



Making Real-Time Insulin Adjustments During Exercise

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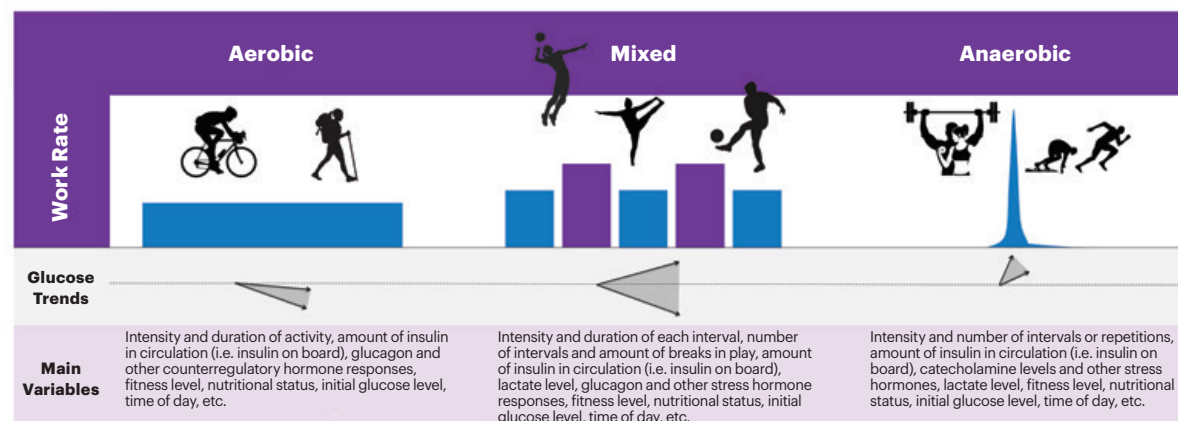
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There's no question that exercise offers immense benefits for people living with type 1 diabetes (T1D), including improvements in insulin sensitivity, better weight control, and a reduced risk of diabetes-related complications.¹ However, insulin adjustments are often needed before, during, and after exercise to avoid glucose excursions.¹ This handout describes various approaches to making those adjustments and uses some case examples to illustrate key points in managing insulin dosing in those with T1D who exercise.

EFFECTS OF EXERCISE ON BLOOD GLUCOSE

Most forms of exercise increase insulin sensitivity, not only during the activity, but also hours after the activity has ended.² However, different types of exercise affect blood glucose (BG) differently (Figure 1).¹ There is also substantial individual variability in metabolic response to exercise influenced by multiple factors, including the duration and intensity of the activity, BG concentrations at the time of exercise initiation, individual fitness level, and nutritional status.¹

FIGURE 1. Effects of Different Types of Exercise on Glucose Levels in Patients Using Insulin Therapy



Reprinted with permission from JDRF. Effects of exercise on type 1 diabetes. Last updated 2018. <https://jdrf.org.uk/exercise-type-1-diabetes/>. Accessed April 26, 2020; and Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol.* 2017;5(5):377-390. Updated image: <https://mridell.lab.yorku.ca/files/2020/04/JDRF-Peak-Poster.pdf?x45163>.

COMMON CHALLENGES FOR PEOPLE WITH T1D

The following challenges are commonly experienced by individuals who are trying to adjust insulin around exercise¹:

- **Hypoglycemia during exercise.** Unless insulin levels are lowered before the start of exercise, most people with T1D will develop hypoglycemia (BG < 70 mg/dL) within 45 minutes of starting aerobic exercise. Therefore, unless they have hyperglycemia (BG levels 182-270 mg/dL) when starting exercise, most people with T1D must increase their pre-exercise carbohydrate intake, reduce their insulin dose, or both before engaging in aerobic exercise.
- **Hypoglycemia after exercise.** In the 24-hour recovery period after exercise, there is an increased risk of hypoglycemia (BG < 70 mg/dL) that can potentially lead to nocturnal hypoglycemia, especially if exercise is performed in the afternoon.
- **Hyperglycemia before exercise.** Generally, the recommended starting BG level before beginning exercise is approximately 126 to 180 mg/dL. Higher BG levels (182-270 mg/dL) may be acceptable if the person with T1D would benefit from added protection against hypoglycemia. However, very high pre-exercise glucose concentrations (BG levels > 270 mg/dL) can lead to pronounced hyperglycemia and ketosis.
- **Hyperglycemia after exercise.** Intense aerobic exercise, resistance exercise, and high-intensity interval training, or HIIT, can all result in a long-lasting, post-exercise increase in BG.

