycated hemoglobin) is a marker of blood-glucose metabolism that estimates the average amount of glucose in your blood over the past 3 months. An HbA1c of 5.7–6.4% is considered elevated; above 6.4% is considered high.

Glycation is a non-enzymatic linking of a sugar (in this case, glucose) to a protein or lipid (in this case, hemoglobin). Hemoglobin is the protein in red blood cells that carries oxygen throughout your body, and red blood cells live for about 4 months. When blood glucose levels rise, the rate of hemoglobin glycation increases, making glycated hemoglobin an estimate of blood glucose levels over months. Several factors, however, can reduce the accuracy of the HbA1c test. For instance:

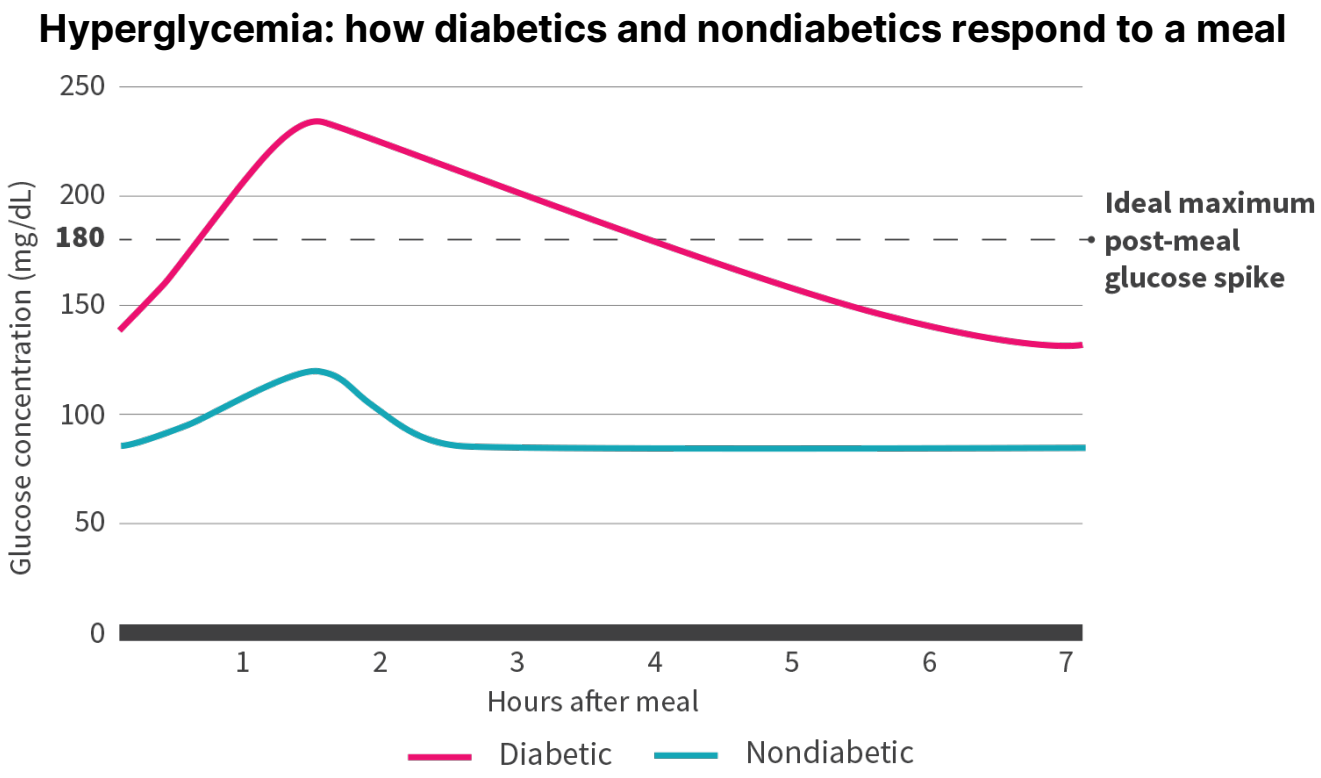
- Nutrient deficiencies that lead to anemia
- Dietary or supplemental changes that reduce glycation
- Severe hyperbilirubinemia or hypertriglyceridemia Conditions that affect the turnover of red blood cells[30] (the red blood cells of diabetics, notably, may have shorter lifespans the higher blood sugar levels get[31])

Acute glycemia

There are two types of acute glycemia tests, the more common being the Oral Glucose Tolerance Test (OGTT). It involves drinking either 75 grams or, less commonly, 100 grams of a glucose solution, after which blood glucose levels are measured at regular intervals over 2 hours (the area under curve being then calculated for each measure). If the last blood sample taken shows a blood glucose of 140–199 mg/dL (7.8–11.0 mmol/L), this is considered elevated; 200 mg/dL or more (≥11.1 mmol/L) is considered high.

In short, the OGTT measures your ability to clear a whole lot of glucose from your bloodstream. It has the advantage of being standardized and easy to administer, but it doesn't reflect the digestive realities of mixed meals.

The other type of acute glycemia test is a postprandial test using real food (the exact same meal must be eaten before each measure is taken). This test is often used to test pharmaceuticals and supplements that may work by reducing the glycemic index (GI) of a meal. The lower the GI of a meal, the less it raises your blood glucose.



Reference: American Diabetes Association. *Clin Diabetes*. 2020.[32]

Random Plasma Glucose Test (RPGT)

For the RPGT (aka causal test), a blood sample is taken at any point during the day if other signs of diabetes are present. As with the last blood sample of an (OGTT)] (https://medlineplus.gov/ency/article/003466.htm), a value of 200 mg/dL or more (≥11.1 mmol/L) is considered high.

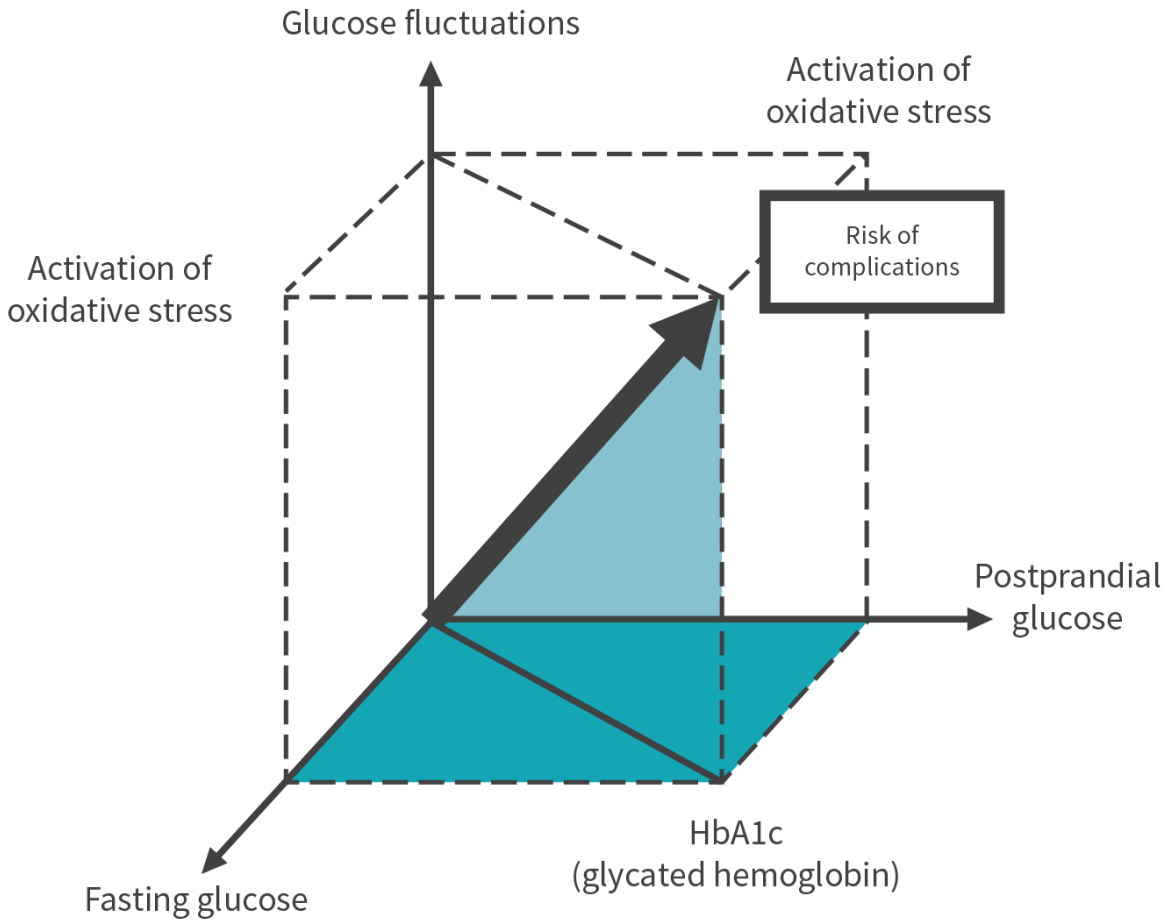
Continuous monitoring

The future is now! At least when it comes to blood glucose measurement. A newer type of glucose monitor is inserted under the skin and continuously measures glucose in interstitial fluid. It can ring an alarm if blood glucose falls too low or rises too high. It can even be paired to an insulin pump for an instantaneous intervention.

And of course, it can collect days' worth of data. A doctor or a researcher can thereby know precisely when blood glucose rose and fell; how high the spikes were after meals; how much time the wearer spent in hyper- or hypoglycemia; what the lowest, highest, and average daily levels were; and more.

Notably, a glucose monitor makes it possible to assess glycemic variability. This is important because research suggests that glucose swings increase oxidative stress and so represent a risk factor (for diabetic complications) independent of average glucose levels.[33][34][35]

Glucose fluctuations play a role in diabetic complications



Adapted from Monnier and Collette. *Diabetes Care*. 2008.[36]

Assessing insulin sensitivity

Fasting insulin

As we saw, during the early stages of insulin resistance, an increase in insulin production can keep your blood glucose in check — but at the cost of creating a feedback loop. As insulin production increases beyond normal levels, so does insulin resistance, and so on and so forth.

This vicious circle is well known, and so different formulae for estimating insulin resistance have been developed based on glucose and insulin levels.[37] The most common of those formulae, each of which has its pros and cons, is HOMA-IR.

There is no standard cutoff value, but some research has suggested that fasting insulin levels above 104 pmol/L (>15 mIU/L) suggest insulin resistance.[38]

Homeostatic Model Assessment of Insulin Resistance (HOMA-IR)

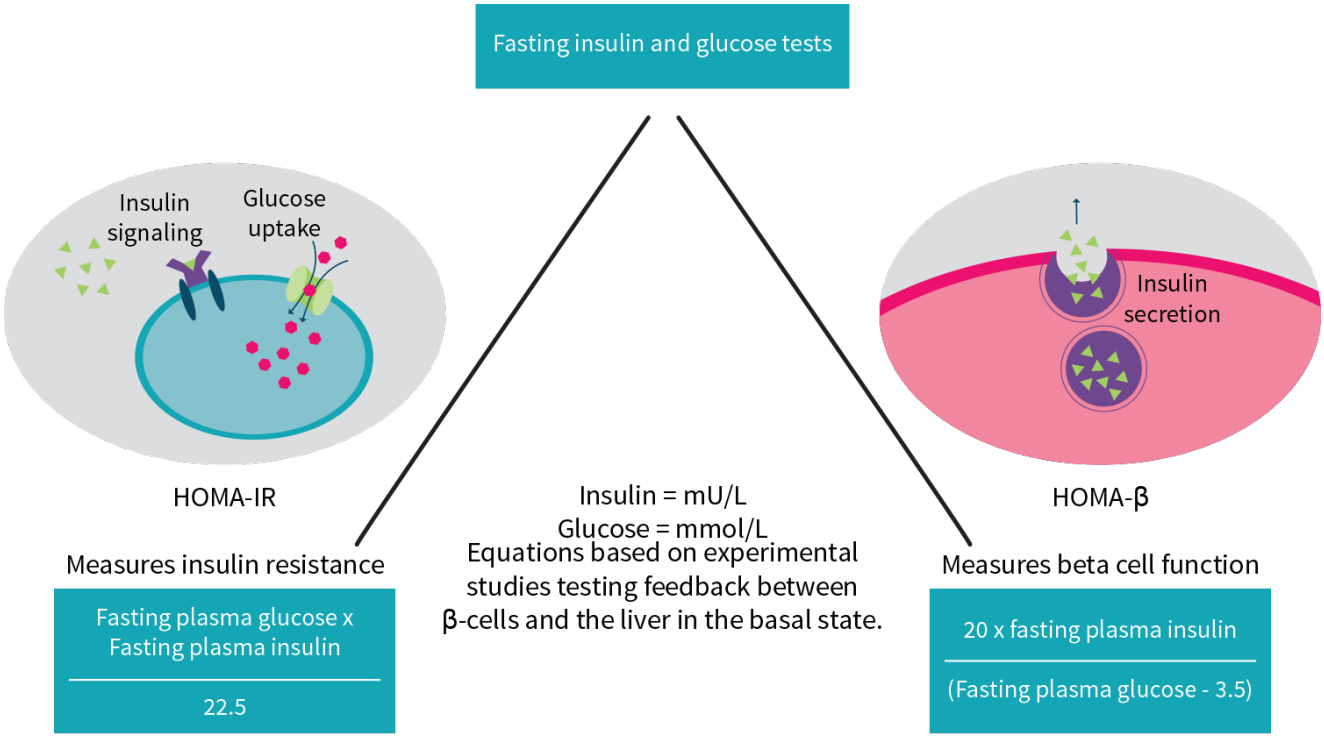
HOMA-IR is calculated based on fasting glucose and insulin, using one of these two formulae:

$$\frac{\text{glucose (mg/dL)} \times \text{insulin (µU/mL)}}{405} \qquad \frac{\text{glucose (mmol/L)} \times \text{insulin (µU/mL)}}{22.5}$$

These simple calculations were derived from experiments and computer modeling that predicted glucose and insulin levels given different levels of insulin sensitivity and described the feedback loop between them.[39] While there is no agreed-upon cutoff value, scores of ≥2 and ≥2.5 have been used to indicate insulin resistance.[40]

HOMA-IR has been updated to HOMA2, which uses the same data (fasting glucose and insulin) but more complex calculations that make it more accurate, yet HOMA-IR is still more commonly used in research — including most of the papers we read to write this guide.

Basic _homeostatic model assessment_ (HOMA) calculations



HOMA-β is similar to HOMA-IR in its approach. HOMA-IR estimates insulin sensitivity based on knowledge about the feedback between glucose and insulin, whereas HOMA-β estimates β cell function based on knowledge about that feedback loop.

For people who use insulin injections (type 1 diabetics and late-stage type 2 diabetics), HOMA is less accurate and a hyperinsulinemic-euglycemic clamp is preferred.

Quantitative Insulin Sensitivity Check Index (QUICKI)

QUICKI, being a modified version of HOMA, is derived from your fasting glucose and fasting insulin. A score of ≤0.35 suggests insulin resistance, whereas ≤0.33 is more strongly associated with insulin resistance.[41]

Matsuda Insulin Sensitivity Index (MISI)

MISI is derived from values obtained during an OGTT. A score under 4.3 suggests insulin resistance.[37]

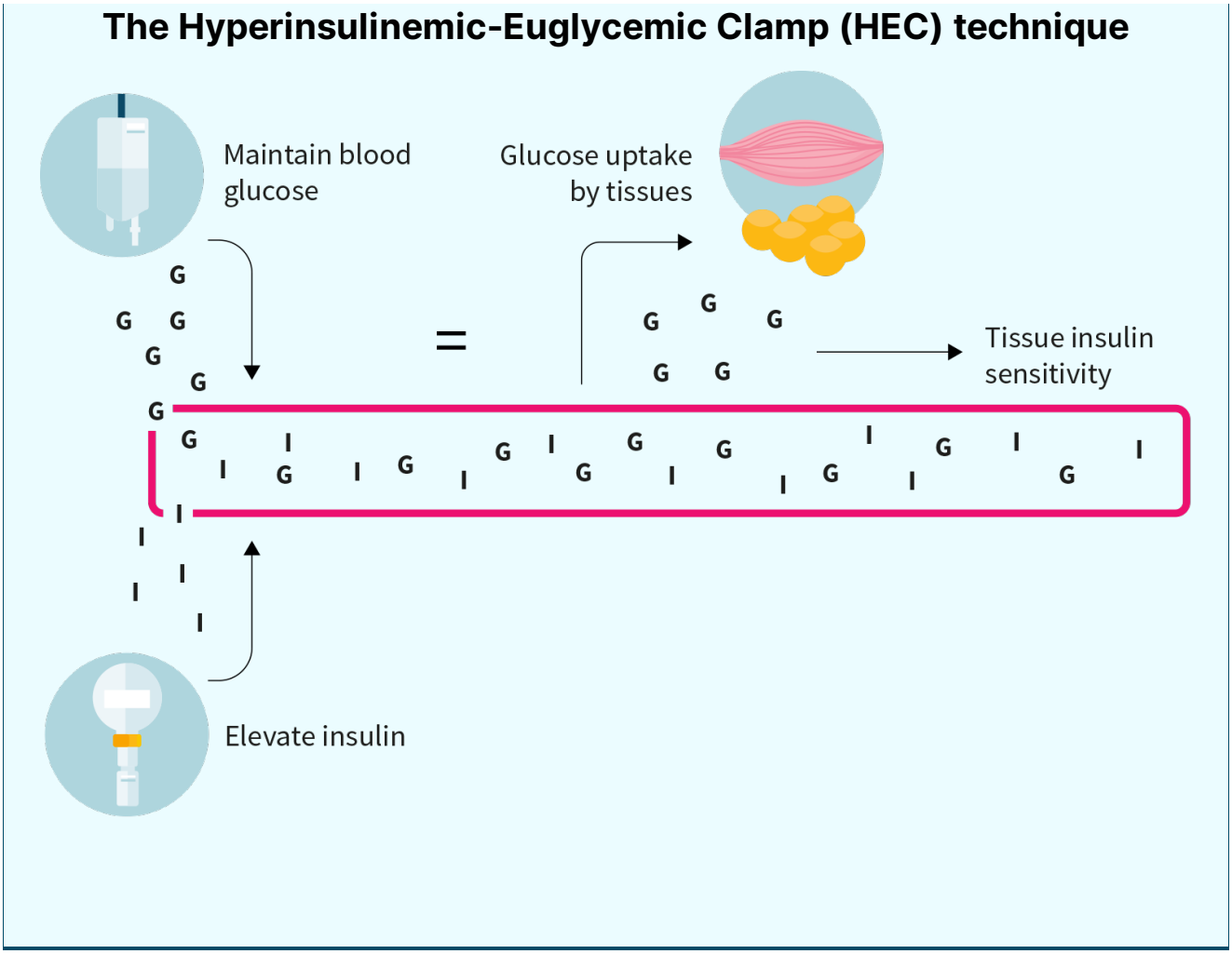
Hyperinsulinemic-Euglycemic Clamp (HEC)

HEC is the gold standard for measuring insulin sensitivity. While you are being infused with both insulin and glucose, an *estimated glucose disposal rate* (eGDR) under 5.3 mg/kg/min suggests insulin resistance.[42]

🔍 ***Digging deeper:*** **The hyperinsulinemic-euglycemic clamp**

The hyperinsulinemic-euglycemic clamp is a clever device that continuously infuses both insulin and glucose so that they balance each other — i.e., so that your blood levels stay normal (normoglycemia) despite the elevated insulin level (hyperinsulinemia). The less glucose you need to maintain normoglycemia, the less insulin sensitive you are.[43]

And with the same device, you can measure insulin secretion by infusing glucose and measuring how much is required to maintain an elevated glucose level (hyperglycemia).



