#### diaTribe<sup>®</sup> Research & Product News for People with Diabetes

As a patient, I always fall into the trap of thinking I'm at fault for out of range blood sugars. But after 13 years of type 1 diabetes, I've learned that there are all kinds of factors that affect blood glucose, many of which are impossible to control, remember, or even account for. Based on personal experience, conversations with experts, and scientific research, I've created a list of 22 factors that can affect blood glucose. I've provided arrows to show the general effect these factors have on my blood glucose, but emphasize that not every individual will respond in the same way. The best way to see how a factor affects you is through personal experience – test your blood glucose more often or wear a CGM and look for patterns. Following the summary below are longer explanations of the factors and why they affect blood glucose.

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diaTribe.org provides free cutting-edge diabetes insights and actionable tips for people with diabetes. Our mission is to help individuals better understand their diabetes and to make our readers happier & healthier.







## Food Factors That Affect Blood Glucose

1.	Carbohydrates	•	Of all the three sources of energy from food (carbohydrates, protein, and fat), carbohydrates affect my blood glucose the most. Accurately counting carbs is very difficult, and getting the number wrong can dramatically affect blood glucose. The type of carbohydrate also matters – higher glycemic index carbs tend to spike blood glucose more rapidly.
2.	Fat	•	Fatty foods tend to make people with diabetes more insulin resistant, meaning more insulin is often needed to cover the same amount of food relative to a similar meal without the fat. On my pump, I typically use temporary basals or extended boluses (square and dual-wave) to cover high-fat meals. This effect is most notable if you eat a lot of fat at one time – for instance, when snacking on nuts, I'll observe a steady rise in blood glucose over many hours.
3.	Protein	<b>→</b> ↑	If you've ever eaten a protein-only meal with very few carbs (e.g., salad with chicken), you may have seen a noticeable rise in blood glucose (~20- 50 mg/dl). Though protein typically has little effect on blood glucose, in the absence of insulin, it can raise blood glucose. When I'm eating a carb- free, protein-only meal, I still take a bit of insulin to cover it (usually an equivalent of about 10-15 g of carbs).
4.	Caffeine	<b>+</b>	Many studies have suggested that caffeine increases insulin resistance and stimulates the release of adrenaline. Personally, I know that if I have a cup of coffee, I'll see at least a 20-30 mg/dl rise in blood glucose, particularly in the morning when I'm more insulin resistant.
5.	Alcohol	<b>*</b>	Normally, the liver releases glucose to maintain blood sugar levels. But when alcohol is consumed, the liver is busy breaking the alcohol down, and it reduces its output of glucose into the bloodstream. This can lead to a drop in blood sugar levels if the alcohol was consumed on an empty stomach. However, alcoholic drinks with carbohydrate- rich mixers (e.g., orange juice) can also raise blood sugar. When drinking alcohol, make sure you test your blood glucose often and that someone responsible nearby knows you have diabetes.





#### **Medication Factors That Affect Blood Glucose**

6.	Medication dose	<b>+</b>	For those of us with diabetes on any medication (pills or insulin injections), the dose of medication directly impacts blood glucose – in most cases (but not always), taking a higher dose of a diabetes medication means a greater blood glucose-lowering effect.
7.	Medication timing	<b>↓</b> ↑	In addition to dose, medication timing can also be critical. For instance, taking rapid-acting insulin (Humalog, Novolog, Apidra) 20 minutes before a meal is ideal for me - it leads to a lower spike in glucose vs. taking it at the start of the meal or after the meal has concluded. The timing of many type 2 diabetes medications matters a lot – some can consistently be taken at any time of day (e.g., Januvia, Victoza), while others are most optimally taken at meals (e.g., metformin).
8.	Medication interactions	••	Non-diabetes medications can interfere with your diabetes medications and blood glucose. Consult the information included in both your diabetes and non-diabetes medications.

### **Activity Factors That Affect Blood Glucose**

9.	Light exercise	<b>+</b> ‡	Light activity can have a surprising glucose-lowering effect – I find that walking tends to lower my blood sugar by about 1 mg/dl per minute. I have seen drops as large as 46 mg/dl in 20 minutes, more than 2 mg/dl per minute, and others see even more.
10.	High- intensity and moderate exercise	<b>+</b>	Exercise is often positioned as something that always lowers blood glucose; however, high-intensity exercise, such as sprinting or weight lifting, can sometimes raise blood glucose. This stems from the adrenaline response, which tells the body to release stored glucose. Often, I find this happens when I'm exercising in the morning on an empty stomach. But this is not a reason to avoid high intensity exercise – studies show it can improve blood glucose for one to three days post-exercise! ote that in some cases high-intensity exercise can also drop blood glucose very rapidly (2-3 mg/dl per minute), especially if you took insulin prior to exercise. The best way to see how individual exercise sessions affect your blood glucose is to test prior and after activity.





