Blood Glucose Control with Sports & Fitness Activities

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What Is My Favorite Sport?

A. Miniature Golf
B. Accounting
C. Basketball
Objectives

1. Optimize glycemic control to enhance physical/athletic performance
2. Prevent hypoglycemia during and after physical activity
3. Prevent exercise-induced hyperglycemia, ketosis and DKA
4. Manage the logistics of wearing an insulin pump during physical activity
Blood Glucose Affects:
- Strength
- Stamina
- Speed/Agility
- Flexibility
- Safety
- Mental Sharpness

Sources:
What BG Is Optimal?

Exercise Performance

Overall Glucose Management Also Counts!

Prior Hyperglycemia Affects:
- Hydration
- Sleep Quality

Prior Hypoglycemia Affects:
- Glycogen Storage
- Sleep Quality
Hypoglycemia
Prevention
# Fuel Utilization During Exercise

<table>
<thead>
<tr>
<th>1st 5-10 seconds</th>
<th>10 sec - ~ 10 min</th>
<th>~ 10 – ~30 min.</th>
<th>~ 30 min onward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stored ATP/CP↓</td>
<td>Anaerobic Glycolysis</td>
<td>Oxidative (aerobic) metabolism</td>
<td></td>
</tr>
<tr>
<td>IM glucose</td>
<td>Hepatic Glycogenolysis</td>
<td>Hepatic Gluconeogenesis (FFA)</td>
<td></td>
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</table>

**Likelihood of Hypoglycemia:**
- Very low
- Low
- Moderate
- Very high

Scheiner, Gary, MS CDE

Energy Sources During Exercise

Substrate vs. Duration

BG drops more rapidly during 15-60 minute phase of prolonged exercise

Scheiner, Gary, MS CDE

Hormonal Responses to Exercise (non-diabetic)

- Insulin Secretion ↓↓
- Counterregulatory Hormone Secretion ↑
  - Epi/Nepi • Glucagon • GH, Cortisol

- Substrate Breakdown
  - Glycogenolysis
  - Lipolysis
  - A.A. Utilization

- BG Holds Steady Despite
  ↑ Glucose Utilization by Muscle
Hormonal Responses to Exercise
(diabetes, using insulin)

- Insulin Levels
  - or

- Counterregulatory Hormone Action Suppressed

- Substrate Breakdown Blocked
  - Glucose Uptake Accelerated

- Hypoglycemia May Result

Scheiner, Gary, MS CDE
How Is Glucose Uptake Accelerated?
Who Is At Risk of Hypoglycemia?

Premixed Insulin Users

MDI/Pump Users

Basal Insulin (Only) Users

Meglitinide Users

Sulfonylurea Users

Combination Med Users
**Insulin Adjustment Based on Timing and Duration**

<table>
<thead>
<tr>
<th>Short Duration (&lt;90 Minutes)</th>
<th>Activity Within 2 Hours After Meal</th>
<th>Activity Before or Between Meals</th>
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<tr>
<td>🔄 Mealtime Bolus (Omit Meglitinide)</td>
<td>Snack Prior to Activity</td>
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Which is better for promoting weight loss?

- Exercise BEFORE eating?
- Exercise AFTER eating?
### Insulin Adjustment Based on Timing and Duration

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<td>Mealtime Bolus (omit meglitinide)</td>
<td>Snack Prior to Activity</td>
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<tr>
<td>Basal Rate</td>
<td>Basal Rate (if using pump)</td>
</tr>
<tr>
<td>Snack at regular intervals</td>
<td>Snack at regular intervals</td>
</tr>
<tr>
<td>Watch for delayed-onset hypoglycemia</td>
<td>Watch for delayed-onset hypoglycemia</td>
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**Long Duration (>90 Minutes)**
Meal Bolus Adjustment
(for post-meal activity)

- Low Intensity Cardio  ↓ 25%
- Mod. Intensity Cardio  ↓ 33%
- High Intensity Cardio  ↓ 50%
- Competitive/Aerobic  ???

Source: Scheiner, Gary: Think Like A Pancreas, Marlowe Publishing, NY, 2005
Basal Adjustment
(for > 90 min. activity)

- CSII: \( \downarrow \) Basal rate 50% starting 1-2 hrs pre-activity, or:
- CSII: Disconnect 1-hr prior, but reconnect hourly and bolus 50% of usual basal rate

(for day-long activity)

- CSII: \( \downarrow \) basal 50% daytime, 25% nighttime
- Shots: \( \downarrow \) basal insulin 25%

Source: Scheiner, Gary: Think Like A Pancreas, Marlowe Publishing, NY, 2005
Pump disconnection: Effect on basal insulin level

Basal insulin is a series of minute boluses.

