JDRF PEAK
T1D Performance in Exercise and Knowledge

PEAK PARTICIPANT CURRICULUM

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JDRF PEAK
T1D Performance in Exercise and Knowledge

DIABETES AND PHYSICAL ACTIVITY: TOP 5 TIPS FOR A SMOOOOOOTH RIDE

Participant Curriculum

General Session

Developed by:
Gary Scheiner MS, CDE, Owner & Clinical Director, Integrated Diabetes Services LLC

Presented by: Lori Laffel

Session agenda **tip sheet**

- Tip #1: It's good to be on the move
- Tip #2: Exercise & blood glucose control is a 2-way street
- Tip #3: Learn to stay in your lane
- Tip #4: Don't run out of gas (preventing lows)
- Tip #5: Don't flood the engine (preventing highs)

1 IT'S GOOD TO BE ON THE MOVE

BE ON THE MOVE

Exercise is amazing medicine

Long-term concern	Exercise effect
Heart disease	Collateral circulation Reduces risk of atherosclerosis
Elevated blood lipids	Improves cholesterol levels
High blood pressure	Reduces diastolic blood pressure
Obesity	Calorie burning Increases metabolism Appetite suppression

ACSM/ADEA joint position statement. *Diabetes Care* 2010;33:e147–e167; ADA Standards of Medical Care in Diabetes. *Diabetes Care* Volume 39, Supplement 1, January 2016; *International Journal of Obesity* (online pub 6/4/13).

BE ON THE MOVE

Exercise is amazing medicine

Short-term concern	Exercise effect
Stress	Tension release More restful sleep
Depression	Sense of control, pride
Pain	Endorphin production

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ACSM/ADEA joint position statement. *Diabetes Care* 2010;33:e147–e167.

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BE ON THE MOVE

Exercise is amazing medicine

Glucose control	Exercise effect
Insulin resistance	Increases insulin sensitivity Increases glucose uptake by muscles
Postprandial hyperglycemia	Slows carbohydrate absorption Increases glucose utilization Accelerated insulin action

ACSM/ADEA joint position statement. *Diabetes Care* 2010;33:e147–e167; ADA Standards of Medical Care in Diabetes. *Diabetes Care* Volume 39, Supplement 1, January 2016; ADA/JDRF Type 1 Diabetes Sourcebook. Alexandria, VA, American Diabetes Association, 2013, p. 249–292.

BE ON THE MOVE

People with Type 1 Diabetes at the top of their game

Gary Hall Jr.
Olympic gold medal swimmer

Doug Burns
Mr. Universe

Monique Hanley
Team Type-1 Cyclist

BE ON THE MOVE

Exercise at all levels is achievable for people with diabetes of all ages

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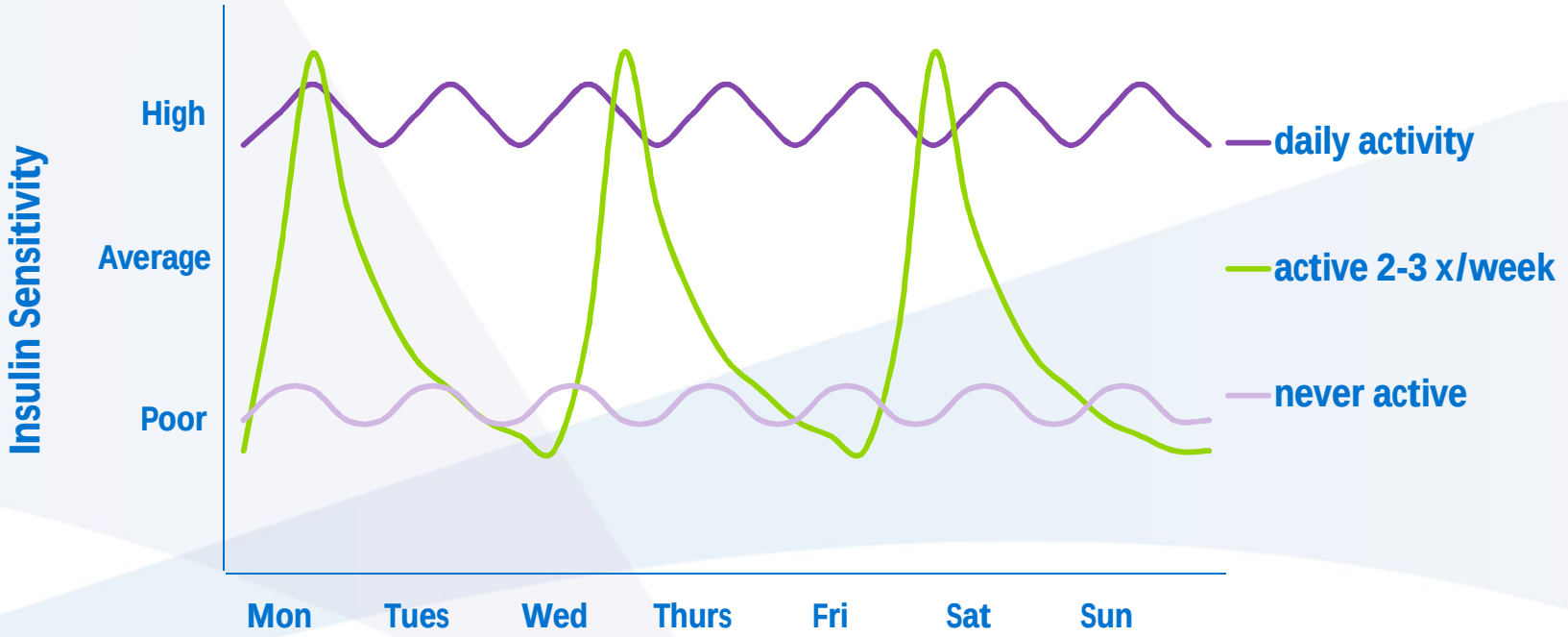
EXERCISE & BLOOD GLUCOSE CONTROL IS A TWO WAY STREET

EXERCISE AND BLOOD GLUCOSE CONTROL

Consistent physical activity produces consistent insulin sensitivity



Scheiner, G: Schematic representation of insulin sensitivity

EXERCISE AND BLOOD GLUCOSE CONTROL

Post-meal benefits of physical activity

Effects of post-meal walking:

Study Results:

30 minutes of casual stop & go walking after meals

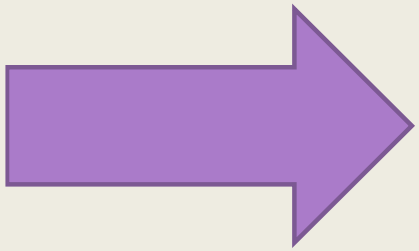
- ✓ **Average 30 mg/dL (1.75 mmol/L) post-meal blood glucose reduction**
- ✓ **Post-meal peak reduced 45%**

Manohar C, *et al., Diabetes Care*. 2012 Dec;35(12):2493-9.