# **Biological Factors That Affect Blood Glucose**

11.	Dawn phenomenon	•	The "dawn phenomenon" occurs in people with and without diabetes. The term refers to the body's daily production of hormones around 4:00-5:00 AM. During this time, the body makes less insulin and produces more glucagon, which raises blood glucose. The best way to figure out how dawn phenomenon affects you is to wear a CGM or wake up and test your blood glucose early in the morning. If you take insulin, you may need to time your dose to cover this early morning rise in glucose. Note that not everyone experiences dawn phenomenon, but it is common!
12.	Infusion set issues	•	Infusion sets are not as well understood as we would like, and a huge number of factors can lead to higher glucose levels: air bubbles in the tubing, an occluded cannula, an infected site, or even the location of the set. If you wear a pump and your glucose is unexpectedly high, a good first step is to change your set out. I find that my glucose always tends to run higher on the third day of wearing an infusion set. In addition, I tend to get the best absorption wearing sets in my buttocks and the worst absorption in my legs – yet again, this varies among patients.
13.	Scar tissue and lipodystrophy	•	Using the same sites on the body for injections or infusion sets can lead to lipodystrophy and scar tissue buildup – these result in erratic absorption of insulin, leading to glycemic variability and making it harder to spend more time in range. To avoid these issues, rotate your injection/ infusion sites and don't reuse needles.
14.	Insufficient sleep	•	In my experience, I have found that I need nearly 25% more insulin on days following less than seven hours of sleep; my highest blood glucose of the day is even higher on days following little sleep; and my glucose is 21% more variable when I do not sleep enough. These findings are consistent with many studies, which have found that not getting enough sleep leads to worse diabetes control, insulin resistance, weight gain, and increased food intake.
15.	Stress and illness	•	Stress and illness can cause the body to release epinephrine (adrenaline), glucagon, growth hormone, and cortisol. As a result, more glucose is released from the liver (glucagon, adrenaline) and the body can become less sensitive to insulin (growth hormone, cortisol). In some cases, people are much more insulin sensitive right before getting sick and can tend to run low blood sugars. Personally, I have found exercise, time outside, and meditation to be most helpful against combatting stress.
16.	Allergies	1	Though I have not found any studies on this topic, some patients report higher glucose levels when they have allergies. Some have speculated that it's due to the stress hormone cortisol.

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17.	A higher glucose level	•	Hyperglycemia can lead to a state known as "glucotoxicity," which can actually cause insulin resistance. Have you ever needed to correct a very high blood sugar with much more insulin than your correction factor would suggest? I find that simply having a high blood glucose for many hours makes me appear much more insulin resistant.
18.	Periods (menstruation)	++	There is not a definite answer to the question of how periods affect women's blood sugars. Many women report having higher blood sugar levels a few days prior to their period starting, but some women notice a sharp drop in sugar levels. To figure out how you respond, your best bet is to test your blood glucose often during this time of month.
19.	Smoking	•	Some studies suggest that smoking can increase insulin resistance, and people with diabetes who smoke are more likely than nonsmokers to have trouble with insulin dosing and managing their diabetes. Smokers also have higher risks for serious complications.

## **Environmental Factors That Affect Blood Glucose**

20.	Insulin that has gone bad	•	I've fried my insulin by exposing it to direct sunlight or leaving it in the car on a hot day. If your insulin is normally clear, but suddenly turns cloudy, that could signal it has gone bad (note: NPH is always cloudy). Aside from a change in appearance, it can be hard to know if a vial of insulin has actually gone bad unless you try a new one. I've found that insulin that has "gone bad" will typically still work, but just not as well – I may need more insulin than I think to bring my glucose down, and the insulin may work unpredictably. Unopened insulin should be stored in a refrigerator at approximately 36-46 °F. According to the FDA, insulin can be left unrefrigerated at a temperature from 59-86 °F for up to 28 days.
21.	An accurate blood glucose reading	•	While this seems fairly obvious, I often find myself testing multiple times in a row, since I do not believe the initial value – in many cases, the second time I get a much lower value, and it's because I failed to wash my hands. For a meter that needs a tiny 0.3 microliter blood sample (the smallest currently on the market), a speck of glucose on the finger the weight of a dust particle will increase the reading by 300 mg/dl! I recommend retesting if you don't believe the value on the meter; if you wear CGM, it's great to reality check the meter value against your sensor reading.
22.	Altitude	?	Though most studies related to diabetes and altitude concern the accuracy of blood glucose meters, there are some reports that altitude can increase insulin resistance. I've found that when I go to high altitude regions like Colorado, I need about 20-30% more basal insulin. However, if you go to a high altitude place to do activity (e.g., skiing), you may find that you need less insulin.

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