Physiology of Exercise in Patients with Type 1 Diabetes

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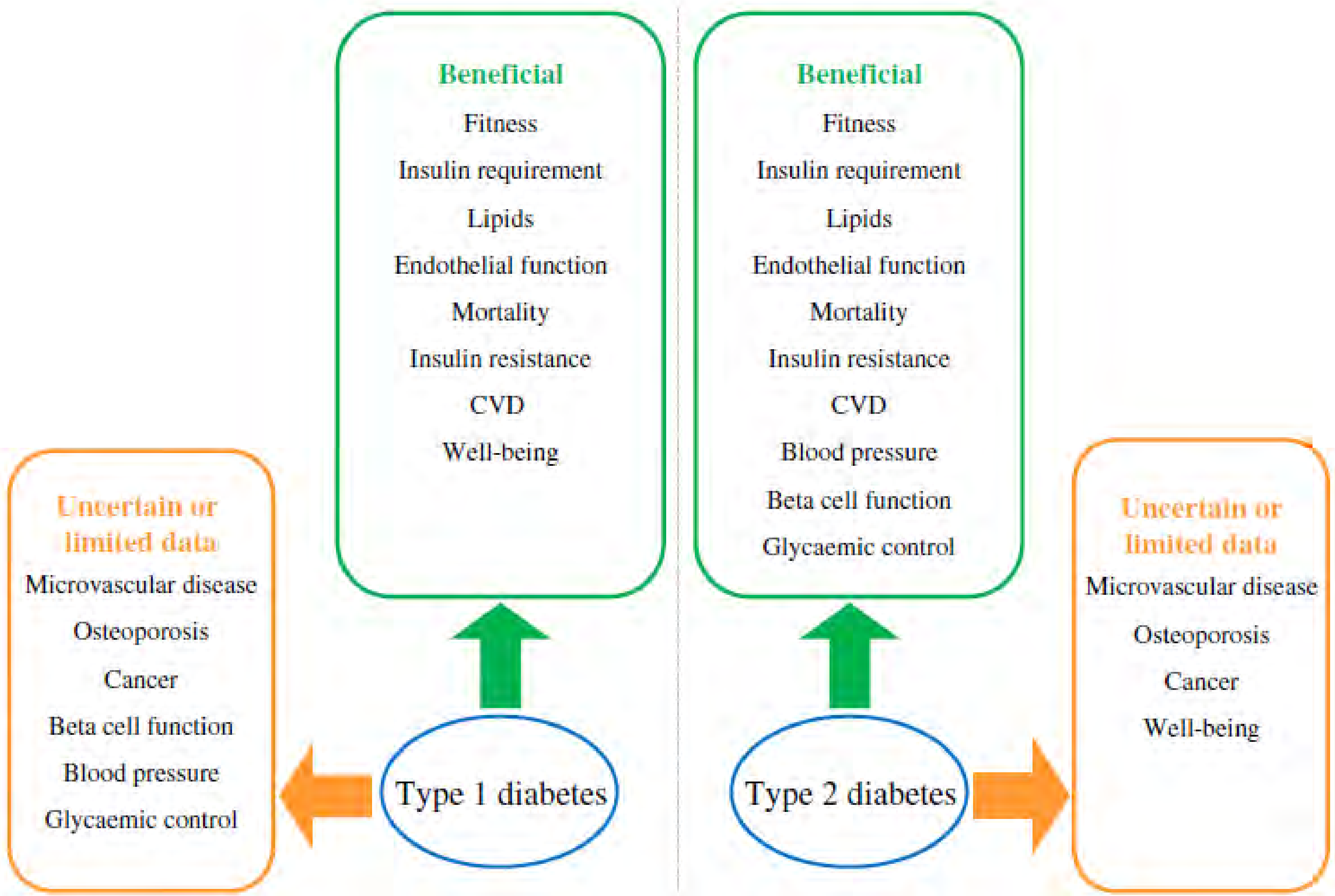
Dr. Michael Riddell, PhD CR Disclosures

- M Riddell has received speakers fees and honoraria from:
  Medtronic, Sanofi-Aventis, and Eli Lilly

- The content in the following presentation is based on published evidence (and personal experiences) without input or influence from any of the above companies

Diabetes-Why Exercise?