EXERCISE AND BLOOD GLUCOSE CONTROL

OVERALL glucose control has physiological effects on the body

- Sleep quality
- Hydration
- Glycogen storage
- Heart/blood vessel health



Athletic Performance

EXERCISE AND BLOOD GLUCOSE CONTROL

Glucose levels during sport impact performance in many ways

- Strength
- Stamina
- Speed/agility
- Flexibility
- Safety
- Mental sharpness

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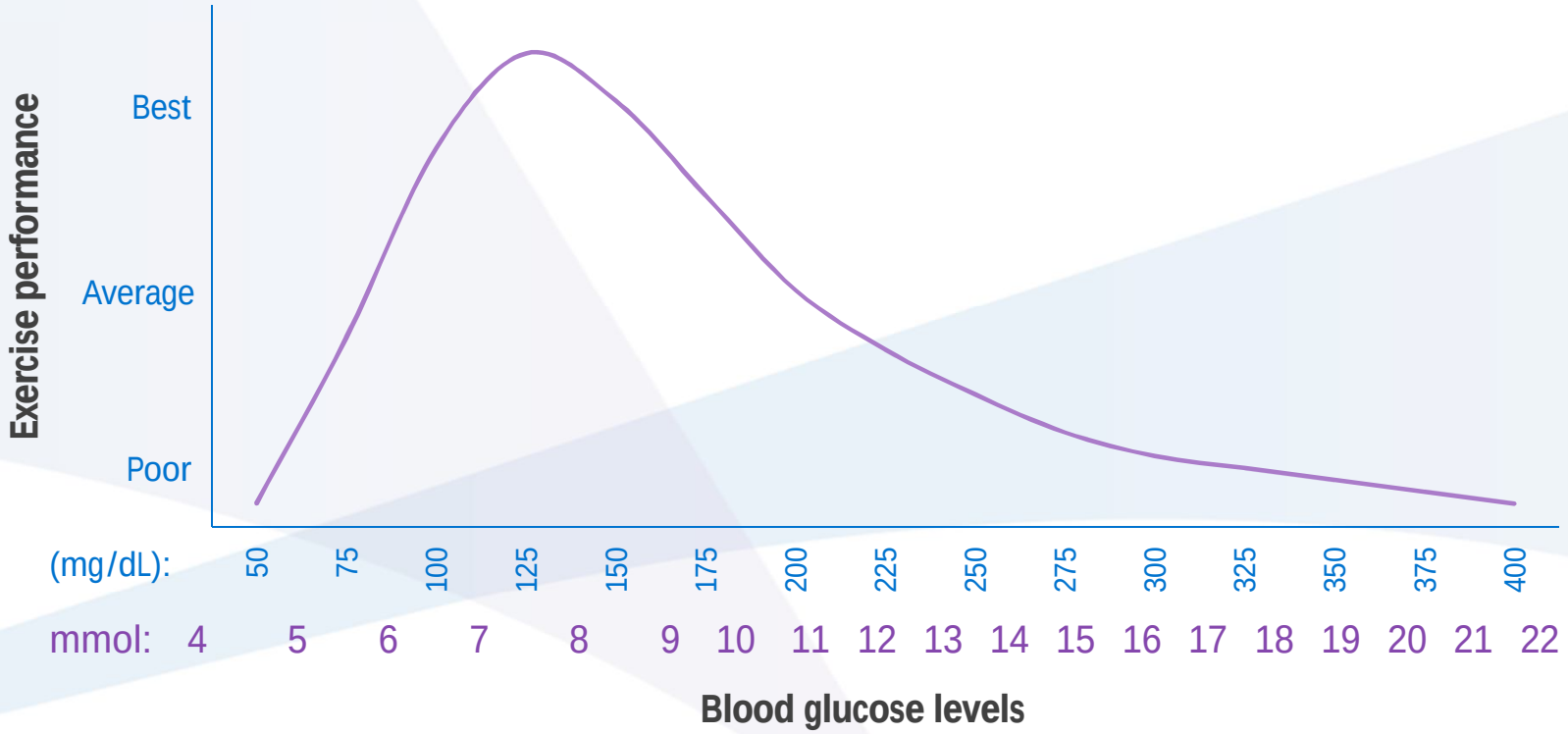
Kelly D and Riddell M. Blood Glucose Levels and Performance in a Sports Camp for Adolescents with Type 1 Diabetes Mellitus: A Field Study. *International Journal of Pediatrics* 2010; Colberg, Sheri: *The Diabetic Athlete*, Human Kinetics, Champaign, IL, 2001; Walsh J *et al:* *Using Insulin*, Torrey Pines Press, San Diego, 2003.

EXERCISE AND BLOOD GLUCOSE CONTROL

Optimal blood glucose levels during exercise



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Scheiner, G: Schematic representation based on clinical experiences and observations.
Kelly D *et al. Int J Pediatr*. 2010; 216167.Published online 2010 Aug 2

