Diabetes in Athletes

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Disclosures

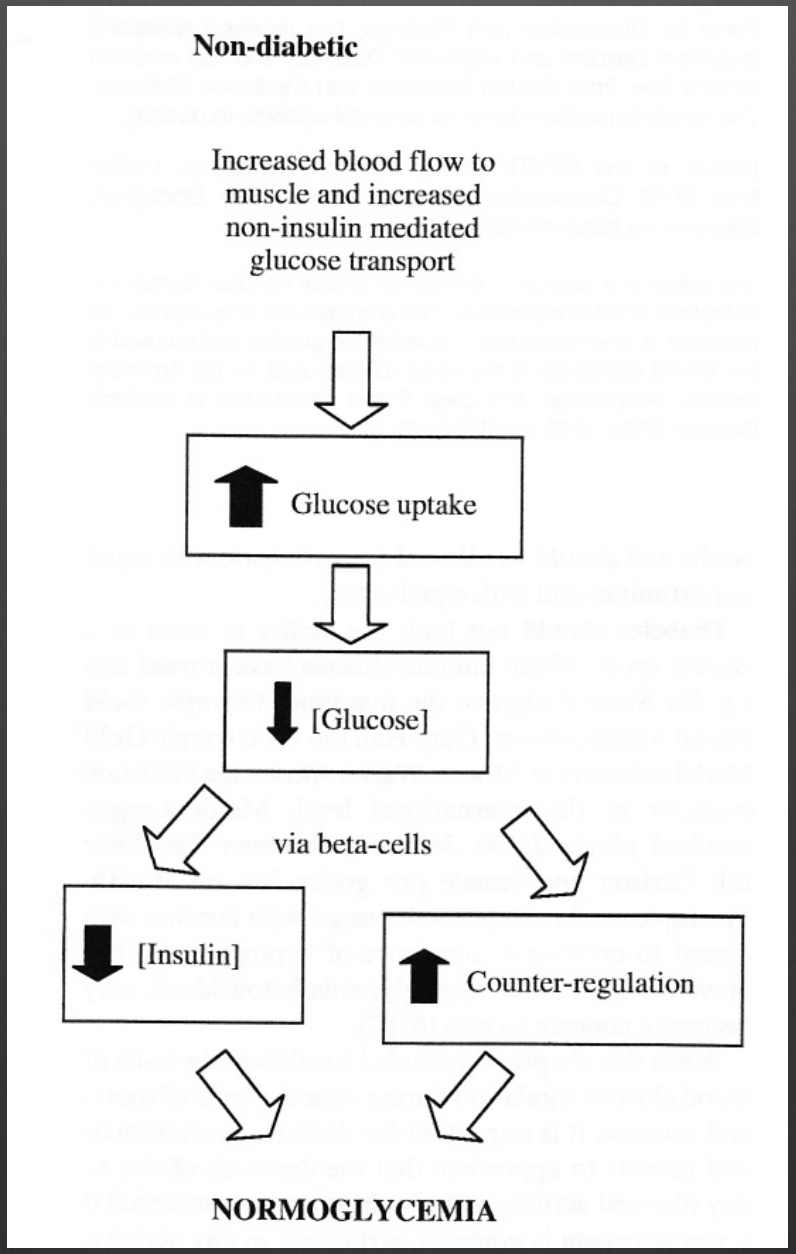
- No Disclosures

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)