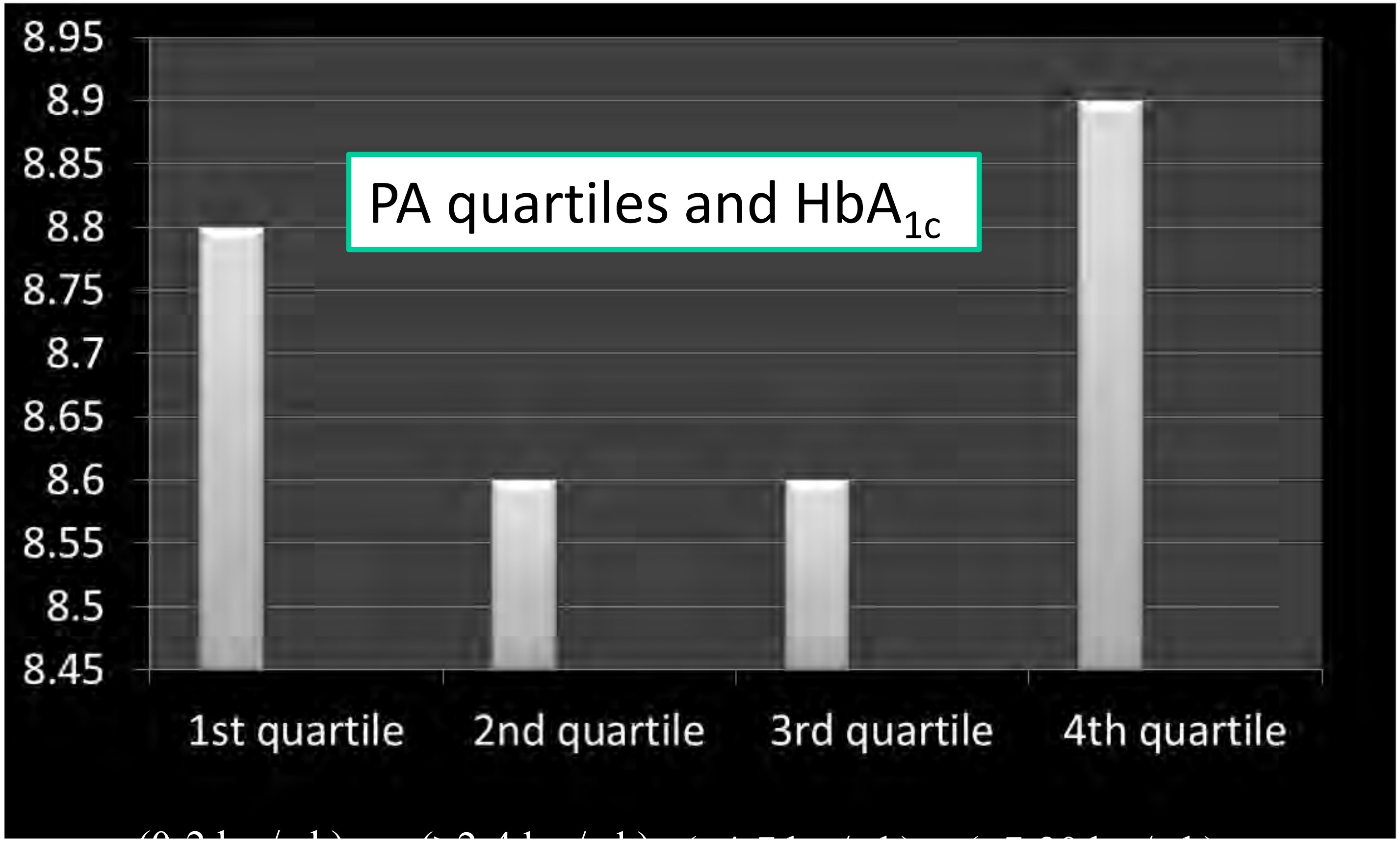


Chimen et al., Diabetologia (2012) 55:542–551

How Much Exercise?

<u>150 minutes per week</u> of accumulated physical activity (at an intensity at least equal to brisk walking), with no more than 2 days "off" in a row… Strength training 2-3 times per week (CDA-Clinical Practice Guidelines 2013)

Associations between physical activity and glycemic control in children, adolescents, and young adults with type 1 diabetes.



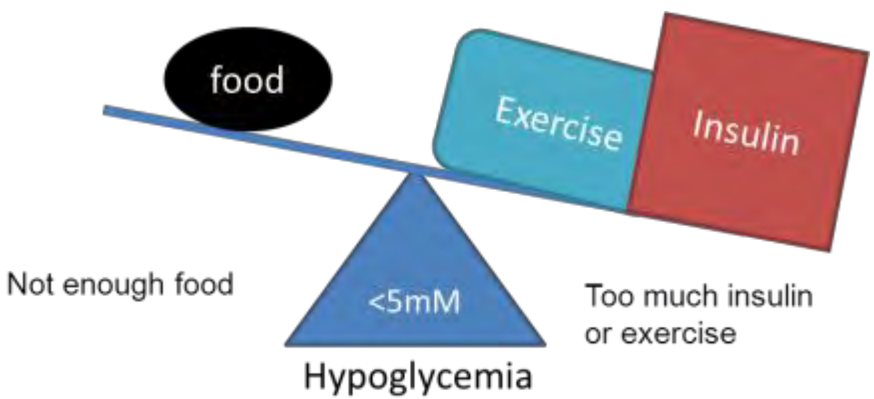
N= 296 children, adolescents, and young adults with type 1 diabetes

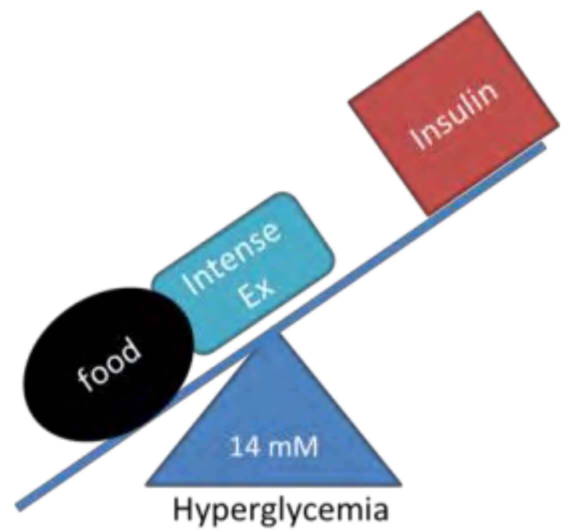
Youth with T1D spend 20 ± 13 hrs/wk watching television and using computers and 5.1 ± 4.5 hrs/wk engaged in physical activity