Based on observed pharmacodynamics of rapid-acting insulin analogs.
Pump disconnection: Effect on basal insulin level

Disconnection during 30 min. exercise (red box) eliminates bolus pulses for 30 minutes

Based on observed pharmacodynamics of rapid-acting insulin analogs
Pump disconnection: Effect on basal insulin level

Level of active basal insulin resulting from 30 minutes disconnection during exercise

Disconnection during a short exercise session has minimal effect!
Pump disconnection: Effect on basal insulin level

Disconnection during 2 hours of exercise (red box) eliminates bolus pulses for 120 minutes.

Based on observed pharmacodynamics of rapid-acting insulin analogs.
Pump disconnection: Effect on basal insulin level

Level of active basal insulin resulting from 2 hrs disconnection during exercise:

Disconnection for > 90 minutes has little benefit early on, and can result in a serious insulin deficiency later!
Pump Temp Basal: Effect on basal insulin level

Temp Basal -50% starting 1-hr prior to 2-hr exercise until 30 minutes before completion:

Based on observed pharmacodynamics of rapid-acting insulin analogs
Pump temp basal: Effect on basal insulin level

Level of active basal insulin from temp basal - 50% starting 1-hr prior until 30 minutes before completion of 2-hour exercise:

This approach results in a modest reduction in basal insulin throughout and immediately post-exercise.
Suspension vs. Temp Basal

Glucose decline (mg/dl) during 60 minutes of moderate-intensity walking

Insulin Adjustment: Case Study

2-Hour Lacrosse Practice (after dinner)

- Dinner bolus 50%
- Disconnect 1-hr pre-practice, re-connect hourly & bolus 50% of usual basal

Snack at midpoint (if BG appears to be dropping)
Snacking to prevent hypoglycemia

Basic Rules:
1. Snack *prior* to activity to *prevent* hypoglycemia
2. Adjust quantity based on pre-activity BG or *direction* of BG
   - BG low or dropping: ↑ usual carbs
   - BG OK or stable: usual carbs
   - BG High or rising: ↓ usual carbs
3. Snack at least once per hour during prolonged activity
4. Choose high-glycemic-index forms of carbohydrate
   - Sports drinks / Sweetened beverages
   - Dry cereal, pretzels, crackers

Source: Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005
Which approach keeps BG in range for the majority of the workout?

Source: Scheiner, Gary, MS CDE
Snacking to prevent a low

| Carbohydrate Requirement Per 60 Minutes of Activity (if no insulin adjustments are made) |
|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| | 50 lbs (24 kg) | 100 lbs (48 kg) | 150 lbs (71 kg) | 200 lbs (95 kg) | 250 lbs (119 kg) |
| Dancing or Gymnastics | 8-12g | 17-23g | 25-35g | 34-46g | 42-57g |
| Tennis (singles) | 18-22g | 37-43g | 55-65g | 74-86g | 92-107g |
| Swimming (fast pace) | 22-25g | 44-50g | 65-75g | 88-100g | 110-125g |

Sources: Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005
## Snacking to prevent a low

<table>
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<th>Carbohydrate Requirement Per 60 Minutes of Activity (if no insulin adjustments are made)</th>
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<tbody>
<tr>
<td></td>
<td>50 lbs (24 kg)</td>
</tr>
<tr>
<td><strong>Cleaning Up</strong></td>
<td>3-7g</td>
</tr>
<tr>
<td><strong>Brisk Walking</strong></td>
<td>8-12g</td>
</tr>
<tr>
<td>(mall/theme park)</td>
<td></td>
</tr>
<tr>
<td><strong>Mowing</strong></td>
<td>13-17g</td>
</tr>
<tr>
<td>(push-mower)</td>
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Sources: Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005
**Snacking to prevent low: Case Study**

<table>
<thead>
<tr>
<th>BG Range</th>
<th>Snack Amount</th>
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<tr>
<td>161-200 / 9-11mmol</td>
<td>20g</td>
</tr>
<tr>
<td>100-160 / 5-9mmol</td>
<td>30g</td>
</tr>
<tr>
<td>&lt;100 / 5mmol</td>
<td>40g</td>
</tr>
<tr>
<td>&gt;200 / 11mmol</td>
<td>No snack</td>
</tr>
</tbody>
</table>

- Check BG prior
- Snack 20g (if BG 161-200 / 9-11mmol)
- Snack 30g (if BG 100-160 / 5-9mmol)
- Snack 40g (if BG <100 / 5mmol)
- No snack (if BG >200 / 11mmol)
- Addl. 20g snack after each hr of play
Hybrid Closed Loop Systems & Exercise

Generally don’t work well to prevent hypos during exercise

May help prevent delayed-onset hypos

Set temp target \(\uparrow \uparrow 2\) hrs ahead (or switch to manual mode)

Post-meal exercise: Enter less carb (or adjust bolus downward manually)
Just a Few Factors that affect Blood Glucose During Exercise

- Active Insulin
- Infusion Site
- What You Ate
- Time of Day
- Emotional State
- Temp/Humidity
- Familiarity w/Activity
- Amt. Of Prior Activity
- Size/Number of Muscles Involved
- **Duration**
- **Intensity**

