Diabetes in Athletes

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Disclosures

- No Disclosures
Objectives

- Understand the benefits of exercise for those who have diabetes
- Become familiar with the contraindications to exercise in the diabetic population
- Learn how to manage diabetes in the athlete (active population)
Diabetes

**Type I**
- Usually diagnosed in adolescence
- Immune-mediated destruction of pancreatic $\beta$cells
  - Insulin Dependent

**Type II**
- Usually diagnosed in adulthood
  - Childhood obesity epidemic leading to earlier diagnosis
- Secondary to insulin resistance
  - Pancreatic $\beta$cells production of insulin decreases with time
- Various treatment options
  - Lifestyle modification
  - Oral hypoglycemics
  - Insulin
Non-diabetic

Increased blood flow to muscle and increased non-insulin mediated glucose transport

Glucose uptake

[Glucose]

via beta-cells

[Insulin] → Counter-regulation

NORMOGLYCEMIA
Well controlled diabetic after insulin

Increased blood flow to muscle and increased non-insulin mediated glucose transport

Glucose uptake

[Glucose]

[Insulin] or Counters-regulation

HYPOGLYCEMIA
Epidemiology

- 20.8 million people in the US have DM
  - 10% Type I
  - 90% Type II

- Higher prevalence of Type I DM in athletes, especially in young athletes
Effects of Diabetes on Exercise

- Impaired aerobic capacity
- Increase fatigability
- Decreased performance
  - Increased rating of perceived exertion secondary to decreased endorphin levels
- Slowed cognitive performance
Benefits of Exercise

- **Weight Loss**
- **Reduced risk of Cardiovascular Disease**
  - Reduced
    - Total Cholesterol
    - LDL
    - Triglycerides
    - Blood Pressure
  - Increased
    - HDL
Benefits of Exercise

- Improved Performance/Trainability
  - Secondary to improved substrate utilization:
    - Reduced protein degradation
    - Greater muscle/liver glycogen stores
    - Increased heat tolerance by increased body water

- Increased insulin sensitivity
  - Improved action of glucose transporter 4 (GLUT-4)

- Improved regulation of blood glucose in type 2 DM
  - HgbA1c not improved in type I DM secondary to exercise induced hypoglycemia compensation
Contraindications to Exercise

- **Cardiovascular Disease**
  - Indications for stress testing:
    - 35 yrs or older
    - 25 yrs and younger if:
      - Type I DM > 15 yrs duration
      - Type II DM > 10 yrs duration
    - Presence of additional risk factors for coronary artery disease
      - Hyperlipidemia, HTN, Smoking
    - Presence of microvascular or peripheral arterial disease
    - Autonomic Neuropathy
Contraindications to Exercise

- **Peripheral neuropathy**
  - Avoid exercise that traumatize the feet

- **Proliferative retinopathy**
  - Ophthalmology evaluation prior to beginning exercise
  - Avoid:
    - Anaerobic exercise
    - Exercise involving jarring or Valsalva-type activity
    - SCUBA diving
    - Inverted Exercise
    - Sustained elevations in systolic blood pressure over 170mm Hg
Contraindications to Exercise

- **Hyperglycemia**
  - Elevated blood glucose tends to increase with exercise
  - Due to increases in counter-regulatory hormones
    - Catecholamines
    - Cortisol
    - Growth Hormone
  - Restrict exercise if:
    - Blood glucose > 250mg/dL if ketones present
    - Blood glucose > 300mg/dL regardless of ketosis
  - Type I Diabetics with HgbA1c > 9%
Adverse effects of Exercise

❖ Hypoglycemia

❖ Increased risk in:
  ❖ Athletes managed with insulin and insulin secretagogues
  ❖ Evening exercise
    ❖ Diurnal variations in cortisol and growth hormone
  ❖ Prolonged exercise
  ❖ Greater exercise intensity*
  ❖ Insulin injection into exercising muscle
    ❖ Abdomen is preferred because absorption is more consistent

❖ May occur at any time during or even after exercise

❖ Treatment needs to be adjusted
Signs and Symptoms

- Hypoglycemia
  - Tachycardia/Palpitations
  - Sweating
  - Hunger
  - Nervousness
  - Headache
  - Trembling
  - Dizziness