Galler et al., Diabetes Care 2011

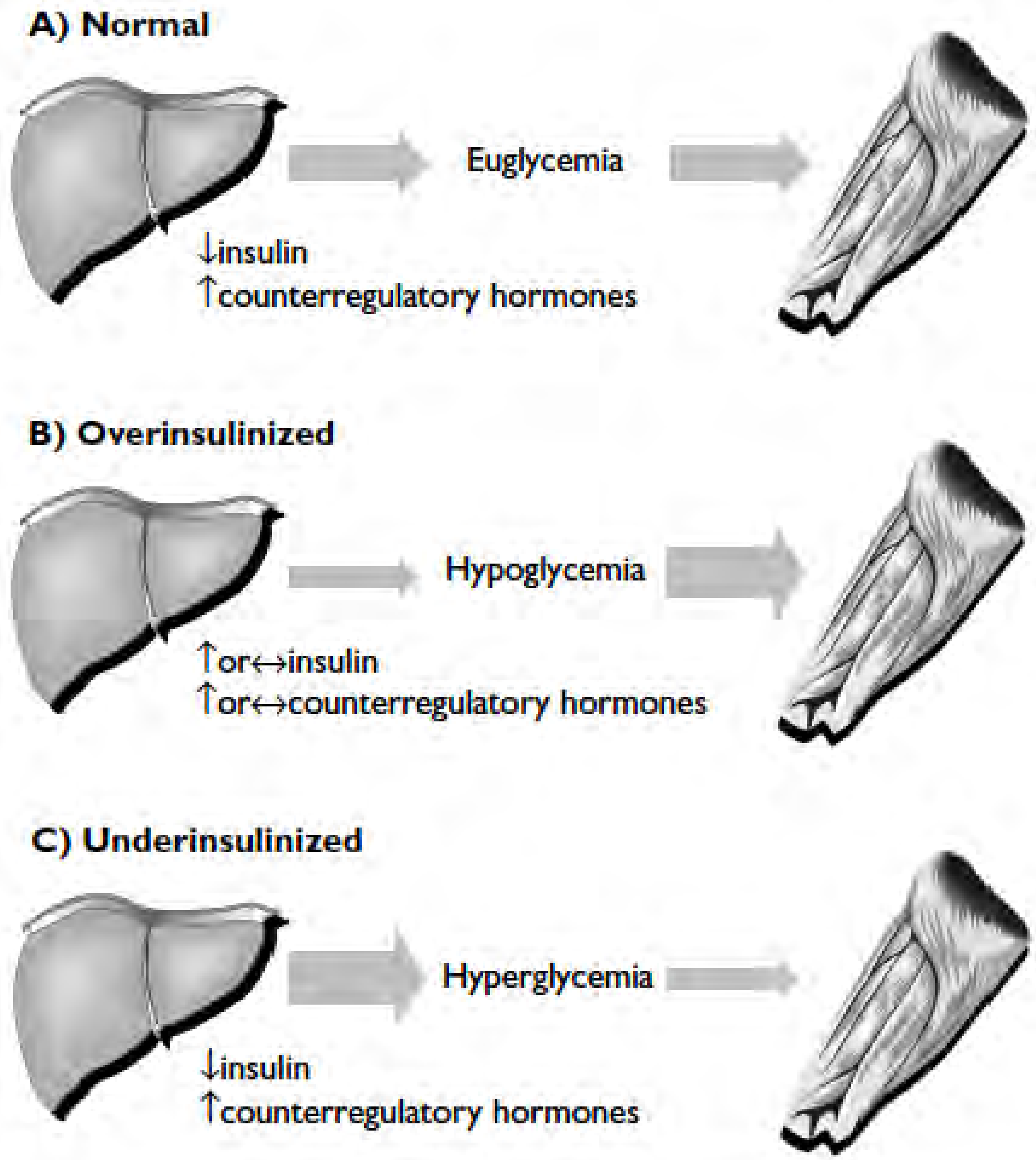
Why is it so hard to balance blood glucose?

50-60 kg adolescent= 4000 ml blood = 40 dl x 100 mg/dl (5.6mM) = 4 grams





Blood Glucose Flux During Exercise in T1DM



Riddell and Perkins, The Canadian Journal of Diabetes, 2006

Types of Exercise

Weightlifting, Tag
Sprinting, Diving, Swimming, Gymnastics,
Wrestling, Dodge ball, Volleyball, Ice hockey, Track cycling

Basketball, Football, Tennis, Lacrosse
Skating
Skiing (slalom & downhill), Field hockey
Rowing (middle distance)
Running (middle distance)

