Sugar Surfing in Practice

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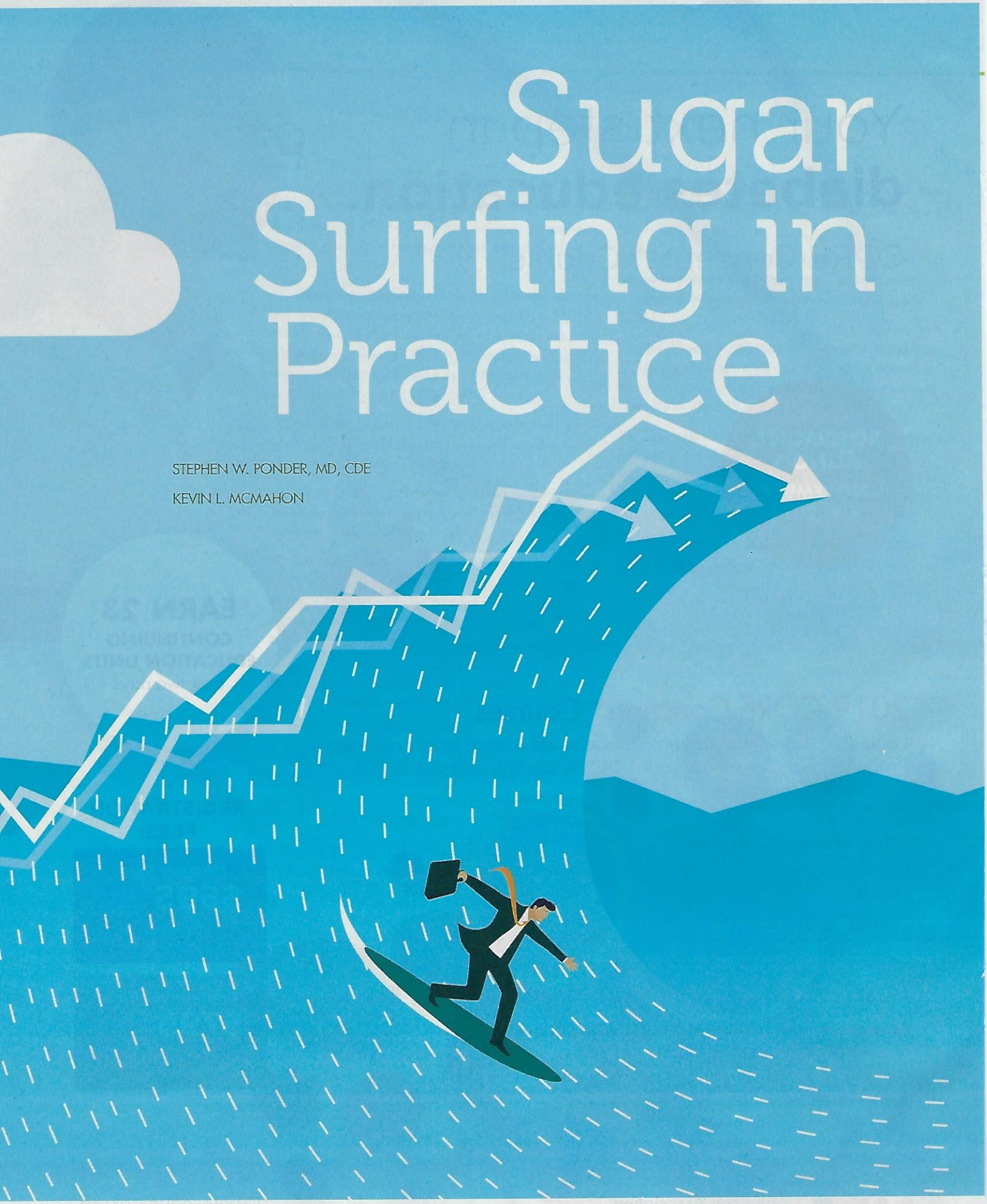


Sugar Surfing uses blood sugar information from a continuous glucose monitor (CGM) in proactive and reactive ways. "Sugar Surfing Basics for Diabetes Educators," which appeared in the September 2019 issue of this journal, explains the practice of Sugar Surfing and defines blood glucose trend lines observed on a CGM (Figure 1). Trend lines inform decisions and actions taken by Sugar Surfers using a CGM. This article focuses on the actions themselves, which include the following:

1. Micro-carbing
2. Micro-bolusing
3. Taking the drop
4. Carb pivot
5. Insulin pivot
6. Waiting for the bend.

Sugar Surfing is a skill that requires time and practice. The following examples demonstrate the process of applying each Sugar Surfing action to an everyday situation.