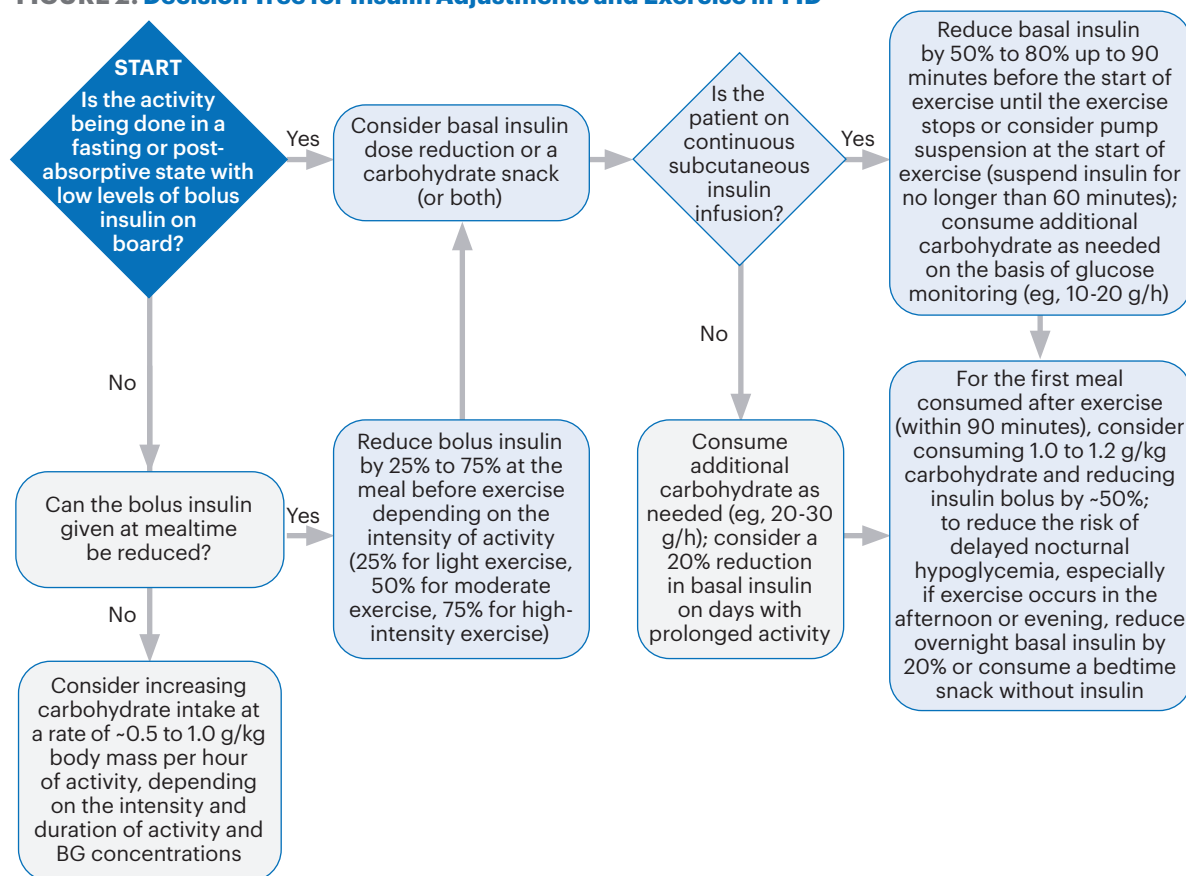
Because of these challenges, individuals with diabetes may feel overwhelmed by the adjustments that are needed to exercise safely. Figure 2 is a decision tree that can help individuals with T1D manage exercise-associated BG excursions.

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FIGURE 2. Decision Tree for Insulin Adjustments and Exercise in T1D



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CASE SCENARIOS

Let's take a look at how these challenges might play out in 4 case scenarios.



CASE 1 JENNA

Jenna is a 42-year-old woman with a 20-year history of T1D. For the last 2 years, work and family commitments have made it challenging for her to find time to exercise. She is now trying to establish an exercise routine but has been experiencing hypoglycemia during exercise.

Currently, she uses a sensor-augmented insulin pump that delivers basal insulin ranging from 1.2 to 1.6 units (U)/hour. Her insulin-to-carbohydrate ratio (ICR) is 1:8 (U/g), and her insulin sensitivity factor (ISF) is 40 mg/dL.