In-line skating
Cross country skiing
Brisk Walking
Jogging
Light Cycling

Hyperglycemia

Hypoglycemia

Aerobic Exercise

Carbohydrate oxidation rate during aerobic exercise

Vigorous exercise

- 1.5 grams per kg body mass per hour

Moderate exercise

- 1.0 grams per kg body mass per hour

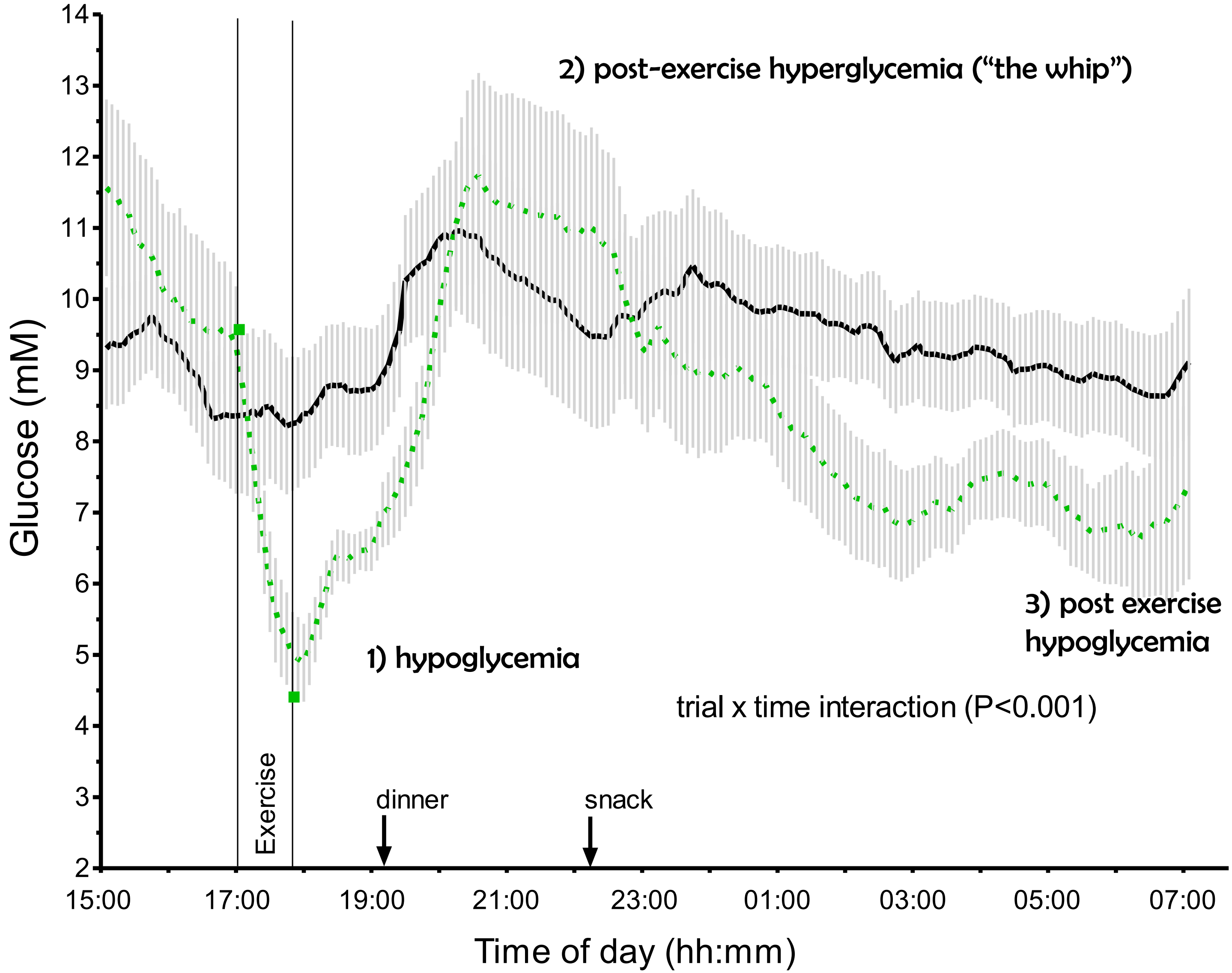
Mild exercise

- 0.5 grams per kg body mass per hour

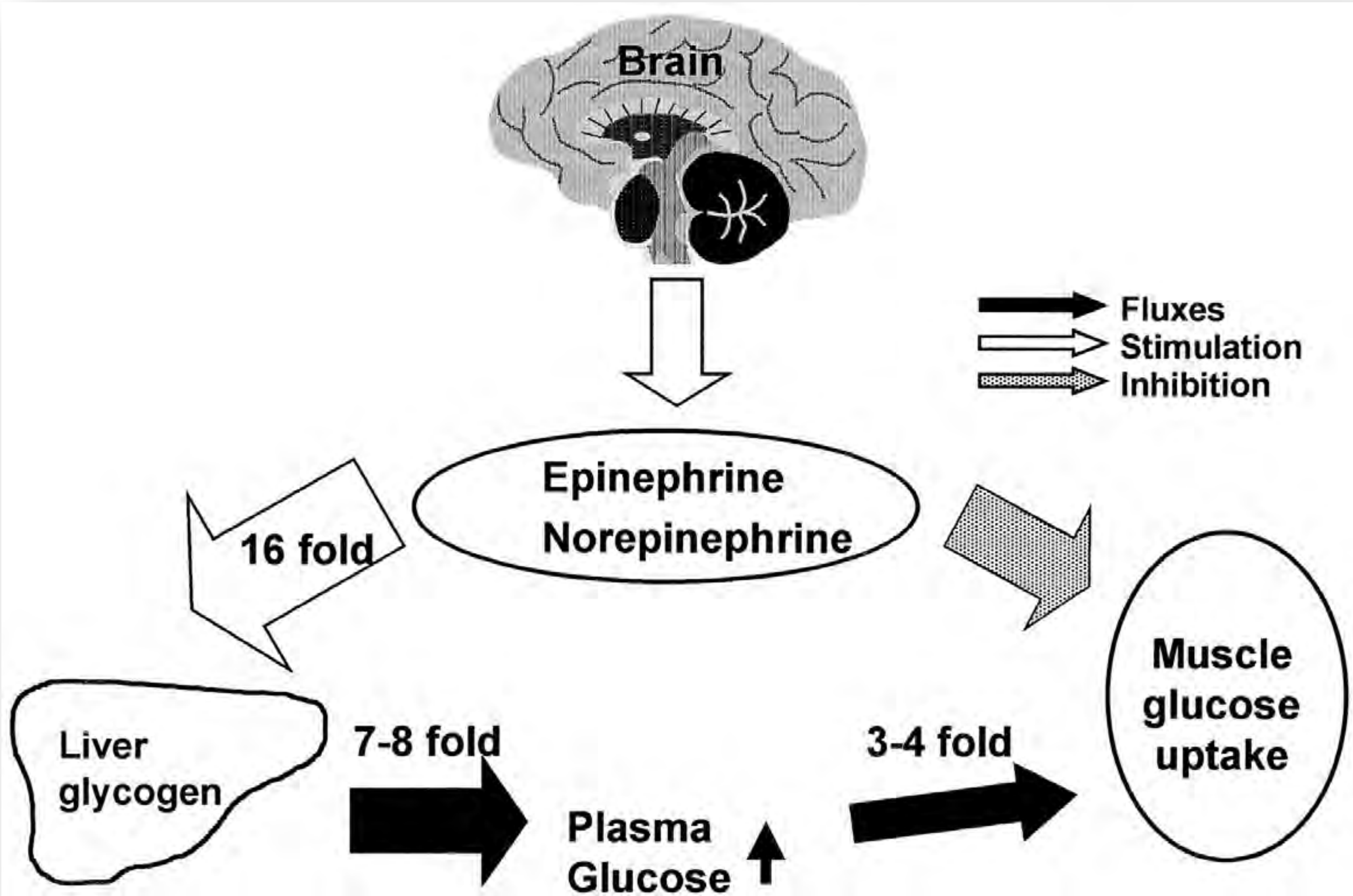
*Note that maximum carbohydrate absorption from the G.I. tract during exercise is ~60g/hour in adult males