- Blurred vision
- Fatigue
- Impaired cognitive function
- Aggressive Behavior
- Loss of motor control
- Seizure/Convulsion
# Treatment Hypoglycemia

## Appendix 2. Treatment Guidelines for Mild and Severe Hypoglycemia\(^{28,29}\)

<table>
<thead>
<tr>
<th>Mild Hypoglycemia</th>
<th>Severe Hypoglycemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Athlete is conscious and able to follow directions and swallow.)</td>
<td>(Athlete is unconscious or unable to follow directions or swallow.)</td>
</tr>
</tbody>
</table>

1. Administer 10 g to 15 g of fast-acting carbohydrate: eg, 4 to 8 glucose tablets, 2 T honey.
2. Measure blood glucose level.
3. Wait approximately 15 min and remeasure blood glucose.
4. If blood glucose level remains low, administer another 10 g to 15 g of fast-acting carbohydrate.
5. Recheck blood glucose level in approximately 15 min.
6. If blood glucose level does not return to the normal range after second dosage of carbohydrate, activate emergency medical system.
7. Once blood glucose level is in the normal range, athlete may wish to consume a snack (eg, sandwich, bagel)

1. Activate emergency medical system.
2. Prepare glucagon for injection following directions in glucagon kit. The glucagon kit has either (1) a fluid-filled syringe and a vial of glucagon powder, or (2) a syringe, 1 vial of glucagon powder, and 1 vial of fluid:
   - Inject the fluid into the vial of glucagon. Note: If the vial of fluid is separate, draw the fluid into the syringe and inject it into the vial of glucagon powder.
   - Gently shake the vial until the glucagon powder dissolves and the solution is clear.
   - Draw fluid back into the syringe and then inject glucagon into the arm, thigh, or buttock.*
   - Glucagon administration may cause nausea and/or vomiting when the athlete awakens. Place the athlete on his or her side to prevent aspiration.
   - The athlete should become conscious within 15 min of administration.
3. Once the athlete is conscious and able to swallow, provide food.
Treatment

Hypoglycemia

- Glucagon not effective after prolonged high intensity exercise or once glycogen stores have been depleted
- Depending on oral medication use, only glucose can be absorbed thus other sources of sugar are ineffective
Adverse effects of Exercise

- Hyperglycemia
  - Increased risk in
    - Uncontrolled metabolic state
    - Decreased medication use to avoid hypoglycemia
    - High intensity exercise
      - Catecholamine release
      - Increased free fatty acids
      - Ketone bodies
    - Increased psychological stress
      - Increase levels of counter regulatory hormones
    - Training in hot environments
Signs and Symptoms

- Hyperglycemia
- Nausea
- Dehydration
- Impaired cognitive function
- Slowed visual reaction time
- Fatigue
- Feeling of sluggishness
- Increased thirst
- Frequent urination
- Loss of consciousness
Treatment
Hyperglycemia

- Dependent on severity

- Administer 5% of total daily dose of insulin and reassess in 15-30 minutes
Energy Use & Exercise

**Figure 1.** Relative energy system involvement for competitive sports. Adapted from Ref. 10.
Management
Pre-Exercise

Type 1 Diabetic

Nutrition

- 3-6 hours prior to exercise
  - 4g/kg of low glycemic index carbohydrates should be ingested
  - Blood sugar levels should be monitored given increased carbohydrate load
- 1 hour before exercise
  - 1g/kg low fat carbohydrate should be ingested
  - 15-30 minutes before exercise high carbohydrate/low fat snack should be ingested if blood sugar less than 120

Type II Diabetics do not require major dietary modifications
Management
Pre-Exercise

Medication

Insulin

- Short Acting
  - Lispro
  - Aspart

- Intermediate Acting

- Long Acting
  - Glargine
  - Detemir
## Appendix 4. Pharmacokinetics of Commonly Used Insulin Preparations