- **Shelf:** A period of relative blood glucose stability when a trend line does not drift further than a width of 30 mg/dL (1.66 mmol/L) over 1 hour
- **Delta wave:** A period of rising blood glucose levels with an increase of at least 30 mg/dL (1.66 mmol/L) over 1 hour
- **Drop:** A period of falling blood glucose levels with a reduction of at least 30 mg/dL (1.66 mmol/L) over 1 hour
- **Pivot:** A full reversal in blood glucose trending in response to an action or stimulus including insulin, exercise, carbohydrate, or stress
- **Inflection:** Any measurable change in the direction of a trend line (up or down)
- **Lag:** The time that passes between an action or stimulus (insulin, exercise, carbohydrate, stress) and a measurable change in the direction of a trend line

Figure 1. Blood glucose trend line patterns.

1. Micro-Carbing

Micro-carbing is the use of small quantities of carbohydrate to raise a low blood sugar, especially a horizontally trending one. It's a method to avoid overcorrecting with a standard 15-g carb treatment or snack ("rule of 15").

For example, let's say the value by fingerstick is 85 mg/dL (4.7 mmol/L), whereas the CGM readout says 68 mg/dL (3.77 mmol/L). The trend line is horizontal and has been for over 15 to 20 minutes. Lunchtime is in 30 minutes. The Surfer has not received any rapid-acting insulin since before breakfast.

The Surfer has previously determined that 5 g of carbohydrate generally raises the blood glucose approximately 25 mg/dL (1.39 mmol/L) in 15 to 20 minutes, assuming the trend line is not dropping rapidly and there is no leftover insulin on board or active physical exertion going on.

The Surfer corrects with 5 g of carbohydrate (micro-carbing) in the form of fruit juice or another fast-acting carbohydrate source. The person knows through prior personal experimentation that blood sugar rises to over 200 mg/dL (11.1 mmol/L) when 15 g of carbohydrate is taken.

After 20 minutes, the trend line is noted to trend upward, indicating a response in the desired direction. A second fingerstick blood sugar is performed, and it's now 90 mg/dL (4.99 mmol/L). Later still, the CGM trend line is noted to have leveled off around 100 mg/dL (5.55 mmol/L). The Surfer then doses insulin for lunch.

Prerequisites for successful micro-carbing include:

- Prior knowledge of the individual's unique range of responses to low carb quantities
- A steady, horizontal blood sugar trend line (shelf)
- No recent rapid-acting insulin doses or intense exercise
- The ability to observe and follow up the response frequently and carefully.

2. Micro-Bolusing

Micro-bolusing is the use of relatively small doses of insulin to create a small change in the direction of the trend line. It results in the blood sugar level changing less than 30 mg/dL (1.66 mmol/L).

In this example, the Surfer notices a gradually upward trending blood sugar level. The upward trend is clearly obvious in the trend line over the last several hours, with blood sugar rising less than 30 mg/dL (1.66 mmol/L) per hour. The blood sugar is now 150 mg/dL (8.32 mmol/L), whereas 2 hours ago it was 125 mg/dL (6.94 mmol/L). No physically

demanding activities are planned in the upcoming hours. Lunch was at 11:25 AM. It is now 2 PM.