Jenna walks 30 to 60 minutes a day, 5 to 7 days a week, at a brisk pace. On weekends, she walks at 9:00 am after eating breakfast at 7:00 am. On weekdays, she walks at 4:00 pm (before dinner) or at 7:00 pm (after dinner). On most days, she eats lunch sometime between noon and 1:00 pm.

When walking at 4:00 pm, Jenna is experiencing low BG, so she now eats a snack containing about 20 g of fast-acting carbohydrate (a banana or a glass of orange juice) before or during her walk. However, she still has low BG when walking after dinner on weekdays or after breakfast on the weekends.

CASE 1 (CONT.)

What Adjustments Might Help?

Jenna can consider reducing her basal insulin rate by 80% 60 to 90 minutes before walking. This would be most effective if she begins walking at least 2 hours after her bolus insulin and meal. If her basal insulin is not reduced before exercise or if her BG is trending downward, she should delay her pre-exercise snack until the sensor glucose drops below 120 mg/dL. Jenna can also reduce her bolus insulin by 50% if she will start walking within 2 hours after her breakfast, lunch, or dinner. In addition, she can reduce her bedtime basal insulin rate by 20% for 6 hours to protect against nocturnal hypoglycemia.

Dietary changes that Jenna can implement include consuming a breakfast with a lower glycemic index that includes some protein and fat, such as steel-cut oats, full-fat milk, and some nuts. This will slow glucose absorption so that the peak would occur on her walk.

Case Insights^{1,2}

- ✓ Moderate aerobic exercise can result in hypoglycemia and typically requires an intake of fast-acting carbohydrate before exercise
- ✓ Insulin dose adjustments may still be necessary and require temporarily reducing the basal insulin rate before exercise
- ✓ A reduction of the basal insulin rate before bedtime can protect against nocturnal hypoglycemia after exercise
- ✓ Low glycemic meals can slow glucose absorption so that her BG peak occurs during exercise



CASE 2 ELENA

Elena is a 20-year-old college student who was diagnosed with T1D at age 18. Her current treatment plan consists of multiple daily injections (MDI) with 28 U of insulin glargine (Lantus®) at bedtime and insulin lispro (Humalog®) at mealtimes, with a target glucose of 110 mg/dL, an ICR of 1:5, and an ISF of 28 mg/dL. Her chief complaint is hyperglycemia after exercise.

Elena goes to a 45-minute power yoga class at 1:00 pm 3 times a week, in between academic classes. At the end of yoga class, her BG has increased from 150 mg/dL to 240 mg/dL. To help lower her post-yoga BG, she immediately walks on the treadmill for about 20 minutes when she can, but she usually only has time for that additional activity once a week.

What Adjustments Might Help?

Elena can consider administering a 50% insulin correction bolus post-exercise on days when she doesn't use the treadmill. This can be calculated by determining the change in BG needed to reach a target of 110 mg/dL—in this case, 130 mg/dL. One-half of the insulin amount needed to lower her BG by 130 mg/dL is calculated using the ISF and rounding to the nearest 0.5 or 1.0 U—in this case, $130 \text{ mg/dL} \div 28 \text{ mg/dL} = 4.6 \text{ U} \times 0.5 = 2.3 \text{ U}$, rounded down to 2 U.

Other actions Elena could take to lower post-exercise hyperglycemia include¹⁻³:

- Eating a low-carbohydrate lunch (6-8 g carbohydrate) on days she participates in power yoga (eg, tuna or egg salad with a few cherry tomatoes and Dijon mustard)
- Completing a 10-minute aerobic cool-down after yoga class and increasing her water intake
- Correcting hyperglycemia at the next meal, if necessary

CASE 2 (CONT.)

Case Insights^{1,2,4}

- ✓ Anaerobic exercise can cause BG to rise
- ✓ For individuals using MDI, adding a corrective dose of rapid-acting insulin based on a formula that uses the individual's ISF can bring BG back into the target range
- ✓ Adding a short period of aerobic exercise after an anaerobic workout and consuming a low-carbohydrate meal earlier in the day can control post-exercise hyperglycemia



CASE 3 JENSEN

Jensen is a 15-year-old high school student who was diagnosed with T1D when he was 8 years old. His insulin regimen includes MDI with 12 U of insulin glargine (Lantus®) at bedtime and insulin lispro (Humalog®) at mealtimes with an ICR of 1:15 and an ISF of 54 mg/dL. He just started using a continuous glucose monitoring (CGM) device about 1 month ago. Jensen plays on his school's soccer team, and his CGM alarm has been going off around the end of his evening games, registering BG levels between 230 and 260 mg/dL, especially during more intense competitions. In addition, after game days, the CGM alarm has woken him up at nights with low BG readings.