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LEARN TO STAY IN YOUR LANE

STAY IN YOUR LANE

A blood glucose balancing act

Carbohydrate

Protein, fat

Insulin resistance

Counterregulatory / stress hormones

Growth hormones

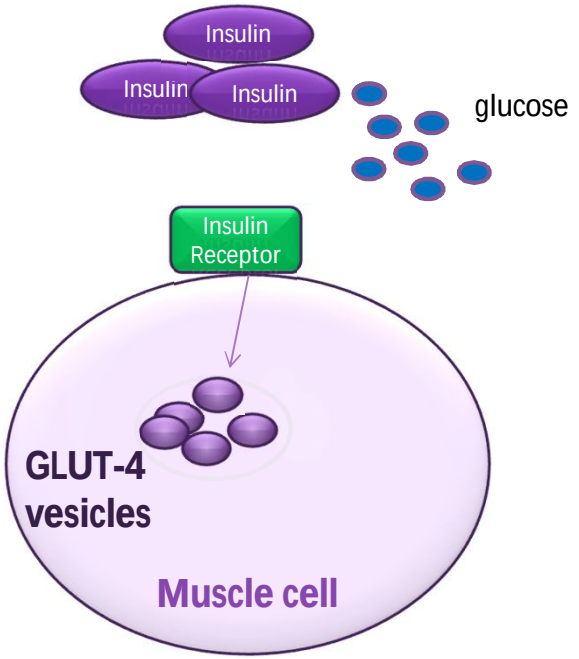
Muscle activity

Insulin

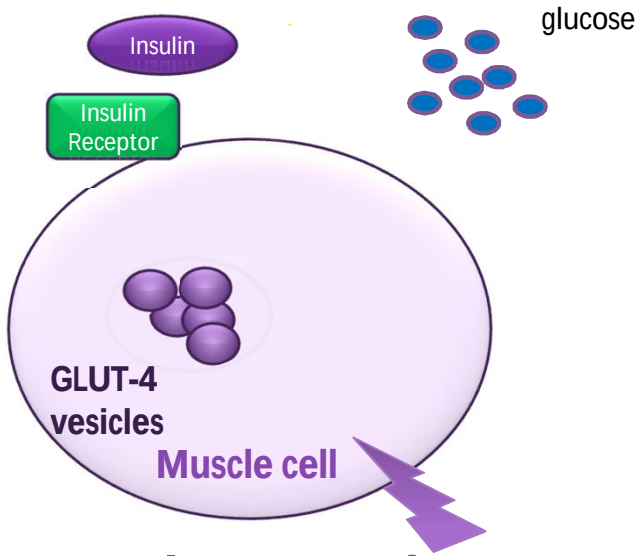
Insulin sensitivity

STAY IN YOUR LANE

Exercise accelerates glucose uptake



Rest

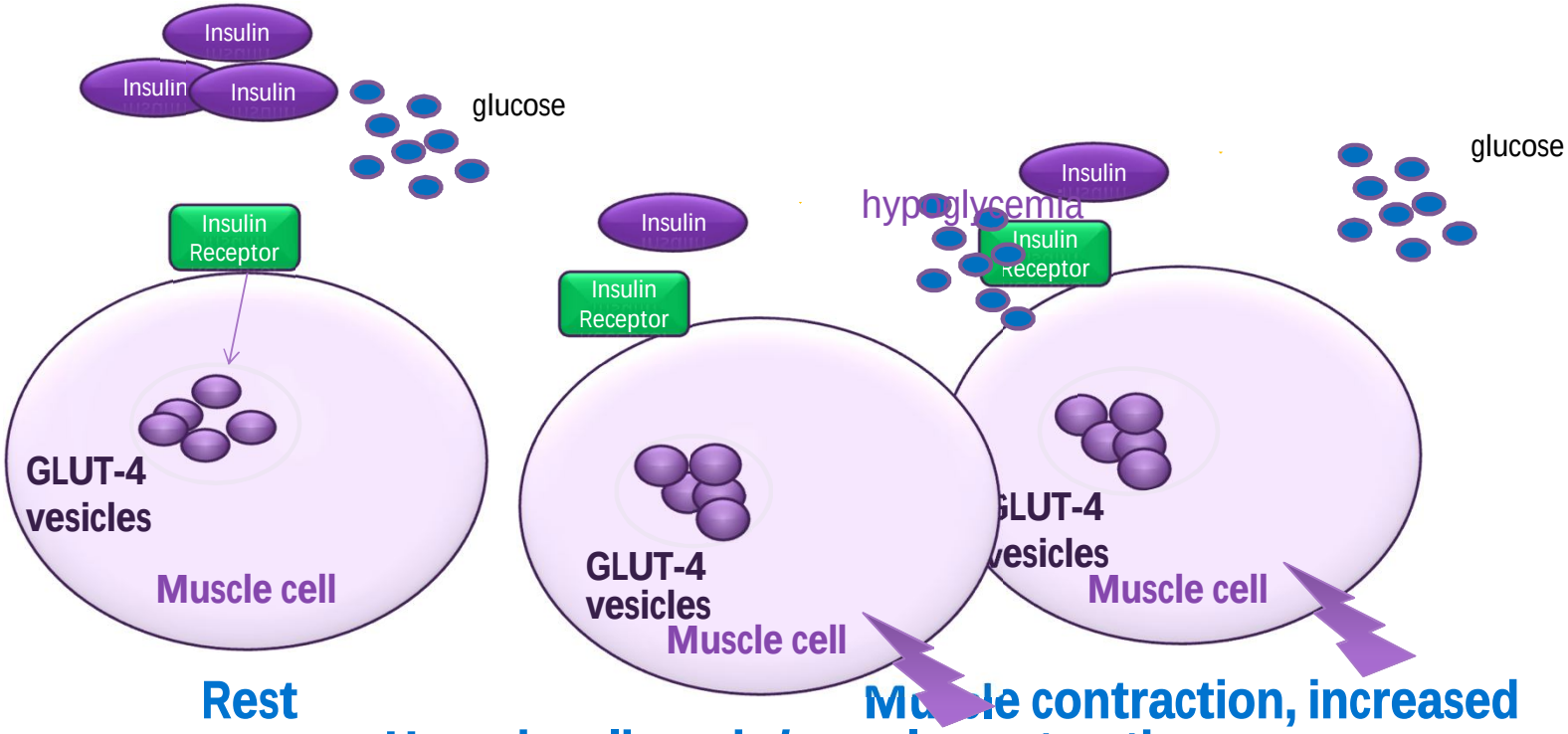


Muscle Contraction

GLUT-4, glucose transporter type 4

STAY IN YOUR LANE

Exercise accelerates glucose uptake



STAY IN YOUR LANE

Hormonal responses to aerobic exercise

Individuals without diabetes:

Insulin secretion ↓↓

Counterregulatory hormone secretion ↑
- Epi/Nepi, Glucagon, GH, Cortisol

Substrate Breakdown
- Glycogenolysis
- Lipolysis
- Amino acid utilization

BG holds *steady* despite ↑ glucose utilization by muscle

Epi, epinephrine; Nepi, norepinephrine; GH, growth hormone; BG, blood glucose

STAY IN YOUR LANE

Hormonal response to aerobic exercise

Individuals with diabetes using insulin:

Insulin levels ↔ or ↑

Counter-regulatory hormone action suppressed

- **Substrate breakdown blocked**
- **Glucose uptake accelerated**

Hypoglycemia may result

STAY IN YOUR LANE

Other effects of exercise

Can exercise cause:

Rise in blood glucose?

Ketoacidosis?

Mitchell et al., 1988. *Diabetes Care* 11:311-317; ADA/JDRF Type 1 Diabetes Sourcebook. Peters A, Laffel L, Eds. Alexandria, VA, American Diabetes Association, 2013; Marliss and Vranic *Diabetes* 2002; Fahey *et al., JCEM* 2012.

STAY IN YOUR LANE

Adrenaline raises blood glucose levels

Activities that often produce a short-term rises in blood glucose include:

- Weightlifting (high weight, low reps)
- Sports with “bursts” of activity (golf, baseball, martial arts)
- Sprints (running, swimming)
- Judged performances (gymnastics, skating)
- Events in which winning is the primary objective

STAY IN YOUR LANE

Type of exercise matters

Weightlifting

Sprints, diving, gymnastics, baseball

Wrestling, volleyball, ice hockey, golf

Rugby, football, basketball, tennis, lacrosse

Skiing (slalom & downhill), field hockey

Middle distance events

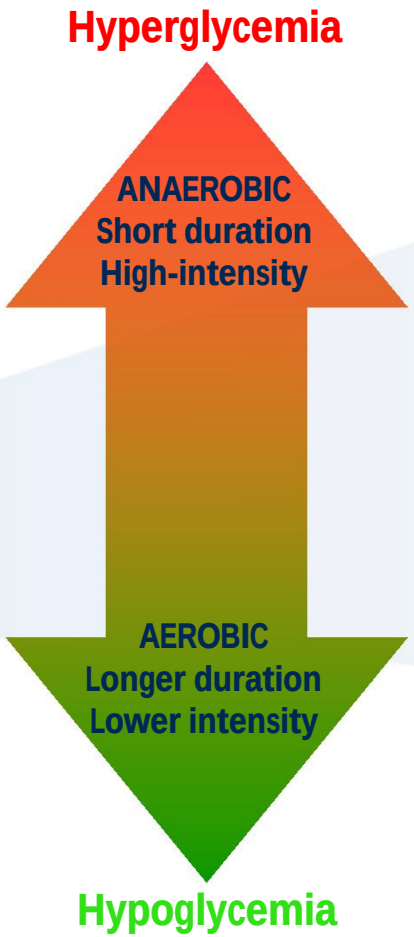
Road cycling

In-line skating

Cross country skiing

Racewalking

Long-distance running/swimming/cycling



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DON'T RUN OUT OF GAS (PREVENTING LOWS)

