Mission POSSIBLE: Managing Glucose During Sports & Exercise

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What Is My Favorite Sport?
A. Miniature Golf
B. Accounting
C. Basketball

Objectives
1. Explain the two-way relationship between glucose control and physical activity in people with diabetes
2. Offer practical recommendations for the prevention of hypoglycemia during and after exercise
3. Offer practical recommendations for the prevention of hyperglycemia and ketosis during exercise
EXERCISE & BLOOD GLUCOSE CONTROL IS A TWO WAY STREET

Activity levels affect insulin sensitivity PROFOUNDLY

How Is Insulin Sensitivity Affected?
Effects of post-meal walking

Study Results:
30 minutes of casual stop & go walking after meals
- Avg. 30 mg/dl (1.75 mmol/L) reduction in post-meal glucose
- Post-meal peak reduced 45%


Does Time of Day Matter?

Afternoon exercise is more efficacious than morning exercise at improving blood glucose levels in individuals with type-2 diabetes: a randomized crossover trial

Blood Glucose Affects:
- Strength
- Stamina
- Speed/Agility
- Flexibility
- Safety
- Mental Sharpness

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>Time Frame</th>
<th>Glucose Utilization</th>
<th>Metabolism</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 5-10 seconds</td>
<td>Anaerobic Glycolysis</td>
<td>Oxidative (aerobic) metabolism</td>
</tr>
<tr>
<td>10 sec - ~10 min</td>
<td>IM glucose</td>
<td>Hepatic Glycogenolysis</td>
</tr>
<tr>
<td>~10 – ~30 min</td>
<td>Hepatic Gluconeogenesis</td>
<td>(FFA)</td>
</tr>
</tbody>
</table>

Likelihood of Hypoglycemia:
- very low
- low
- moderate
- very high

Scheiner, Gary, MS CDE

Energy Sources During Exercise

- Substrate vs. Duration
- Substrate vs. Intensity

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

Scheiner, Gary, MS CDE

Hormonal Responses to Exercise (non-diabetic)

- Insulin Secretion
- Counterregulatory Hormone Secretion
  - Epinephrine
  - Glucagon
  - GH, Cortisol

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

- BG Holds Steady Despite Glucose Utilization by Muscle

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Hormonal Responses to Exercise (diabetes, using insulin or insulin secretagogue)

- Insulin Levels
- Counterregulatory Hormone Action Suppressed
- Substrate Breakdown Blocked
- Glucose Uptake Accelerated
- Hypoglycemia May Result

Who Is At Risk of Hypoglycemia?

Premixed Insulin Users
MDI/Pump Users
Basal Insulin (Only) Users
Meglitinide Users
Sulfonylurea Users
Combination Med Users

Med Adjustment Based on Timing and Duration

<table>
<thead>
<tr>
<th>Activity Within 2 Hours After Meal</th>
<th>Activity Before or Between Meals</th>
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<tbody>
<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?

Med Adjustment Based on Timing and Duration

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<tr>
<th>Activity Within 2 Hrs After Meal</th>
<th>Activity Before or Between Meals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Duration (&gt;90 Minutes)</td>
<td></td>
</tr>
<tr>
<td>➖ Mealtime Bolus (omit meglitinide)</td>
<td>Snack Prior to Activity</td>
</tr>
<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>
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Insulin Adjustments

**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
Insulin Adjustments

**Basal Adjustment**
(for > 90 min. activity)
- CSII: Basal rate 50-80% starting 1-2 hrs pre-activity, or:
- CSII: Disconnect 1-hr prior, but reconnect hourly and bolus 20-50% of usual basal rate

**Basal Adjustment**
(for day-long activity)
- CSII: Basal 50% daytime, 25% nighttime
- Injections: basal insulin 25% (night prior or morning)

Source: Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005


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**Pump disconnection: Effect on basal insulin level**

Basal insulin is a series of minute boluses.

Based on observed pharmacodynamics of rapid-acting insulin analogs

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**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!

Based on observed pharmacodynamics of rapid-acting insulin analogs.

Pump disconnection: Effect on basal insulin level

Level of active basal insulin resulting from 2 hours 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:

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

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:

Suspension vs. Temp Basal

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

Insulin Adjustment: Case Study

Pump wearer, 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: ½ usual carbs
   - BG OK or stable: usual carbs
   - BG High or rising: ¼ 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 (90 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)            | 22-28g                          | 44-50g          | 66-75g          | 98-109g         | 118-125g        |

**Sources:**
Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005

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### Snacking to prevent a low

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| 50 lbs (24 kg)                  | 100 lbs (48 kg)                 | 150 lbs (71 kg) | 200 lbs (90 kg) | 250 lbs (119 kg) |
| Cleaning Up                     | 3-7g                            | 7-13g           | 10-20g          | 14-26g          | 17-32g          |
| Brisk Walking (mall/theme park) | 8-12g                           | 17-23g          | 25-35g          | 34-46g          | 42-57g          |
| Mowing (push-mower)             | 13-17g                          | 27-33g          | 40-50g          | 54-66g          | 67-82g          |

**Sources:**
Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005

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### Snacking to prevent low: Case Study

**After School Tennis (85 lb/40 kg)**

- 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 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 heavy activity
- Wear a continuous glucose monitor

**Can Exercise** *Cause*  
**Rise in BG?**  
**Ketoacidosis?**
Blood Glucose Homeostasis: The Grand Balancing Act

- Muscle Activity
- Carbohydrate
- Insulin
- Counterregulatory / Stress Hormones

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

Sources: Colberg, Sheri: The Diabetic Athlete, Human Kinetics, Champaign, IL, 2001

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 300 mg/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
Exercise During Insulin Deficiency

**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 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 ß Ketone test)
- OK to exercise if nonketotic - take 50% of usual "correction" bolus and drink plenty of water
- Do not disconnect from pump for more than 90 minutes

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 & CGM Adhesion During Exercise**

- **Smart Set Placement**
  - Under tight clothing
  - Body part with less skin movement
- **Skin prep agent w/adhesive**
  (IV Prep, Skin Prep, Mastisol)
- **Tape over site** (GrifGrips, Infusion Set IV 3000, Dexcom overtape)
- **Antiperspirant** (Hypercare 20% AlCl solution, Stratus Pharma.)

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**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 (36C)
- Stored or worn > 86°F (30C) for extended periods

Pump function OK under most conditions

Sources: insulin package inserts, insulin pump manufacturers

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**Pump & Temperature Extremes During Exercise**

“Cool” Ideas:
- Keep pump out of direct sunlight
  - Wear under clothing
  - Store in a cool place when disconnected
  - Don’t forget the tubing!!!
- Spend less time in extreme heat
  - Get into a/c and shade periodically
  - Humidity is not a factor
- FRIO Cooling Case

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There is nothing you can't accomplish…

If you think like a pancreas!