<table>
<thead>
<tr>
<th>Product</th>
<th>Action Type</th>
<th>Basal or Bolus Use</th>
<th>Onset</th>
<th>Peak Effect</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humalog (lispro; Eli Lilly and Co, Indianapolis, IN)</td>
<td>Rapid acting</td>
<td>Bolus in MDI*</td>
<td>5–15 min</td>
<td>45–75 min</td>
<td>3–5 h</td>
</tr>
<tr>
<td>Novolog (aspart; Novo Nordisk Inc, Princeton, NJ)</td>
<td></td>
<td>Basal and bolus in insulin pump</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apidra (glulisine; Sanofi-Aventis, Bridgewater, NJ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humulin (regular; Eli Lilly and Co)</td>
<td>Fast acting</td>
<td>Bolus in MDI</td>
<td>30 min</td>
<td>2–4 h</td>
<td>5–8 h</td>
</tr>
<tr>
<td>Novolin (regular; Novo Nordisk Inc)</td>
<td></td>
<td>Basal and bolus in insulin pump</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humulin N (NPH; Eli Lilly and Co)†</td>
<td>Intermediate acting</td>
<td>Basal insulin in MDI</td>
<td>1–2 h</td>
<td>4–10 h</td>
<td>14+ h</td>
</tr>
<tr>
<td>Novolin N (NPH; Novo Nordisk Inc)†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantus (glargine; Sanofi-Aventis)†</td>
<td>Long acting</td>
<td>Basal in MDI</td>
<td>1.5–2 h</td>
<td>Flat</td>
<td>18–24 h</td>
</tr>
<tr>
<td>Detemir (levimir; Novo Nordisk Inc) †</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 5. Variables That Affect Insulin Absorption Rate\textsuperscript{31,32,60,61,66,67}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise of the injected area</td>
<td>Exercise of injected area within 1 h of injection may increase the rate of absorption.</td>
</tr>
<tr>
<td>Massage of the injection site</td>
<td>Do not rub or vigorously massage injection sites within 1 h of injection.</td>
</tr>
<tr>
<td>Thermal modalities</td>
<td>Heat increases absorption, whereas cold decreases absorption.</td>
</tr>
<tr>
<td>Insulin dose</td>
<td>Avoid using thermal modalities for 1 to 3 h postinjection.</td>
</tr>
<tr>
<td>Lipohypertrophy (accumulation of subcutaneous fatty lumps caused by repeated injections of insulin into the same spot)</td>
<td>Larger doses are associated with slower absorption rates. Injection into lipohypertrophic sites delays absorption.</td>
</tr>
</tbody>
</table>
Management
Pre Exercise

- Avoid exercise during time when athletes insulin peaks
- Decrease rapid and short acting insulin depending on length of exercise
  - In general:
    - <60 minutes-30% reduction
    - 1-2 hours-40% reduction
    - >2 hours-50% reduction
- Must be individualized
Management
Pre-Exercise

Medication

Insulin Pump

- Must be removed prior to contact/water sports
- Caution used if pump worn during exercise as catheter may become dislodged
- If high intensity exercise is planned decrease basal rate by 50% 1-hour before exercise
- If low intensity exercise is planned leave basal rate the same but decrease pre meal bolus
  - Generally 20%-50% but needs to be individualized
- If pump will be removed, remove 30 minutes prior to exercise
- Give bolus of basal insulin at 50% of normal rate
Medication

Oral Hypoglycemics

- Insulin Sensitizers
  - Biguanides, i.e. metformin
    - Increase insulin sensitivity of muscle and hepatic tissue
    - Inhibit gluconeogenesis and glycogenolysis
  - Thiazolidinediones (TZDs)
    - Increase insulin sensitivity of muscle and hepatic tissue

- No pre-exercise adjustment needed

- As glycemic control improves, may need to be decreased
Medication
Oral Hypoglycemics

- **Insulin Secretagogues**
  - Sulfonylureas, i.e. glipizide, glyburide
    - Improve insulin secretion by causing pancreatic β cell depolarization through potassium dependent ATP channel
    - Suppresses hepatic gluconeogenesis
    - Best used as adjuvant to insulin sensitizer
  - Glinides, i.e. repaglinidine, nateglinide
    - Taken with meals
    - Rapidly increase insulin production/secretion by pancreatic β cell
    - Do not take if exercise follows meal

- General guideline is to decrease dose by 50% on days of exercise
Medication
Oral Hypoglycemics