DON'T RUN OUT OF GAS

Preventing hypoglycemia

	Activity during peak meal insulin action	Activity before or between meals (minimal IOB)
Short duration (up to 60 min)	↓ Mealtime dose	Snack prior to activity

IOB, insulin-on-board

Mauvais-Jarvis *et al. Diabetes Care* 2003. 26(4):1316-7; Hernandez *et al. Medicine & Science in Sports & Exercise* 2000. 32(5):904-10; Rabasa-Lhoret *et al. Diabetes Care* 2001. 24(4):625-30; DirecNet Study Group *et al. Diabetes Care* 2006. 29(10):2200-4.

DON'T RUN OUT OF GAS

Insulin adjustments

Meal bolus adjustments (for post-meal activity):

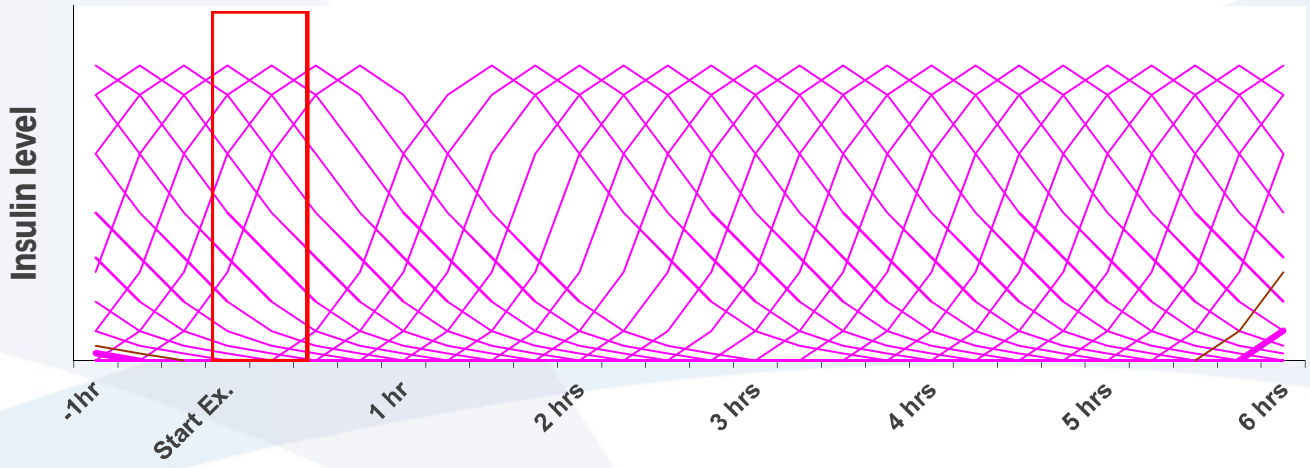
- Low intensity aerobic ↓ 25%
- Moderate intensity aerobic ↓ 50%
- High intensity aerobic ↓ 75%
- Competitive/anaerobic ???

Riddell MC, *et al. Lancet Diabetes Endocrinol* 2017, Published Online January 23, 2017.

DON'T RUN OUT OF GAS

Effect of pump disconnection on basal insulin levels

Disconnection/suspension during 30 minutes of exercise eliminates basal pulses for 30 minutes



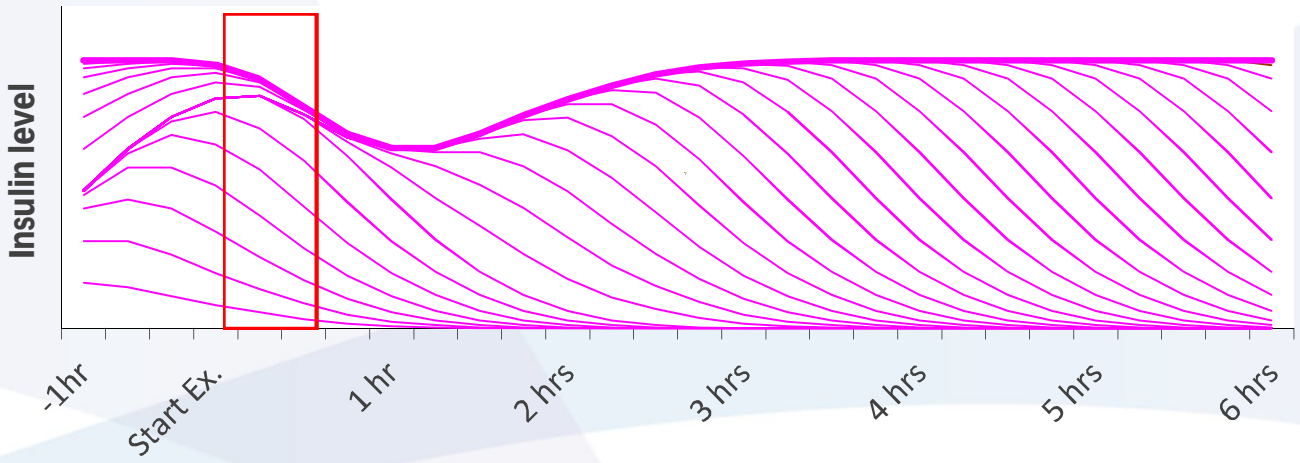
Ex, exercise

Scheiner, G: Schematic representation of basal insulin delivery, based on pharmacokinetics of rapid insulin analogs.

DON'T RUN OUT OF GAS

Effect of pump disconnection on basal insulin levels

Level of active basal insulin resulting from disconnection/suspension during 30 minutes of exercise



Disconnection during a short exercise session has minimal effect on insulin levels

Scheiner, G: Schematic representation of basal insulin delivery, based on pharmacokinetics of rapid insulin analogs.