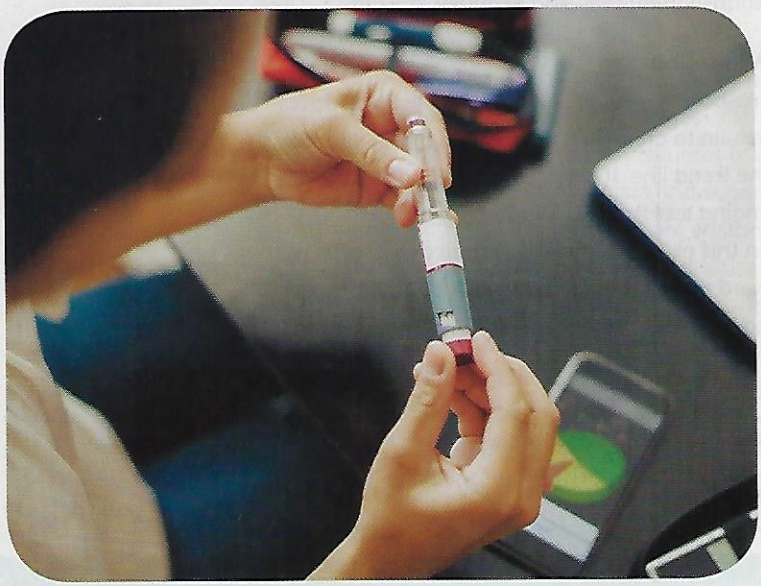
The Surfer has determined that a micro-bolus of insulin (by injection or via insulin pump) changes the direction of the blood glucose trend line, creating a small pivot effect. This person successfully uses micro-bolusing to redirect the upward trend line and lower the blood glucose level, targeting a blood glucose level of 110 mg/dL (6.1 mmol/L) plus or minus 15 mg/dL (0.83 mmol/L) in the next 2 to 3 hours. The Surfer is practiced in using micro-bolusing when blood sugars are trending upward above 150 to 180 mg/dL (8.32-9.99 mmol/L).

The micro-bolus results in a change in the direction of the trend line, and in 1 to 2 hours, the blood sugar levels begin to approach 115 mg/dL (6.38 mmol/L). Blood sugar levels then inflect into a horizontal trend line around 120 mg/dL (shelf), staying within 15 mg/dL (0.83 mmol/L), plus or minus, of the target (110 mg/dL, or 6.1 mmol/L).

Prerequisites for successful micro-bolusing include:

- Awareness of the changing trend line by periodic glancing at the CGM readout
- Absence of other forces (meal, snack, or exercise) that would alter the trending pattern
- Absence of any residual insulin on board
- Ability to glance at the trend line following the action.

Taking the drop is the Sugar Surfer's approach to moving from one steady level of blood sugar trending to a new, lower level. It requires allowing time for insulin to work.



3. Taking the Drop

Taking the drop is the Sugar Surfer's approach to moving from one steady level of blood sugar trending to a new, lower level. It requires allowing time for insulin to work. The process can often take 1.5 to 3 hours.

In this example, the Surfer's blood sugar trend line is straight at 200 mg/dL (11.1 mmol/L) at 10 AM. The individual has previously determined that 4 units of rapid-acting insulin by injection will reduce blood sugar on average by 80 mg/dL (4.44 mmol/L), assuming the basal insulin is balanced and that no strenuous physical activity or stress is present.

The Surfer spends the next 2 hours working at a desk, and it is right before lunch now. The glucose began to reduce about 20 minutes after the insulin injection and fell slowly over the next hour. It then inflected horizontally around 130 mg/dL (7.21 mmol/L) and has remained there for the last 15 minutes (a new shelf is emerging). If the drop passed 100 mg/dL (5.55 mmol/L) with an angled trend line, then the Surfer would attempt to "brake" the drop with 5 to 15 g of rapid-acting carbohydrate, thus preempting a low blood sugar.

