Exercise Concerns in Youth with Type 1 Diabetes

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Disclosures

- None
What We Will Cover

- Why exercise is good
- Two case presentations
- Concerns over exercise
- Physiology
- Factors affecting exercise in T1DM
- Tips for exercise with T1DM
- New research
- Back to cases
- Take home points
Objectives

- Appreciate **challenges** for young people with type 1 diabetes when trying to exercise
- Understand **physiology of glucose utilization** during exercise in type 1 diabetes
- Identify **ways to promote euglycemia** during and after exercise for young people with type 1 diabetes
Health Benefits of Exercise

- Lower blood pressure and cholesterol
- Lower risk of heart disease and stroke
- Stronger heart, better circulation
- Stronger muscles and bones
- More flexible joints
- Can help lose or maintain weight
- Helps sleep better
- Increased energy for daily activities
- Relieves stress
- Improved mental health
Two Case Presentations
Case 1

- 16 year old girl
- Trying be healthy and lose weight
- Joins gym
- Having frequent low blood sugars during and after exercise
- Needs snack before exercise
- Treats lows with juice, glucose tabs, skittles, etc.
- Gaining weight!
Case 2

- 9 year old boy
- Avid soccer player
- Plays >6 hours a day in the summer
- If not playing soccer, he swims, bikes or goes to the gym
- Hyperglycemia right after exercise
- Several hours later has hypoglycemia
Concerns

- May be trying to exercise to lose weight. Exercise causes hypoglycemia, that needs to be treated with high-calorie foods or drinks, which may cause weight gain
- May have delayed hypoglycemia
- May need to postpone starting to exercise until BG in optimal range
- May need to sit out during part of exercise to recover from hypoglycemia
- Young child may not be able to verbalize hypoglycemic symptoms
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Physiology

- Parking lot analogy
Parking Lot Analogy (Charlie O’Connel)

www.fitscript.com

The Parking Lot Analogy: Where and how glucose stores in your body

Glucose Molecule

Blood Vessels

Brain, Liver, Muscles, Fat

Insulin
Parking Lot Analogy

- **Glucose** - “car”
- After a meal, looking for “parking spot” in one of three “parking lots”:
  - Liver
  - Skeletal muscle
  - Adipose tissue
- Plus “VIP parking lot”, brain
- Technically, brain does not store glucose, but it is the first place a glucose molecule will try to park in (even if one brain parking spot is empty, the body feels low)
- If brain full, then go on to the other three parking lots
Parking Lot Analogy, continued

- Next parking lot: **Liver**- “Valet parking”.
  - Limited number of spots. If full, no matter how much insulin, will be bypassed.
  - Glucose stored as glycogen.

- Next parking lot: **Muscle**- “Short-term garage”.
  - Also limited number of spots. Number of spots can change (unlike liver): more if you exercise more, less if you have less muscle or have stopped exercising.
  - Glucose stored as glycogen.

- Last parking lot: **Fat**- “Long-term parking”.
  - Can always find space. Can create more parking space by building new garages (new adipocytes) or by making each spot bigger (increasing size of adipocytes).
  - Glucose stored as triglycerides.
Parking Lot Analogy, continued

- **Insulin** - “traffic cop”
  - Hormone that causes liver, fat and muscle cells to absorb glucose from the blood stream AND prevents use of fat as energy source
  - “Stop fat”, “Glucose Go” (into 3 parking lots)

- **Exercise** - “gets rid of glucose traffic jam” (creates more parking spots)
  - Causes insulin sensitivity by:
    - Emptying parking lots of muscle and liver
    - More glucose in the blood stream is directed into muscle and liver (and lower blood glucose) instead of being stored as fat
If liver and muscle spots are full, a lot of insulin is needed to direct the glucose into the fat cells.

When parking spots are empty because of exercise, less insulin is needed to direct the glucose into the liver and muscle parking lots.

- **For T1DM, depletion of glycogen stores and increased insulin sensitivity explain hypoglycemia after exercise.**
- In T2DM or pre-diabetes, consistent exercise can be helpful to increase insulin sensitivity and improve BG control.

This is why injected insulin can cause weight gain.

