Blood Glucose Control with Sports & Fitness Activities

Gary Scheiner MS, CDE
Owner/Clinical Director
Integrated Diabetes Services
Wynnewood, PA
877-735-3648
www.integrateddiabetes.com
Gary@integrateddiabetes.com
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

Hypoglycemia

Prevention
## Fuel Utilization During Exercise

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

Likelihood of low glucose
Hypoglycemia: low 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
  - or

- Counterregulatory Hormone Action Suppressed

- Substrate Breakdown Blocked

- Glucose Uptake Accelerated

- Hypoglycemia May Result

Scheiner, Gary, MS CDE
How Is Glucose Uptake Accelerated?
### 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>
</tr>
</thead>
<tbody>
<tr>
<td>Mealtime Bolus</td>
<td>Snack Prior to Activity</td>
<td></td>
</tr>
</tbody>
</table>

Which is better for promoting weight loss?

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

<table>
<thead>
<tr>
<th>Long Duration (&gt;90 Minutes)</th>
<th>Activity Within 2 Hrs After Meal</th>
<th>Activity Before or Between Meals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✷ Mealtime Bolus</td>
<td>Snack Prior to Activity</td>
</tr>
<tr>
<td></td>
<td>✷ Basal Rate</td>
<td>✷ Basal Rate (if using pump)</td>
</tr>
<tr>
<td></td>
<td>Snack at regular intervals</td>
<td>Snack at regular intervals</td>
</tr>
<tr>
<td></td>
<td>Watch for delayed-onset hypoglycemia</td>
<td>Watch for delayed-onset hypoglycemia</td>
</tr>
</tbody>
</table>
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% starting 1 hr pre-activity, or:
- CSII: Disconnect 1-hr prior, but reconnect hourly and bolus 50% of usual basal rate

(for day-long activity)

- CSII: ↓ basal 50% daytime, 25% nighttime
- Shots: ↓ 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.
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

<table>
<thead>
<tr>
<th>Activity</th>
<th>50 lbs (24 kg)</th>
<th>100 lbs (48 kg)</th>
<th>150 lbs (71 kg)</th>
<th>200 lbs (95 kg)</th>
<th>250 lbs (119 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dancing or Gymnastics</td>
<td>8-12g</td>
<td>17-23g</td>
<td>25-35g</td>
<td>34-46g</td>
<td>42-57g</td>
</tr>
<tr>
<td>Tennis (singles)</td>
<td>18-22g</td>
<td>37-43g</td>
<td>55-65g</td>
<td>74-86g</td>
<td>92-107g</td>
</tr>
<tr>
<td>Swimming (fast pace)</td>
<td>22-25g</td>
<td>44-50g</td>
<td>65-75g</td>
<td>88-100g</td>
<td>110-125g</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Carbohydrate Requirement Per 60 Minutes of Activity (if no insulin adjustments are made)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 lbs (24 kg)</td>
</tr>
<tr>
<td></td>
<td>100 lbs (48 kg)</td>
</tr>
<tr>
<td></td>
<td>150 lbs (71 kg)</td>
</tr>
<tr>
<td></td>
<td>200 lbs (95 kg)</td>
</tr>
<tr>
<td></td>
<td>250 lbs (119 kg)</td>
</tr>
<tr>
<td><strong>Cleaning Up</strong></td>
<td>3-7g</td>
</tr>
<tr>
<td></td>
<td>7-13g</td>
</tr>
<tr>
<td></td>
<td>10-20g</td>
</tr>
<tr>
<td></td>
<td>14-26g</td>
</tr>
<tr>
<td></td>
<td>17-32g</td>
</tr>
<tr>
<td><strong>Brisk Walking</strong></td>
<td>8-12g</td>
</tr>
<tr>
<td>(mall/theme park)</td>
<td>17-23g</td>
</tr>
<tr>
<td></td>
<td>25-35g</td>
</tr>
<tr>
<td></td>
<td>34-46g</td>
</tr>
<tr>
<td></td>
<td>42-57g</td>
</tr>
<tr>
<td><strong>Mowing</strong></td>
<td>13-17g</td>
</tr>
<tr>
<td>(push-mower)</td>
<td>27-33g</td>
</tr>
<tr>
<td></td>
<td>40-50g</td>
</tr>
<tr>
<td></td>
<td>54-66g</td>
</tr>
<tr>
<td></td>
<td>67-82g</td>
</tr>
</tbody>
</table>

Sources: Scheiner, Gary: *Think Like A Pancreas*, Marlowe Publishing, NY, 2005
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)
✓ Addtl. 20g snack after each hr of play
Variables:

Just a Few Factors that affect Blood Glucose During Exercise

- Active Insulin
- Infusion Site
- What You Ate
- When You Ate
- 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
Symlin:

**Exercise Implications**

Acts on central nervous system
- ↓ Appetite
- Slows gastric emptying
- Inhibits glucagon secretion

**Main benefit:** blunt post-meal spike

!!! Symlin is not needed or recommended if exercise is planned after the meal.

!!! Avoid using Symlin immediately after heavy or long-duration exercise due to risk of low BG.

Source: Symlin product insert
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, Marlowe Publishing, NY, 2005
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

Liver

(Body Cell)

ENERGY

Fatty Acid

Fatty Acid

Fatty Acid

Blood Stream

Kidney

To Urine

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 w/BG > 250 mg/dl (14 mmol)
- No exercise w/positive ketones (small or more on urine ketostix; >.5 mmol/l on β Ketone test using Precision Xtra meter)
- 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)
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!!!

- Spend less time in extreme heat
  - Get into a/c and shade periodically
  - Humidity is not a factor

- FRIO Cooling Case
There is nothing you can’t accomplish...

If you think like a pancreas!