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

Mimmi Hjorth

Chris Dudley

Wasim Akram

Charlie Kimball

Jay Hewitt
The CHO Varsity Squad

Alex Riley – Univ. of Oregon

Gino Inzerillo – Chapman Univ.

Spenser Linney – Stanford Univ.

Ryan Graumann – USGA Junior Amateur
The Players

Insulin

Glucagon

Adrenaline
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
The issues with diabetes type 1

- Can’t decrease the insulin once it’s given
- Glucagon release is impaired
- Adrenaline response is attenuated in type 1 diabetes
- And yet adrenaline can also increase BG’s

So you are susceptible to lows and highs!
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\(_{2}\)\(_{\text{max}}\) of 60%
<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$_{2\text{max}}$
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 VO$_{2\text{max}}$ of 30% or 50% had two bike sessions 90 min each with a 180 min rest period
Effect of anaerobic exercise...

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

\[ n = 7 \text{ T1DM males (age } 21 \pm 4) \]

Exercise: cycling at 40% VO2 max x 20’ followed by rest or 10 second max sprint
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
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 catcholamines which augments glycogenolysis.

\[\text{Exercise: aerobic - treadmill at 60\% VO}_{2}\text{max} \times 45 \text{ min}\]

\[\text{Exercise: resistance - 3 sets of 8 repetitions with 90 sec rest in between sets} \times 45 \text{ min}\]
(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)"
Exercise management in type 1 diabetes: a consensus statement

Type 1 diabetes is a challenging condition to manage for various physiological and behavioural reasons. Regular exercise is important, but management of different forms of physical activity is particularly difficult for both the individual with type 1 diabetes and the health-care provider. People with type 1 diabetes tend to be at least as inactive as the general population, with a large percentage of individuals not maintaining a healthy body mass nor achieving the minimum amount of moderate to vigorous aerobic activity per week. Regular exercise can improve health and wellbeing, and can help individuals to achieve their target lipid profile, body composition, and fitness and glycaemic goals. However, several additional barriers to exercise can exist for a person with diabetes, including fear of hypoglycaemia, loss of glycaemic control, and inadequate knowledge around exercise management. This Review provides an up-to-date consensus on exercise management for individuals with type 1 diabetes who exercise regularly, including glucose targets for safe and effective exercise, and nutritional and insulin dose adjustments to protect against exercise-related glucose excursions.
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

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’ed 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 and muscle repair
- 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>
</tr>
</thead>
<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>
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<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>30</td>
</tr>
<tr>
<td>30 m/min breast stroke</td>
<td>55</td>
</tr>
<tr>
<td>Tennis</td>
<td></td>
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<tr>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>Cross-country ski</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Basketball (game)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Snow shoeing</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Soccer</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Figure skating</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Ice Hockey (ice time)</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10</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
Starting BG

- **< 90 mg/dL**
  - 10-20 g of carb prior to exercise
  - Wait til BG > 90 mg/dL

- **90-120 mg/dL**
  - 10 g before aerobic
  - Nothing before anaerobic

- **120-180 mg/dL**
  - start

- **180-270 mg/dL**
  - Start aerobic
  - With anaerobic beware of rise in BG

- **> 270 mg/dL**
  - Check blood ketones
    - If < 0.6 mmol/L
      - Aerobic exercise
    - If < 1.4 mmol/L
      - Light intensity
      - < 30 min exercise
      - Small amount of insulin
    - If > 1.5 mmol/L
      - No exercise
Carbs and exercise

• Carb up hours prior to the exercise (fill the tanks)
  – Take half the rapid acting insulin

• During the exercise,
  – If < 30 min, no carbs
  – If 30-60 min, take about 10-15 g of carb after 30 min without insulin for aerobic; nothing for anaerobic
  – If 60-150 min, take about 15-30 g of carb every 30 min
  – If > 150 min, take about 20-30 g of carb every 20 min
Carbing Up

- Gatorade is about 6% glucose
  - 8 oz is 14 grams
- G2 is about 2% glucose
  - 8 oz is 5 grams
- Generally drinks > 8% is too much
  - Juice is about 11% glucose
  - Slows gastric absorption
- Consider gels, blocks, etc
Reducing pre-exercise insulin for meals

<table>
<thead>
<tr>
<th>Exercise intensity (% VO_{2max})</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>
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</tbody>
</table>

*Extrapolated.

AM vs PM exercise

- 35 adults on CGM
- Treadmill exercise
  - 3 x 15 min
  - 5 min breaks
- Crossover study
  - 7-14 day washout

Gomez et al, 2015
After the exercise

• Refill the tanks
  – 1 g/kg
  – Give 50% of the bolus

• Lower basals by 20% or more

• If BG < 120 mg/dL
  – take 15-20 grams of a low glycemic index food

• If BG < 80 mg/dL
  – Take 15 grams of a high glycemic index food every 10 min until BG > 80 mg/dL
  – Then follow with a 15-20 g low glycemic index food
  – Check BG at 2 or 3 am, unless you have a CGM
Insulin Pumps

• Do not disconnect for > 2 hours
• May need to reduce basal 90 min prior to exercise.
• After reconnecting, remember 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