Exercise And Diabetes

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Presenter Disclosure Info

- I have no financial relationships pertinent to this presentation to disclose.
Objectives

• Understand how we maintain our “blood sugar”.
• What things to keep in mind when you have diabetes and you exercise.
• How to have fun and be safe.
What do we see?

What do we choose to see?
Athletes with Type 1 Diabetes

Gary Hall Jr

Sir Steve Redgrave

Jason Johnson

Chris Dudley

Mimmi Hjorth

Charlie Kimball

Jay Hewitt
Wasim Akram
The Varsity Squad

Insulin

Alex Riley – Univ. of Oregon

Spenser Linney – Stanford Univ.

Glucagon

Adrenaline

Gino Inzerillo – Chapman Univ.
Ying and Yang

Glucagon

Insulin
When we eat carbs...

- Insulin goes up
- Glucagon goes down
When we fast...

- Insulin decreases
- Glucagon increases
When we exercise...

- Insulin decreases
- Glucagon increases
- During and after the exercise, muscles and the liver are more sensitive to insulin
Tanks of Sugar

Our defense against hypoglycemia

Pancreas Response:
- ↓ Insulin
- ↑ Glucagon

~ 72-108 mg/dL

Autonomic Response:
- Shaky
- Palpitations
- Anxious
- Sweating
- Hunger
- Numbness

~ 65-70 mg/dL

Brain Alert:
- Warmth
- Weakness
- Fatigue
- Confusion

~ 50-55 mg/dL
Our defense against hypoglycemia

- Decrease Insulin
- Increase Glucagon
- Increase of counter-regulatory hormones
Effects of exercise on Type 1 teens

n = 50 children and teens

Exercise: 4x15 min treadmill periods with 3 x 5 minute rest periods at VO$_{2max}$ of 60%

Diabetes Care, Vol 29, Number 1, January 2006
Hypoglycemia and teens

<table>
<thead>
<tr>
<th>Baseline BG level (mg/dl)</th>
<th>Hypoglycemia risk (% of subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;120</td>
<td>86%</td>
</tr>
<tr>
<td>120-180</td>
<td>13%</td>
</tr>
<tr>
<td>&gt;180</td>
<td>6%</td>
</tr>
</tbody>
</table>
Hypoglycemia overnight

- 2x as many kids aged 11-17 years old had a low BG overnight after an exercise day compared to when they had no exercise.
Hypoglycemia the night after exercise

- McMahon et al, noted that glucose needs to maintain targets may be increased not only during exercise but 7-11 hrs after.

$n = 9$ teens

Exercise: 4 pm 45 min on cycle at $50\% VO_{2max}$
And the next day...

- Adrenaline response to hypoglycemia was blunted the day after low or moderate exercise

n = 27 adults with type 1 DM

Exercise: 2 groups either $\text{VO}_{2\text{max}}$ of 30% or 50% had two bike sessions 90 min each with a 180 min rest period
When we exercise…

- Insulin decreases
- Glucagon increases
- During and after the exercise, muscles and the liver are more sensitive to insulin
BUT sometimes when we exercise...

- Insulin decreases
- Glucagon and **catecholamines** increase
- Catecholamines make it harder for glucose to enter muscle during the activity
- After the exercise, muscles and the liver are more sensitive to insulin
Effect of anaerobic exercise…

• With 10 s of maximal exercise there is a transient increase in BG for up to 2 hours after exercise

\[ n = 7 \text{ T1DM males (age } 21\pm4) \]
\[ \text{Exercise: cycling at 40% VO2 max x 20' followed by rest or 10 second max sprint} \]
Resistance Exercise vs Aerobic Exercise

- Resistance exercise relies more on lipids for fuel and has greater increase in GH levels, and lactate levels which increase gluconeogenesis, and increased catecholamines which augments glycogenolysis.