Course of action

In this guide, we review the evidence for the effects of various supplements on various measures of glycemic control and talk about what can be expected. For each supplement, we offer insights into the most effective form and dosage, as well as warnings about possible adverse effects. However, if you are worried about diabetes, your first step should be to get tested.

Before you talk to your doctor, though, you may want to record what you eat in real time (for a week at least) to get a better idea of your usual diet — your findings may surprise you, as we often misremember and underestimate what we ate, even shortly after eating.[44][45][46][47] You should record the calories, macronutrients (carbs, fat, and protein), and sugar content of each food you consume. Then when you visit your doctor, you can not only mention the different tests in this introduction, but also share your food diary.

Fast forward: you have been tested. Now what should you do?

If you have neither diabetes nor prediabetes, you should exercise and eat a balanced diet rich in a variety of whole foods. Supplementation for blood sugar control isn't necessary.

If you have prediabetes, you should exercise, eat a balanced diet rich in a variety of whole foods, and minimize the *glycemic index* (GI) of your meals (you can check the GI of different foods here). You may also want to consider supplementation — read this guide carefully, and if you decide to try anything, mention it to your doctor.

If you have diabetes, you should exercise, eat a balanced diet rich in a variety of whole foods, and minimize

the *glycemic index* (GI) of your meals (you can check the GI of different foods here). You may also want to consider supplementation, but consult your doctor before trying anything. Your doctor has probably prescribed you some medicine (metformin being the most common), and supplements and medicine can interact. Read the "Warnings" sections especially carefully.

Good reading!

Wyatt Brown, Researcher

Combos

⚠️ ***Caution:*** **Read this before taking any supplement**

Supplements in the combo sections can lower your blood sugar. When taken in combination with each other or drugs known to lower blood sugar (i.e., antidiabetic drugs), they might have additive effects and could cause a hypoglycemic event (i.e., very low blood sugar). For these reasons, take the following precautions.

Before assembling your combo, speak with your physician about your intention to begin taking supplements that can affect your blood sugar, as adjustments to current medications or treatments may be needed.

Do not begin any specialized combo until you have supplemented with the core fiber supplement for at least 2 weeks to determine its effects on your blood sugar levels. You may find that a fiber supplement alone could suffice for your health needs.

Though some specialized combos have multiple suggested supplements, you should add them to your diet in a methodical fashion, step-by-step. Instructions are provided on how to do so in each section.

Core Combo

First, try to increase your dietary intake of fiber-rich foods.

Take one of the following fiber supplements. Doses should be taken within 15 minutes before a meal and split across meals.

- Psyllium: 10–15 g/day
- Beta-glucan: 5–10 g/day
- Raw guar gum: 10–20 g/day

💡 ***Tip:*** **Try one combo alone for a few weeks**

Taking too many supplements at once may prevent you from determining which ones are truly working. Start with just one of the combos suggested here for a couple of weeks before you consider making any modification, such as adding another supplement, altering a supplements dosage, or incorporating the supplements from an additional combo.

When adding another supplement to your regimen, be methodical. For example, you may wish to take all the supplements from two combos. Select the combo that you wish to try first and take this for a couple of weeks. Then, add one supplement from the second combo and wait another week to see how it affects you. Continue this process until you've added all the supplements you wish to.

If a supplement appears in two combos you wish to combine, don't stack the doses; instead, combine the ranges. For instance, if the range is 2–4 mg in one combo and 3–6 mg in the other, your new range becomes 2–6 mg. Always start with the lower end of the range — especially in this case, since the reason why one of the ranges has a lower ceiling in one combo may be due to a synergy with another supplement in the same combo. Reading through the full supplement entry may help you decide which dose to aim for, but if you're not sure, lower is usually safer.

Specialized Combos

For people with elevated fasting blood glucose or HbA1c

Take 300–500 mg of berberine three or four times per day (900–2,000 mg total) with, during, or very shortly after a meal containing carbs. Start at the low end of the range, since higher dosages are more likely to cause stomach discomfort and diarrhea.

After taking berberine for a week or two, take 25–30 mg/day (30–40 mg/day if you have high blood sugar) of elemental *zinc sulfate* or *gluconate*, preferably on an empty stomach. If this causes nausea or discomfort, take the zinc with food that is not rich in phytates (grains, legumes, seeds, and nuts), as they may reduce zinc absorption.

After testing out berberine and zinc over a 2–4 week period, you can add in 200–350 mg/day of elemental *magnesium citrate*, *gluconate*, or *glycinate*. Magnesium gluconate should be taken with a meal; other forms can be taken on an empty stomach. Take 200 mg/day of elemental magnesium to avoid deficiency or if you regularly consume magnesium-rich foods. Up to 350 mg/day can be used if magnesium intake is particularly low.

After testing out the above primary options over a 4- to 6-week period, you can try adding the following secondary options. Add them in one at a time, separating each new addition by a 1- to 2 week period.

- 600–1,000 mcg/day of chromium picolinate in divided doses throughout the day, with meals containing carbohydrates
- 500 mg of *Cinnamomum cassia* — as a powder or in capsule form — twice daily, with a meal containing carbohydrates, for 2 weeks. After this period, stop using for 2 weeks and then repeat this cycle for as long as desired.

- 1.2 g/day of pinitol with food. Though less studied, myo-inositol may be an alternative option if pinitol does not produce any notable results. To supplement with myo-inositol, take 4 g/day with food.

For people with insulin resistance

Take 300–500 mg of berberine three or four times per day (900–2,000 mg total) with, during, or very shortly after a meal containing carbs. Start at the low end of the range, since higher dosages are more likely to cause stomach discomfort and diarrhea.

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After testing out berberine and zinc over a 2- to 4-week period, you can also add in 200–350 mg/day of elemental *magnesium citrate*, *gluconate*, or *glycinate*. Magnesium gluconate should be taken with a meal; other forms can be taken on an empty stomach. Take 200 mg/day of elemental magnesium to avoid deficiency or if you regularly consume magnesium-rich foods. Up to 350 mg/day can be used if magnesium intake is particularly low.

After testing out the above primary options over a 4- to 6-week period, you can try adding the following secondary options.

- 1.2 g/day of pinitol with food. Though less studied, myo-inositol may be an alternative option if pinitol does not produce any notable results. To supplement with myo-inositol, take 4 g/day with food.

For people with diabetes or prediabetes who exercise regularly

Zinc and magnesium can be lost in sweat, so regular exercisers and people who sweat a lot should be particularly mindful of their intake of these minerals.

Take 25–30 mg/day (30–40 mg/day if you have high blood sugar) of elemental *zinc sulfate* or *gluconate*, preferably on an empty stomach. If this causes nausea or discomfort, take zinc with food that is not rich in phytates (grains, legumes, seeds, and nuts), as they may reduce zinc absorption.

After taking zinc for a week or two, add in 200–350 mg/day of elemental *magnesium citrate*, *gluconate*, or *glycinate*. Magnesium gluconate should be taken with a meal; other forms can be taken on an empty stomach. Take 200 mg/day of elemental magnesium to avoid deficiency or if you regularly consume magnesium-rich foods. Up to 350 mg/day can be used if magnesium intake is particularly low.

For people on a high-carb diet

Take 300–500 mg of berberine three or four times per day (900–2,000 mg total) with, during, or very shortly after a meal containing carbs. Start at the low end of the range, since higher dosages are more likely to cause stomach discomfort and diarrhea.

After taking berberine for a week or two, take 500 mg of *Cinnamomum cassia* — as a powder or in capsule form — twice daily, with a meal containing carbohydrates, for 2 weeks. After this period, stop use for 2 weeks and then repeat this cycle for as long as desired.

For people with polycystic ovary syndrome (PCOS)

Take 2–4 g of inositol-for-PCOS|myo-inositol] per day with food.

Primary Supplements

Fiber

What makes *fiber* a core supplement

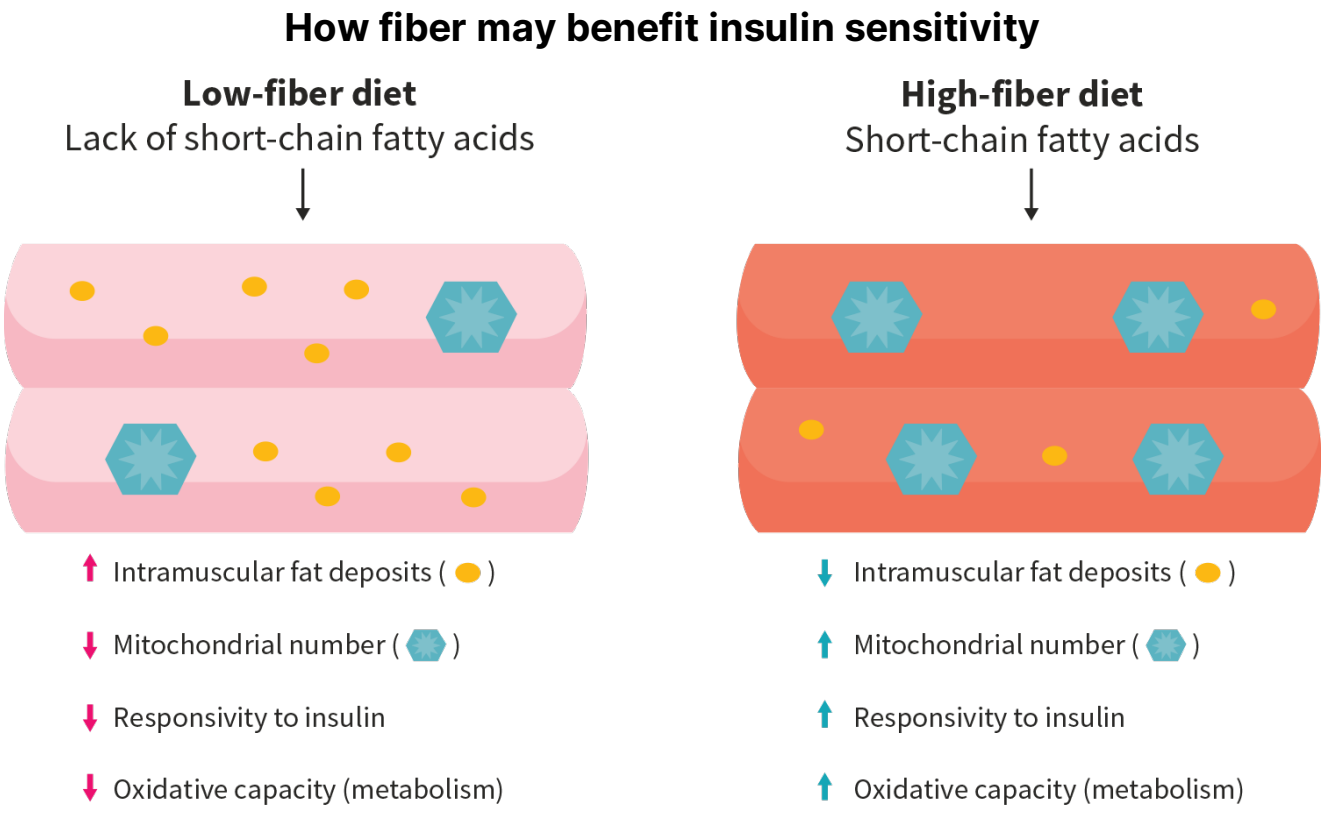
Fiber can improve blood sugar control in healthy and diabetic individuals. It may also reduce the risk of developing type 2 diabetes.

Fiber is a category of carbohydrates resistant to digestion that pass through our small intestine to be excreted or fermented in the large intestine by microbes. Fiber helps slow down the absorption of carbohydrates, which explains why it — notably the soluble type — has a favorable effect on blood sugar regulation.

Primarily found in fruits, vegetables, legumes, and whole grains, fiber can be roughly divided into two categories.

Soluble fiber dissolves in your stomach into a gel that slows down the digestion of food. This gel also helps lower blood sugar by delaying and reducing carbohydrate absorption in the body.[48] Soluble fibers may also increase insulin sensitivity, possibly due in part to the short-chain fatty acids born from their fermentation by the gut microbiome.[49]

Insoluble fiber does not dissolve in your stomach but gently "scrubs" your digestive tract. It speeds up the rate at which food moves through your intestinal tract, yet it may also increase insulin sensitivity and bind to potentially harmful chemicals, such as carcinogens, allowing them to be excreted.[48][49][50]



Adapted from McNabney and Henagan. *Nutrients*. 2017.[51]

Soluble fibers with a higher viscosity have shown the greatest and most consistent results at improving blood sugar control, the most studied types being psyllium, guar gum, and beta-glucan.[52][53][54][55][56][57] Viscosity refers to the fiber's ability to form a gel-like substance when mixed with fluids.[58]

Dietary requirements for fiber have been established as *Adequate Intake* (AI) levels.[59] The AI for fiber can be thought of as the minimum level needed to ensure nutritional adequacy. While the recommended intake for adults ranges from 21 to 38 g/day, the US average intake is just 16 g, which falls 23.8–57.9% below the AI.[60]

Adequate Intake (AI) for total fiber (g)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	—	—	—	—
7–12 months	—	—	—	—
1–3 years	19	19	—	—
4–8 years	25	25	—	—
9–13 years	31	26	—	—
14–18 years	38	26	28	29
19–30 years	38	25	28	29
31–50 years	38	25	28	29
51–70 years	30	21	—	—
70+ years	30	21	—	—

Reference: Institute of Medicine. Dietary, Functional, and Total Fiber (chapter 7 in *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids.* The National Academies Press. 2005.)[59]

Getting more than the AI — up to 50 g/day — can provide further glycemic benefits, particularly in people with high blood sugar or advanced insulin resistance.[61] Intakes above 50 g/day may provide further benefits in these areas, but the improvements tend to be very small,[61] and many people may find it difficult to consume more than 50 g of fiber every day, even with supplementation.

A high-fiber diet has not only been shown to improve blood glucose control, especially in people with type 2 diabetes, but also been consistently associated with a decreased risk of type 2 diabetes.[62][63] Thus, fiber can help people with normal blood sugar maintain or modestly improve their blood glucose control while decreasing their type 2 diabetes risk.

It's important to note that the vast majority of studies showing a reduction in type 2 diabetes risk from fiber intake were in people who consumed fiber primarily from food sources (i.e., people with lower diabetes risk tended to have a higher overall intake of vegetables, whole grains, fruits, legumes, etc.).[62] It is *very likely* that a diet rich in fiber will be better for diabetes prevention than relying on fiber supplements.

Warnings about *fiber*

To date, no *Tolerable Upper Intake Level* (UL) has been set for fiber.[59][64] Ill effects from a higher fiber intake vary greatly from person to person and may include flatulence, bloating, cramping, diarrhea, or general intestinal discomfort. These may be more common under the following circumstances:

- When consuming isolated fiber supplements
- When fiber intake is abruptly increased
- When consuming very high levels of fiber (>50 g/day)
- When consuming highly fermentable fibers (e.g., guar gum, inulin/chicory root, pectin, beta-glucan, konjac glucomannan)

If not consumed with sufficient fluids, a high-fiber diet may cause a blockage in your intestines (aka an intestinal obstruction). This is a particular concern in people who may have impaired intestinal motility, which occurs when the nerves or muscles in your intestinal tract don't function properly; this may cause intestinal muscle contractions to occur at an abnormally slow rate, which may cause food to get stuck.

A common ingredient in protein bars — isomalto oligosaccharide (IMO) — was once thought to be fiber, because it isn't broken down early in the digestion process. But it was later found that IMO gets mostly absorbed in the small intestine, providing 2.7–3.3 calories per gram (compared with 4 kcal/g for fully digestible carbohydrates).[65][66][67]

While not inherently low in fiber, very low calorie, low-carbohydrate, and ketogenic diets can sometimes be lower in fiber than other diets due to a reduction in plant matter intake.[68][69][70]

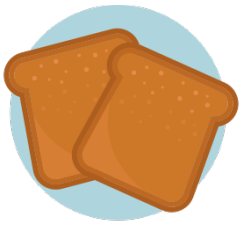
Supplemental fiber may interfere with the absorption of digoxin (Digox, Lanoxin Pediatric, Digitek),[71] carbamazepine (Tegretol XR, Equetro, Epitol),[72] levothyroxine (Synthroid, Tirosint, Unithroid),[71] and lithium.[71] Do not take fiber within at least 30 minutes of taking these medications. It's possible that supplemental fiber may interfere with other medications not listed above. Out of caution, it may be prudent to separate pharmaceutical intake from fiber by at least 30 minutes as well. (This can also apply to other supplements).

Fiber supplements are not known to cause low blood sugar (i.e., hypoglycemic events), but it is theoretically possible — though not probable — when taken with other supplements or pharmaceuticals that can lower blood sugar, such as most antidiabetic drugs.

How to take *fiber*

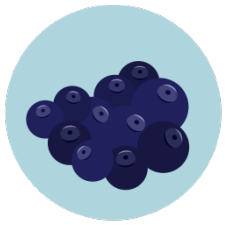
First, try to eat your fiber via whole foods, as isolated fiber supplements do not fully replicate the health benefits obtained from fibrous foods.

What 25 grams of fiber a day looks like*



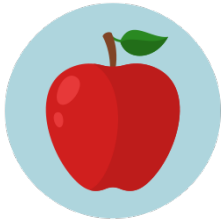
Two slices of whole wheat bread (6g)

Cup of oatmeal (4g)



Half cup of blueberries (2g)

Two cups of spinach (4g)



Apple (5g)

Cup of brown rice (4g)

Values are approximate and can vary

In people with impaired blood glucose control, taking ≈10–15 g/day of a supplemental soluble viscous fiber over at least 8 weeks has been shown to provide the following benefits:

- HbA1c reduction of −0.88 to −0.28%
  - People with an HbA1c of ≥9.15% may see a −1.54 to −0.51% reduction.
- Fasting blood glucose reduction of −1.32 to −0.31 mmol/L (−23.78 to −5.59 mg/dL)
  - People with a fasting blood glucose of ≥9.75 mmol/L (≥175 mg/dL) may see a −2.05 to −0.43 mmol/L (−36.94 to −7.75 mg/dL) reduction.
- Fasting insulin reduction of −18.97 to +0.60 pmol/L (−2.73 to +0.09 mIU/L)
- HOMA-IR (a measure of insulin sensitivity) reduction of −3.45 to −0.33
  - People with a HOMA-IR of ≥5.44 may see a −6.14 to −2.32 reduction.