What Adjustments Might Help?

Jensen can add a 50% insulin correction after intense games with insulin aspart (Fiasp®) and a high-glycemic bedtime snack if his bedtime glucose is less than 135 mg/dL. The bedtime snack should contain approximately 12 g of carbohydrate, some protein, and fat (eg, Glucerna® Mini Treat). Jensen should also consider changing to a split dose of insulin glargine (eg, 7 U in the morning, 5 U at bedtime) to improve 24-hour basal insulin coverage or switching to a basal insulin with a longer activity profile (insulin glargine U300 [Toujeo®] or insulin degludec [Tresiba®]). If he chooses the split dose of glargine, the slightly higher morning dose and reduced insulin coverage overnight will help combat the early evening hyperglycemia associated with intense, late-afternoon competition. Other options would be to change to insulin glargine U300 or degludec at bedtime or transition to a hybrid closed-loop insulin pump.

Case Insights^{1,5-7}

- ✓ Stress associated with sports competition can affect BG levels
- ✓ High-intensity exercise in the afternoon can cause hyperglycemia followed by nocturnal hypoglycemia
- ✓ A conservative insulin correction after exercise followed by a bedtime snack can correct these excursions
- ✓ Insulin degludec and glargine U300 are ultra-long-acting basal insulins (up to 42 hours and 36 hours, respectively) that have a significantly lower risk of hypoglycemia than insulin glargine
- ✓ A hybrid closed-loop insulin pump may be an option for managing exercise-induced glucose excursions



CASE 4 **MARCUS**

Marcus is a 28-year-old man who was diagnosed with T1D at age 10. He currently uses a hybrid closed-loop insulin pump (Medtronic MiniMed™ 670G) to manage his diabetes. He is training for his first marathon. He has always exercised regularly and runs for about an hour every day, but he experiences hyperglycemia before his training runs. He wants to know how to manage this during the marathon. He also worries about the potential for hypoglycemia during both his training runs and the race.

What Adjustments Might Help?

Marcus can consider setting his insulin pump temporary target mode to 150 mg/dL 1 hour before the start of each training session and the race. Additionally, to minimize insulin delivery at the onset of exercise, he can delay carbohydrate intake until he has begun his workout and glucose is trending below 150 mg/dL on the CGM.

It's also recommended that Marcus consume his main pre-exercise meal 4 hours before the start of training or the marathon. However, if he must eat later, he should do so 1 to 2 hours before exercise, take his usual bolus insulin, and consume low-glycemic foods (eg, peanut butter on pumpernickel bread with one-half of a grapefruit). He can also consume extra carbohydrate in small amounts if his glucose level drops before the start of the race. If high glucose still occurs, he can also do a low-intensity aerobic warmup (eg, stretching and brisk walking) just before the workout or marathon to attenuate the pre-exercise hyperglycemia. He should drink plenty of water, as well, to maintain hydration if pre-exercise hyperglycemia occurs.

Case Insights^{1,2,4}

- ✓ Hybrid closed-loop insulin pump technology can help manage pre- and post-exercise glucose excursions; the temporary target mode, set at 150 mg/dL, can be used to override the auto mode (120 mg/dL)
- ✓ Doing a pre-exercise, low-intensity aerobic warmup and consuming a low-glycemic meal 4 hours before the start of exercise can help control hyperglycemia



ADDITIONAL RESOURCES

We hope you found this to be a useful summary of information to help illustrate challenges and strategies for managing exercise-related BG excursions in individuals with T1D. The following additional resources may be helpful:

- **JDRF:** Exercise resources for people with T1D (<https://www.jdrf.org/t1d-resources/living-with-t1d/exercise/>)
- **diaTribe.org:** Exercising well with diabetes using automated insulin delivery (<https://diatribe.org/exercising-well-diabetes-using-automated-insulin-delivery>)
- **Sansum Diabetes Research Institute:** ExCarbs (<https://excarbs.sansum.org/>)

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