Prerequisites for effectively taking a drop include:

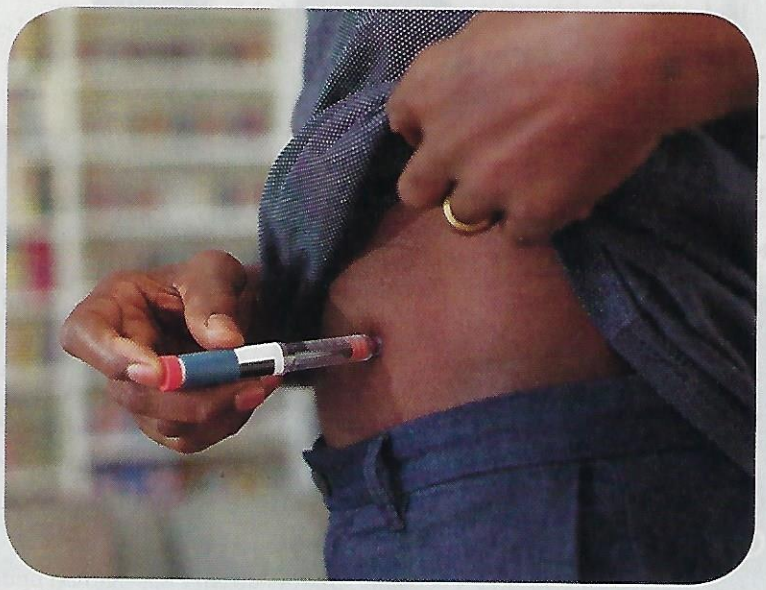
- A steady, trending blood glucose level at a nondesired level with a proper basal insulin effect working in the background
- Absence of rapid-acting insulin on board
- No significant physical activity anticipated
- Prior experience practicing this skill under controlled conditions
- Access to fast-acting glucose if the blood sugar target is passed.

4. Carb Pivot

A carb pivot is when carbohydrate is used to stop and reverse a downward blood glucose trend line.

In this example, the Sugar Surfer is a student who notes a 40 mg/dL (2.22 mmol/L) fall in blood sugar level over the past hour (a drop). It's now 80 mg/dL (4.44 mmol/L) and is still slowly trending downward. It's midafternoon, about an hour after recess.

The Surfer's parent sees this pattern on their mobile device and contacts school staff to request the student eat 15 g of fast carbs. This is based



on prior experience the parent has had in similar situations.

The staff provides the 15 g (fruit juice). After 20 minutes, the trend line has leveled out at 65 mg/dL (3.61 mmol/L) and begins to trend upward. After 30 minutes, the trend line inflects into a shelf at a value of around 110 mg/dL (6.1 mmol/L). It continues to drift steady in that range (100-130 mg/dL or 5.55-7.21 mmol/L) over the next hour until the student leaves for home. If the trend line had continued to drop below 60 mg/dL (3.33 mmol/L), another 15 g of carbohydrate would likely be given.

Recognize that treating a downward trending blood sugar back to target will take longer than treating a horizontal trending value at the same blood sugar level (see earlier micro-carbing example). The dose of carbs used to manage a downward blood sugar trend is different from a horizontal trend but corrects the same since the situation behind the action is different. In this case, the trend line did not change direction immediately because it takes time for the juice to get into the bloodstream and convert to sugar. As the juice turns into sugar, the drop is stopped and reversed. Compared to the micro-carbing example, some of the carbs were needed in this instance to stop the fall and push the blood sugar level back up to a desired level. There is also the additional time it takes for the sensor to detect the changes (lag). The student might say they are feeling better even though the sensor has not picked it up yet.

Prerequisites for an effective carb pivot include:

- Early recognition of a slowly dropping blood sugar trend line; alarms on the CGM can be used as a method of early detection
- Prior experience using the chosen carb treatment to reverse the direction of the trend line
- Patience and frequent follow-up glancing at the trend line to ensure the line begins to move upward and settles into a new pattern.

5. Insulin Pivot

An insulin pivot is when rapid-acting insulin is used to reverse an upward blood glucose trend line.

In this example, the Surfer observes a straight-line blood sugar inflecting to trend upward 2 hours after a large meal covered by rapid-acting insulin. The trend line inflects upward into a delta wave, with the blood sugar level rising more than 30 mg/dL (1.66 mmol/L) from the inflection point.

The Surfer chooses to deliver another insulin dose to counteract the upward trend line. As the glucose exceeds 200 mg/dL (11.1 mmol/L), the Surfer doses the standard correction dose for that level of glycemia, plus a small additional amount (10%-20%) based on the angle of the rising glucose level.