- If injecting insulin and not exercising, the only place the body can store the glucose is in the fat tissue.
Factors Affecting Blood Glucose During Exercise

- Blood glucose before starting exercise
- Food prior to and during exercise
- Type of activity
- Intensity of activity
- Length of time of activity
- Time of day
- Amount of active insulin, changes to insulin doses
Ideal Blood Glucose

- Need to test BG before, during and after exercise
- Prior to exercise:
  - **<100**: may be too low, especially if exercising for more than 30 minutes
    - Eat something with carbs (granola bar, fruit, ~15 grams of carbs)
  - **100-250**: ok zone
  - **>250**: check for ketones
    - Avoid vigorous exercise if positive
    - Exercise if negative ketones
  - **>300**: May be too high to exercise
    - Take a correction
    - Consider giving IM correction to bring the number down faster
When BG is too High, it Can Get Higher with Exercise

- Not enough insulin is causing the high BG
- During exercise, the quickest form of energy is glucose
- Muscles may not be receiving enough glucose from blood (if not enough insulin)
- Muscles send a message asking for more energy
- Body releases more glucose
- Still not enough insulin, so muscle can’t receive the glucose
- BG rises
What to Eat Prior to Exercise

- Insulin inhibits use of fat during exercise
- If having high carb foods and drinks prior to exercise, fat will not be used as source of energy
- Start exercise with very little insulin on board (eat low carb foods prior to exercise to need less insulin to cover them)

- For example, “Green juice”
  - Benefits for T1DM:
    - little/no insulin, so less risk of hypoglycemia
    - little/no insulin, will burn fat
Green Juice

- Kale or spinach
- Cucumber
- Celery
- Carrots
- ½ green apple
- ¼ lemon
- Ginger
- Water
- (Big ratio of vegetable to fruit)

- Blend!
Snacks During Exercise

- Short-acting carbs:
  - Apple Sauce
  - Juice Boxes
  - Iced Tea/Lemonade
  - UCAN sports drinks

- Long-acting carbs:
  - Granola Bars
  - Chia Bars
Types of Physical Activity

“Aerobic Exercise”/“Cardio”
- Examples:
  - Running, walking
  - Spinning
  - Swimming
  - Cardio machines (ellipticals, treadmills, etc.)
- **Lowers** blood sugar

“Aerobic Exercise”/“Resistance Training”
- Examples:
  - Lifting weights
  - Short bursts of sprinting
  - Push-ups
- **Raises** blood sugar
Types of Physical Activity

- Anaerobic exercise raises BG
- Cardio exercise lowers BG
  - Start with lifting weights (higher BG), end with cardio (lower BG)
  - This decreases the amount of snacking needed prior to exercise
Why Does Anaerobic Exercise Increase Blood Sugar?

- During strenuous exercise, GH is higher during entire exercise session
- More fat is used than glucose
- Build up of lactate can be recycled into glucose (prevents low blood sugar)
Heart Rate and Blood Glucose

- Depending on different heart zone (different primary energy zone) and presence of insulin, BG may go high or low
- Heart rate can be a good indicator of potential BG changes
- Also perceived exertion level
Example: Long Distance Biking

- Usually done at 50-70% of maximum heart rate (lower zone)
- Recruits majority of energy from fat stores, very minimally from glycogen stores (liver, muscle)
- Only small drop in BG expected
- But many people with T1D experience lows:
  - Not matching insulin, carbs and the specific type of exercise
  - Too much insulin on board, cannot use fat stores (the fuel for this type of exercise), low BG
- Other tips: ride with at least one other person, bring cell phone, have plenty of test strips
How Does Exercise Time of Day Affect Blood Sugars?

- **Early morning**
  - May see hyperglycemia (dawn phenomenon)
  - This variable may trump any other variable such as starting glucose level or type of exercise

- **Mid-morning**
  - May go low: may not have eaten, or breakfast insulin may be peaking

- **Afternoon, evening, night:**
  - Timing of last insulin administration (or adjustment) will have an effect of whether BG may be low, normal or high
Role of Insulin

- What causes hypoglycemia during exercise is presence of insulin, not exercise.
- Don’t exercise when injected insulin is peaking.
- Injectable insulin is another variable that trumps all others: can have lows regardless of starting BG, type of exercise, time of day, etc.
Exercising with an Insulin Pump

Before exercise:
- Think about type of exercise and location of the infusion set
  - Buttocks - not great for biking
  - Abdomen - not great for golf or baseball
  - Secure with lots of tape or change site

(~1 hr prior):
- Set lower temp basal (decreases need for pre-exercise snacking, which is helpful for weight loss)
Role of Insulin