DON'T RUN OUT OF GAS

Snacking to prevent hypoglycemia

Basic rules:

1. Snack prior to activity to prevent hypoglycemia
2. Adjust quantity based on pre-activity blood glucose and direction of blood glucose (if using CGM)
   - Blood glucose low or dropping: increase usual carbohydrates
   - Blood glucose OK or stable: maintain usual carbohydrates
   - Blood glucose high or rising: reduce usual carbohydrates
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

DON'T RUN OUT OF GAS

Snacking to prevent hypoglycemia (pre- or between-meal activity)

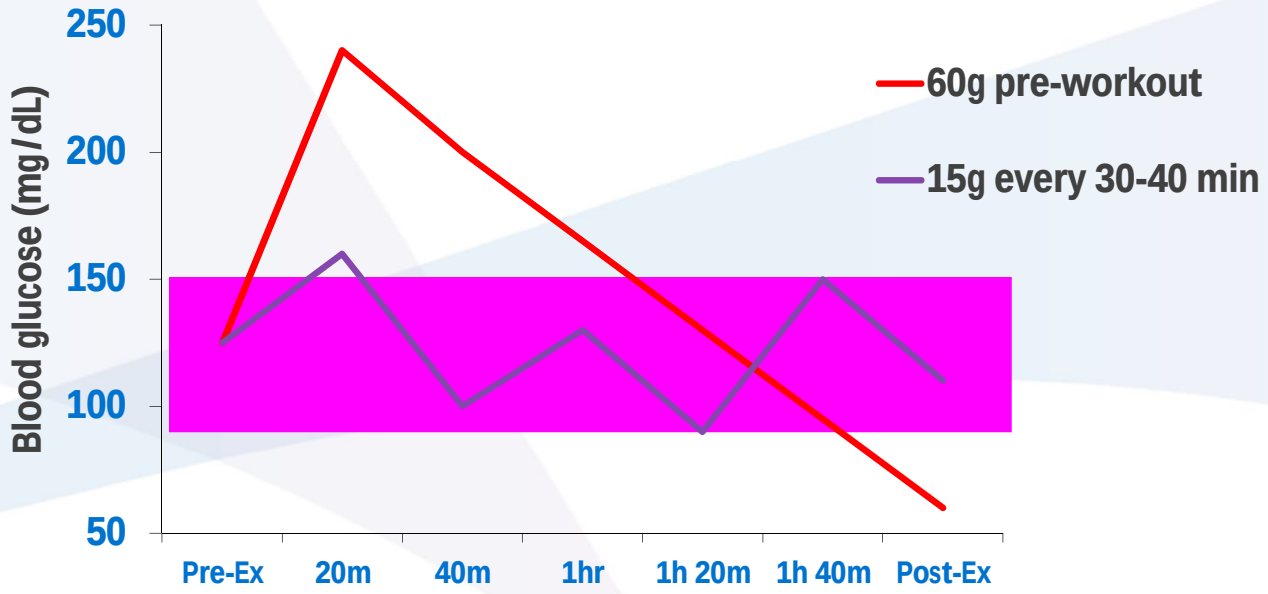
Activity level	Approximate amount of carbohydrate needed per 60 minutes of physical activity				
	50 lbs (23 kg)	100 lbs (45 kg)	150 lbs (68 kg)	200 lbs (91 kg)	250 lbs (114 kg)
Low intensity	5-8g	10-16g	15-25g	20-32g	25-40g
Moderate intensity	10-13g	20-26g	30-40g	40-52g	50-65g
High intensity	15-18g	30-36g	45-55g	60-72g	75-90g

Francescato *et al. International Journal of Sports Medicine* 2008. 29(9):706-12; Mauvais-Jarvis *et al. Diabetes Care* 2003. 26(4):1316-7; Ramires *et al. Journal of Applied Physiology* 1997. 83(2):608-14; Riddell *et al. Journal of Applied Physiology* 2000. 88(4):1239-46; West *et al. Medicine & Science in Sports & Exercise* 2001. 43(2):204-10.

DON'T RUN OUT OF GAS

Keeping blood glucose in range for the majority of a long workout

Example:
Two hours moderate-intensity exercise, weight 150 lbs
Total carbohydrate requirement = 60g



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Scheiner, G: Schematic representation of glucose response to carbohydrate intake during exercise.

DON'T RUN OUT OF GAS

For mealtime insulin users trying to lose weight

- Better to Exercise BEFORE eating?
- Better to Exercise AFTER eating?

DON'T RUN OUT OF GAS

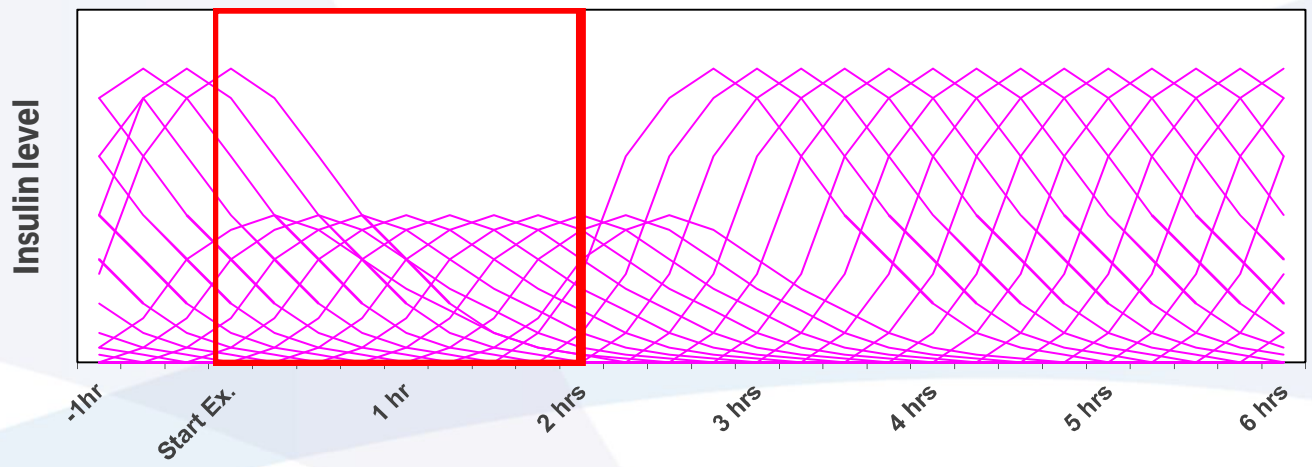
Preventing hypoglycemia

	Activity starting during peak insulin action	Activity starting before or between meals
Long duration (>90 minutes)	↓ Mealtime bolus ↓ Basal rate Snack at regular intervals Watch for delayed-onset hypoglycemia	Snack prior to activity ↓ Basal rate (if using pump) Snack at regular intervals Watch for delayed-onset hypoglycemia

DON'T RUN OUT OF GAS

Effect of pump temp rate on basal insulin levels

Temp basal -50% starting 1-hr prior to 2-hr exercise until 30 minutes before completion:

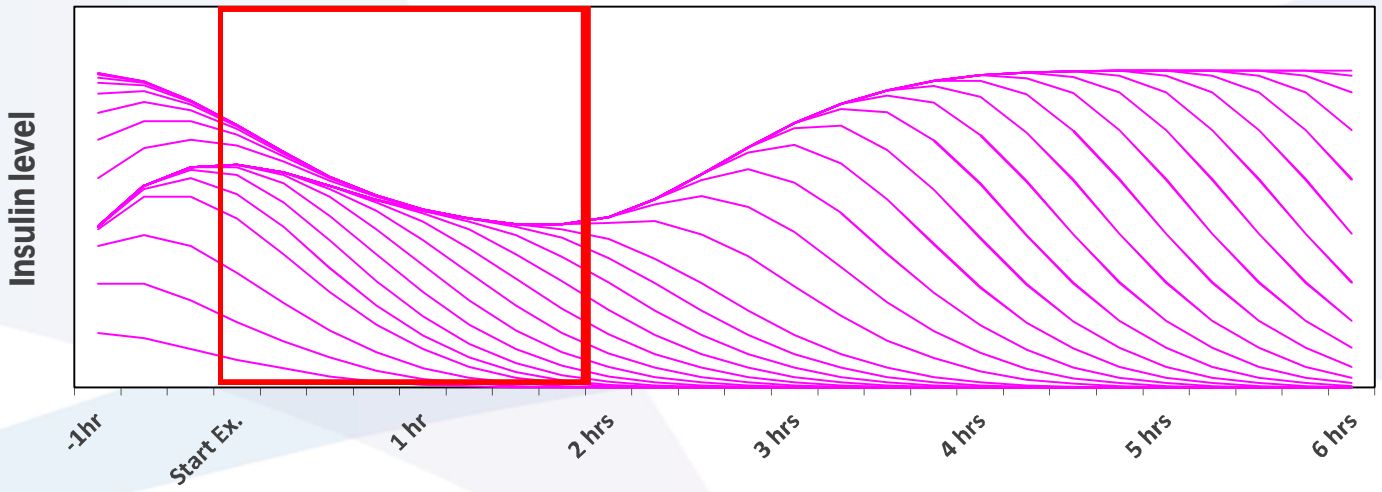


Scheiner, G: Schematic representation of basal insulin delivery, based on pharmacokinetics of rapid insulin analogs.

DON'T RUN OUT OF GAS

Effect of pump temp basal on basal insulin levels

Level of active basal insulin from temp basal -50% starting 90 minutes prior until 90 minutes before completion of 2-hour exercise:



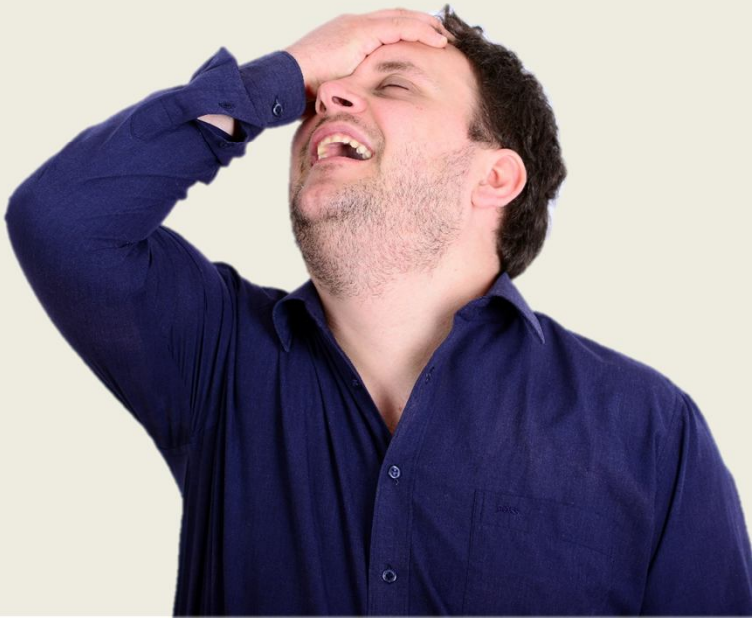
This approach results in a modest reduction in basal insulin throughout and immediately post-exercise

Scheiner, G: Schematic representation of basal insulin delivery, based on pharmacokinetics of rapid insulin analogs.

DON'T RUN OUT OF GAS

Watch out for "**D'OH!**" (**D**elayed **O**nset **H**ypoglycemia)

- Following exhaustive forms of exercise
- Due to replenishment of muscle glycogen stores and enhanced insulin sensitivity
- May occur up to 24 hours afterwards (typically 6-12 hours later)

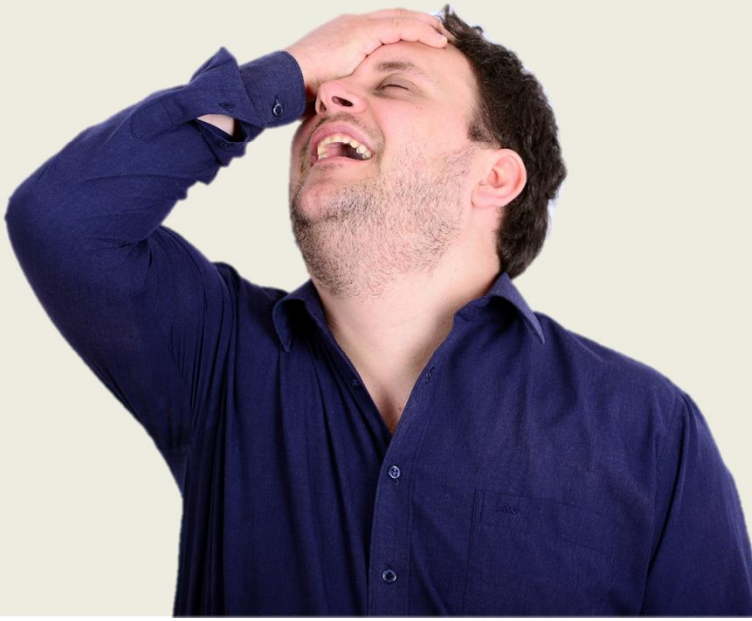


Iscoe *et al. Can J Diabetes* 2008; Jensen and Richter. *J Physiol* 2012.

DON'T RUN OUT OF GAS

"D'OH!" prevention

- Keep records – track the patterns
- Use CGM!
- ⬇ basal insulin or ⬇ meal boluses post-activity
- "Free" snacks (slow-acting carbohydrates) following activity



CGM, continuous glucose monitoring

Taplin *et al. Journal of Pediatrics* 2010. 157(5):784-8 e1; Perry and Gallen. *Practical Diabetes International* 2009. 26 (3) (pp 116-123); Campbell *et al. BMJ Open Diabetes Research and Care* 2015. 3:e000085.

5

DON'T FLOOD THE ENGINE (PREVENTING HIGHS)

DON'T FLOOD THE ENGINE

Preventing or offsetting the rise in blood glucose

1. Keep records to determine which activities/situations lead to a rise
   - *Find your average blood glucose rise*
2. Check BG 30-60 minutes before activity
3. Bolus 30-60 minutes prior to activity to offset rise
   - *Give 50% of usual amount required*
4. If elevated post-workout, give 50% of usual correction dose

BG, blood glucose
Turner *et al., Diabet Med*. 2015 Jul 29.