The above potential benefits will be affected by your current fiber intake and baseline test values assessing blood glucose regulation. Also, a fiber supplement will perform better if it adds to your overall fiber intake, so don't decrease your fibrous food intake simply because you start taking a supplement.

For all supplemental fiber options below, doses should be taken within 15 minutes before a meal, if not immediately before, and split evenly across meals. Start with the lowest suggested dose to see how you react before increasing, if needed.

To supplement with *psyllium*, take 10–15 g/day. Psyllium may be preferred for its high viscosity, which can aid in blood sugar regulation, and low degree of fermentation, which makes it less likely to produce unwanted side effects. In studies of soluble viscous fibers, it has also produced greater favorable effects on blood glucose control.[54]

To supplement with *beta-glucan*, take 5–10 g/day. Note that side effects may be more common with beta-glucan compared with psyllium, as beta-glucan has higher fermentation potential.

To supplement with *raw guar gum*, take 10–20 g/day. It's important to use raw guar gum, as partially hydrolyzed guar gum has low viscosity, which reduces its effectiveness.[73][74] Raw guar gum tends to have an undesirable taste and may be best consumed in capsule form, rather than added to foods or drinks.

Alternatively, you can mix the options listed above, but keep an eye on your total dosage. For instance, in one day you could take one third of the upper dosage for psyllium (5 g), one third of the upper dosage for beta-glucan (≈3 g), and one third of the upper dosage for guar gum (≈6 g).

If you opt for a fiber blend supplement, make sure it is primarily composed of highly viscous soluble fibers, such as the ones listed above. Keep in mind, it's difficult to know what effects various blends might have on blood sugar control or what dose to take. Broadly speaking, aim for ≈5–15 g/day.

Other soluble viscous fibers, such as xanthan gum, pectin, locust bean gum, konjac glucomannan, and the proprietary product PolyGlycopleX®(aka PGX), may be viable options but haven't been well studied (or studied at all) with regard to blood sugar management. So their potential benefits or drawbacks are not as well documented.

Functional properties and sources of dietary fiber

FIBER	FUNCTIONAL PROPERTIES			MAIN SOURCES
	Viscosity	Solubility	Fermentation	
	Higher is better		*Lower is better*	
Bran	Low	Low	Low	Whole grains
Cellulose				Vegetables
Hemicellulose				Vegetables
Lignin				Seeds
Inulin	Low	High	High	Roots and tubers
Dextrin				Wheat and corn starch
Oligosaccharides				Fruits, vegetables, legumes, grains
Resistant starch				Type 1: Whole grain Type 2: High-amylose maize starch, raw potato, and banana Type 3: Cooked and cooled starchy foods Type 4 & 5: Modified starches
Pectin	High	High	High	Fruits, vegetables, legumes
Beta-glucan				Oats and barley
Glucomannan				Tuberous roots of the konjac plant
Guar gum				Seed plants (guar, locust bean), seaweed extracts (carrageenan, alginates), microbial gums (xanthan, gellan)
Xanthan gum				Sugars fermented by the bacterium *Xanthomonas campestris*
Psyllium	High	High	Low	Husks of ripe seeds from *Plantago ovate*
Methylcellulose				Derived from cellulose

Adapted from McRorie. *Nutr Today*. 2015.[53] ● McRorie. *Nutr Today*. 2015.[73]

Regardless of where your fiber comes from (foods, supplements, or both), take these three steps to minimize unwanted side effects.

1. Gradually increase your fiber intake over a period of 1–2 weeks. This will allow time for your microbiome to adjust and help you identify your tolerance threshold. If taking a fiber supplement, begin with 3–4 g a day for the first few days before increasing your dose.
2. Ensure you are taking in enough fluids as you increase your fiber intake. A fiber intake of 40–70 g/day can be generally well tolerated, with sufficient fluid intake, in healthy adults without intestinal issues (e.g., IBD, IBS, celiac, Crohn's, ulcerative colitis, low intestinal motility).[59] If your fiber supplement comes with instructions on how much fluid to consume per dose, follow these. If not, consume at least 355 mL (12 oz) of fluids for every 5 g of fiber.
3. Split your fiber intake evenly across meals to ease digestion.

💡 ***Tip:*** **Why don't you recommend brands or specific products?**

For two reasons:

- We don't test physical products. What our researchers do — all day, every day — is analyze peer-reviewed studies on supplements and nutrition.
- We go to great lengths to protect our integrity. As you've probably noticed, we don't sell supplements, or even show ads from supplement companies, even though either option would generate a lot more money than our Supplement Guides ever will — and for a lot less work, too.

If we recommended any brands or specific products, our integrity would be called into question, so … we can't do it. That being said, in the interest of keeping you safe, we drew a short list of steps you should take if a product has caught your interest.

Secondary Supplements

Berberine

> ⚠️ ***Caution:*** **An important disclaimer**
>
> Much of the research on berberine is available only in Chinese, so this section relies heavily on English-language review papers and meta-analyses covering these studies. While we are able to assess the methodology of the reviews and meta-analyses, we are unable to directly evaluate some of the individual papers included in them. Therefore, we have given extra caution to berberine's classification and dosages in this guide.

What makes *berberine* a primary option

Berberine can improve blood sugar control, HbA1c, and insulin sensitivity, particularly in those with type 2 diabetes.

Berberine is an alkaloid compound extracted from various plants, such as *Berberis aquifolium*, *Berberis aristata*, and *Argemone mexicana*. It can lower blood sugar levels by activating enzymes that draw blood glucose into cells and signaling that glucose should be used for energy production.[75]

Most berberine trials looking at blood glucose control have lasted 3 months, with a few trials lasting longer (four RCTs were ≥6 months). But it's unclear how long it takes to see the full effects of berberine.

In six placebo-controlled trials conducted in China, berberine lead to a large reduction in blood sugar levels and HbA1c in patients with type 2 diabetes.[76] It may do the same and improve insulin sensitivity in people who are not type 2 diabetic but have impaired blood glucose control or insulin resistance.[77][78][79] Additionally, extracts and juices derived from the berberine-containing barberry fruit showed similar results (i.e., reduced blood sugar and HbA1c, improved insulin sensitivity) in people with type 2 diabetes.[80][81][82][83]

Further research has compared berberine to antidiabetic drugs and compared berberine + antidiabetic drugs to the drug alone. This research suggests that using berberine along with either of the diabetes drugs metformin or gliclazide is more effective than berberine or the drugs are separately. Some results indicated that berberine may be just as effective as some pharmaceuticals, such as metformin, gliclazide, and glyburide.[76]

Despite many studies suggesting a notable benefit of berberine supplementation, the quality of the studies presents some limitations. For example, detailed information about the blinding of participants (i.e., if they knew they were taking berberine or a placebo) is absent from many of the studies conducted in type 2 diabetes patients, which increases the risk for bias. So, while we have good reason to believe that berberine is effective in managing blood glucose, just *how* effective remains to be seen.

Warnings about *berberine*

While low blood sugar (i.e., hypoglycemic events) has not been readily observed in clinical trials, no long-term trials tracked this outcome. It is possible berberine may cause low blood sugar, so some caution is warranted, particularly when taken with supplements or pharmaceuticals that can lower blood sugar.[84] *If you are taking any medication that can lower blood sugar, do not begin taking berberine without talking to your physician.*

Research assessing berberine's safety tends to be short term, making it difficult to predict adverse effects with prolonged use. The larger, more effective doses (1.5 g/day or more) of berberine may lead to a higher occurrence of adverse effects.[85] While major adverse events haven't been associated with berberine supplementation, gastrointestinal symptoms such as nausea, diarrhea, constipation, and abdominal swelling from gas or fluid may result from taking high doses.

Berberine should only be taken by people with elevated fasting blood sugar (≥5.55 mmol/L; ≥100 mg/dL) or HbA1c (≥5.7%). Most of the research is in type 2 diabetics, and much of the rest is in people at risk for becoming diabetic. While it's possible that berberine could help people with normal blood sugar levels and insulin sensitivity maintain lower fasting blood sugar, it's not clear if the benefits outweigh the risks when used consistently for years. Additionally, it's unclear if berberine can provide any benefit for people with gestational diabetes or polycystic ovary syndrome (PCOS),[86] a condition that is often accompanied by insulin resistance.[86]

Berberine interacts with several enzymes and thus has the potential to interact with many pharmaceuticals. Not all are known, but documented drug interactions include losartan (Cozaar), dextromethorphan (Vicks, Robitussin, Tussin Cough, Delsym), midazolam (Versed), and various oral contraceptives.[87] *Do not take berberine if you are on **cyclosporine** (Neoral, Sandimmune, Gengraf), as berberine may interfere with its metabolism.*

Do not supplement with berberine if pregnant or breastfeeding, as it has barely been studied under these conditions. What studies we do have point to some potential harm (unusual uterine contractions, miscarriage, and kernicterus in jaundiced newborns), but these events are not confirmed to be caused by berberine.[88][89] Even so, caution is warranted until more research has been conducted.

Lastly, berberine can increase bilirubin levels (a substance found in bile, which aids digestion), which may interfere with lab tests of bilirubin. If you plan on getting this tested, stop taking berberine at least 7 days prior to testing.

How to take *berberine*

Take 300–500 mg of *berberine* three or four times per day (900–2,000 mg total) before or with a meal, especially any containing carbohydrates. It could also be taken immediately following a meal, but this may lessen berberine's effects. Start at the low end of the range, as higher doses are more likely to cause an upset stomach and/or diarrhea.

People with type 2 diabetes who *are not* currently taking pharmaceuticals for their condition may see a reduction in fasting blood sugar between −1.37 and −0.67 mmol/L (−24.68 to −12.07 mg/dL) and a reduction in HbA1C of −0.90 to −0.44%.

People with type 2 diabetes who *are* currently taking pharmaceuticals for their condition may see a reduction in fasting blood sugar between −1.03 and −0.47 mmol/L (−18.56 to −8.47 mg/dL) and a reduction

in HbA1C of −1.29 to −0.05%.

In people who have signs of prediabetes, berberine supplementation may lead to reductions in blood sugar, HbA1c, and insulin resistance. However, far less research has been conducted on this population than in people with type 2 diabetes, so what improvements may be seen are much less certain.

Individual results for all the above scenarios will vary depending on berberine dosage. A higher dose is more potent until about 1.5 g/day, after which it's not known if doses exceeding this are better. Age can also influence how effective berberine can be, because it may become a little less effective after 50, as can the type of diabetes medication, if any, being taken.[76] In the case of those taking glipizide, adding berberine may only lead to a small improvement. With those taking metformin, the addition of berberine appears to lead to moderate improvement.[76]

Inositol (for PCOS)

> 💡 ***Tip:*** **The evidence for inositol varies by condition**
>
> When researching inositol, we found that the quality and strength of the evidence differed depending on what condition this supplement was studied for. Thus, we have three inositol entries in this guide.
>
> - *Primary Option:* Inositol (for PCOS)
> - *Secondary Option:* Inositol (for type 2 diabetes and prediabetes)
> - *Unproven Supplements:* Inositol (for gestational diabetes)

What makes *inositol* a primary option

In females with polycystic ovary syndrome (PCOS), inositol (myo-inositol specifically) can reduce insulin resistance and fasting insulin levels.

Inositol encompasses nine vitamin-like compounds that are structurally similar to blood glucose. The most common of those, in nature as well as in health stores, is called *myo*-inositol. Supplemental myo-inositol is often called just "inositol" or sometimes "vitamin B_8" (a misnomer, as inositol is not related to the B vitamins, nor is it a true vitamin).

Inositol is in most foods, notably whole grains and citrus fruits, and your body can produce it, so dietary deficiencies are rare.[90] Insulin resistance, however, can lower your levels of inositol,[90][91] which in turn lowers levels of PIP_3 (a component of cell membranes), resulting in poor insulin signaling.

For PCOS, studies suggest that inositol can notably reduce insulin resistance and modestly reduce fasting insulin levels.[92][93][94][95][96] There's also the question of efficacy when combining different inositol forms. One study found that 1,100 mg of myo-inositol and 27.6 mg of D-chiro-inositol daily was more effective at improving blood sugar control than 2,000 mg of myo-inositol alone 3 months into the study, but no differences were noted at 6 months.[97] It's possible that this combination may lead to more rapid improvements in the short term, but results may level out in the long term. This is currently an open research question.

Warnings about *inositol*

Studies haven't reported notable adverse effects from taking inositol, though they haven't been particularly meticulous about their accounting.[98] Myo-inositol might cause some gastrointestinal discomfort, but this is not a frequent occurrence.

In pregnant females taking up to 4 g of myo-inositol, no notable adverse effects were noted in the females or in their babies at birth.[99][100][101] There is insufficient evidence on the effects of taking myo-inositol while breastfeeding.

How to take *inositol*

While there are a few forms of inositol, myo-inositol is the most extensively researched form for PCOS.

To supplement with *myo-inositol*, take 2–4 g/day with food.

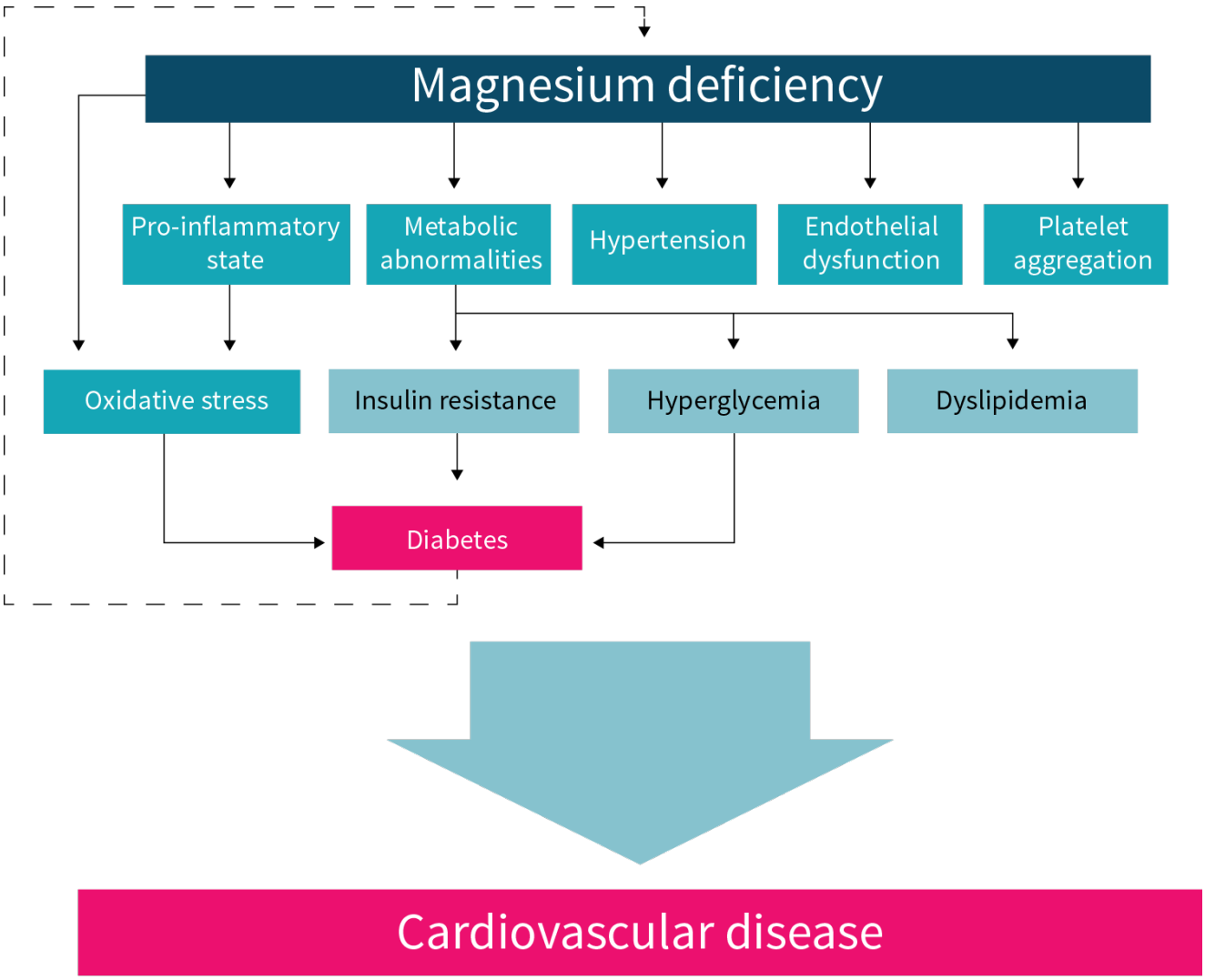
Females with PCOS taking myo-inositol may see a reduction in fasting insulin between −12.43 and −1.74 pmol/L (−1.79 to −0.25 mIU/L) and their HOMA-IR score (a measure of insulin sensitivity) between −1.15 and −0.03.

Magnesium

What makes *magnesium* a primary option

Magnesium may help improve insulin sensitivity, especially in people with type 2 diabetes or prediabetes who have low magnesium levels.

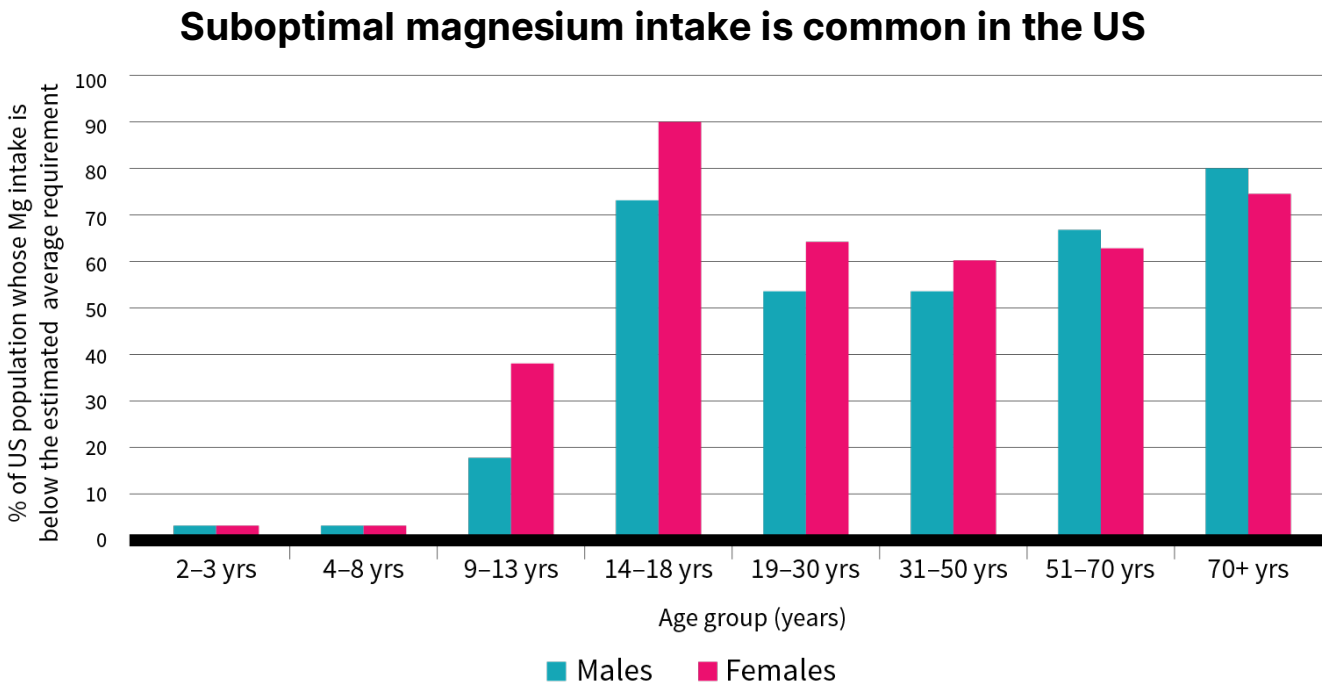
Role of magnesium in diabetes and cardiovascular disease



Adapted from Bo and Pisu. *Curr Opin Lipidol*. 2008.[102]

Magnesium is a factor in blood sugar metabolism[103] and may also assist in regulating inflammation, thus improving insulin sensitivity.[104]

It has been estimated that in developed countries, hypomagnesemia (subnormal magnesium levels in the blood) affects less than 15% of healthy people but up to 50% of people with type 2 diabetes.[105] Low magnesium intake is common in the US, as seen below. This is important because patients with low magnesium levels and type 2 diabetes can end up in a vicious cycle, with low magnesium increasing insulin resistance, which in turn decreases magnesium levels.[103]



Reference: Rosanoff et al. *Nutr Rev.* 2012.[106]

The good news is, supplementing with magnesium can improve insulin sensitivity and modestly reduce fasting blood sugar levels in people with hypomagnesemia.[107][108][109]

The effects of supplementation in people with normal magnesium levels are less clear, but they don't seem to be as potent. If you have been diagnosed with diabetes, it may be worth testing your magnesium levels before beginning supplementation.