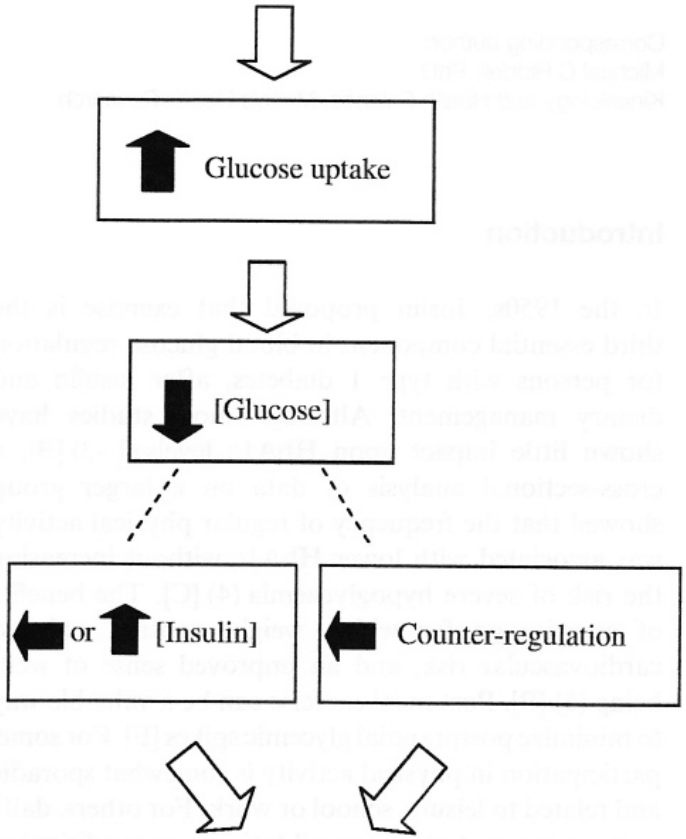
Diabetes

- Type I
  - Usually diagnosed in adolescence
  - Immune-mediated destruction of pancreatic βcells
    - Insulin Dependent
- Type II
  - Usually diagnosed in adulthood
    - Childhood obesity epidemic leading to earlier diagnosis
  - Secondary to insulin resistance
    - Pancreatic βcells 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



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 peformance

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 ultilization:
    - 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>300mb/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]

Mild Hypoglycemia (Athlete is conscious and able to follow directions and swallow.)	Severe Hypoglycemia (Athlete is unconscious or unable to follow directions or swallow.)
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 15-30minutes