- Incretin potentiators
  - Glucagon-like peptide-1 derived incretin hormone, i.e. exenatide
    - Administered subcutaneously
    - Stimulates insulin secretion
    - Suppresses hepatic glucose release
    - Inhibits gastric emptying
    - Reduces appetite
  - Dipeptidyl peptidase IV inhibitor (DDP-4), i.e. sitagliptin
    - Enhances insulin secretion and action
    - Suppresses glucagon

- Do not increase risk of hypoglycemia, no exercise adjustment
Medication
Oral Hypoglycemics

- Carbohydrate-absorption blockers (alpha-glucosidase inhibitors), i.e. acarbose, miglitol
  - Not first-line treatment, usually adjunct medication
  - Taken before meals to block carbohydrate absorption and subsequent blood glucose elevation
    - Important to note in hypoglycemic episodes
      - Blocks sugar absorption, only glucose can be used
  - High incidence of GI discomfort, diarrhea, flatulence
Management During Exercise

- Exercise of less than 30-45 minutes does not necessitate specific nutritional guidelines
  - Blood sugars should be monitored and treated accordingly

- Exercise lasting more than 30-45 minutes
  - 15g carbohydrate snack every 30-60 minutes
    - Adjusted according to blood glucose levels
    - Hold snack if blood glucose greater than 180
  - Sports drinks/Fluids with 6-8% carbohydrates
Table 2. Exercise Exchanges of 100 kcal (420 kJ) in Children of Various Body Masses. Assuming that, on average, 60% of total energy is provided by carbohydrate, one exchange is equivalent to 60 kcal or 15 g carbohydrate.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Body Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Basketball (game)</td>
<td>30</td>
</tr>
<tr>
<td>Cross-country skiing</td>
<td>40</td>
</tr>
<tr>
<td>Cycling</td>
<td></td>
</tr>
<tr>
<td>10 km/h</td>
<td>65</td>
</tr>
<tr>
<td>15 km/h</td>
<td>45</td>
</tr>
<tr>
<td>Figure skating</td>
<td>25</td>
</tr>
<tr>
<td>Ice hockey (ice time)</td>
<td>20</td>
</tr>
<tr>
<td>Running</td>
<td></td>
</tr>
<tr>
<td>8 km/h</td>
<td>25</td>
</tr>
<tr>
<td>12 km/h</td>
<td>—</td>
</tr>
<tr>
<td>Snow shoeing</td>
<td>30</td>
</tr>
<tr>
<td>Soccer</td>
<td>30</td>
</tr>
<tr>
<td>Swimming</td>
<td></td>
</tr>
<tr>
<td>30 m/min breast stroke</td>
<td>55</td>
</tr>
<tr>
<td>Tennis</td>
<td>45</td>
</tr>
<tr>
<td>Walking</td>
<td></td>
</tr>
<tr>
<td>4 km/h</td>
<td>60</td>
</tr>
<tr>
<td>6 km/h</td>
<td>40</td>
</tr>
</tbody>
</table>
Management During Exercise

In general:

- **Blood glucose <120**
  - Ingest 15g of carbohydrates
  - Then ingest 30g of carbohydrates every 30-60 minutes of light to moderate exercise according to repeat blood glucose levels

- **Blood glucose 120-180**
  - No pre-exercise snack
  - Ingest 30g of carbohydrates every 30-60 minutes of light to moderate exercise according to repeat blood glucose levels

- **Blood glucose 180-250**
  - No pre-exercise snack
  - If exercise lasts longer than 30-45 minutes check blood glucose level and treat as above
Management
Post-Exercise

- Risk of delayed post exercise hypoglycemia
  - Prolonged insulin sensitivity
    - Decrease basal/long acting insulin
    - Decrease pre-meal short acting insulin
  - Depleted glycogen stores
    - Primary cause of delayed hypoglycemia
    - Carbohydrate-rich at the conclusion of exercise
      - 30-40g of carbohydrates for every 30 minutes of intensive exercise
      - Small amount of protein helps facilitate carbohydrate absorption
  - Frequent blood glucose checks especially at night

- No evidence based guidelines
Summary

- Clear benefits of exercise
- Clear risks of exercise
- Treatment and diet before, during and after exercise must be adjusted
  - Trial and error ➔ Frequent monitoring and adjusting
Questions
Bibliography