Warnings about *magnesium*

High doses of supplemental magnesium can cause diarrhea and general intestinal discomfort;[110] fortunately, magnesium obtained via food has not been seen to cause such problems.[110]

Tolerable Upper Intake Level (UL) for supplemental magnesium (mg)

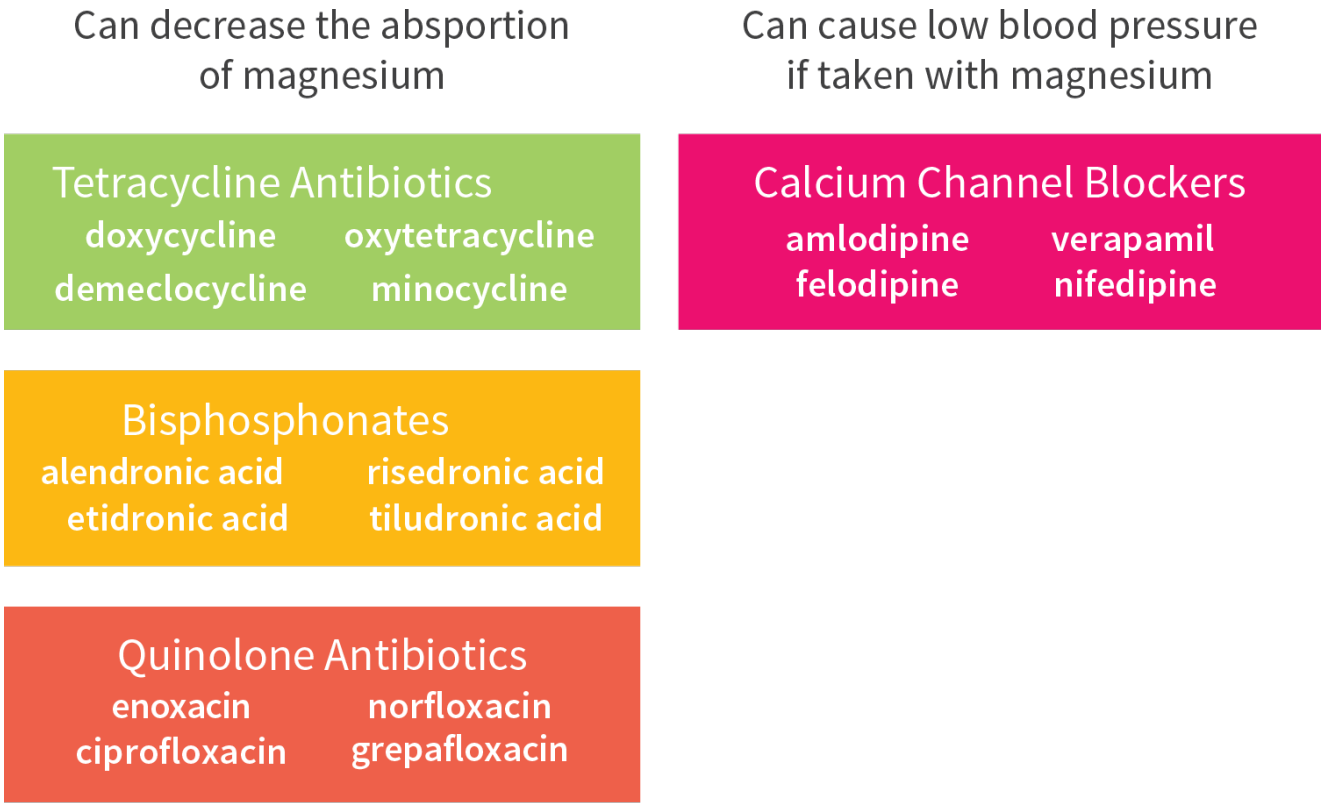
AGE	MALE	FEMALE	PREGNANT	LACTATING
0–12 months	—	—	—	—
1–3 years	65	65	—	—
4–8 years	110	110	—	—
8+ years	350	350	350	350

Reference: Institute of Medicine. Magnesium (chapter 6 in *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride*. The National Academies Press. 1997.)[111]

Magnesium can lower blood sugar and may have additive effects when taken with other supplements or pharmaceuticals that can lower blood sugar, such as antidiabetic drugs.

But magnesium may impair the absorption of other pharmaceuticals, notably bisphosphonates and antibiotics, especially those in the tetracycline class (e.g., doxycycline) or quinolone class (e.g., ciprofloxacin).[112] Take magnesium at least 6 hours apart from bisphosphonates or antibiotics.

Potential drug interactions with magnesium



Reference: Pazianas et al. *Ther Clin Risk Manag*. 2013.[112] ● Crippa et al. *Ann Ital Med Int*. 1999.[113]

Certain diuretics, proton pump inhibitors, and the antifungal medication amphotericin B can cause significant magnesium loss.[114][115]. However, potassium-sparing diuretics (e.g., amiloride, eplerenone/Inspra, spironolactone/Aldactone, triamterene/Dyrenium) may not.[114]

Since calcium, iron, magnesium, and zinc compete for absorption, it is better to take them at least one hour apart from each other.

Because magnesium might have a sedative effect and improve sleep quality, it is best to take it before bed.

How to take *magnesium*

There is no single agreed-on, satisfactory method for assessing magnesium status.[116] To get a better sense of your_ _typical magnesium intake, you should track what you eat for a week. If, on average, you are getting less than 80% of your Recommended Dietary Allowance (RDA), supplementation becomes an option, but you should first try eating more foods rich in magnesium.

Recommended Dietary Allowance (RDA) for magnesium (mg)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	30*	30*	—	—
7–12 months	75*	75*	—	—
1–3 years	80	80	—	—
4–8 years	130	130	—	—
9–13 years	240	240	—	—

AGE	MALE	FEMALE	PREGNANT	LACTATING
14–18 years	410	360	400	360
19–30 years	400	310	350	310
31–50 years	420	320	360	320
50+ years	420	320	—	—

* Adequate intake (AI)

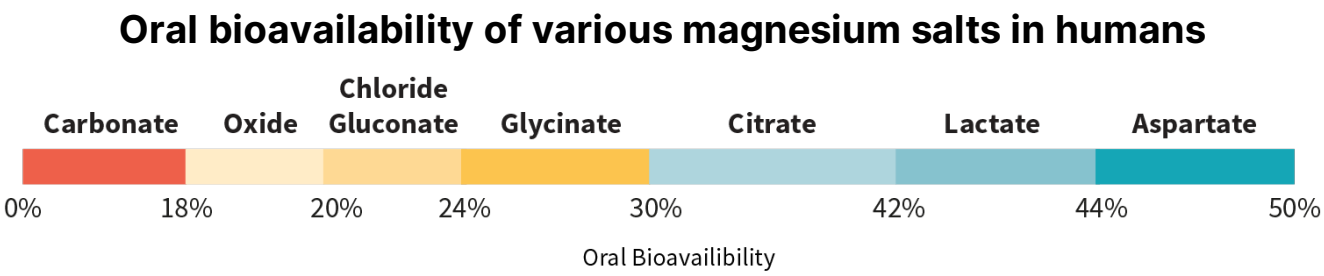
Reference: Institute of Medicine. Magnesium (chapter 6 of *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride*. The National Academies Press. 1997.)[111]

If you cannot get enough magnesium through foods, start supplementing with *200 mg* of magnesium once a day. Capsules with 400 mg are common, but keep in mind that the Tolerable Upper Intake Level (UL) for supplemental magnesium for adults is 350 mg. The higher the dose, the higher the risk of gastrointestinal issues.

If your magnesium intake is very low, take up to *350 mg* of magnesium once a day.

People with elevated blood sugar taking magnesium may see a reduction in fasting blood sugar of −0.82 to −0.2 mmol/L (−14.77 to −3.60 mg/dL) after 3 months of supplementation, with greater reductions more likely in those with lower starting magnesium levels.

Commonly supplemented forms include citrate, gluconate, and glycinate. To increase absorption, magnesium gluconate should be taken with food; other forms can be taken on an empty stomach. *Avoid magnesium oxide.* It has poor bioavailability (rats absorbed only 15% in one study;[117] humans, only 4% in another[118]) and is especially liable to cause intestinal discomfort and diarrhea.[118][119][120]



Reference: Ranade et al. *Am J Ther*. 2001.[121]

Zinc

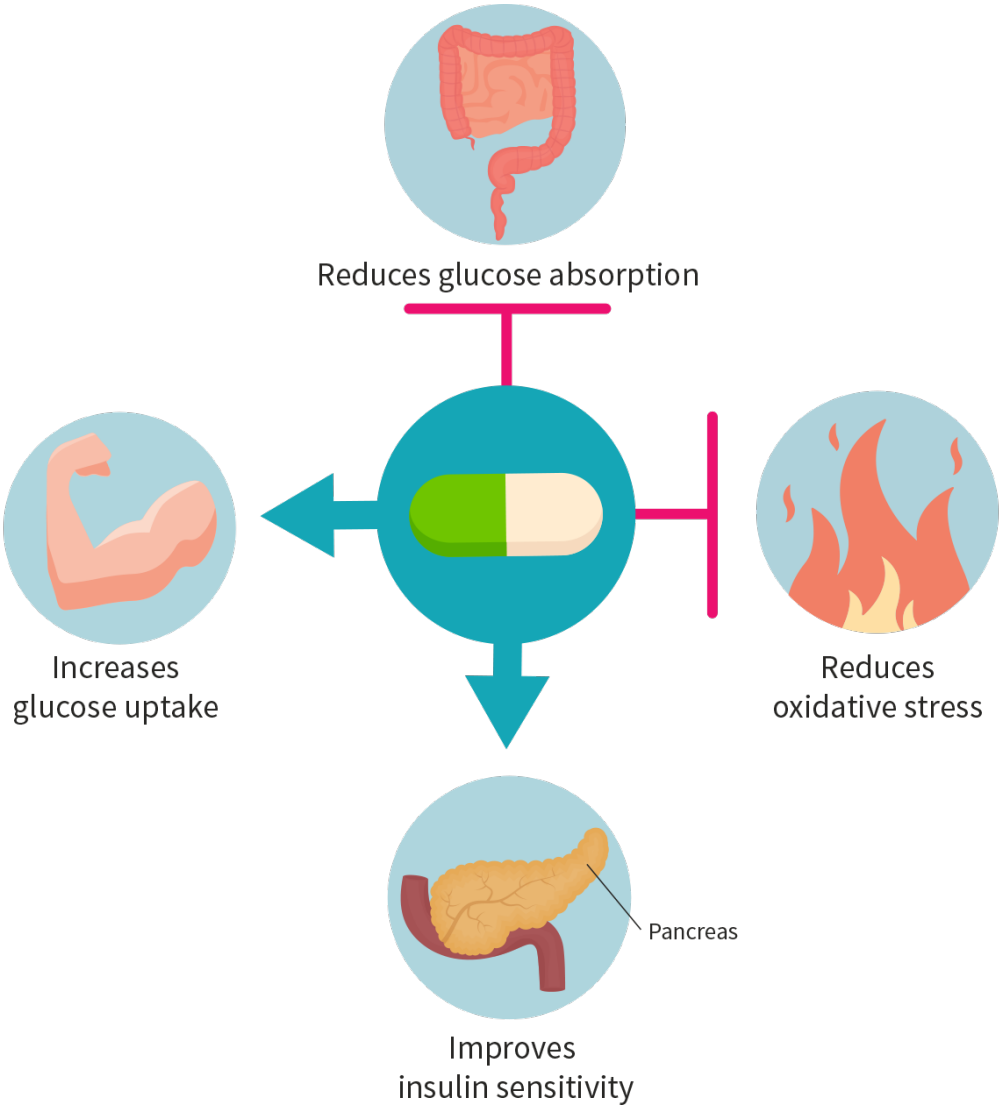
What makes *zinc* a primary option

Zinc can aid in improving insulin sensitivity, especially in people with type 2 diabetes or prediabetes who have low zinc levels.

Zinc is an essential dietary mineral. Around one fifth of the world's population is thought to be at risk for zinc deficiency, but low zinc intake is rarer in developed countries, in part due to higher meat consumption.[122][123]

Dietary zinc isn't the only consideration when it comes to zinc status, however. People with type 2 diabetes or insulin resistance may be more likely to have low levels of zinc in their blood. This doesn't seem to be explained by differences in intake; it's more likely that the disease itself may reduce zinc levels.[124] A reduction of zinc levels due to insulin resistance may create a vicious cycle: Insulin resistance lowers zinc levels, and lower zinc levels worsen insulin resistance, due to the role zinc plays in blood sugar metabolism and insulin secretion.[125][126][127]

Possible benefits of zinc supplementation in people with type 2 diabetes



Reference: Ranasinghe et al. *Daru*. 2015.[126]

For people with type 2 diabetes or prediabetes, a zinc supplement can improve insulin sensitivity and thus lower levels of fasting blood sugar and HbA1c (a measure of average glucose levels over the past ≈3 months).[128][129][130][131][132][133][134][135][136][137][138] On the whole, supplementation trials support the use of zinc for this purpose, but there's a fair bit of inconsistency among them. This may be explained by the simple fact that zinc supplementation is only likely to have an effect if the dose is high enough and taken for long enough to increase zinc status or if zinc status is very low to begin with. For these reasons, not everyone with high fasting blood sugar levels will see notable results.

It's not known if maintaining adequate zinc intake preserves insulin sensitivity or prevents type 2 diabetes in healthy, nonobese people. There are barely any trials that can assess prevention, and these trials aren't nearly long enough to do so, though we can't yet rule out the possibility.[139][140][141] However, in people who

are overweight or obese and insulin resistant but not prediabetic or diabetic, zinc supplementation may reduce insulin resistance. The evidence for this isn't as strong as for people with type 2 diabetes, though, and the effects are not nearly as pronounced.[142]

Warnings about *zinc*

Zinc should be taken with food to prevent potential nausea, but studies observing nausea have used large doses, so it's unclear what risk there is when not exceeding the Tolerable Upper Intake Level (UL) (see table below). Since calcium, iron, magnesium, and zinc compete for absorption, it is better to take them at least one hour apart.

Although to a lesser extent than magnesium, zinc may also impair the absorption of antibiotics, notably the tetracycline (e.g., doxycycline) and quinolone (e.g., ciprofloxacin) classes, so consider taking zinc and antibiotics at least 6 hours apart. Zinc can also impair the absorption of penicillamine, a drug used to treat rheumatoid arthritis, so these should be taken at least 2 hours apart. Thiazide diuretics may increase zinc excretion, thus causing zinc deficiency if taken in the long term.[143]

Excessive intake of zinc can be toxic and cause copper deficiency, and high-dose supplementation increases this risk.[144][145] *Do not exceed the UL for zinc for more than 2 weeks unless under the direction and supervision of a physician.*

Zinc can lower blood sugar and may have additive effects when taken with other supplements or pharmaceuticals that can lower blood sugar, such as antidiabetic drugs.

Tolerable Upper Intake Levels (ULs) for zinc (mg)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	4	4	—	—
7–12 months	5	5	—	—
1–3 years	7	7	—	—
4–8 years	12	12	—	—
9–13 years	23	23	—	—
14–18 years	34	34	34	34
18+ years	40	40	40	40

Reference: Institute of Medicine. Zinc (chapter 12 in *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. The National Academies Press. 2001.)[146]

How to take *zinc*

First, you should determine if you really need to supplement with zinc. This can be done by checking your current blood plasma levels, but this test is not always very accurate,[147] so it can be more practical to track your food intake for a week to determine your average dietary zinc intake.

If, on average, you are getting less than 80% of your Recommended Dietary Allowance (RDA), supplementation becomes an option, though you should first try eating more foods rich in zinc.

If you have high blood sugar or insulin resistance, getting your zinc levels tested may be a better option, as you could have an adequate dietary intake but still have low blood levels.[124]

Blood plasma zinc status

HEALTH STATUS	µmol/L	mcg/dL
Severe deficiency	<4.6	<30
Deficiency	4.6–9.1	30–59
Mild deficiency	9.2–12.7	60–83
Normal	12.8–24.3	84–159
Intoxication	>24.3	>159

Reference: Yanagisawa. *JMAJ.* 2004. Vol:47-9:359–364

In case of *deficiency or severe deficiency*, a medically supervised intervention will be needed. *Do not begin supplementing without discussing it with your physician first.* Common medical interventions include taking a short-term oral dose of 1–2 mg/kg/day of elemental zinc; for severe deficiency, a short-term oral dose of 3 mg/kg/day may be used.[148][149]

In cases of *mild deficiency*, 30–40 mg per day of elemental zinc for 2–4 weeks may raise zinc levels to normal, at which point 10–20 mg/day may suffice for maintenance.

In people on the *lower end of the normal range* (12.9–16.7 µmol/L, 84–109 mcg/dL) with:

- *normal blood sugars and no insulin resistance:* take 5–10 mg/day of elemental zinc for maintenance
- *elevated blood sugars or insulin resistance:* take 20 mg/day of elemental zinc

In people on the *higher end of the normal range* (18.6–24.3 µmol/L, 121.5–159 mcg/dL), a zinc supplement may not be necessary, but taking 5 mg/day of elemental zinc may help maintain normal levels.

In cases of *intoxication* (which can cause serious adverse effects), do not supplement with zinc, cease use of any zinc-containing supplements unless specifically instructed to by a medical professional, and consult your physician.