Jeukendrup AE. Curr Opin Clin Nutr Metab Care. 2010

Aerobic Exercise Causes 2 Phases of Hypoglycemia



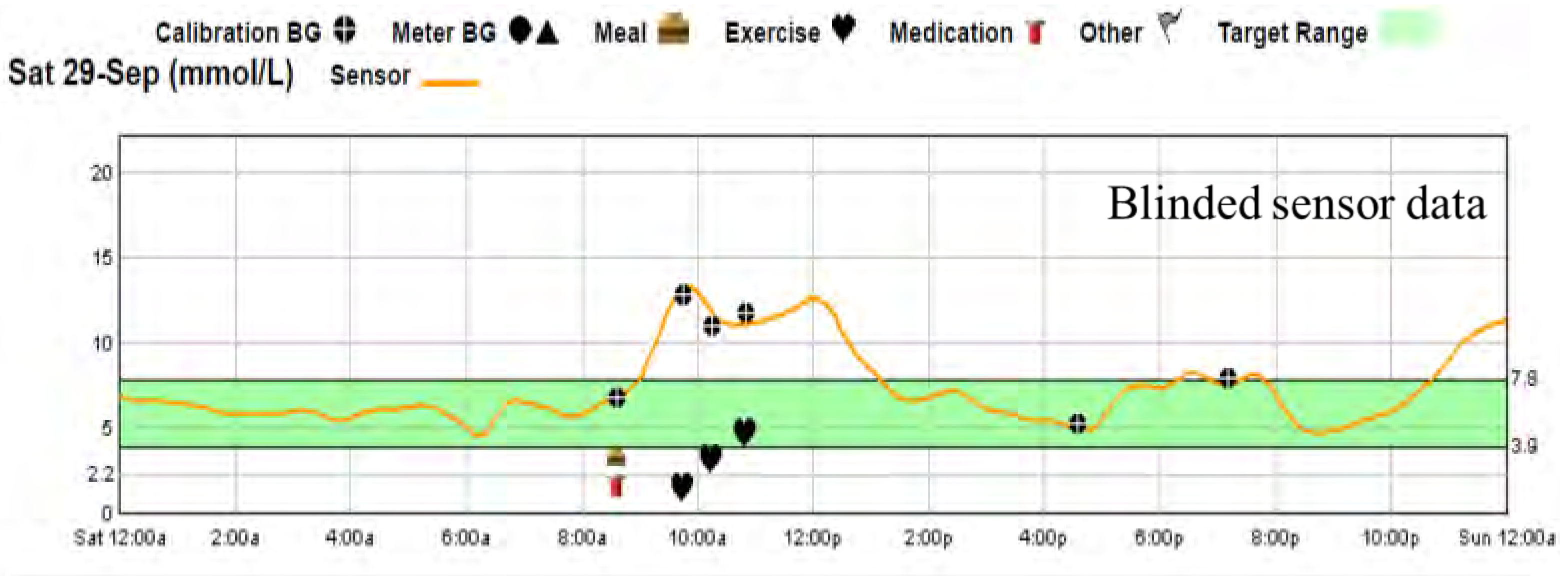
Mechanisms of Exercise Induced Hyperglycemia

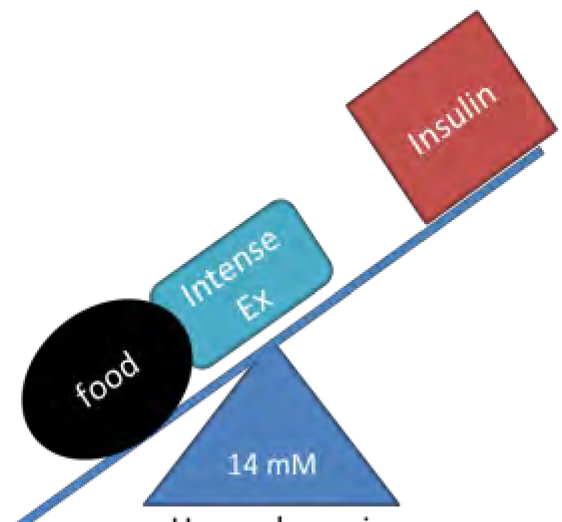


Marliss and Vranic Diabetes 2002

Hyperglycemia and Exercise

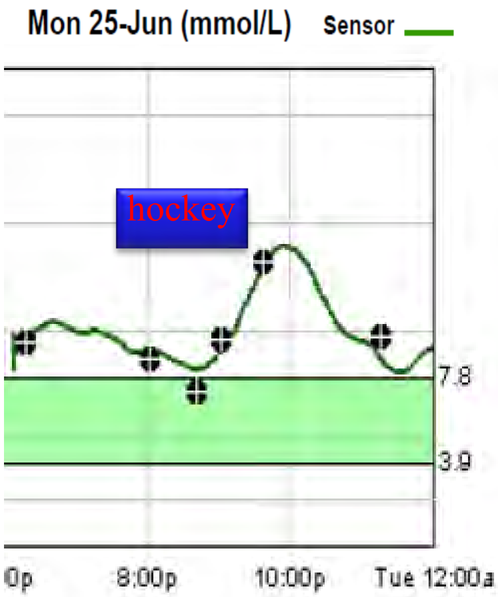
Case study - Exercise hyperglycemia

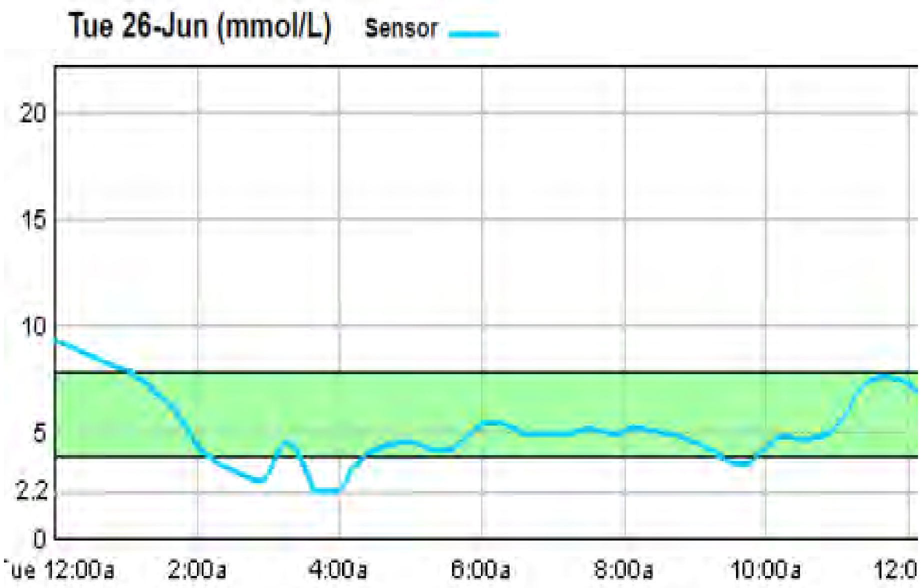




Correcting post exercise hyperglycemia should be done with caution, since it may increase the risk of late-onset hypoglycemia

