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  - Learners must attend the full activity and complete the evaluation in order to claim continuing education credit/hours

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Who inspires You???

Abigail Katherine Corcoran graduates with honors from Aspen High School !!!
May, 2015

Toughness

“Toughness isn’t physical. It has nothing to do with size, physical strength, or athleticism. (or, A1C). It’s an intangible, an attitude, a philosophy. Some people may be born with the aptitude to be tougher than others, but I believe that true toughness is a skill that can be developed and improved in everyone.”
- Jay Bilas, in Toughness

Toughness

“The ability to come back, to fight adversity or difficulties, is a measure of true toughness. Every athlete and every person has to face difficulties, and to address them honestly and head-on, and to overcome them takes resilience, a major part of toughness.”
- Jay Bilas, in Toughness
EXERCISE PHYSIOLOGY

T1D and Exercise
- Regular exercise may increase longevity by 10 years.
- 1993 data in T1D demonstrated a 50% reduction in 7-year mortality rate by expending 2000 kcal weekly (7 hours of brisk walking).

T1D and Exercise
- Exercise has not been shown to improve glycemic control in most studies of T1D; however, sedentary behavior is associated with poor glycemic management in pediatrics and adults.
- Fear of hypoglycemia is the strongest barrier to regular PA in persons living with T1D.

Cardiorespiratory Fitness in T1D
- Some, but not all, with T1D have the same aerobic capacity as similar aged without DM.
- May have lower anaerobic threshold and lung capacity, with similar aerobic capacity.
- Poor glycemic control may impair pulmonary, cardiac and vascular responses to exercise.
  - Trained individuals in one study were able to achieve same cardiopulmonary response as trained without diabetes, but response was reduced in those with A1c > 7%.

Cardiorespiratory Fitness in T1D
- Mitochondrial oxidative capacity may depend upon glycemic control in women.
- Sex and DM control may be significantly associated with cardiorespiratory fitness.
  - Women with T1D have exhibited lower level of fitness.
  - Those with poorer glycemic control with lower level of fitness.
- Unclear whether reduced fitness in children and others with T1D is attributable to lower PA levels or to physiological changes resulting from diabetes.

Diabetes Fuel Metabolism & Keys to Exercise Success
- In T1D, a reduced ability to precisely match glucose production and utilization results in daily glucose fluctuations.
- Glucose control requires a near-normal balance between hepatic glucose production and peripheral glucose uptake combined with an effective insulin response.
Diabetes Fuel Metabolism & Keys to Exercise Success

- Optimize athletic performance via fuel availability, i.e., balance exercise blood glucose (and glycogen) use and availability.
- Prevent and rapidly manage hypoglycemia (low blood glucose) caused by or following exercise, as well as hyperglycemia (elevated blood glucose).

Aerobic Exercise Response in T1D

- Several-fold increments in hormone concentrations help maintain fuel and fluid homeostasis in exercise.
- Substrate oxidation in T1D exercisers with normal glucose levels is similar to those without diabetes.

Aerobic Exercise Response in T1D

- If exercising in hyperglycemic state the fuel metabolism is dominated by CHO oxidation, but muscular glycogen is not spared by greater use of blood glucose.
- Exercise in hyperinsulinemic state also increases blood glucose use without sparing muscle glycogen.

Role of Hepatic Glucose Production

- Wasserman Am J Physiol Endocrinol Metab 296:11-21, 2009

Glucose Control: Moderate Exercise

- Non-diabetes: 
  - Blood Glucose Constant
  - Insulin decreases
  - Glucagon increases

- Diabetes: 
  - Blood Glucose Decreases
  - Insulin decreases
  - Glucagon response impaired

Glucose Control: Moderate Exercise

- Insulin decreases
- Glucagon increases
**Aerobic Exercise Response in T1D**

- Liver glycogen is affected by glycemic control.

- In those without diabetes, increase in HGP during exercise is almost entirely result of hepatic glycogenolysis.

**Aerobic Exercise Response in T1D**

- In moderately controlled T1D, increase in HGP (rest and exercise) are primarily from increase in gluconeogenesis.

- Poor control of T1D will result in marked reduction in hepatic glycogen synthesis and breakdown that is improved (not normalized) by short term restoration of normal levels of insulin and blood glucose.

**EXERCISE-INDUCED HYPOGLYCEMIA**

**Hypoglycemia**

- Abnormally low plasma glucose concentration that exposes an individual with diabetes to potential harm.

- Glycemic thresholds for symptoms (and other responses) are dynamic, making it difficult to assign a single threshold value.

**Hypoglycemia**

- Recent ADA/Endocrine Society work group emphasized importance of an alert value: those at risk should be alert to the possibility of developing hypoglycemia at a concentration of 70 mg/dL.