After about 30 minutes, the trend line starts to turn around and slowly trends downward over the next hour, until inflecting to a horizontal trend line (shelf) around 130 mg/dL (7.21 mol/L). It then remains in that range, plus or minus 15 mg/dL (0.83 mmol/L), for the next couple of hours until a new pattern emerges. If the blood glucose had continued downward below an agreed-on level, in this case 100 mg/dL (5.55 mmol/L) might be chosen, then a fast-acting carbohydrate would be taken to slow or stop the drop.

After-meal delta waves often happen when the insulin effect is going away and the effect of anti-insulin forces (food, stress) are taking over. A relative imbalance is happening. The large meal or slow digesting food has outlasted the single insulin dose taken to manage it, resulting in the blood glucose trending upward. An insulin pivot action attempts to stop the momentum of the rising blood sugar level.

Prerequisites for an effective insulin pivot are:

- At least 2 to 3 hours since the last rapid-acting insulin doseClear proof of a rising glycemic trend line (delta wave)

The dose of carbs used to manage a downward blood sugar trend is different from a horizontal trend but corrects the same, since the situation behind the action is different

Since many meals convert to sugar before insulin can get started, the ability to synchronize insulin and food is important for preventing high blood sugars or spikes after meals.

- Use of a modified correction dose that increases the total insulin taken compared to a standard correction factor given for a that blood sugar level
- Prior experience with this method under the supervision of family or the care team
- Carefully glancing at the trend line in the dropping phase
- A ready source of fast-acting carbohydrate to slow down or "brake" a falling blood sugar level
- Treatment threshold individualized for the Sugar Surfer; in a school setting, higher, more conservative treatment cutoffs would be considered proper.

6. Waiting for the Bend

Waiting for the bend is the art of timing the blood sugar lowering effect of a rapid-acting insulin dose to work effectively with the blood sugar raising effect of the meal to be eaten. This method could also be called "pre-bolusing."

The "bend" is the first downward inflection in the blood glucose trend line after the insulin dose, which suggests the insulin is starting to work. When the bend occurs, the Surfer then begins to eat the meal.

Since many meals convert to sugar before insulin can get started, the ability to synchronize insulin and food is important for preventing high blood sugars or spikes after meals. If spikes (delta waves) after meals are common, the A1C level eventually rises.

The Surfer must have a good idea of how fast or slow the food being eaten will turn to sugar over the next 1 to 2 hours (maybe longer). Over time, Sugar Surfers learn this by trial and error and careful glancing of the blood glucose trend line after eating certain foods and meals, which helps them get the best after-meal blood sugar profile.

Sugar Surfers may not always have time to wait for the bend. If the blood sugar is already trending downward, no waiting is needed, and in some cases, the meal might be eaten before the injection to prevent a low blood sugar.

Prerequisites for waiting for the bend include:

- Glancing to discern the direction and speed of the glucose trend line around mealtime
- Appreciation of how fast the carbohydrate in the meal to be eaten will raise blood sugar
- Ability to wait for the bend to happen and then not delay eating once it occurs
- Eating the complete meal that the insulin dose was based on.

Caveats to Consider

CGM technology is still imperfect, as are handheld blood glucose meters. Therefore, it's wise to not accept every blood glucose reading at face value if it conflicts with other observations made in the moment. Repeated blood glucose measurements might be needed if the CGM seems at odds with the situation at hand.

The trend line arrows on CGMs are created from the last several data points. A cresting blood glucose level may show an upward trend even when the person's glucose level has stopped rising or is starting to drop. This is an artifact of CGM technology. There is no substitute for good judgment.

Some CGMs may develop the ability to internally sense falling, rising, or steady blood glucose trends. This is attributed to the biofeedback effect the sensor provides to users who glance often at their readouts and make mental notes of their internal sensations. This can be a powerful advantage for helping individuals detect shifting blood glucose levels, allowing for preemptive action to be taken before a low or excessively high reading happens. ■

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