If you do not know your zinc levels and cannot get them tested but are intent on taking a zinc supplement, it would be prudent to limit yourself to a maintenance dose of 5–20 mg/day. If you cannot get your levels tested and have high blood sugar or insulin resistance, take up to 20 mg/day of elemental zinc.

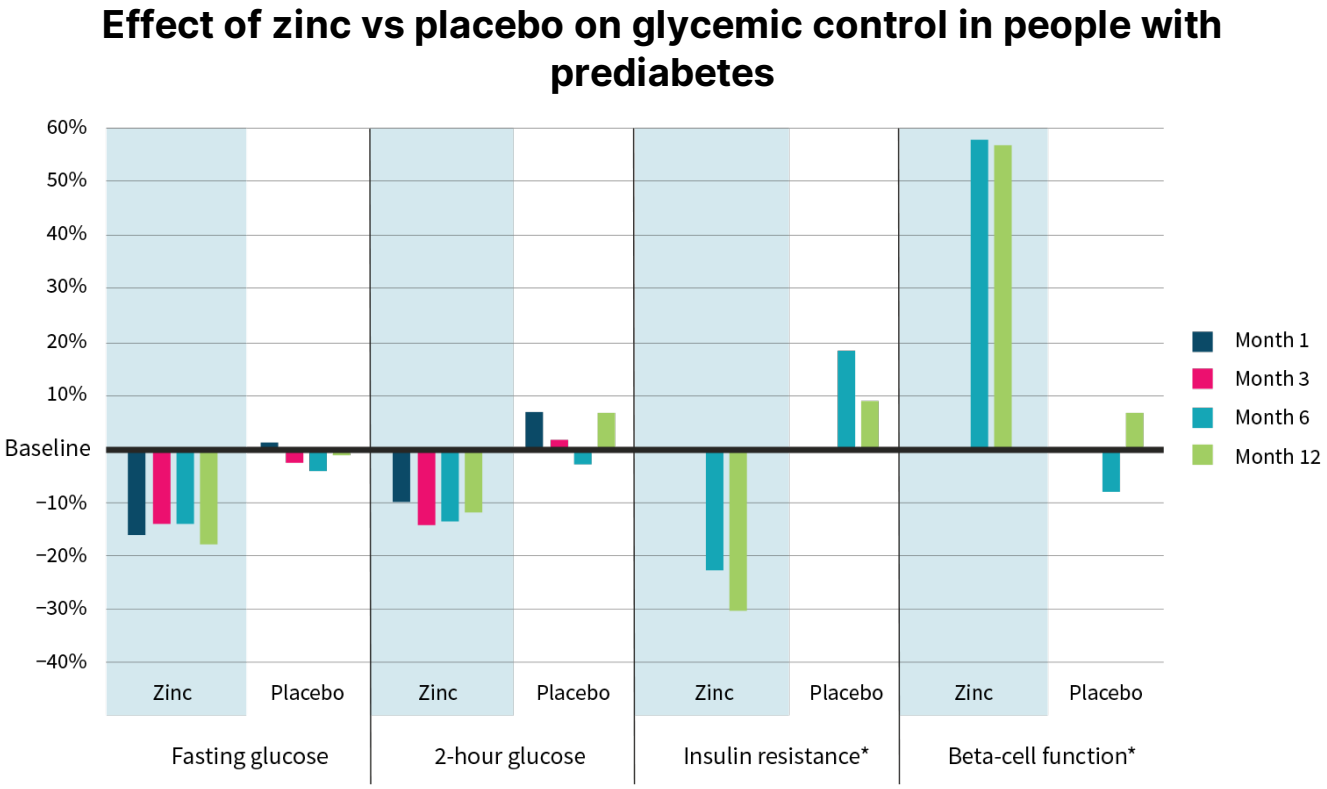
The Recommended Dietary Allowance (RDA) for zinc for adults ranges from 8–12 mg/day.[146] While the 20–40 mg/day doses discussed here exceed that, they do not exceed zinc's Tolerable Upper Intake Level (UL) of 40 mg/day.[146]

Zinc sulfate and *gluconate* are the most researched forms of oral supplementation and are preferred. *Zinc citrate* seems to have comparable absorption to gluconate, whereas *zinc oxide* is less well absorbed.[150] *Zinc picolinate* and *bis-glycinate* may have greater absorption rates than gluconate, but more research is needed.[151][152]

Zinc absorption can be reduced if consumed with foods rich in phytates — namely, grains, legumes, seeds, and nuts.[153][154] If you're unable to take zinc on an empty stomach, the next best way is with some low phytate food.

People with type 2 diabetes, prediabetes, or insulin resistance taking zinc may see a reduction in fasting

blood sugar of −1.27 to −0.16 mmol/L (−22.88 to −2.88 mg/dL) and in HbA1c of −1.56 to −0.06%. Greater effects are more likely when baseline zinc levels are lower.



* Measures were only taken at months 6 and 12.

Reference: Ranasinghe et al. *J Diabetes*. 2018.[135]

Promising Supplements

Chromium

What makes *chromium* a secondary option

Chromium supplements may improve overall glycemic control in people with type 2 diabetes

Chromium is a trace element involved in insulin signaling to some degree, though just *how* remains a matter of debate.[155][156] There is no standard and universally recognized measure of chromium status, but chromium levels in whole blood, blood plasma, toenails, and hair tend to be lower in people with type 1 or 2 diabetes than in people with normal blood sugar.[157][158][159][160][161][162][163] This is likely a result of increased chromium excretion (via urine, sweat, etc.) due to insulin resistance.[157]

Many randomized, controlled trials have evaluated chromium supplementation in type 2 diabetes. There's solid evidence for modest reductions in fasting glucose and HbA1c but only limited evidence for improving fasting insulin and insulin resistance.[164] Studies are of moderate quality overall but inconsistent, with many finding a neutral effect and a few indicating a worsening in the chromium group.[165][166][167] It's not clear why studies differ, though the severity of diabetes and baseline chromium levels are possible reasons. Research in females with polycystic ovary syndrome (PCOS) suggests a possible reduction in fasting glucose, insulin, and insulin resistance, but more research is needed to confirm this.[168][169][170]

It's unknown if taking chromium will improve insulin sensitivity or prevent the development of T2D. Only a single observational study has been conducted and, while it found chromium supplementation decreased the risk of developing T2D, no firm conclusions should be drawn from this.[171]

In a short-term clinical trial, a single dose of chromium with a meal reduced the post-meal blood sugar spike in healthy subjects.[172] Yet results from longer-term clinical trials in healthy subjects are mixed and don't generally support the use of chromium for blood sugar management in this population.[173][174][175][176][177][178]

Warnings about *chromium*

Adverse effects weren't common in the studies that looked at chromium for type 2 diabetes, and no clear link between chromium supplementation and adverse effects can be made. The lack of observed chromium toxicity has led to a lack of Tolerable Upper Intake Levels (UL) for chromium, but supplemental chromium's long-term safety hasn't been sufficiently studied. To date, only an Adequate Intake (AI) for chromium has been set.

Adequate Intake (AI) for chromium (mcg)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	0.2	0.2	—	—

AGE	MALE	FEMALE	PREGNANT	LACTATING
7–12 months	5.5	5.5	—	—
1–3 years	11	11	—	—
4–8 years	15	15	—	—
9–13 years	25	21	—	—
14–18 years	35	24	18	44
19–50 years	35	25	30	45
50+ years	30	20	—	—

Reference: Institute of Medicine. Chromium (chapter 6 in *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. The National Academies Press. 2001.)[146]

Chromium may interact with the medications listed below. If you take any of these, check with your physician before taking chromium. There have been a few instances where kidney or liver harm was reported in people with existing kidney or liver disease taking chromium. If you have preexisting kidney or liver disease, it would be advisable to avoid taking chromium.

Possible chromium-medication interactions

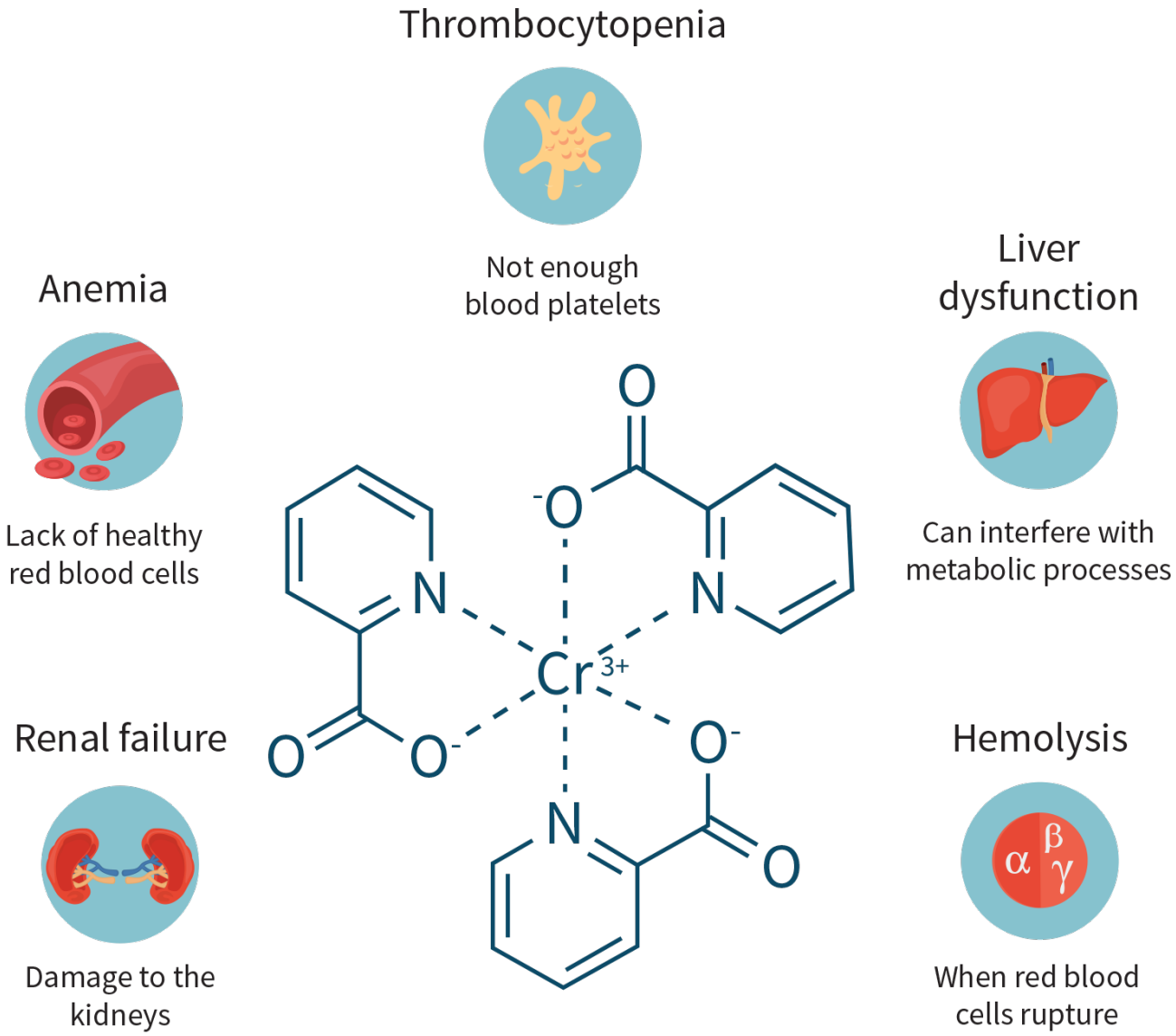
May alter stomach acidity, impair chromium absorption, or enhance chromium excretion	May enhance medication effects or increase chromium absorption
Antacids	Beta-blockers
Corticosteroids	Corticosteroids
Histamine H2-receptor antagonists (H2 blockers)	Insulin
Proton-pump inhibitors	Nicotinic acid
	Nonsteroidal anti-inflammatory drugs (NSAIDS)
	Prostaglandin inhibitors

Adapted from Chromium: Dietary Supplement Fact Sheet. NIH ODS. Last updated July 9, 2019; accessed October 27, 2019.

Some supplements and multivitamins may "superdose" their product with chromium. Though chromium picolinate is generally considered nontoxic, chromium toxicity is not unheard of.[146]

The dosages listed in this guide may lower blood sugar and may have additive effects when taken with other supplements or pharmaceuticals that lower blood sugar, such as antidiabetic drugs.

Potential adverse effects of chromium toxicity



Chromium is an essential trace element. Your body only needs a very little bit so supplementation may quickly put you over the top and place you at risk for chromium toxicity.

Reference: Cerulli et al. *Ann Pharmacother*. 1998.[179]

How to take *chromium*

Take 600–1,000 mcg/day of chromium picolinate. It's best to divide the dose throughout the day and take it with meals, particularly meals containing carbohydrates.

People with type 2 diabetes taking chromium picolinate may see a reduction in fasting blood sugar of −2.03 to −0.07 mmol/L (−36.58 to −1.26 mg/dL) and a reduction in HbA1c of −1.13 to −0.22%.

While other forms of chromium have been tested, such as brewer's yeast and chromium chloride, studies to date have not indicated notable or reliable benefits to blood sugar management.

Cinnamon

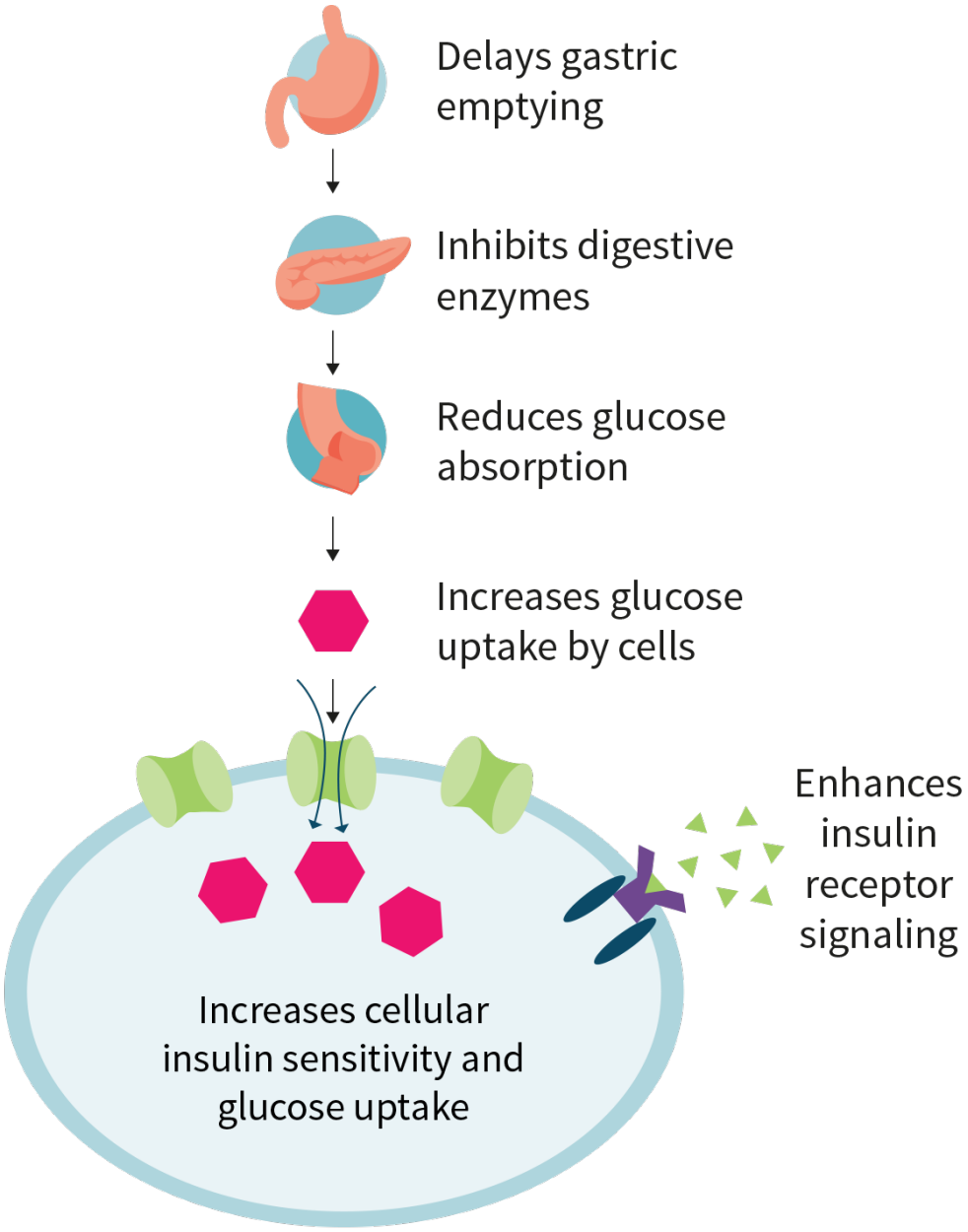
What makes *cinnamon* a secondary option

In people with type 2 diabetes or prediabetes, particularly if their HbA1c is 8% or higher, cinnamon may be able to reduce fasting blood sugar levels and make small improvements to their HbA1c.

Cinnamon is a spice extracted from the bark of various _Cinnamomum _evergreen trees, such as the *Cinnamomum cassia* (which provides cassia cinnamon) and *Cinnamomum verum* (aka *Cinnamomum zeylanicum*, which provides ceylon cinnamon or “true cinnamon”).

Some of the chemicals in cinnamon aid in increased insulin production, while others increase insulin sensitivity, allowing cells to respond more readily to insulin.[180] If taken daily, cinnamon can reduce fasting blood sugar in people with elevated levels, commonly seen in people with type 2 diabetes or prediabetes. Cinnamon is heavily researched, as far as supplements go, and these findings are based on a large number of human studies.[181][182][183][184][185][186][187][188][189][190][191][192][193][194][195][196][197][198] Though there’s a notable effect as a whole, studies are inconsistent, likely owing to differences in the severity of glucose intolerance and cinnamon dosages used — with people who took less than 2 g daily experiencing less reliable effects.

Cinnamon's proposed antidiabetic mechanisms of action



Reference: Medagama. *Nutr J.* 2015.[180]

Cinnamon may reduce insulin resistance in people whose fasting blood sugar levels aren't yet in the prediabetic range (5.6–7.0 mmol/L; 100–125 mg/dL) but are at risk for diabetes later in life, such as those with non-alcoholic fatty liver disease and polycystic ovary syndrome (PCOS).[199][200][201] However, more research is needed on this specific health endpoint.