**Glucose Counterregulation**

<table>
<thead>
<tr>
<th>Response</th>
<th>Glucose Threshold</th>
<th>Physiological Effect</th>
<th>Risk of Potential Harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>60-70</td>
<td>Increase glucose appearance &amp; decrease disappearance</td>
<td>Mild, reversible</td>
</tr>
<tr>
<td>Fatigue</td>
<td>60-70</td>
<td>Increase glucose appearance &amp; decrease disappearance</td>
<td>Moderate, reversible</td>
</tr>
<tr>
<td>Somnolence</td>
<td>50-60</td>
<td>Increase glucose appearance &amp; decrease disappearance</td>
<td>Severe, not fatal</td>
</tr>
<tr>
<td>Symptomatic</td>
<td>&gt; 50</td>
<td>Increase glucose ingestion</td>
<td>Maladaptive behavioral alterations</td>
</tr>
</tbody>
</table>

**Glucose Counterregulation**

| Glucose Counterregulation | | |
|---------------------------|------------------|
| Response                  | Glucose Threshold|
| Alcohol                   | 60-70            |
| Fatigue                   | 60-70            |
| Somnolence                | 50-60            |
| Symptomatic               | > 50             |

**EXERCISE-INDUCED HYPOGLYCEMIA**

**Hypoglycemia**

- Recent ADA/Endocrine Society work group emphasized importance of an alert value: those at risk should be alert to the possibility of developing hypoglycemia at a concentration of 70 mg/dL.
T1D, Exercise & Hypoglycemia
• Strong barrier to regular exercise and PA.
• Risk factor for severe hypoglycemia.
• Impact on performance and metabolic response to subsequent exercise/training.
• Premature fatigue.
• May necessitate cessation of training/exercise.
• Discouragement, sense of defeat, & depression.

Risk Factors for Hypoglycemia
• Relative or absolute insulin excess
  – Dose: excessive, ill-timed or wrong type
  – Decrease in exogenous glucose delivery
  – Decrease in endogenous glucose delivery
  – Increase in glucose utilization
  – Increase in insulin sensitivity
  – Decrease in insulin clearance

The Typical Response
• 83% with drop in glucose of at least 25%
• Average fall is 40% from baseline
• 52% experience glucose < 70 mg/dL
• Incidence of hypo varies with baseline BG
• 15 grams CHO insufficient to reliably treat hypoglycemia in exercise
• Only 1 subject with meaningful increase in BG
Baseline Glucose Predicts Risk

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Hypoglycemia (≤ 60mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 120</td>
<td>86% (100)</td>
</tr>
<tr>
<td>120-180</td>
<td>13% (44)</td>
</tr>
<tr>
<td>&gt; 180</td>
<td>6% (28)</td>
</tr>
</tbody>
</table>

After controlling for baseline BG, no other factors associated with hypoglycemia.

The Diabetes Research in Children Network (DirecNet) Study Group

Causes of Exercise-induced Hypoglycemia

- Defective counter-regulatory mechanisms.
- Acute increase in insulin mobilization & sensitivity.
- Increased glucose utilization.
- Replenishing glycogen stores.
- Delayed effects of physical activity.

Defective Counterregulation

- In adults without diabetes, short duration moderate hypoglycemia blunts key neuroendocrine and metabolic counterregulatory responses to subsequent hypoglycemia.
- Episodes of antecedent exercise and prior hypoglycemia now known to blunt counterregulatory response during subsequent exposures of hypoglycemia or exercise.

Exercise & Next Day Hypoglycemia

Sandoval, DA, et al., Diabetes, 53: 1798-1806, 2004

Hypoglycemia & Next Day Exercise


Hypoglycemia & Next Day Exercise

- In individuals with T1D, antecedent hypoglycemia produces an acute counterregulatory failure during a subsequent episode of prolonged moderate-intensity exercise, resulting in blunted neuroendocrine and ANS responses and the inability of endogenous glucose production to match the increased glucose requirements of exercise.
  - Increase in cortisol may play a role.
  - Severity of antecedent hypoglycemia affects subsequent response, progressively greater blunting of response from 70 to 60 to 50...
A Vicious Cycle

Antecedent hypoglycemia blunts the neuroendocrine & metabolic responses to exercise.

Prior exercise blunts counterregulatory response to next-day hypoglycemia.

Episode of hypoglycemia or exercise can feed forward to down-regulate neuroendocrine & ANS response to subsequent episode of other stressor.

Delayed Onset & Nocturnal Hypoglycemia

- Sleep impairs the counterregulatory response to hypoglycemia in those with and without diabetes.
- A biphasic increase in glucose requirements to maintain euglycemia after exercise has been reported, suggesting a unique pattern of early and delayed risk for nocturnal hypoglycemia following afternoon exercise.
- Hypoglycemia is common 1-4 hours after exercise, and again 7-11 hours after exercise.

Hypoglycemia Prevention

- Strategies and technologies are used to help detect and prevent hypoglycemia:
  - Improved patient education
  - Frequent self-monitoring of blood glucose (SMBG)
  - Use of insulin analogues: basal and rapid
  - Insulin pump therapy
  - Exercise-related insulin and fueling adjustments
  - Continuous glucose monitoring

Assessing Risk

- Best indicator may be the athlete’s own experience: Hypoglycemia begets hypoglycemia!
- TID > 10 years.
Assessing Risk
- Individuals with low CHO intake.
- Long term complications of T1D.
- Threshold for symptoms of hypoglycemia < 54 mg/dL.
- Alcohol intake.
- Meds: beta blockers.

