

Type 1 Diabetes, Exercise, and Hyperglycemia: A Case Study

Developed in collaboration



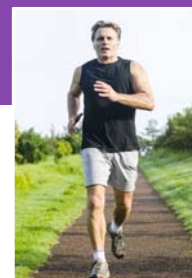
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INTRODUCTION TO THE PATIENT

Andrew

- **Chief complaint:** interested in increasing exercise frequency and intensity to further lower HbA1c
- **History of present illness:**
 - 45-year-old man
 - T1D x 30 years
 - HbA1c usually 7.0–7.5%
 - No significant diabetic retinopathy or neuropathy
- **Medical history:** hypertension, hypercholesterolemia
- **Medications** include lisinopril, atorvastatin
- **Current diabetes treatment:**
 - Insulin pump and CGM
 - Insulin aspart 1 unit per 10 g carb, 1 unit per 40 mg/dL above target fasting glucose of 100 mg/dL
 - Basal rate varies from 0.6–1.0 units per hour over 24 hours

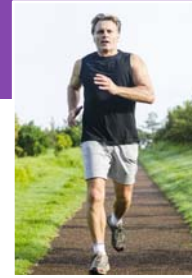


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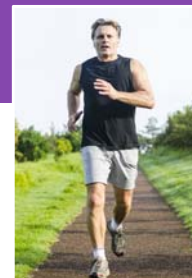
Current Exercise

- 1–2 days per week, usually running
- Occasionally does 30- to 90-minute bike rides
- Occasional long trail hikes
- Past history of hypoglycemia with exercise, resolved with changes in carbohydrate intake and insulin administration
- Recently had a few more high blood glucose levels
- Wants to be able to perform his best without difficulties with blood glucose levels before, during, or after workouts



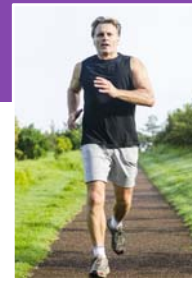
Current Diet

- Usually eats a meal within 1 hour of exercise
- Brings carbohydrate with him in case it is needed during exercise
- Eats again shortly after exercise to refuel and prevent lows
- Includes rapidly digestible carbohydrate because he feels “they will improve his energy and performance with exercise”





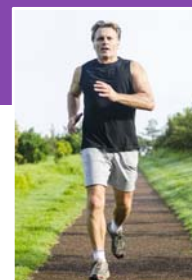
Chief Exercise-Related Complaint: Hyperglycemia Before Exercise



- Eats (energy bar, banana, coffee) approximately 1 hour before run
- Does not want too much insulin on board during a workout, so takes only 50% of usual bolus
- Blood sugars rising to 280 mg/dL instead of usual 180 mg/dL
- Feels dehydrated and sluggish



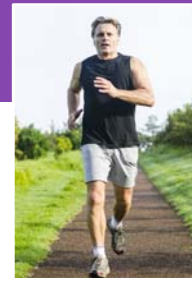
Recommendations for Managing Hyperglycemia Before Aerobic Exercise



- Reducing insulin on board to avoid hypoglycemia during workout is associated with increased risk of hyperglycemia, especially when eating foods that contain carbohydrate
- Eat pre-workout meal 3–4 hours before, or workout in fasting state
- If meal is closer to workout time, choose more slowly digested carbohydrate with lower glycemic index
 - Avoids sharp spikes when insulin is appropriately decreased
- Low-intensity or short-duration (≤ 30 minutes) aerobic exercise requires only a 25% reduction in pre-meal insulin
 - Would also prevent some hyperglycemia



Recommendations for Managing Hyperglycemia Before Anaerobic or Mixed Exercise



- Likely to have a further increase in blood sugars with this activity
- May not need to decrease pre-workout bolus insulin
- Could also use a brief aerobic warm up before his activity to reduce blood glucose slightly before anaerobic or mixed exercise

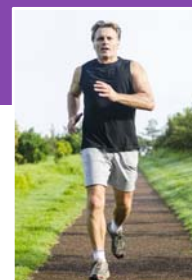
Riddell M, et al. *Lancet Diab Endo*. 2017;5:377-90.



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Chief Exercise-Related Complaint: Hyperglycemia During Exercise



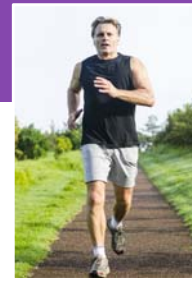
- Recently, on a race day (10K), Andrew decreased his basal rate on his insulin pump by about 50% approximately 1 hour before the race start
- 30 minutes before the race, his blood sugar was 110 mg/dL, lower than intended (140–180 mg/dL), so he eats a banana
- 10 minutes after the banana, his blood sugar was still 110 mg/dL, so he ate 5 glucose tabs
- He started the race at a very fast pace and noticed that his blood sugars rose to about 250 mg/dL



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Recommendations for Managing Hyperglycemia During Aerobic Exercise

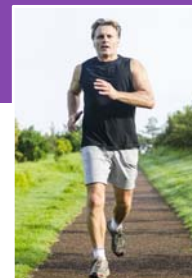


- Hyperglycemia during exercise is likely the result of:
 - Rapid-acting carbohydrate just before exercise
 - Anxiety about blood sugars
 - Adrenaline during the competition
- Reduction of basal insulin rate may have been too much
- Ingest 20 g carbohydrate if blood sugars are below target before the run
- Use CGM to ensure that carbohydrate intake is adequate
- Meditation or visualization exercises may be helpful to reduce anxiety
- Insulin boluses via the pump during continuous aerobic exercise should be used very carefully
 - Expect that blood-glucose-lowering effect of 1 unit of insulin may be ≥ 2 -fold increased than at rest

Expert opinion. Riddell M, et al. *Lancet Diab Endo*. 2017;5:377-90. Zaharieva DP, et al. *Can J Diabetes*. 2017;41:507-16.