DON'T FLOOD THE ENGINE

The pre-workout rise

POSSIBLE CAUSE:

- Emotional stress

POSSIBLE SOLUTIONS:

- Relaxation exercises
- Paced breathing
- Visualization
- Distraction

DON'T FLOOD THE ENGINE

The post-workout rise

POSSIBLE CAUSES:

- Pump suspension/disconnection
- Delayed food digestion
- Excess carbohydrates during workout
- Latent stress hormones

POSSIBLE SOLUTIONS:

- Post-workout bolus
- Delay all (or part) of pre-workout meal bolus
- Limit suspension/disconnection time
- Appropriate carbohydrate supplementation

DON'T FLOOD THE ENGINE

Exercising with hyperglycemia

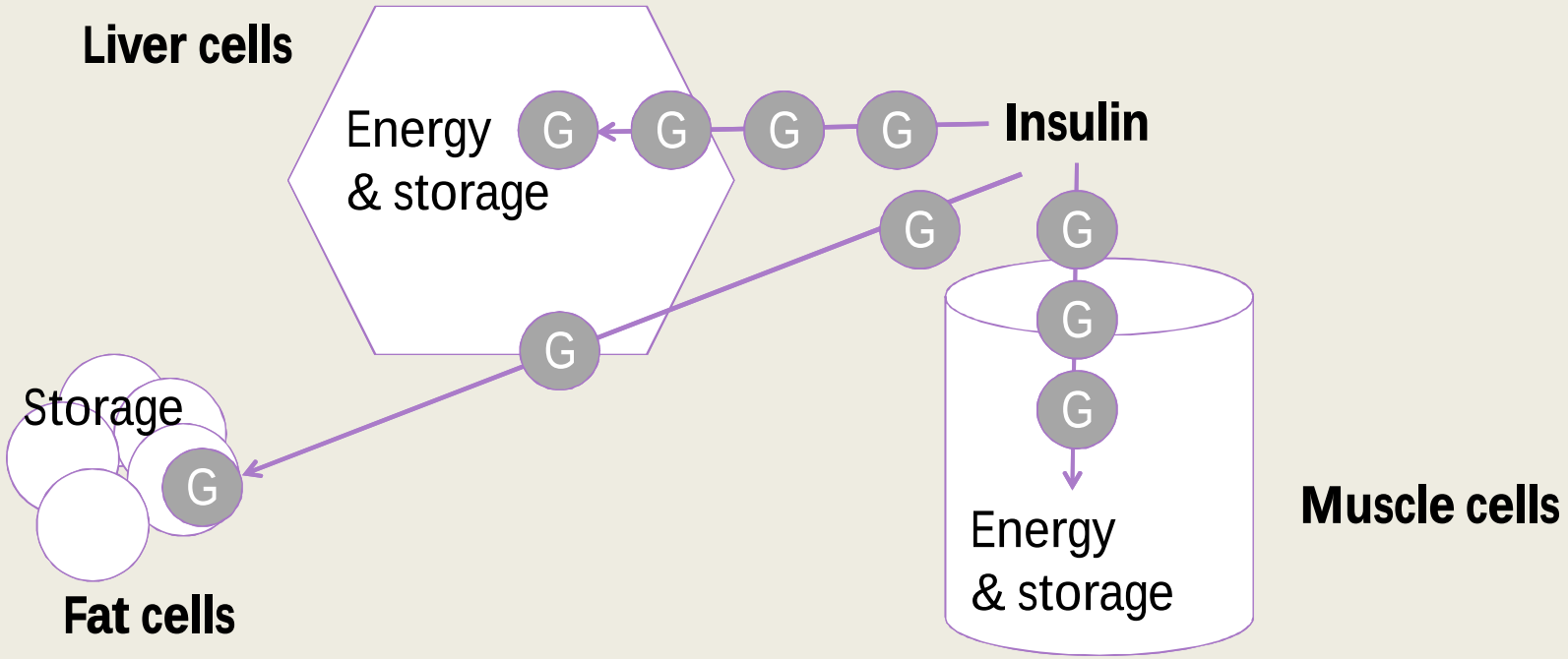
How high is too high?

→ No such number

- Performance may suffer
- Hydrate
- Administer rapid-acting insulin
- **The exception: Ketosis**

DON'T FLOOD THE ENGINE

Normal insulin (insulin sufficiency)



G, glucose

Wahren J *et al. J Clin Invest* 1975. 55:1303-1314; Gary Scheiner and Michael Riddell.

DON'T FLOOD THE ENGINE

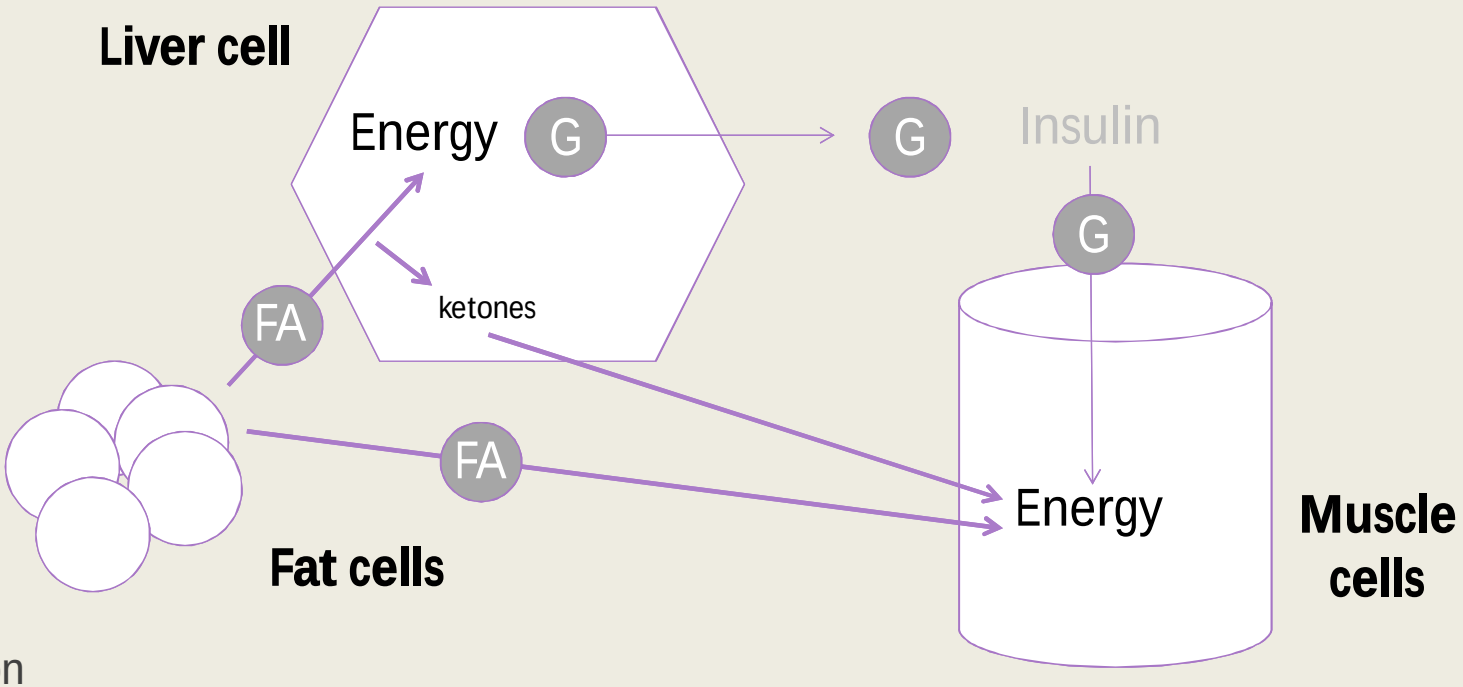
Abnormal insulin (insulin deficiency)

Possibly due to:

- Missed injections
- Spoiled insulin
- Poor absorption
- Insufficient dose
- Illness/infection

Pump problems:

- Occlusion
- Air in tubing
- Cannula dislodgement
- Extended disconnection



G, glucose; FA, fatty acid

Wahren J *et al. J Clin Invest* 1975. 55:1303-1314; Gary Scheiner and Michael Riddell.