Watch Out for *D’OH!* *(Delayed Onset Hypoglycemia)*

- Following high-intensity exercise
- Following extended duration activity
- Due to replenishment of muscle glycogen stores, enhanced insulin sensitivity
- May occur up to 24 hours afterwards (typically 6-12 hours later)

D’OH! Prevention

- Keep records – track the patterns
- Decrease basal insulin (modestly) or meal/snack boluses post-activity
- “Free” Snacks (slow-acting carbs) following activity
D’OH! Prevention

- Check BGs more frequently
  - q 2 hrs during “high risk” period
  - 3am night following activity

- Wear a continuous glucose monitor
Can Exercise Cause Rise in BG? Ketoacidosis?
Blood Glucose Homeostasis: The Grand Balancing Act

- Muscle Activity (↓)
- Insulin (↓)
- Carbohydrate (↑)
- Counterregulatory / Stress Hormones (↑)

Adrenaline Raises BG!
Adrenaline Raises BG!

Activities that often produce a short-term blood glucose rise include:

- **Weight lifting** (high weight, low reps)
- **Sports w/ “bursts” of activity** (golf, baseball, martial arts)
- **Sprints** (running, swimming)
- **Judged performances** (gymnastics, skating)
- **Events in which WINNING is the primary objective**

Preventing / Offsetting BG Rise

☑ Keep Records to determine avg. BG rise

☑ Check BG 30-60 Min. Pre-Activity

☑ Bolus 30-60 min. prior to activity to offset rise (give 50% of usual amount required)

☑ Take 50% of Usual “Correction Dose” If High (reduce based on insulin-on-board)

Sources: Scheiner, Gary: Think Like A Pancreas, DaCapo Press, 2012
Snacking to prevent high: Case Study

Late-Morning Basketball; disconnects for 1 hour; BG typically rises from 100 to 300mg/dl (5.5 to 16.6 mmol).

- Check BG 30 min prior
- Bolus 50% of amount required to cover current BG (including IOB)
- Bolus 50% of amount needed to offset 200 mg/dl (11 mmol) rise
- Check BG at halftime; keep sugared drinks handy.
Post-Workout Rise?

Possible Causes:
- Pump suspension / disconnection
- Delayed food digestion
- Excess carbs during workout
- Latent stress hormones

Possible Solutions:
- Post-workout bolus
- Delay all (or part) of meal bolus
- Limit suspension / disconnection time
- Appropriate carb supplementation
How High is Too High?

No Such Number.

- Performance may suffer
- Hydrate
- Administer Rapid-Acting Insulin (i.m.?)

The Exception: Ketosis
What the *&!/%#! Is a KETONE???
Normal (Sufficient Insulin)

Source: Scheiner, Gary, *Think Like a Pancreas*, Marlowe Pub., NY, 2005
Abnormal (Insulin Deficiency)

possibly due to:
- Missed Injection
- Spoiled Insulin
- Poor Absorption
- Insufficient Dose
- Illness

● Pump Problem:
  - Occlusion
  - Air in Tubing
  - Canula Dislodgement
  - Extended Disconnection

Source: Scheiner, Gary, Think Like a Pancreas, Marlowe Pub., NY, 2005
Exercise During Insulin Deficiency

(results:
Higher Blood Sugar
+ More Ketones
+ Dehydration (urination, perspiration)

**KETOACIDOSIS**

Source: Scheiner, Gary, *Think Like a Pancreas*, Marlowe Pub., NY, 2005
To Prevent Ketoacidosis

✓ Check urine for ketones prior to exercise with *unexplained* high BG

✓ No exercise w/positive ketones (small or more on urine ketostix; >.5 mmol/l on blood β Ketone test)

✓ OK to exercise if nonketotic – take 50% of usual “correction” bolus and drink plenty of water

✓ Do not disconnect for more than 2 hours

Source: Diabetes Care vol. 30 Supplement 1: ADA Clinical Practice Recommendations 2007
Alternatives to extended pump disconnection

Wear It!

✓ Clip to tight clothing
✓ Sport Pack
✓ Fanny Pack
✓ Backpack Harness
Infusion Set Adhesion During Exercise

- Smart Set Placement
  - Under tight clothing
  - Body part w/less skin movement
- Skin prep agent w/adhesive
  (IV Prep, Skin Prep, Mastisol)
- Tape over site (Smith+Nephew, 3M)
- Antiperspirant (Hypercare 20% AlCl solution, Stratus Pharma.)
Pump & Temperature Extremes During Exercise

Cold:
Generally not a concern when pump is worn against body

Heat:
Insulin analogs can denature if:
- Exposed to > 98°F (36°C)
- Stored or worn > 86°F (30°C) for extended periods

Pump function OK under most conditions

Sources: insulin package inserts, insulin pump manufacturers
“Cool” Ideas:

- Keep pump out of direct sunlight
  - Wear under clothing
  - Store in a cool place when disconnected
  - Don’t forget the tubing!!!
There is nothing you can’t accomplish...

If you think like a pancreas!