Recommendations for Managing Hyperglycemia During Anaerobic or Mixed Exercise

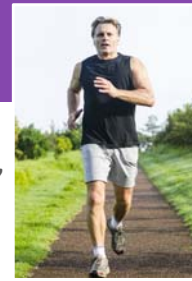


- Stress response will be more pronounced
- He would not have needed to consume any carbohydrate with his BG before exercise
- If consistently high blood glucose levels during training or competition due to anaerobic exercise, use CGM to determine a small bolus of insulin or increase in basal rate to offset this

Expert opinion. Riddell M, et al. *Lancet Diab Endo*. 2017;5:377-90. Zaharieva DP, et al. *Can J Diabetes*. 2017;41:507-16.



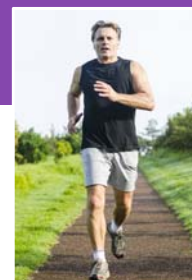
Chief Exercise-Related Complaint: Hyperglycemia After Exercise



- After a bike ride, Andrew's blood sugar was 120 mg/dL
- Pump was set at 50% of basal rate starting 90 minutes before the ride
- He consumed 20 g carbohydrate every 30 minutes during the 1-hour workout
- He went home, showered, changed and was surprised to see that his blood sugars had risen to 220 mg/dL



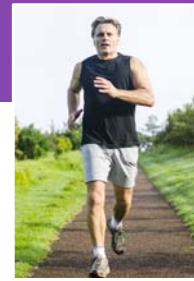
Recommendations for Managing Hyperglycemia After Aerobic Exercise



- Hyperglycemia was likely the result of persistent adrenaline hormones causing insulin resistance combined with a drop in muscle glucose uptake after exercise
 - Other causes could be the effect of his decreased basal rate or delayed glucose absorption from carbohydrate ingested during workout
- Consider a conservative bolus of 50% of usual correction for post-workout hyperglycemia
- Low-intensity cooldown of 10–15 minutes of walking would also reduce the spike in blood sugars



Recommendations for Managing Hyperglycemia After Anaerobic or Mixed Exercise

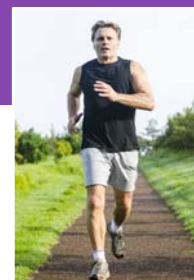


- Recommendations are the same as for managing post-aerobic-activity hyperglycemia

Expert opinion. Riddell M, et al. *Lancet Diab Endo*. 2017;5:377-90.



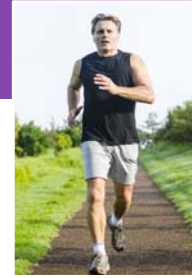
Chief Exercise-Related Complaint: Elevated Ketone Levels



- Andrew woke up at 6 a.m. ready to go for his morning run
- He found his blood sugars to be 250 mg/dL; they were 150 mg/dL when he went to bed
- He checked his pump and tubing and discovered that the infusion set became dislodged overnight while he was sleeping
- He had a dry mouth and was feeling nauseated
- He checked his blood ketones and found that they were significantly elevated (2.0 mmol/L)



Recommendations for Managing Elevated Ketone Levels



- Check ketone levels and follow recommendations below based on level

Ketone Levels	Exercise Recommendation
Blood ketones <0.6 mmol/L	Mild to moderate aerobic exercise can be started
Blood ketones 0.6—1.4 mmol/L	Light intensity and short duration (<30 min) is acceptable possibly with small dose of corrective insulin
Blood ketones ≥ 1.5 mmol/L	Exercise is contraindicated

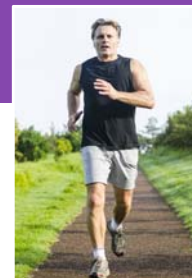
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Case Wrap Up



- Moving Andrew's meal earlier before exercise and adjusting the type of carbohydrate would help him begin his exercise in the target glucose range with a minimum of insulin on board
 - Using continuous glucose monitoring is helpful to see the trend information before exercise
- Considering the stress response during competition, he reduced his pre-exercise carbohydrate intake for races
 - He set his basal rate at 75% instead of 50% to avoid hyperglycemia
 - Using CGM, he was able to adjust his carbohydrate intake during exercise



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Case Wrap Up

- Discontinuing his temporary basal rate before stopping exercise and giving a small bolus of insulin just after his workout allows him to offset the rise in blood sugars from the exercise
- By checking ketones before exercise, he is able to know when it is safe or unsafe to participate in aerobic activity