Blinded sensor data





<u>Resistance</u> before <u>Aerobic</u> protects against Hypoglycemia

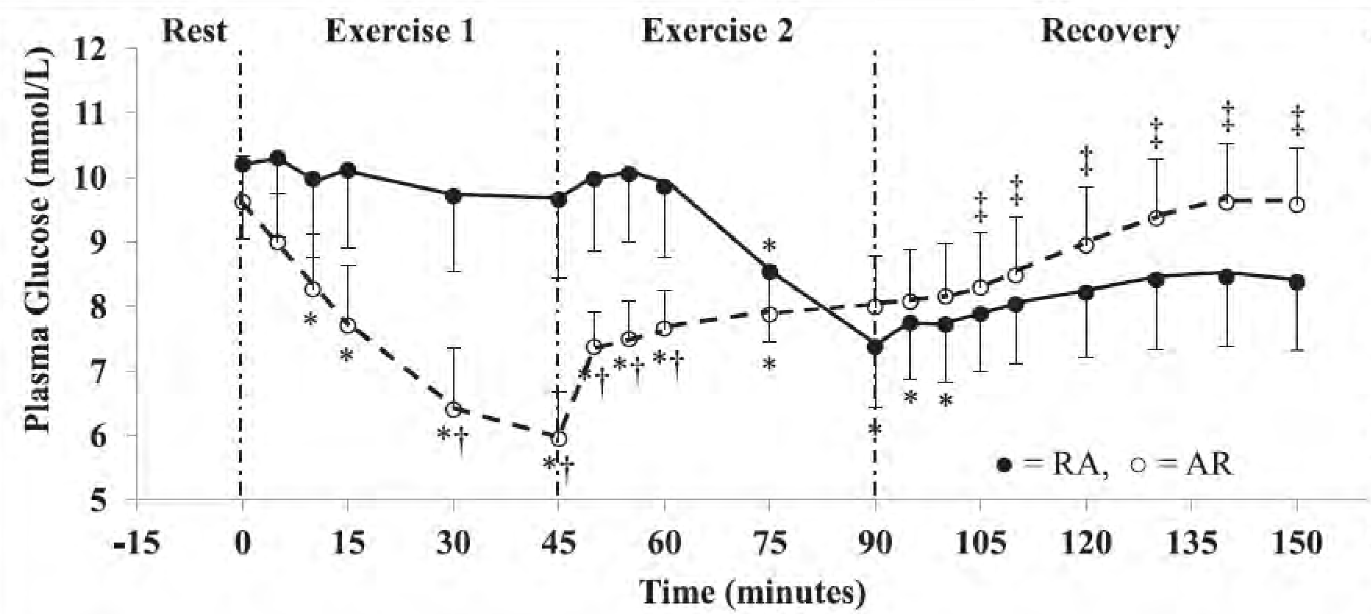


Figure 1—*Mean ± SE plasma glucose during exercise and recovery for aerobic exercise performed before resistance exercise (AR, dashed line with ○) and resistance exercise performed before aerobic exercise (RA, solid line with ●) (n = 11). *Difference from baseline during exercise where P < 0.05. †Difference between conditions where P < 0.05. ‡Change throughout recovery from end-exercise level where P < 0.05.*