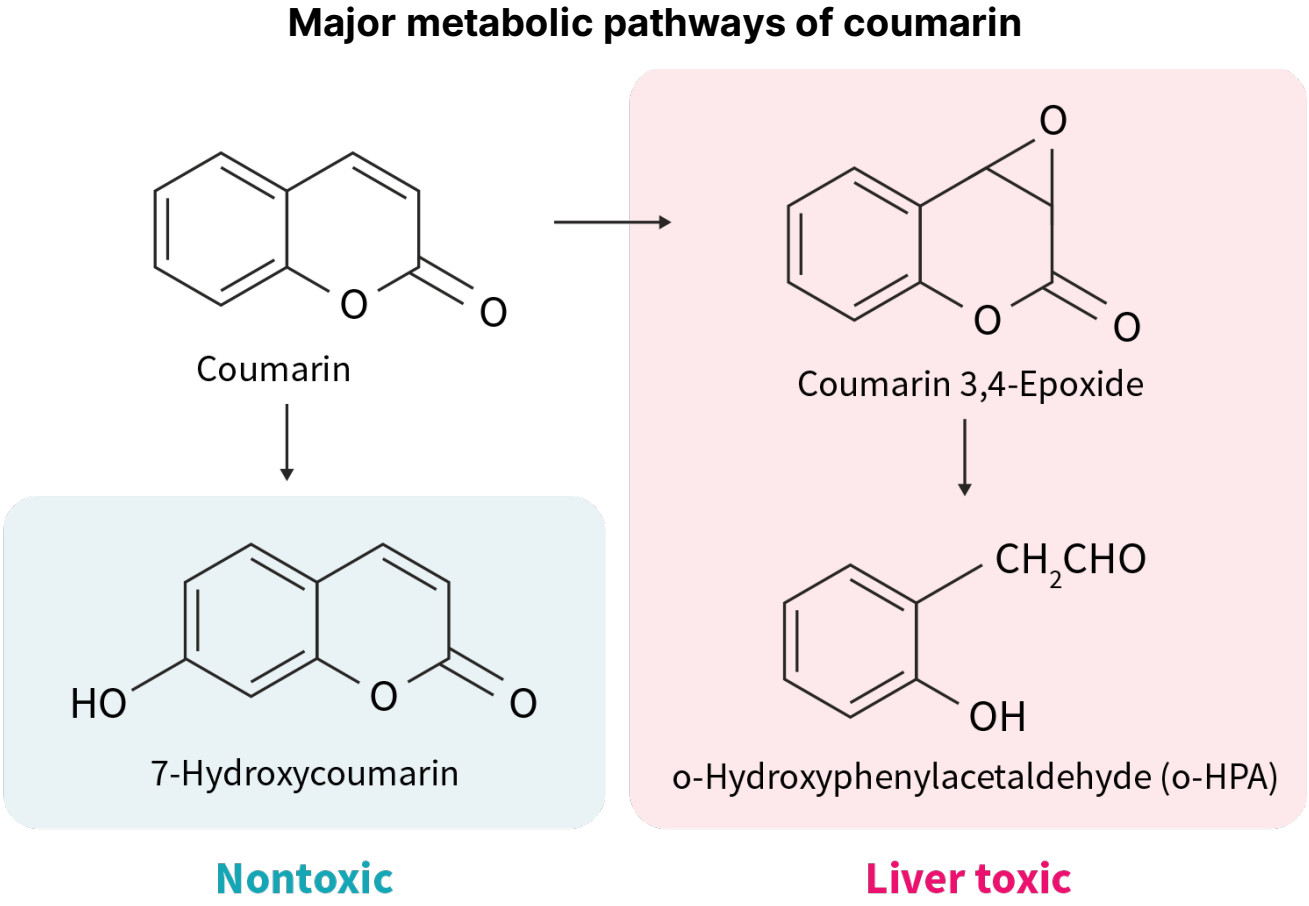
When taken with carbohydrates by people with normal blood sugar, cinnamon may also modestly tame the post-meal spike in blood sugar levels (though mostly in the studies that used high doses of 6 g at a single meal).[202][203][204][205][206][207][208][209][210][211] Cinnamon for reducing blood sugar spikes in the hours after a meal hasn't been studied in people with insulin resistance, so it's unclear whether it would have an effect. It also isn't known if taking cinnamon will reduce the risk of developing glucose intolerance in the future when taken by people with normal blood sugar.

Though multiple studies suggest cinnamon can lower both blood sugar and insulin levels, much more research is needed to determine the optimal dosage and timing and specific populations that may benefit from it.

Warnings about *cinnamon*

If you have liver disease or liver damage, had a liver transplant, or are taking any drugs that can be hard on the liver (see this searchable database), do not supplement with Cinnamomum cassia (cassia cinnamon).

Cinnamon contains coumarin, a potential liver toxin. Cassia cinnamon is especially rich in coumarin.[212][213] Even regular consumption of small amounts can place your coumarin intake over the tolerable daily intake (TDI) threshold of 0.1 mg/kg body weight, set by the European Food Safety Authority.[214] While it appears many people may be able to safely and regularly consume daily amounts above this threshold, some 1–9% of individuals may be more sensitive to low doses of coumarin, which can result in liver injury and hospitalization.[213]



Reference: Abraham et al. *Mol Nutr Food Res*. 2010.[213]

The coumarin content of cassia cinnamon can vary widely, and there is no easily accessible method for determining the content of the cinnamon you might buy. Additionally, there is currently no easy way to determine if you might be sensitive to coumarin. Thus, the dosage and intake schedule for cassia cinnamon in this guide are particularly cautious, to greatly minimize the potential for adverse effects.

Additional effects may include headaches, heartburn, and gastrointestinal complaints.[215]

In addition to lowering blood sugar, cinnamon may also reduce blood pressure. It is possible that cinnamon may have additive effects when taken with some antidiabetic or blood pressure pharmaceuticals or supplements.

How to take *cinnamon*

Take 500 mg of cassia cinnamon_ _twice daily, each time with a meal containing carbohydrates, for 2 weeks. After this period, stop for 2 weeks and then repeat this cycle for as long as desired.

Research has indicated that higher doses, such as 3 or 6 g/day, can deliver quicker results and larger improvements, *but the potential for liver harm via coumarin is much greater*.[181][213] A 2 g/day dose of cassia cinnamon can put many people over the TDI for coumarin.[213][214] If you're considering using *cinnamomum verum* (ceylon cinnamon)_ _as an alternative, know that there are far fewer studies looking at the effects of this cinnamon type on blood sugar regulation. At present, the available studies have not found a consistent, worthwhile effect.[207][216]

Cinnamon supplements should be dosed as a powder, mixed with food or in capsule form. While cinnamon water and oil extracts are widely available, these forms aren't commonly standardized and can contain wildly different amounts of cinnamon compounds. Without knowing what compounds are in these extracts, it is difficult to know how effective they might be, if at all.

Similarly, cinnamon infusions and teas are also difficult to dose properly. While these methods have the advantage of eliminating some of the coumarin, most of which is left behind in the dregs,[217] there is insufficient evidence to say how these preparation methods affect the compounds responsible for cinnamon's blood sugar–lowering effects.

People with type 2 diabetes or prediabetes taking a 2 g daily dose (so, twice as much as the dose we recommend above to minimize toxicity risks) may see a change in fasting blood sugar of −1.99 to +0.61 mmol/L (−35.77 to +10.95 mg/dL). While it's unclear if notable reductions in HbA1c will be seen, on average, with the 1 g daily doses recommended here, it's possible that people with HbA1c levels over 8% may see a small benefit. Greater beneficial effects for fasting blood sugar might be more likely when HbA1c levels are at a higher starting point.

Inositol (for type 2 diabetes and prediabetes)

> 💡 ***Tip:*** **The evidence for inositol varies by condition**
>
> When researching inositol, we found that the quality and strength of the evidence differed depending on what condition this supplement was studied for. Thus, we have three inositol entries in this guide.
>
> - *Primary Option:* Inositol (for PCOS)
> - *Secondary Option:* Inositol (for type 2 diabetes and prediabetes)
> - *Unproven Supplements:* Inositol (for gestational diabetes)

What makes *inositol* a secondary option

In people with type 2 diabetes or prediabetes, inositol (pinitol, specifically) may improve glycemic control.

Inositol encompasses nine pseudovitamins structurally similar to glucose. The most common of those

pseudovitamins, in nature as well as in health stores, is called myo-inositol. Supplemental myo-inositol is often called just "inositol" or sometimes "vitamin B_8" (a misnomer: inositol is not related to the B vitamins, nor is it even a vitamin).

Inositol is in most foods — notably, whole grains and citrus fruits — so dietary deficiencies are rare. Some diseases, however, can lower your levels of inositol,[90][91] which translates to lower levels of PIP_3 (a component of cell membranes), resulting in impaired insulin signaling.

For people with impaired glucose tolerance, such as in type 2 diabetes, the most studied form of inositol for this condition is 3-O-Methyl-D-chiro-inositol (pinitol). Overall, studies suggest it helps reduce fasting blood sugar and insulin resistance,[218][219][220][221][222][223][224][225] and four that found considerable reductions were generally of longer duration than the others.[218][219][222][223]

When it comes to people without insulin resistance, little research has been conducted to date.[226]

Warnings about *inositol*

Studies haven't reported notable adverse effects from taking inositol, but they also haven't been particularly meticulous about their accounting.[98] Inositol might cause some gastrointestinal discomfort, although this is not a frequent occurrence.

In pregnant females supplementing with up to 4 g of myo-inositol, no notable adverse effects were noted in the females or in their babies at birth.[99][100][101] There is insufficient evidence on the effects of taking myo-inositol while breastfeeding.

How to take *inositol*

There are a few forms of inositol. The pinitol form (more commonly sold under the name D-chiro-inositol) is the more well researched form for type 2 diabetes and prediabetes.

To supplement with *pinitol*, take 1.2 g/day with food.

People with type 2 or prediabetes taking pinitol may see a reduction in fasting blood sugar of −0.89 to −0.55 mmol/L (−16.0 to −9.9 mg/dL); in their HOMA-IR score (a measure of insulin sensitivity) of −3.34 to −0.08; and in their HbA1c of −0.83 to −0.48%.

Though less studied, myo-inositol may be an alternative option if pinitol does not produce any notable results.

To supplement with *myo-inositol*, take 4 g/day with food.

Unproven Supplements

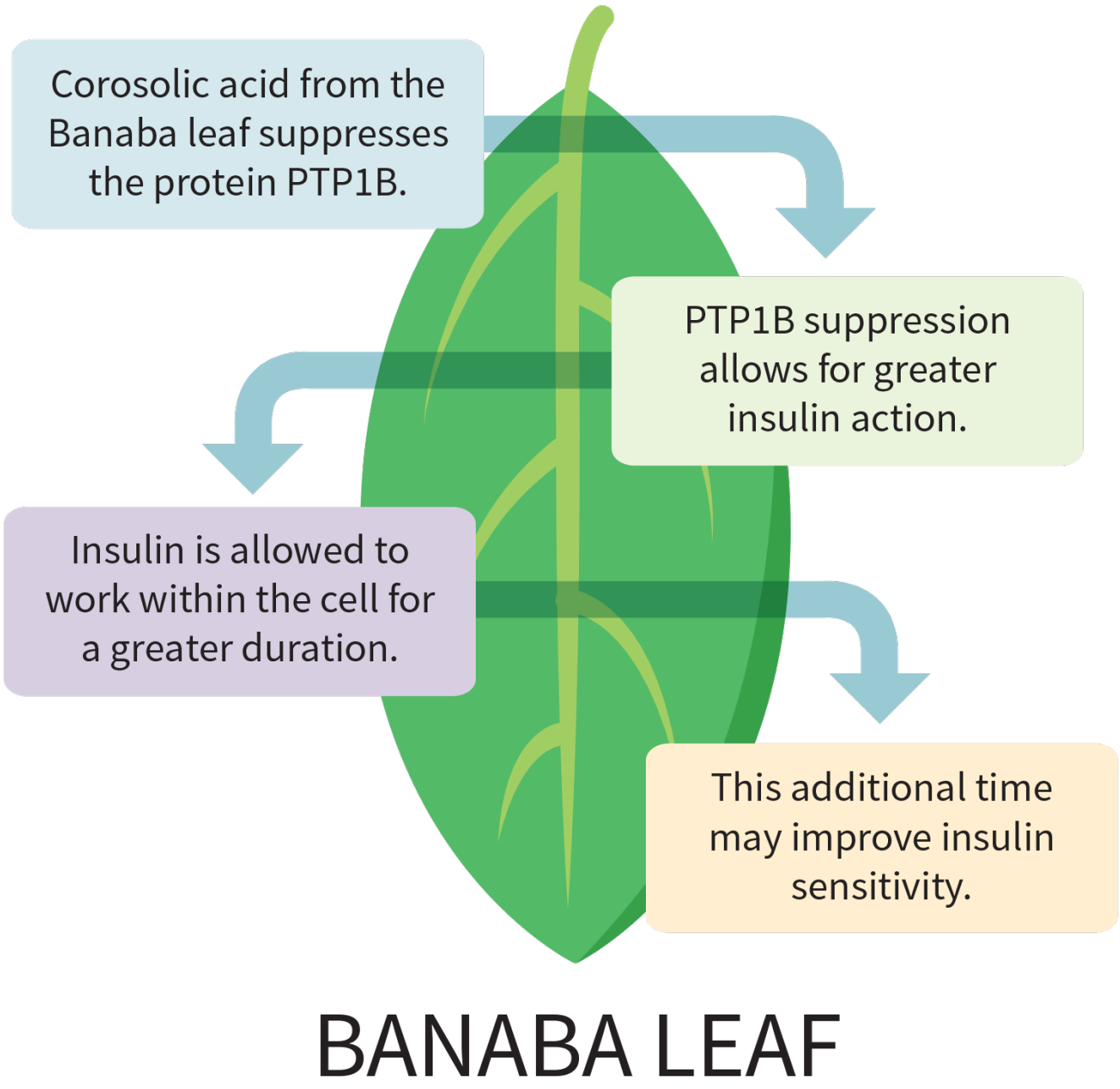
Banaba Leaf

What makes *Banaba leaf* an unproven option

Banaba leaf (*Lagerstroemia speciosa*) is a source of corosolic acid and ellagitannins, compounds that can increase the uptake of blood sugar by your cells.[227][228] Corosolic acid can also reduce the rate of carbohydrate absorption during digestion in mice and inhibit gluconeogenesis (the process by which your body makes glucose).[227][229]

Corosolic acid appears to improve insulin signaling, but more human studies are needed to confirm this. The clinical research is limited to two small, low-quality studies[230][231] and three that combined Banaba with other herbs, thus not revealing how effective Banaba is alone.[232][233][234]

Corosolic acid's proposed antidiabetic mechanisms of action



Reference: Miura et al. *Complement Alternat Med.* 2012.[227]

Branched Chain Amino Acids (BCAAs)

What makes *BCAAs* an unproven option

Proteins are composed of amino acids, some of which your body can make and others it cannot. The ones you need to ingest, because your body cannot synthesize them, are called essential amino acids (EAAs). The best-known EAAs are the three BCAAs: isoleucine, leucine, and valine. These amino acids, both in isolation and in combination, can influence the body's response to carbohydrates.[235][236] A combination of BCAAs, as well as isoleucine and leucine in isolation, have been tested to see how they might affect blood sugar control.

In four small, short-term trials (typically <24 hours) of BCAAs, a one-time dose of ≈7.5 g was not able to reliably lower blood sugar or affect insulin secretion in healthy, trained, young males.[237][238][239][240]

In two small, short-term trials of isoleucine[241][242] and two small, short-term trials of leucine[241][243] (each <24 hours), 7–10 g — but not 5 g — was able to notably increase insulin production and lower blood sugar when taken with carbohydrates, compared with carbohydrates alone, in healthy young to middle-aged males and females.

However, in longer trials — lasting 15 days,[244] 3 months,[245] and 6 months[246] — daily doses of leucine ranging from 7.5 to 12 g did not improve fasting blood sugar or insulin, HbA1c, or responses to an oral glucose tolerance test (OGTT) in adults with normal blood sugar or those with type 2 diabetes. Combined, these three interventions tested nearly 100 people, 60 of whom had type 2 diabetes.

Given the amount of evidence from cellular and animal studies indicating BCAAs do play a role in blood sugar regulation, ensuring you get an adequate amount of BCAAs in your diet may be prudent.[247][248]

Generally speaking, the daily minimum BCAA requirement for adults is:

- 40–50 mg/kg/day for leucine
- 20–30 mg/kg/day for isoleucine
- 17–25 mg/kg/day for valine

This is 77–105 mg/kg of BCAAs per day.[249] For a 68 kg (150 lb) person, this would be 5.2–7.1 g of BCAAs per day (more examples can be seen in the table below). For reference, 85 g (3 oz) chicken breast provides 4.6 g of BCAAs), and 237 mL (8 oz) of milk has 2 g.

Adequate BCAA intake per day

BODY WEIGHT		TOTAL BCAAs	LEUCINE	ISOLEUCINE	VALINE
Pounds	Kilograms				
100	45	3.5–4.7	1.8–2.3	0.9–1.4	0.8–1.1
125	57	4.4–6.0	2.3–2.9	1.1–1.7	1.0–1.4
150	68	5.2–7.1	2.7–3.4	1.4–2.0	1.2–1.7
175	79	6.1–8.3	3.2–4.0	1.6–2.4	1.3–2.0
200	91	7.0–9.6	3.6–4.6	1.8–2.7	1.5–2.3
225	102	7.9–10.7	4.1–5.1	2.0–3.1	1.7–2.6
250	125	8.7–11.9	4.5–5.7	2.3–3.4	1.9–2.8
275	125	9.6–13.1	5.0–6.3	2.5–3.8	2.1–3.1

Reference: Kurpad et al. *J Nutr.* 2006.[249]

Creatine

What makes *creatine* an unproven option

Creatine might modestly improve insulin sensitivity — when paired with regular exercise — in people with insulin resistance.

There is strong mechanistic evidence indicating creatine can play a role in blood sugar management, but under what conditions and to what degree is presently not well known.[250] The best available evidence indicates that creatine may help reduce blood sugar in people who exercise regularly. There are three main avenues through which creatine may influence blood sugar.[250]

1. It can increase blood sugar uptake during muscle contractions, particularly during exercise.
2. Via indirect stimulation, it may increase insulin secretion, thus speeding blood sugar clearance from the bloodstream.
3. By increasing exercise performance, which can further improve insulin sensitivity.

In studies testing creatine's modulating effects on blood sugar, results have indicated that it may produce minor improvements in insulin sensitivity and fasting blood sugar.[251][252][253][254][255][256] Yet, positive effects have not been seen across all studies.[254][257][258][259] What's more, the majority of these studies have been conducted in healthy subjects; only three RCTs to date were conducted in people with type 2 diabetes or signs of metabolic syndrome.[252][259][260]

However, there are a couple of major caveats to consider.

People who had poorer blood sugar control were more likely to experience the greatest improvements, small as they may be.[252][253][259][260]

The positive effects on blood sugar occurred more commonly in trials where creatine was paired with exercise.[251][252][253][258][260][261] Creatine alone may not be enough to affect relevant endpoints (insulin sensitivity, fasting glucose/insulin, glycemic control, etc).

If you want to give creatine a try, the dose best supported by current evidence is 5 g of *creatine monohydrate* per day with food. People with more muscle mass may benefit from as much as 10 g/day, but this claim is not fully supported by evidence. To supplement with 10 g/day, take 5 g twice a day.