- After exercise:
  - Liver still producing glucose even though muscles no longer need as much
  - Some people notice higher blood sugars immediately after exercise
  - It may help to give a small bolus around the end of the exercise session to turn off glucose production by the liver
  - More insulin sensitive after exercise:
    - May need to decrease post-exercise carb insulin amount
    - May need to set lower temp basal for the next few hours (pump only)
Other important tips

- Stay hydrated
- Wear medical alert bracelet
- If organized sports, let coach know about diabetes
Exercise Intervention Studies in T1DM to Improve Glycemic Management

- Danne et al. Predictive low-glucose suspension of insulin delivery based on CGM. Shorter duration of hypoglycemia than threshold-suspension of insulin delivery.
- Bussau et al. Ten second sprint before or after moderate exercise. Prevention of early post-exercise hypoglycemia via increased counterregulatory hormones and decreased glucose disposal.
Other New Research

- Closed-loop exercise snacking
- Mini-dose glucagon for exercise
Back to the Cases

- How can we help our first friend?
- How can we help our second friend?
Take Home Points

- Need to test BG before, during and after exercise
- <100, may be too low. Eat something with carbs (juice, fruit, granola bar)
- 100-250- ok zone
- >250: check for ketones. Exercise if negative
- >300: May be too high to exercise
- Not all exercise is the same
- May want to do resistance training first, then do aerobic exercise
Thank you for your attention!

- Any questions?
References

- Joslin Center
- Fitscript.com
Extras
- Untrained, rested major muscles: enough energy for 2 hrs vigorous exercise
- Can increase this by training, lower intensity levels and carb loading
Low carb, frequent miniboluses

Start exercise with very little insulin on board (eat low carb foods prior to exercise to need less insulin to cover them)

Moderate intensity endurance activities may require high glycemic index carbohydrate to be consumed after 20 minutes of exercise at a rate of up to approximately 1g/kg/hr. Lower intensity activities or intermittent high intensity activities are likely to require smaller rates of carbohydrate supplementation.
Top 10 Practical tips for coaching kids with Type 1 Diabetes:

- Safety first! T1D athletes must always check their blood glucose before beginning any exercise or activity.
- Know how to recognize and respond to symptoms of Hypoglycemia (low blood sugar)
- Always ensure T1D athlete has access to diabetes equipment and food snacks AT ALL TIMES
- Never make food or medication decisions for your T1D athlete
- Understand athlete must always check glucose levels during and after activity
- Create a practice and game environment that makes glucose testing easy and discreet
- Communicate practice and game schedules ahead of time so your T1D athlete and family can prepare
- Understand that glucose management patterns can differ based on different activities and if practice times and game times differ
- Include your T1D athlete in all team functions and never withhold practice or playing time due to T1D
- Understand managing T1D is an art form, not a science, and support and encourage your T1D athlete when they are struggling to manage glucose levels
Golfing

- Also low intensity exercise, need little insulin on board
- Sucralose, acesulfame stimulate secretion of insulin in rats (does this matter in T1D?)
Role of insulin

- Types of insulin
- Insulin causes liver, muscle and fat tissue to take up glucose and store it as glycogen
- Insulin stops the use of fat as an energy source by inhibiting the release of glucagon
How Protein Impacts Blood Glucose Levels

- When protein is eaten, digested into amino acids
- Can go to liver for protein synthesis
- Or can get deaminated (nitrogen removed, excreted as urea, leaves carbon behind)--- can be used to create new glucose (gluconeogenesis). Theoretically, 60% of protein can be used to generate glucose. In practice, if protein is eaten alone, it affects BG very little
- Protein often comes with fat (egg, meat, cheese)
- Carb meal + fat: slower absorption, but same amount insulin
- Carb meal + protein: more insulin needed
Some people get to a trial and error value: bolus for carb ratio (for carbs), 50% of their carb ratio for the protein and 10% of the carb ratio for the fat

20 grams of carb, 20 grams of protein, 10 grams of fat; carb ratio is 1:10; bolus for 20 grams carbs, 10 grams protein, 1 gram of fat (31 grams, or 3.1 units)

Most people would not know how much protein and fat are in their food
Anaerobic exercise

- The liver releases more glucose
- At rest, body uses 60% of energy from fat and 40% from glucose
- The harder the muscles work, the less fat and more glucose is used
- In anaerobic activity 100% glucose is used, so more insulin is needed (not always available, which raises BG)