Yardley et al., Diabetes Care, 2012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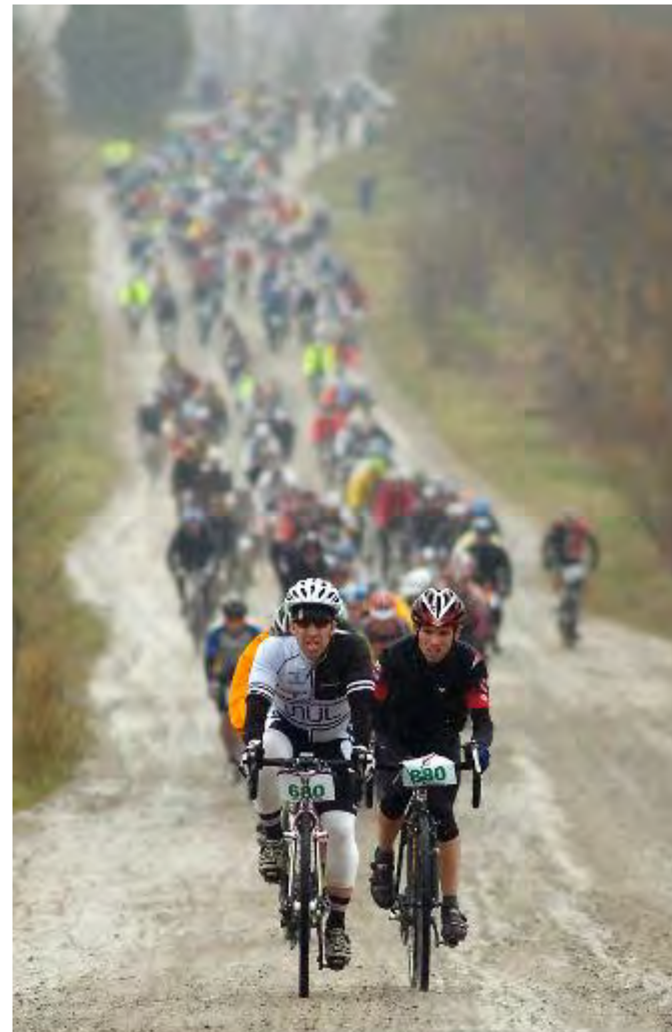
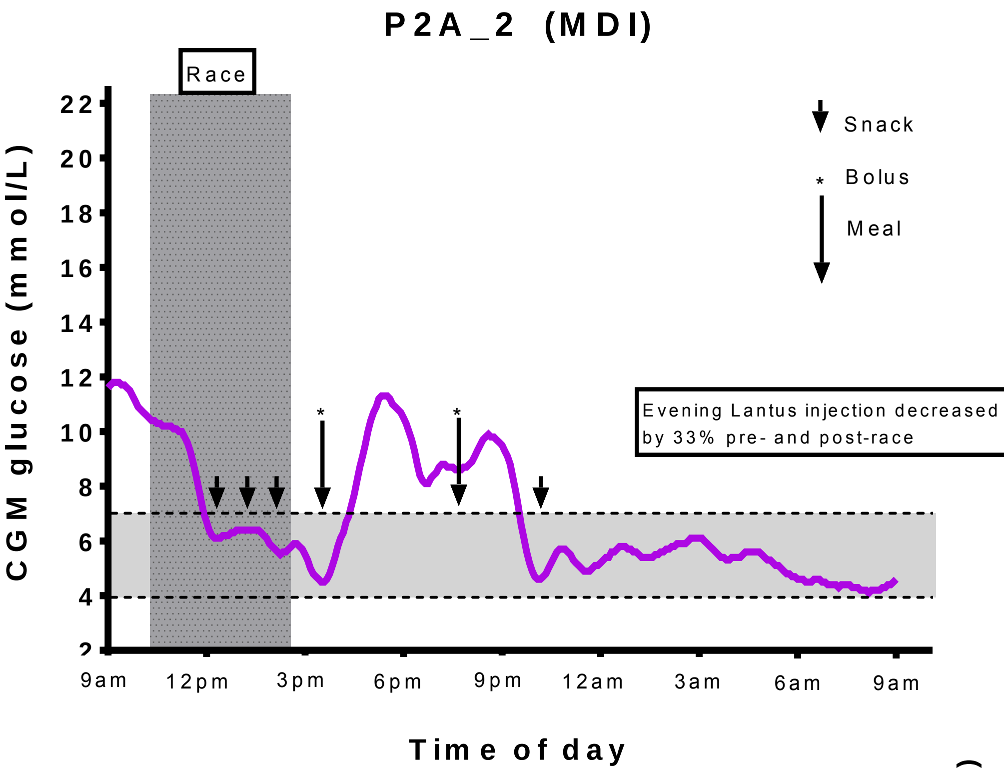
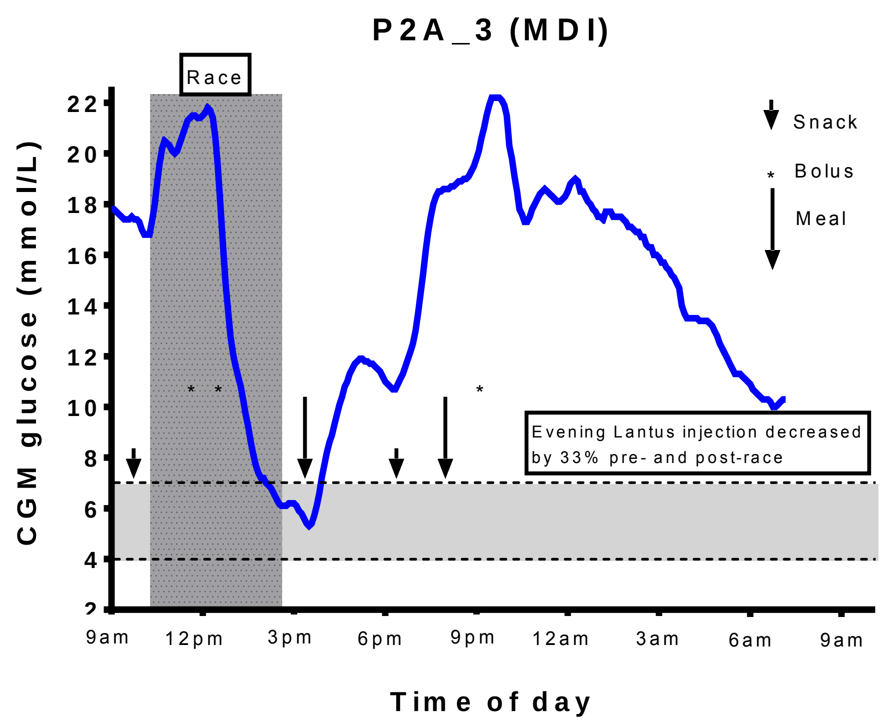
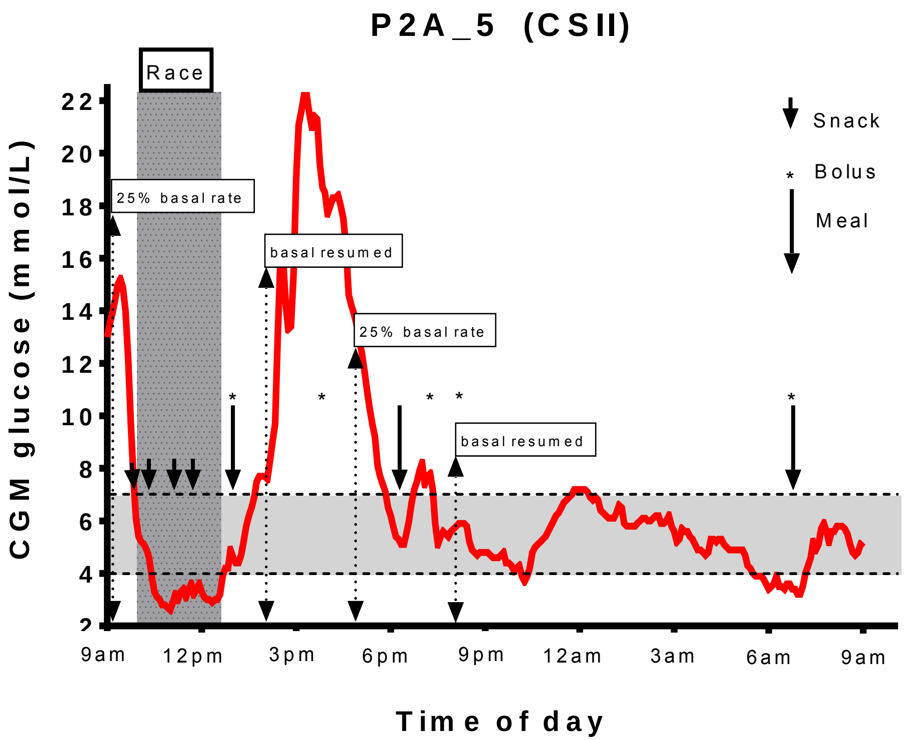