In people with elevated blood glucose or insulin resistance, 5 g of creatine, *when paired with exercise*, might lead to a −11.04 to −0.69 pmol/L (−1.59 to −0.01 mIU/L) reduction in fasting insulin and a change in HOMA-IR (a measure of insulin sensitivity) of −1.7 to +0.59, particularly in people with insulin resistance. Negligible effects are seen in individuals with normal blood sugar levels.

Glycine

What makes *glycine* an unproven option

Glycine is a nonessential amino acid that has a number of roles in the body, including as a neurotransmitter and as a component of collagen, which helps form your skin, tendons, and ligaments. Blood levels of

glycine tend to be low in type 2 diabetics, and a number of reasons have been proposed for this.[262] Research examining these ideas indicates supplemental glycine may cause a reduction in inflammation and an increase in insulin production.

When it comes to human trials, glycine appears to be a promising supplement, as it can reduce the rise in circulating blood sugar in the short term and reduce fasting blood sugar and HbA1c if taken daily.[263][264] It's an unproven option because, of the studies that have been conducted, nearly all lasted <24 hours — necessitating further higher-quality and longer-term ones to establish its blood sugar impact.

However, if you want to give glycine a try anyway, the dose best supported by current evidence is 15 g/day of glycine divided into 5 g doses, taken right before a meal.

Inositol (for gestational diabetes)

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What makes *inositol* an unproven option

Based on limited evidence, in females at high risk of developing gestational diabetes, inositol supplementation might reduce their risk.[265][266] For females who already have gestational diabetes, the research is very unclear if inositol is a viable treatment option.[267]

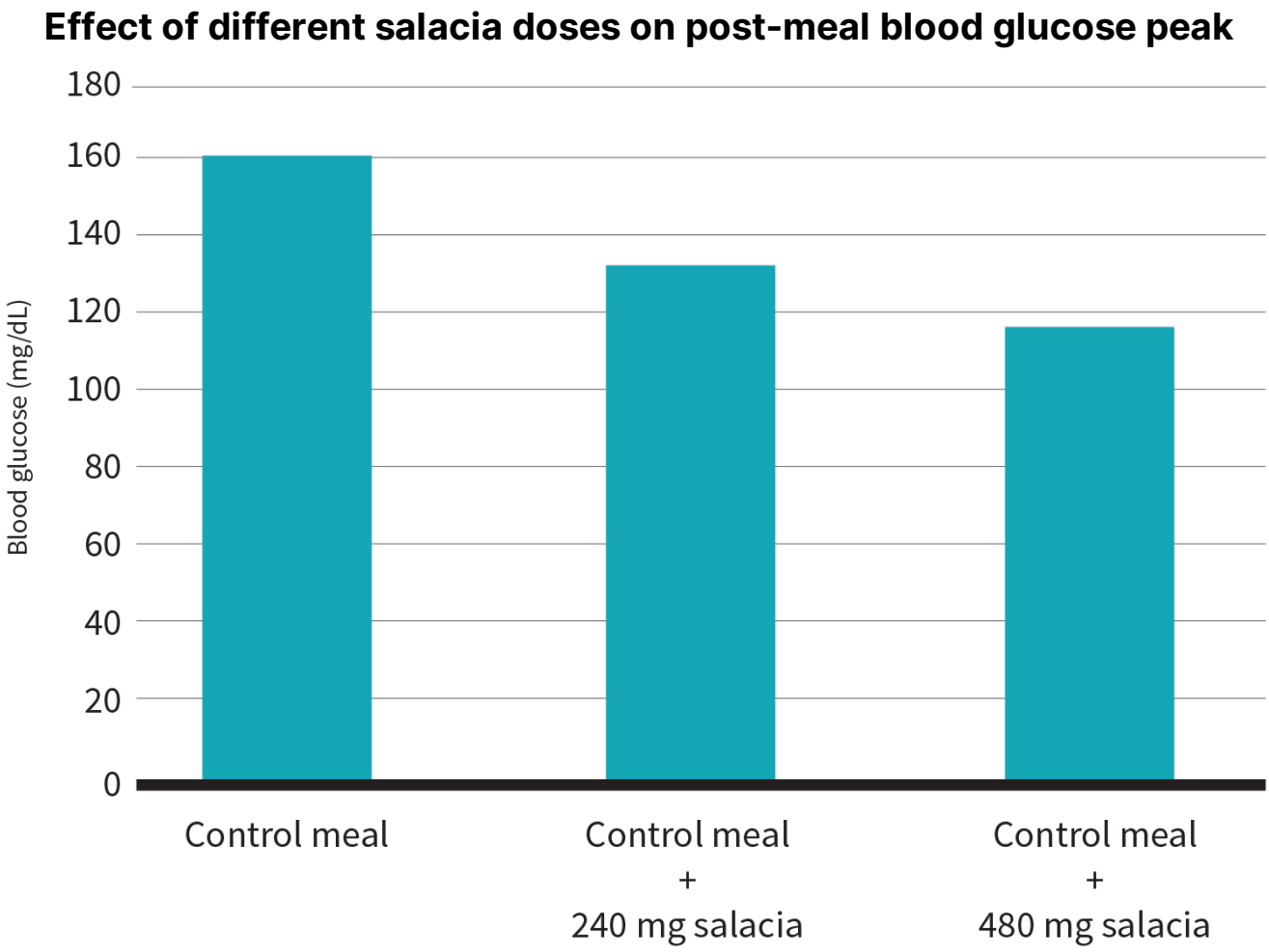
Salacia reticulata

What makes _*salacia reticulata*_ an unproven option

Salacia refers to the herbs *Salacia reticulata* ("kothala himbutu" in Ayurvedic medicine,_ Salacia oblonga, _and chinensis.[268] Salacia can prevent the absorption of carbohydrates, potentially reducing the increase in blood sugar and insulin that occurs after consuming carbs. Additionally, salacia contains a wide variety of phytochemicals (plant chemicals) that may influence the metabolism of glucose.[269]

Because of its effect on carbohydrate absorption, salacia has mainly been researched with regard to its

ability to lower post-meal blood sugar and insulin concentrations.[270][271][272][273][274][275] The results of these short-term (<24 hours) studies suggest that salacia can notably reduce the rise in blood sugar and insulin after consuming a meal containing carbohydrates. It should be noted that three of these six studies were funded by industries with financial conflicts of interest. Only one study has looked at the effects of daily salacia supplementation on fasting blood sugar levels in people with impaired glucose tolerance.[276] It found a notable reduction after 6 weeks, but further studies are needed to ascertain long term efficacy.



Adapted from Williams et al. *Am J Clin Nutr.* 2007.[272]

While we have rated salacia to be an unproven supplement due to a lack of long-term trials, there is evidence from very short-term trials to suggest it does reduce glucose and insulin levels after meals. While it's unclear how this translates to effects on long-term metabolic health and diabetes, it could theoretically produce some benefits. It would be prudent to wait for higher-quality studies, including long-term ones, before you go out of your way to take salacia.

However, if you want to give salacia a try anyway, the dose best supported by current evidence is 240–500 mg of *Salacia reticulata* or *Salacia oblonga* extract with each meal containing carbohydrates.

Due to limited long-term data, it is not recommended to exceed 1,500 mg/day.

Because of its ability to reduce carbohydrate absorption, higher doses of salacia may cause adverse gastrointestinal effects such as nausea, flatulence, belching, abdominal pain, and diarrhea. This was observed in one study where a group received 480 mg of a *Salacia oblonga* extract alongside a mix of maltodextrin, sucrose, and corn syrup; they experienced considerably more adverse effects than the group that received 240 mg or a placebo.[272] However, another study didn't find any gastrointestinal adverse effects after dosing with 200, 300, or 500 mg of salacia during consumption of sucrose. People taking salacia may want to start at smaller doses and increase their dosage gradually as a precaution.

It is possible that, because it can lower blood sugar, salacia may have additive effects when taken with some antidiabetic drugs or other supplements that can lower blood sugar. People who are pregnant or breastfeeding may want to forgo taking salacia, as it has not been studied in this population.

Tribulus terrestris

What makes *Tribulus terrestris* an unproven option

Tribulus terrestris is an herb that has been used in Iranian, Persian, Turkish, Sudanese, Indian Ayurveda, and Chinese traditional medicines to treat an assortment of diseases.[277]

To date, only a single double-blind RCT has tested the potential effects of this herb on blood sugar.[278] This 3-month trial saw 98 females with type 2 diabetes take either 1 g of *Tribulus terrestris* per day or a placebo. People taking the herb saw meaningful reductions in their fasting blood sugar, HbA1c, and 2-hour post-meal blood sugar test (i.e., blood glucose levels 2 hours after a standardized meal). Importantly, all participants were taking their prescribed oral diabetes medications, indicating that the addition of *Tribulus terrestris* may provide synergistic benefits.

While promising, these results will need to be replicated in additional clinical trials.

Vinegar

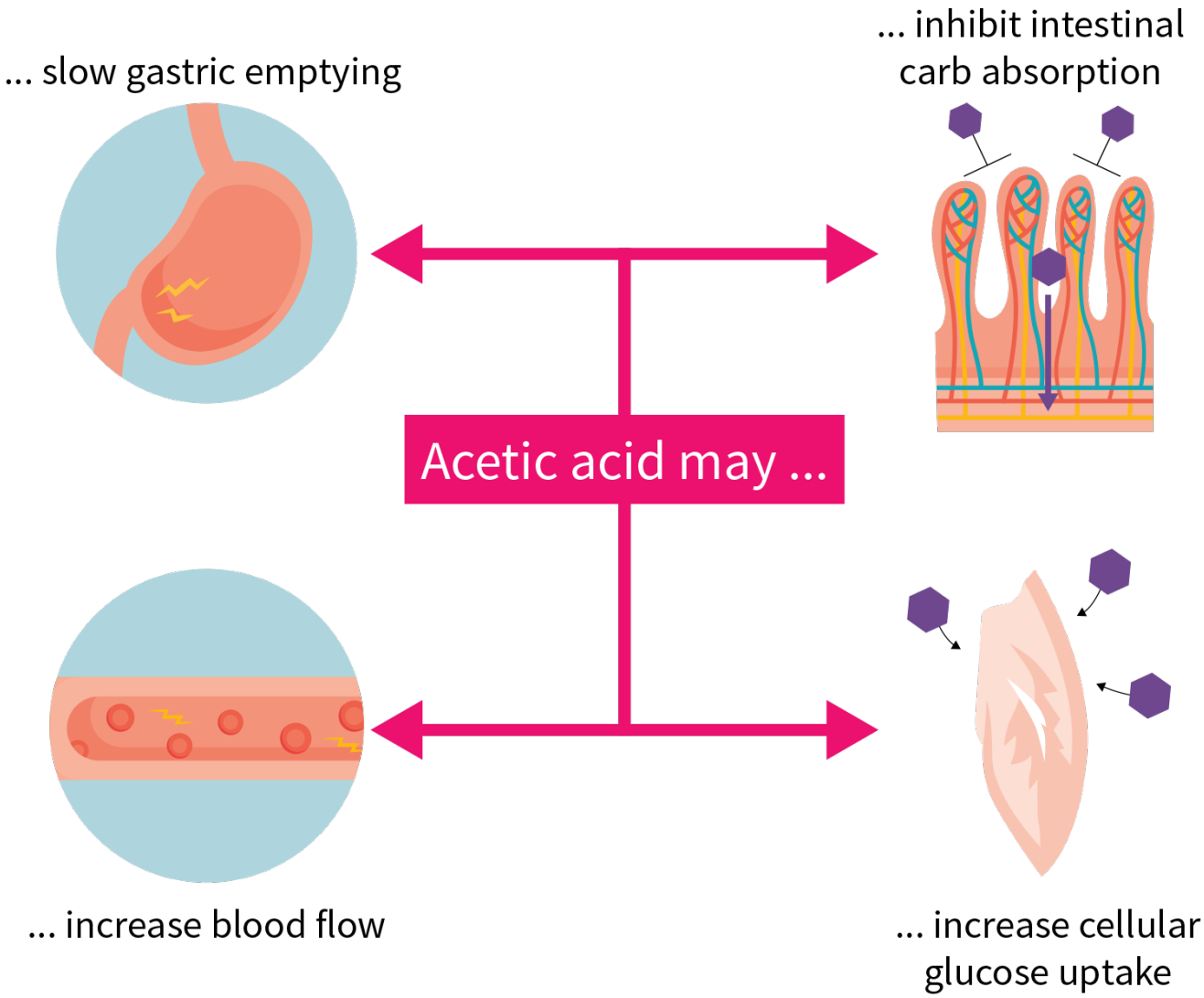
What makes *vinegar* an unproven option

Acetic acid is, after water, the main component of vinegar. It may slow the passage of food from the stomach to the small intestines, thus slowing the absorption of carbohydrates and reducing both insulin response and damage from hyperglycemia. It may also improve insulin signaling via various molecular mechanisms.[279]

The overall research suggests a smaller increase in post-meal blood glucose when vinegar is taken before or with a meal,[280] but this reduction is modest and doesn't last long (roughly 2 hours). Moreover, the studies are small and short term, and their methodologies don't give us full confidence in their findings.

As for the reductions in HbA1c (a biomarker of glucose metabolism) and fasting blood glucose, they may not be strong enough to have a meaningful long-term effect on health and are supported by scant evidence.[281][282][283][284][285][286]

Vinegar's proposed antidiabetic mechanisms of action



In short, vinegar's ability to prevent or treat type 2 diabetes is uncertain, as is its long-term benefit for people with impaired glucose tolerance. You should wait for studies of higher quality, including long-term studies, before you go out of your way to take vinegar with all your meals.

However, if you want to give vinegar a try anyway, here is the dose best supported by current evidence:

- 2.8 g/day of acetic acid divided into 1.4 g doses taken right before breakfast and dinner

Alternatively, you can take the following.

- 2 tablespoons (29.6 mL) of apple cider vinegar right before breakfast and dinner (59.2 mL/day; which is approximately 3.6 grams of acetic acid per day)

Vitamin C

What makes *vitamin C* an unproven option

Vitamin C (L-ascorbic acid) is a water-soluble essential vitamin. It is a very popular dietary supplement due to its antioxidant properties, safety, and low price. From existing research, it seems theoretically possible that vitamin C could help improve blood sugar control,[287][288][289][290] but the evidence is mixed at this point.

Some 12 trials have examined the effects of vitamin C on markers of glycemic control (blood glucose, HbA1c, insulin levels) in type 2 diabetics .[291][292][293][294][295][296][297][298][299][300][301][302]

A meta-analysis summarizing the findings from all of the above-mentioned trials found no notable effects on insulin or HbA1c in diabetic individuals or those with normal blood sugar, and only a small reduction in fasting glucose levels (−0.44 mmol/L; −7.9 mg/dL) for those with type 2 diabetes.[303]

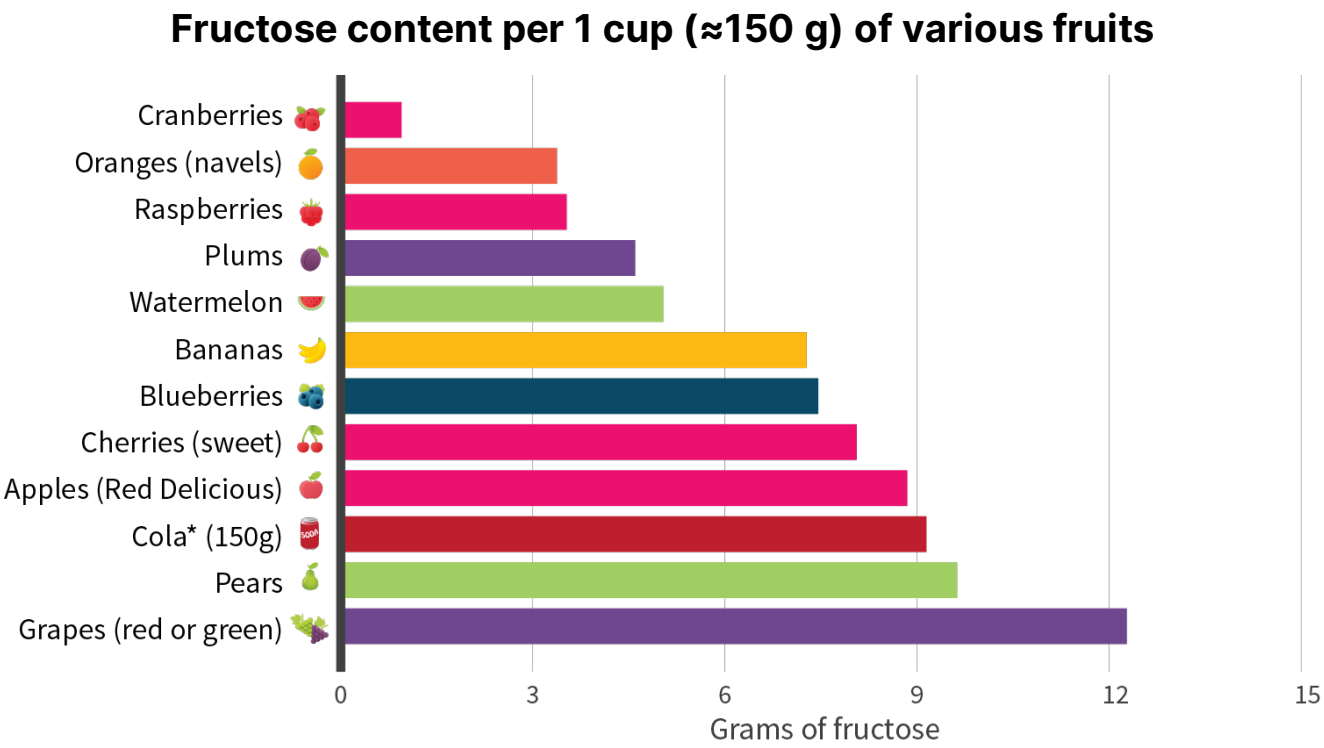
However, big differences in what the trials measured (fasting glucose vs post-meal glucose) and how the vitamin C was administered (orally vs injected) prevent any strong conclusions from being drawn. More research is needed before we can know if or when vitamin C might be useful for glycemic control.

Inadvisable Supplements

Fructose

What makes *fructose* an inadvisable option

When fructose replaces other forms of refined dietary carbohydrate — glucose, dextrose, maltodextrin — it can provide minor reductions in HbA1c[304][305] and may reduce fasting blood sugar.[304][305][306] Some small benefits to blood sugar levels have also been shown with small, ≈10 g doses given prior to a meal, without replacing other carbs.[307] These reductions may be more pronounced in people with higher blood sugar. Consequently, these studies may partially explain why higher consumption of fruits, which often contain appreciable amounts of fructose, have been associated with lower risk of developing type 2 diabetes and metabolic syndrome.[308][309]



* Cola listed as comparison reference

Reference: USDA Food Composition Databases. Accessed September 27, 2019. https://ndb.nal.usda.gov/ndb/

There is some evidence that high fructose consumption might contribute to liver fat accumulation and insulin resistance more so than other refined carbohydrates.[310][311] However, these effects may only be seen in people who are physically inactive and/or regularly overconsume calories.