Energy Use & Exercise

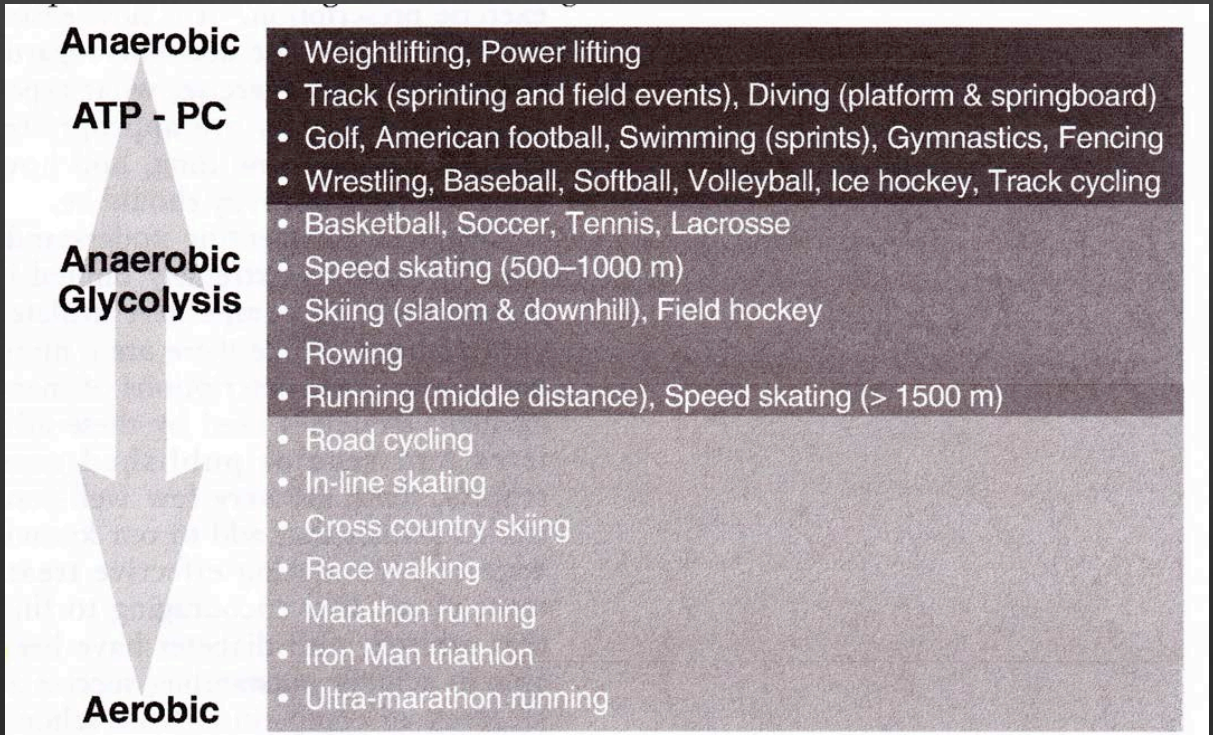


Figure 1. Relative energy system involvement for competitive sports. Adapted from Ref. 10.

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
      - NPH
    - Long Acting
      - Glargine
      - Detemir

Insulin

Appendix 4. Pharmacokinetics of Commonly Used Insulin Preparations[60–64]

Product	Action Type	Basal or Bolus Use	Onset	Peak Effect	Duration
Humalog (lispro; Eli Lilly and Co, Indianapolis, IN)	Rapid acting	Bolus in MDI*	5–15 min	45–75 min	3–5 h
Novolog (aspart; Novo Nordisk Inc, Princeton, NJ)		Basal and bolus in insulin pump			
Apidra (glulisine; Sanofi-Aventis, Bridgewater, NJ)					
Humulin (regular; Eli Lilly and Co)	Fast acting	Bolus in MDI	30 min	2–4 h	5–8 h
Novolin (regular; Novo Nordisk Inc)		Basal and bolus in insulin pump			
Humulin N (NPH; Eli Lilly and Co)†	Intermediate acting	Basal insulin in MDI	1–2 h	4–10 h	14+ h
Novolin N (NPH; Novo Nordisk Inc)†					
Lantus (glargine; Sanofi-Aventis)†	Long acting	Basal in MDI	1.5–2 h	Flat	18–24 h
Detemir (levimir; Novo Nordisk Inc) †					

Insulin

Appendix 5. Variables That Affect Insulin Absorption Rate[31,32,60,61,66,67]

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

Management
Pre Exercise

- Avoid exercise during time when athletes insulin peaks
- Decrease rapid and short acting insulin depending on length of exercise
  - In general:
    - <60minutes-30% reduction
    - 1-2hours-40% reduction
    - >2hours-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 βcell 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 βcell
    - 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 secreation
    - 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

Carbohydrate Intake Guidelines

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.

	Body Mass (kg)		
Activity	20	40	60
Basketball (game)	30	15	10
Cross-country skiing	40	20	15
Cycling			
10 km/h	65	40	25
15 km/h	45	25	15
Figure skating	25	15	10
Ice hockey (ice time)	20	10	5
Running			
8 km/h	25	15	10
12 km/h	—	10	10
Snow shoeing	30	15	10
Soccer	30	15	10
Swimming			
30 m/min breast stroke	55	25	15
Tennis	45	25	15
Walking			
4 km/h	60	40	30
6 km/h	40	30	25

Management During Exercise

- In general:
  - Blood glucose <120
    - Ingest 15g of carbohydrates
    - Then ingest 30g of carbohydrates every 30-60minutes of light to moderate exercise according to repeat blood glucose levels
  - Blood glucose 120-180
    - No pre-exercise snack
    - Ingest 30g of carbohydrates every 30-60minutes 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

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