Proactive Strategies
- Self-monitoring blood glucose
- Establish blood glucose goals
- Fueling exercise: CHO & Food Intake
- Insulin dose adjustments
- High intensity exercise
- Bedtime strategies

Fueling Strategies
- No definitive evidence that in uncomplicated T1D, the fueling strategy should be different from that of the athlete without T1D.
- Restore and preserve glycogen stores.
- Hypoglycemia prevention may require 45-60 grams of carbs per hour, especially without insulin adjustment.

Fueling Strategies
- Maintain separation of 3-4 hrs from last rapid acting insulin as possible.
- Fuel endurance activities with food and basal insulin.
- Rapid acting carbs to manage hypoglycemia; the 15 gram rule does not apply to the exerciser with hypoglycemia.
Fueling Strategies

- More slowly absorbed carbs prior to and during activity - athletes utilize bars, gels, sports drinks, etc.

Carb Supplementation

- Disregard liver’s contribution and use carbs to match glucose disposal into muscle.
  - Basic strategy:
    - 15 grams of CHO every 20-30 minutes (240-300 cal)
    - CHO requirement estimated by body mass:
      - Peak insulin activity may require 1 gram/kg/hour
      - Pre, during, & post exercise
    - ExCarb estimations:
      - Anecdotal, not tested in clinical trial settings.

CHO Expenditure:

- DTC 2008 Ex Phys Data
- The Chicago Experience

CHO utilisation
- 60% HR max: 2 kcal/min (30 gms)
- 70% HR max: 3.2 kcal/min (48 gms)
- 80% HR max: 5.8 kcal/min (90 gms)
- 90% HR max: 9-10 kcal/min (150 gms)

* Tremendous Variation

Supplemental Carbs

- 10% carb drink slightly better
- 60 min of exercise at 55-60% VO2max
- Av. ~22 oz. (53.3 vs. 66.5 gm carbs)

Perrone C et al., Diab. Care, 28(10): 2537-8, 2005

The Goal

- Maintenance of more normal blood glucose levels is the most effective strategy to optimize liver glycogen stores in T1D.

Insulin Dosing Adjustments

- Utilize and optimize basal insulin.
- Timing of basal insulin injection will impact glycemic response to exercise.
- Consider 20-50% decreases in basal insulin levels.
- Basal rate changes on pump: timely and proactive.
- Consider avoid peaking rapid acting insulin & understand expected response of exercising on basal or bolus insulin.
Utilize Basal Insulin

• 50-80% basal
• Timing of rate changes is critical
• Timing of long acting insulin injection
• Multiple trials
• Incremental changes: 10-20%
• Re-assess with incremental fitness gains and weight changes

Dosing Meals Prior To Workout/Comp.

Decreasing the pre-meal insulin dose reduced hypoglycemic episodes by 75%.

Pre-Exercise Bolus Reductions

<table>
<thead>
<tr>
<th>Exercise Duration</th>
<th>Intensity: Moderate</th>
<th>Intensity: High</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 minutes</td>
<td>10-25%</td>
<td>25%</td>
</tr>
<tr>
<td>60 minutes</td>
<td>50%</td>
<td>50-75%</td>
</tr>
<tr>
<td>90 minutes</td>
<td>50%</td>
<td>50-75%</td>
</tr>
<tr>
<td>120 minutes</td>
<td>50-75%</td>
<td>75%</td>
</tr>
</tbody>
</table>

1985

“A 50-66% reduction of the insulin dose in anticipation of postprandial exercise of moderate intensity resulted in near-normal glycemic values and prevented hypoglycemia. Alternatively, in the case of unplanned postprandial exercise of 45 minutes duration, the intake of 25-30 grams of glucose may prevent hypoglycemia in the CSII and MSI-treated type 1 diabetic patients.”

Schiffrin and Parikh, Diabetes Care, 1985; 8:337-342

The 10 Second Sprint Approach

10 sec sprint at start of ex followed by 20 min of mod. cycle ex. keeps BG higher early in recovery

Schiffrin and Parikh, Diabetes Care, 1985; 8:337-342
Preventing Nocturnal Hypoglycemia:
1) Insulin reductions
2) CHO supplements
3) Medications
4) Other approaches

A Champion’s Mind
Pete Sampras with Peter Bodo

“Paul knew that different people needed to be handled in different ways. He could coach me, or he could coach Andre. He was a good reader of character and temperament, knowing what I needed to hear and how to say it. And that is a huge, repeat, huge—part of being a high-level coach. You have to understand a guy and work within his comfort zone, avoiding the temptation to change him or make him conform to how you want him to be—even when you know that kind of change would be beneficial. His bedside manner was great.”

Very Special Thank You!

Q & A

The Pancreatic Disconnect: A 30 minute pump disconnect

Insulin interruption & resulting insulin levels and metabolic control (pump disconnect in well controlled type 1 DM).
Arial Bold 35pt Title Case

• Bullet lists at 30pt Arial Regular
  – Sub bullets at 25pt Arial Regular