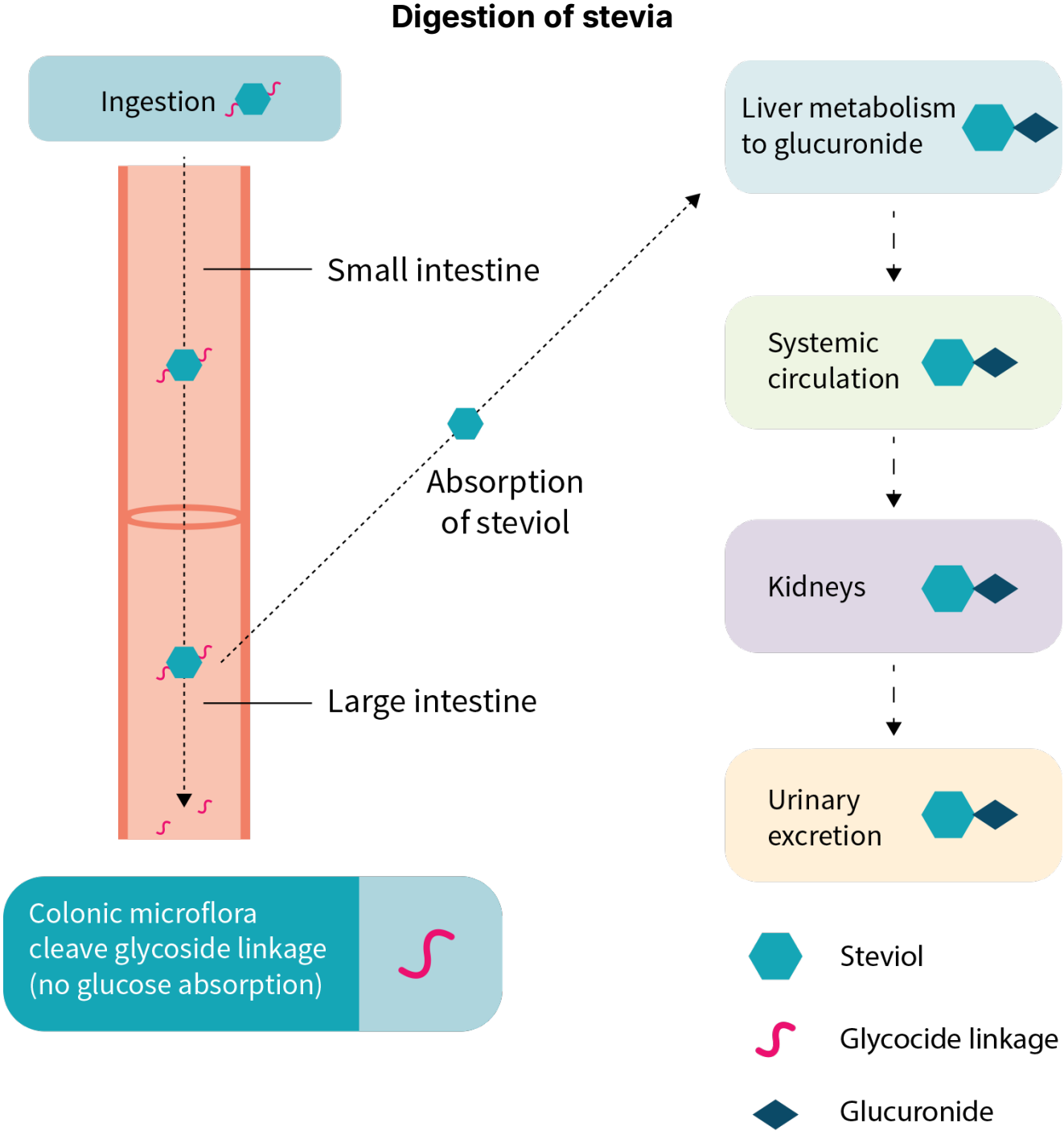
Out of caution, isolated fructose is currently an inadvisable supplement for blood sugar control. Whole fruit consumption is more likely to benefit both glycemic control (due to better effects on satiety) and health in general (due to phytochemical content).

Stevia (Stevia rebaudiana)

What makes *stevia* an inadvisable option

Stevia rebaudiana Bertoni, a plant common to South America (Paraguay, in particular), contains natural, noncaloric sweeteners known as steviol glycosides.[312] Among these steviol glycosides, stevioside and rebaudioside A (aka Reb A, or Rebiana™) are the most abundantly occurring.[313] Stevioside, Reb A, and mixtures of the two are the most commonly available forms on the market.[314] Brand-name examples include Truvia®, Pure Via®, Enliten®, Splenda® Naturals Stevia Sweetener, Stevia Extract in the Raw®, and SweetLeaf®.

Raw stevia leaves and crude extracts have not been widely approved to be sold as sweeteners due to the lack of safety data. However, purified stevia extracts (purity of 93–95%) have been tested and approved in many countries, including the US, Canada, Japan, the European Union, and New Zealand and Australia.



Adapted from Magnuson et al. *Nutr Rev.* 2016.[315]

When taken as a dietary supplement, neither purified stevioside nor Reb A appear to consistently or notably improve blood sugar control. RCTs lasting 6 months to 2 years, using daily doses between 750 and 1,500 mg (usually stevioside) in people with elevated fasting blood sugars saw trivial changes in HbA1c, insulin sensitivity, and fasting blood sugar and insulin.[316][317][318] Shorter RCTs (<6 months) in people with prediabetes or type 2 diabetes, using daily doses between 500 and 1,500 mg, also did not show appreciable improvement.[319][320][321][322][323][324] When analyzed, there was no relationship seen between higher doses of steviosides and greater reductions in fasting blood sugar.[325]

A few RCTs have indicated that, while stevioside may not reduce fasting blood sugar levels, it might help keep them stable, preventing them from rising over time.[317][322][324] However, this effect has not been seen consistently across longer-term RCTs.[316][318]

Stevia may be able to improve blood sugar control when it *replaces* other carbohydrates in the diet, as opposed to adding them on top of your normal diet as a supplement. However, the same can be said of

many other low- or zero-calorie sweeteners.

Tinospora crispa

What makes *Tinospora crispa* an inadvisable option

> ⚠️ ***Caution:*** **This supplement has the potential to harm your health**
>
> Please read the following section carefully. The available evidence indicates this supplement may have harmful effects. It should not be added to your supplement regimen.

Tinospora crispa, not to be confused with Tinospora cordifolia,[326] is an herb traditionally used in Ayurvedic medicine.

In four clinical trials (two of them RCTs) lasting 1–6 months, doses of 0.5–3 g per day showed no improvements in fasting blood sugar, insulin, or HbA1c.[327][328][329] Short-term trials, all lasting only a few hours, have also not shown beneficial results.[329][330] It's possible a larger dose may be needed to see favorable effects, as one short-term trial using a single 6 g dose brought a modest decrease to blood sugar — the only trial to date to see a beneficial effect.[329] Yet, even at this higher dose, positive effects are not uniformly seen; a second short-term trial using this dose saw no effect.[329]

Data on the toxicity of *Tinospora crispa* in humans are limited. However, in five clinical trials and one case report, enzymes used as indicators of potential liver damage (AST and ALT) were elevated in some of the participants taking *Tinospora crispa*.[327][328][329][330][331] These markers returned to normal after treatment stopped. Such elevations have been seen in animal studies as well.[332] Additionally, there are open questions about the effects *Tinospora crispa* may have on cholesterol, as it *might* cause an increase.[328]

Because current evidence has not shown a benefit of *Tinospora crispa* for blood sugar and there is some evidence it may be harmful to the liver or cholesterol levels, this herb should not be supplemented.

FAQ

Q. What about the supplements not covered in this guide?

Our guides are regularly updated, often with new supplements. We prioritize assessing (and reassessing) the most popular of them and those most likely to work. However, if there is a specific supplement you'd like to see covered in a future update, please let us know by filling out this survey.

Q. Can I add a supplement not covered in this guide to my combo?

Supplement with your current combo for a few weeks before attempting any change. Talk to your physician and research each potential addition. Check for known negative interactions with other supplements and pharmaceuticals in your current combo, but also for synergies. If two supplements are synergistic or additive in their effects, you might want to use lower doses of each.

Q. Can I modify the recommended doses?

If a supplement has a recommended dose range, stay within that range. If a supplement has a precise recommended dose, stay within 10% of that dose. Taking more than recommended could be counterproductive or even dangerous. Taking less could render the supplement ineffective, yet starting with half the regular dose could be prudent — especially if you know you tend to react strongly to supplements or pharmaceuticals.

Q. At what time should I take my supplements?

The answer is provided in the "How to take" section of a supplement entry whenever the evidence permits. Too often, however, the evidence is either mixed or absent. Starting with half the regular dose can help minimize the harm a supplement may cause when taken during the day (e.g., fatigue) or in the evening (e.g., insomnia).

Q. Should I take my supplements with or without food?

The answer is provided in the "How to take" section of a supplement entry whenever the evidence permits. Too often, however, the evidence is either mixed or absent. Besides, a supplement's digestion, absorption, and metabolism can be affected differently by different foods. Fat-soluble vitamins (A, D, E, K), for instance, are better absorbed with a small meal containing fat than with a large meal containing little to no fat.

Q. What are DRI, RDA, AI, and UL?

The Dietary Reference Intakes (DRIs) is a system of nutrition recommendations designed by the Institute of Medicine (a US institution now known as the Health and Medicine Division). RDA, AI, and UL are part of this system.

- Contrary to what the name suggests, a *Recommended Dietary Allowance* (RDA) doesn't represent an *ideal* amount; it represents the *minimum* you need in order to avoid deficiency-related health issues. More precisely, it represents an amount just large enough to meet the minimum requirements of 97.5% of healthy males and females over all ages — which implies that the RDA is too low for 2.5% of healthy people.
- The *Adequate Intake* (AI) is like the RDA, except that the number is more uncertain.
- The *Tolerable Upper Intake Level* (UL) is the maximum safe amount. More precisely, it is the maximum daily amount deemed to be safe for 97.5% of healthy males and females over all ages — which implies that the UL is too high for 2.5% of healthy people.

As a general rule, a healthy diet should include at least the RDA of each nutrient — but less than this nutrient's UL. This rule has many exceptions, though. For instance, people who sweat more need more salt (i.e., sodium), whereas people who take metformin (a diabetes medicine) need more vitamin B12.

Moreover, the DRIs are based on the median weight of adults and children in the United States. Everything else being equal (notably age, sex, and percentage of body fat), you likely need a lesser amount of nutrients if you weigh less, and vice versa if you weigh more. The numbers, however, are not proportional — if only because the brains of two people of very different weights have very similar needs. So you can't just double your RDIs for each nutrient if you weigh twice as much as the median adult of your age and sex (even if we overlook that people weighing the same can differ in many respects, notably body fat).

Q. Can any of these supplements cause low blood sugar?

If dosages are followed, there is little risk that any supplement *by itself* will cause low blood sugar (i.e., hypoglycemic events). The risk increases when supplements are combined with each other or with medications meant to lower blood sugar, since their effects can be synergistic.

Q. What's the difference between elemental magnesium/zinc and other kinds of magnesium/zinc?

"Elemental" refers to the weight of the mineral by itself, separately from the compound bound to it. For instance, ingesting 500 mg of magnesium gluconate means consuming 27 mg of elemental magnesium; consuming 50 mg of zinc gluconate means consuming 7 mg of elemental zinc.

Product labels display the elemental dosage. On a label, "27 mg of magnesium (as magnesium gluconate)" means 27 mg of elemental magnesium and 473 mg of gluconic acid; "7 mg of zinc (as zinc gluconate)" means 7 mg of elemental zinc and 43 mg of gluconic acid.

Q. Which food groups offer the greatest benefits for blood sugar management?

Insoluble and soluble fiber content can differ greatly between food groups.[333][334] It stands to reason that these differences may cause some food groups to produce superior blood glucose–regulating abilities compared with others.

In a large analysis of 88 observational prospective studies with some 230,000 participants, grains, vegetables, fruits, and dairy were the food groups consistently seen to decrease the risk of developing type 2 diabetes.[335]

Following up on these observational studies, another analysis of 66 RCTs examining 3,600 participants found the following.[336]

- For reducing fasting blood sugar, nuts, grains, legumes, and dairy provided the greatest reductions.
- For improving HOMA-IR (a measure of insulin sensitivity), grains, legumes, nuts, fish, fruits, and vegetables provided the greatest improvements.
- For reducing HbA1c, grains, legumes, fruits, vegetables, and nuts provided the greatest reductions.

Across all these measures (from more to less potent), grains, nuts, legumes, fruits, and vegetables had the greatest impact on improving overall blood glucose control.

Q. Will insoluble fiber supplements help control my blood sugar?

The most common insoluble fiber supplement out there is wheat fiber. However, it hasn't been studied enough under well-controlled conditions to know its effects, and what information we have doesn't clearly support its use for blood sugar management.[337][338][339] The same goes for studies on isolated arabinoxylan, the dominant form of fiber in wheat.[340][341]

Q. I've heard that I should "load" creatine. What does that mean?

Loading creatine means taking a high daily dose for a few days before moving down to a smaller maintenance dose, which can be taken indefinitely. This is not necessary for effective supplementation, however; benefits may be felt sooner through loading, but they normalize after a few weeks.

If you wish to load creatine, take 20–25 g/day for 7 days (splitting your daily intake into smaller doses, taking them with some food, and drinking more fluids may help prevent intestinal discomfort). Take 5 g/day thereafter.

Q. Creatine doesn't seem to work for me. What should I do?

Some people are creatine nonresponders: the creatine they ingest largely fails to reach their muscles.

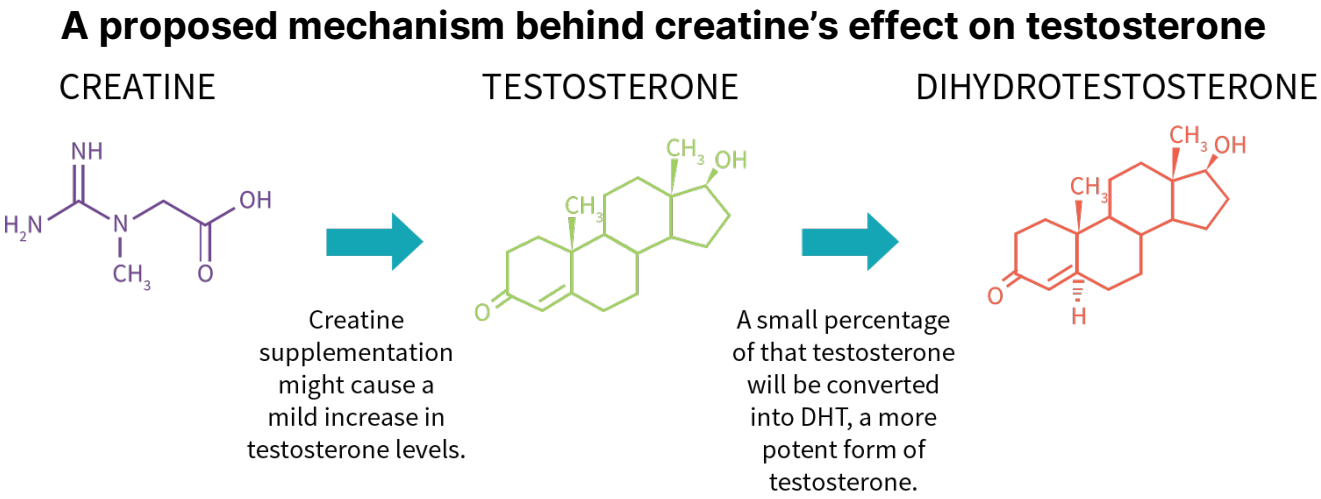
Alternate forms of creatine, such as creatine ethyl-ester, have been marketed to nonresponders, but they lack scientific support. Currently, the best way to lessen creatine nonresponse is to take 5 grams twice a day, each time with protein and carbs, preferably close to a time of muscle contraction (i.e., before or after your workout).

Note that even if supplemental creatine fails to enter your muscles it can still benefit you in other ways, such as by improving your body's methylation status (methylation being a way for your cells to help manage gene expression).

Q. Will creatine cause hair loss?

The idea that creatine *might* increase hair loss stems from a single randomized controlled trial (RCT) whose participants (20 healthy, young, male rugby players) saw a small but statistically significant increase in *dihydrotestosterone* (DHT) after supplementing with creatine for 21 days.[342] When DHT, a potent metabolite of testosterone binds to DHT receptors on the hair follicles of the scalp, those follicles may shrink and stop producing hair.[343][344]

To date, this RCT is the only one to have tested creatine's effects on DHT. However, a number of RCTs have examined creatine's effects on testosterone. Out of 12 additional RCTs, two saw a significant increase in testosterone,[345][346] but 10 saw no effect.[342][347][348][349][350][351][352][353][354][355] Of those 12 RCTs, five also tested creatine's effects on free testosterone, the form that gets converted into DHT, and all saw no significant increases.[347][348][350][352][354]



Creatine *could* nonsignificantly increase free testosterone yet significantly increase DHT (i.e., a small increase in free testosterone, which can convert into DHT, could lead to a much greater increase in total DHT). So while it's *technically* possible that creatine might have some effect on hair loss, current evidence and mechanistic data indicate it's quite unlikely.

A summary of creatine-testosterone studies

BETWEEN-GROUP EFFECT	STUDY	SAMPLE SIZE	POPULATION	AVG AGE	DURATION	DOSE	EFFECT ON TESTOSTERONE
Significant	Arazi 2015	20	Active males	20	1 week	20 g/day	↑
	Vatani 2011	20	Trained males	20	6 days	20 g/day	↑

BETWEEN-GROUP EFFECT	STUDY	SAMPLE SIZE	POPULATION	AVG AGE	DURATION	DOSE	EFFECT ON TESTOSTERONE
Mixed Results	van der Merwe 2009	20	Male rugby players	18	3 weeks	25 g/day loading 5 g/day maintenance	↑ DHT ↔ Test
No effect	Cook 2011		Male rugby players	20	10 weeks	4.5 g and 9 g	↔
	Cooke 2014	20	Active males	61	12 weeks	20 g/day loading Then 0.1 g/kg 3x/week (avg. 8.8 g/day)	↔
	Crowe 2003	28	Male rugby players	25	6 weeks	3 g/day HMB* + 3 g/day creatine	↔
	Eijnde 2001	11	untrained males	20	8 days	20 g/day	↔
	Faraji 2010	20	Male Sprinters	21	1 week	20 g/day	↔
	Hoffman 2006	33	Male football players	College	10 weeks	10.5 g/day	↔
	Rhimi 2010	27	Trained males	21	1 week	20 g/day	↔
	Tyka 2015**	19	Male runners	19–30***	6 weeks	0.07 g/kg of lean body mass	↔
	Volek 1997	13	Active males	23	1 week	25 g/day	↔
	Volek 2004	17	Trained males	21	6 weeks	20 g/day loading 4 g/day maintenance	↔

* While there was no creatine-only group, studies have not shown HMB to independently affect testosterone.[356][357][358][359]

** This study used creatine malate instead of creatine monohydrate.

*** This study reported an age range but not an average age.

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