**n = 12 adult type 1 DM**

**Exercise:**
- Aerobic - treadmill at 60% \( \text{VO}_{2\text{max}} \) x 45 min
- Resistance - 3 sets of 8 repetitions with 90 sec rest in between sets x 45 min
Role of adrenaline, GH, and lactate

(AR, dashed line) (RA, solid line)
The issues with exercise and diabetes

- Can’t suppress insulin once it’s given
- Glucagon release may be impaired
- Adrenaline can increase BG’s
- Adrenaline response can be attenuated after

So you are susceptible to lows and highs!
So why exercise?

- Reduces risk of
  - Heart attacks
  - Stroke
  - High cholesterol
  - High blood pressure
  - Increase life expectancy
- Increases team comaraderie
- Improves mental health and self-confidence
“People with diabetes should be advised to perform at least 150 min/week of moderate-intensity aerobic physical activity (50–70% of maximum heart rate), spread over at least 3 days per week with no more than 2 consecutive days without exercise. (A)”
BG Targets

No diabetes

Diabetes

Exercise and diabetes
Factors affecting response to exercise

- Duration and Intensity
- Type of activity
- Metabolic control
- BG level
- Type and timing of insulin injections
- Type and timing of food
- Absorption of insulin
Anaerobic vs Aerobic

- Period of maximal $O_2$ use
- Anaerobic is only a short time, sometimes seconds
- BG rises lasting typically 30-60 min

- Aerobic tends to lower BG both during (usually within 20-60 min after onset) and after the exercise
Metabolic control

- When control is bad, circulating insulin may not be enough, and counter-regulatory hormones may be exaggerated
  - Ketosis
- High BG associated with reduced beta-endorphins during exercise
Timing of Insulin

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Serum Insulin Conc. (ng/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>60</td>
<td>1.0</td>
</tr>
<tr>
<td>120</td>
<td>1.5</td>
</tr>
<tr>
<td>180</td>
<td>2.0</td>
</tr>
<tr>
<td>240</td>
<td>2.5</td>
</tr>
<tr>
<td>300</td>
<td>3.0</td>
</tr>
<tr>
<td>360</td>
<td>0.2 mU/min/kg insulin infusion</td>
</tr>
<tr>
<td>420</td>
<td>Mean + SE</td>
</tr>
<tr>
<td>480</td>
<td></td>
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</tbody>
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Type and timing of food

- 3-4 h prior to competition meals with fat, carbs, and protein
- Faster acting glucose just prior to exercise or within an hour to help build glycogen stores faster
- Fill those “tanks”
Absorption of insulin

- **Choice of site**
  - Avoid extremity which will be used
- **Ambient temperature**
  - Increases metabolic demands and greater potential for BG drop
Other considerations

• More muscles used
  – Greater drop
• Adrenaline, being amp’d up
  – Game days will be different from practice days
• Mornings have higher counter-regulatory hormones
  – May have less likelihood of lows
• Sports unfamiliar with may have more likelihood of low
• Remember to hydrate
Recovery

• Quickly provide carbs post-exercise to rebuild glycogen stores within the first few hours
  – Take advantage of the heightened insulin sensitivity
  – Adding protein helps with glycogen formation
• Short duration high intensity anaerobic activities (weight lifting, sprints, diving, and baseball), you can have delayed drops and may only need carbs after activity
  – Remember, opposite for aerobic or mixed (soccer, cycling, jogging, and swimming)
    • Use carbs before, during, and after
Estimated number of min covered by 15 grams of extra carb and no change in basal activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Body mass (kg)</th>
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<tbody>
<tr>
<td></td>
<td>20</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>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>
<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>Cross-country ski</td>
<td>40</td>
</tr>
<tr>
<td>Basketball (game)</td>
<td>30</td>
</tr>
<tr>
<td>Snow shoeing</td>
<td>30</td>
</tr>
<tr>
<td>Soccer</td>
<td>30</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>20</td>
</tr>
</tbody>
</table>

Riddell et al, 2006
In General: Carbing Up

- 15 grams for every 20-30 minutes of play
- Gatorade is about 6% glucose
- G2 is about 2% glucose
- Generally drinks > 8% is too much
  - Juice is about 11% glucose
  - Slows gastric absorption
- Powerade is about 8% glucose
Reducing pre-exercise insulin for meals