P2A_2- male type 1 for ~ 4 years normal weight, recreational cyclist, mid 40s, MDI -18 units Insulin Glargine at bedtime (reduced by 1/3)- woke up at 5.8 mM. Ate 90g CHO, 8 units rapid acting insulin.

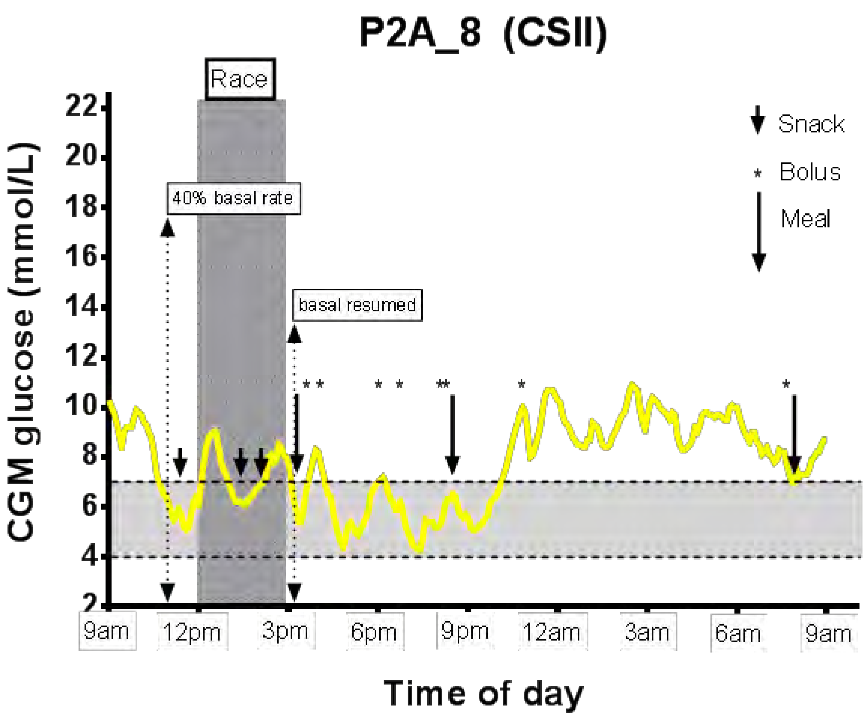
P2A_3- male type 1 for ~ 5 years normal weight, recreational cyclist, mid 20s, 28 units Insulin Glargine at bedtime- woke up at 11.2mM…Ate a bag of peanuts and M&Ms, ½ Cliff bar for breakfast





P2A_5- male elite athlete mid 30s. Sensor-augmented pump. Had full breakfast and insulin 3 hours before race. Reduced basal to 25% ~60 minutes before race. Had mechanical issues before the race and forgot to eat pre race snack. Could not get sugars up despite pump suspend and had to stop. Resumed race in frustration. Overall carb intake 156g during race.

P2A_8- male recreational athlete early 40s. Sensor-augmented pump. Had full breakfast and insulin 4 hours before race. Reduced basal to 40% ~90 minutes before race. Overall carb intake ~60g during 2 hour race.



Exercise Physiology Summary

- Metabolic control may be compromised in those most *physically* active

- Nutritional and insulin adjustment strategies depend on the:
  - Nature of the activity (aerobic vs anaerobic)
  - Timing of the activity
  - Duration of the activity

- Prolonged exercise necessitates basal insulin adjustments and modified Ex Carbs
  - Gastric emptying is delayed in heavy exercise

- Real-time sensor-augmented pumps allow for flexibility with basal insulin for exercise and early recovery

Exercise and Type 1 Diabetes: Strategies for Glucose Control Resource –Available now as a 6-page downloadable resource

Exercise and Type 1 Diabetes: Strategies for Glucose Control

Michael C Riddell, PhD | Physical Activity and Diabetes Unit | York University

IS IT IMPORTANT TO "MONITOR" MY BLOOD GLUCOSE DURING EXERCISE, OR CAN I JUST RELY ON MY SYMPTOMS?

We often hear the following "I don't need to test my blood when I exercise, because I feel my lows and highs." This may not be true. In fact, we don't think you can feel your highs and lows as well when you are exercising. In fact, exercise can often mask the symptoms of both hypo- and hyperglycemia. In one study conducted in adolescents with type 1 diabetes, it was found that adolescent boys with type 1 tended to underestimate their blood sugar when it was high and overestimate it when it was low (4). This means that you might be hypoglycemic or hyperglycemic during exercise even though you think your blood sugar is perfectly fine.

EXERCISE AND INSULIN PUMPS

The following are examples of basal reductions that can be done to compliment your exercise schedule if you are on an insulin pump:

- Reduce basal insulin by 20-90% about 60-90 minutes BEFORE the start of exercise (that lasts 60-120 minutes) until immediately at the end of exercise. The higher the intensity of aerobic exercise, the greater the reduction. In addition, if you are not going to snack during the activity, the greater the reduction.
- The greater the reduction in basal insulin, the lower the risk of hypoglycemia but the greater the risk for hyperglycemia.
- With day-long activities: reduce basal insulin for the day by 20-50% and by 20% for the night before and/or the night after the day of activity, but make