DON'T FLOOD THE ENGINE

Exercise during insulin deficiency

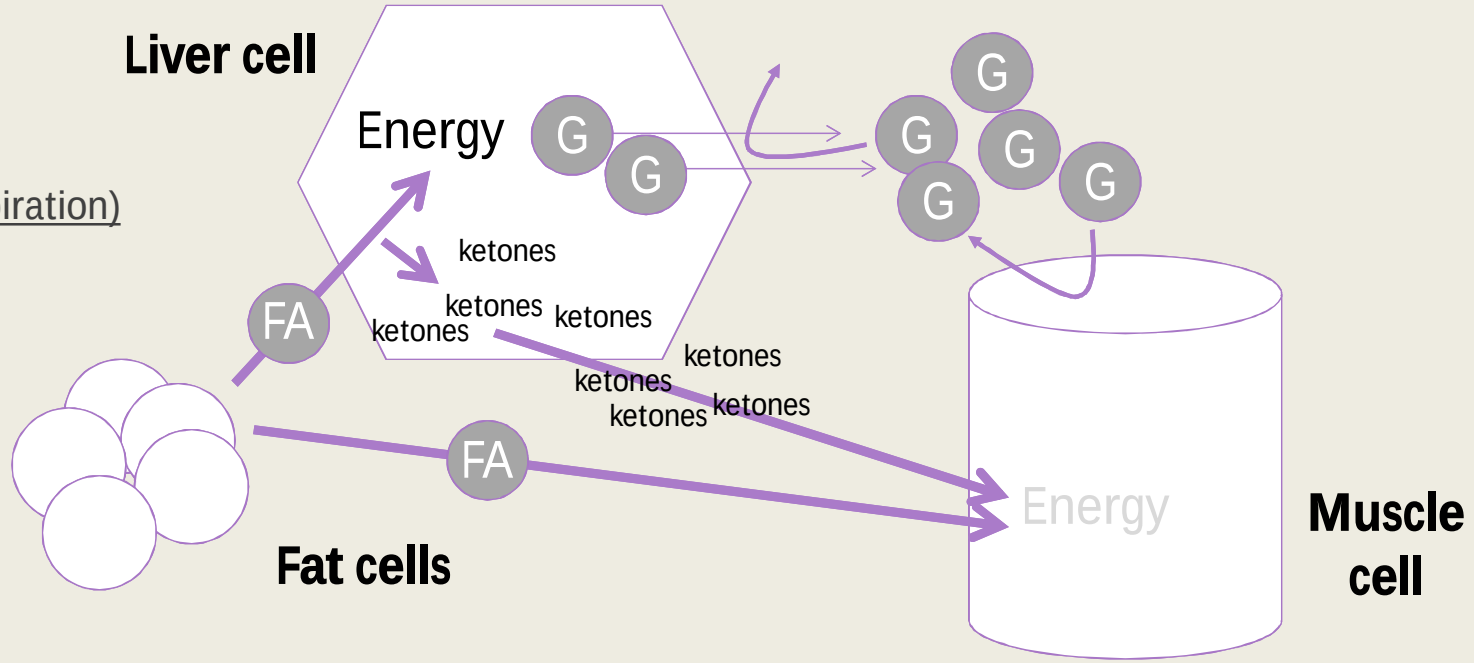
Results:

Higher blood glucose

+ More ketones

+ Dehydration (urination, perspiration)

****KETOACIDOSIS****



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G, glucose; FA, fatty acid

Wahren J *et al. J Clin Invest* 1975. 55:1303-1314; Gary Scheiner and Michael Riddell.

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DON'T FLOOD THE ENGINE

A lack of insulin causes ketone production

To prevent ketoacidosis:

- Check for ketones prior to exercise when blood glucose levels are high for no apparent reason
- Do not exercise when positive for ketones
- Do not exercise if insulin dose was missed
- Do not exercise if ill or infection is present
- If using a pump – do not disconnect for more than 90 minutes without replacing missed insulin

DON'T FLOOD THE ENGINE

Factors that affect blood glucose during exercise

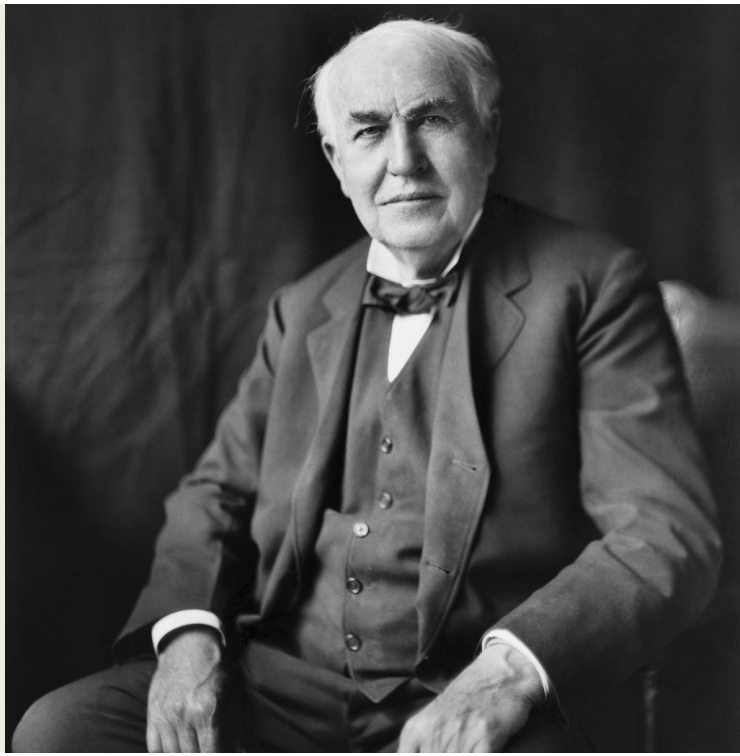
- Active insulin
- Infusion site
- Food consumed
- Time of day
- Emotional state
- Temperature and humidity
- Amount of prior activity
- Size and number of muscles involved
- Duration
- Intensity
- Familiarity with activity (training effect)

There are A LOT of variables!!!

Romijn *et al., Am J Physiol* 1993; Van Loon *et al., J Physiol* 2001; San Millan, I and Brooks, GA. 2015.

“I have not failed. I’ve just found 10,000 ways that won’t work”

Thomas Edison (1847-1931)



Get your motor runnin'…

- Physical activity **IS** important
- Exercise affects glucose control, glucose control affects exercise
- Consider the big blood glucose picture
- Strategize to avoid lows
- Strategize to avoid highs

Acknowledgements:

JDRF IMPROVING LIVES. CURING TYPE 1 DIABETES.

Thank you!