<table>
<thead>
<tr>
<th>Exercise intensity (% $\text{VO}_{2\text{max}}$)</th>
<th>% Dose reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 min of exercise</td>
</tr>
<tr>
<td>25</td>
<td>25*</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

*Extrapolated.
Insulin Pumps

- Do not disconnect for > 2 hours
- May need to reduce basal 90 min prior to exercise.
- After reconnecting, may need to correct with only 50% of usual dose.
- Can use temp basals, before, during, and after exercise.
Practical points

- Always have a form of glucose readily available
- On activities, buddy system
- Have at least one person who knows how to use glucagon
- Don’t keep insulin in direct sunlight or warm temperatures
Red Flags

• **Hypoglycemia**
  – Glazed look
  – Incoherent
  – Unresponsive
  – Pale

• **Hyperglycemia**
  – Fruity-smelling breath
  – Nausea and vomiting
  – Shortness of breath
  – Dry mouth
  – Weakness
  – Confusion
  – Coma
  – Abdominal pain
What to do for hypoglycemia

- Check the BG
- If < 80 mg/dL, treat with 15 grams of fast acting carbs (ie juice, Gatorade, glucose tabs, gels)
- Re-check in 10 minutes, if still < 80 mg/dL repeat 15 grams of fast acting carbs
- If > 80 mg/dL give 15 grams of slow acting carbs (ie snack bar, powerbar, trail mix) and go and play
- If unresponsive, unable to swallow, or SEIZURE, 1 mg of glucagon given IM, if < 6 years old, give 0.5 mg (remember to mix powder with liquid)
  - Patient’s BG should increase within 10 min, and patient may throw up from the glucagon, don’t worry about this.
- Consider giving extra carbs at bedtime and check BG’s overnight
What to do for hyperglycemia

- Check the BG
- If > 250 mg/dL check for ketones
- If there are moderate to large ketones, sub out, hydrate, give insulin
- If no ketones, use insulin scale but give 50% of what they normally use, may need even less for some activities
- If they are unconscious or vomiting with elevated BG, call 911, or take to the ER.
Good things to have in your bag of tricks!

- Glucagon
- Fast acting glucose
- Meter and strips
- Serum ketone meter
- Insulin and needles
- Water
- Snack bar (mixed protein/fat/carbs)
- Doctor’s and parents phone numbers
- Medic-Alert
- Don’t need to have it, but good if the athlete has a paper with their doses.
Let’s sum up…

• Reduce pre- and post-exercise insulin boluses and basal rates
• Carb up before exercise, make sure glycogen stores are full
• For daylong activities (camp, long distance walking, skiing, water sports) consider 30-50% reduction in long acting insulin or basal the night previous and following night
• Check BG’s before exercise and every 30 min or so during exercise if possible
Let’s sum up…

• Bursts of anaerobic (high intensity) activity before.

• To prevent overnight hypoglycemia
  – Bedtime snack (low glycemic index) if BG < 120 mg/dL
  – Lower overnight basal (by 20-30%)
  – Reduce pre-dinner bolus (with PM exercise)
  – Exercise in AM instead of PM
  – Consider a continuous glucose monitor

• Consider a serum ketone meter
Shameless plug for Diabetes Camp!
UCSF Benioff Children’s Hospital
Oakland
Division of Endocrinology

• Diabetes Nurses
  – Kathy Love (R.D)
  – Barb King-Hooper
  – Lois Carelli
  – Victor Woolworth
  – Rosibel Silva (R.D.)

• Endocrine Nurses
  – Anita Markoff
  – Andrea Pederson

• Research Nurse
  – Betty Flores

• Social Workers
  – Amy Warner
  – Kristin Avicolli
  – Karen West

• Office Staff
  – Kim Lawas
  – Juliet Miller
  – Yira Cordova

• Physicians
  – Jenny Olson
  – Ivy Aslan
  – Sonali Belapurkar
  – Alison Reed
  – Tariq Ahmad
THANK YOU
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