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IMPROVING LIVES. CURING TYPE 1 DIABETES. **T1D**



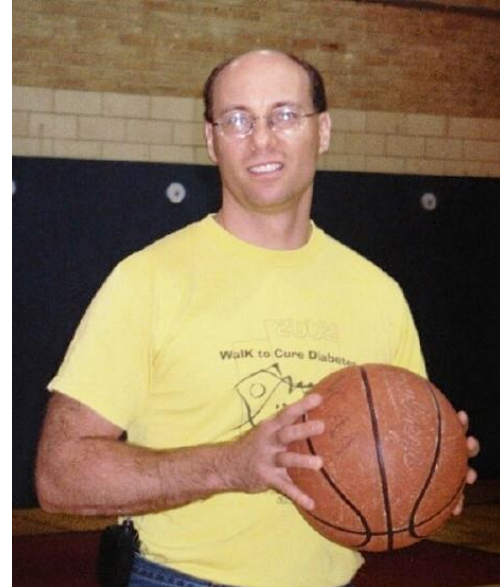
BLOOD GLUCOSE CONTROL WITH SPORTS & FITNESS ACTIVITIES

Presented by: Gary Scheiner MS, CDE

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What Is My Favorite Sport?

- A. Miniature Golf
- B. Accounting
- C. Basketball





Objectives

- Optimize glycemic control to enhance physical/athletic performance
- Prevent hypoglycemia during and after physical activity
- Prevent exercise-induced hyperglycemia, ketosis and DKA
- Manage the logistics of wearing an insulin pump during physical activity

Blood Glucose Affects:



- ✓ **Strength**
- ✓ **Stamina**
- ✓ **Speed/Agility**
- ✓ **Flexibility**
- ✓ **Safety**
- ✓ **Mental Sharpness**

Sources: Colberg, Sheri: [The Diabetic Athlete](#), Human Kinetics, Champaign, IL, 2001.

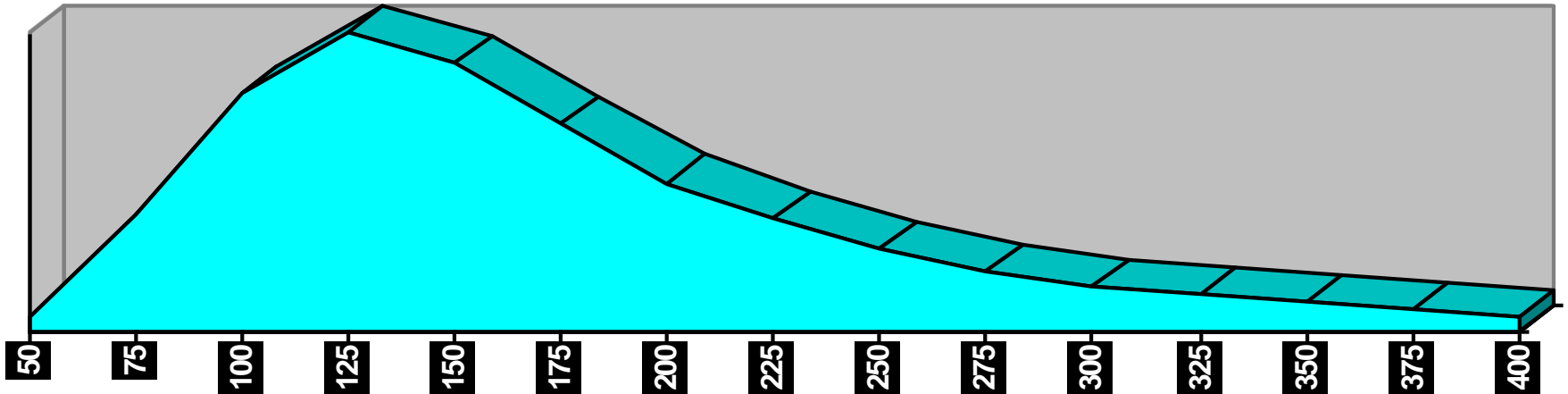
Walsh J et al: [Using Insulin](#), Torrey Pines Press, San Diego, 2003.

Powers & Howley: [Exercise Physiology](#), Wm C Brown Publishers, 1990.

Diabetes Exercise & Sports Association North American Conferences, 2004 through 2007

What BG Is Optimal?

Exercise Performance



Mmol: 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

Source: Diabetes Exercise & Sports Association North American Conferences, 2004 through 2007

Overall Glucose Management Also Counts!

Prior Hyperglycemia Affects:

- ✓ Hydration
- ✓ Sleep Quality

Prior Hypoglycemia Affects:

- ✓ Glycogen Storage
- ✓ Sleep Quality



Hypoglycemia Prevention

Fuel Utilization During Exercise

1 st 5-10 seconds	10 sec - ~ 10 min	~ 10 – ~30 min.	~ 30 min onward
Stored ATP/CP ↓	Anaerobic <u>Glycolysis</u>	<u>Oxidative (aerobic) metabolism</u>	
	IM glucose	Hepatic Glycogenolysis	Hepatic (FFA) Gluconeogenesis

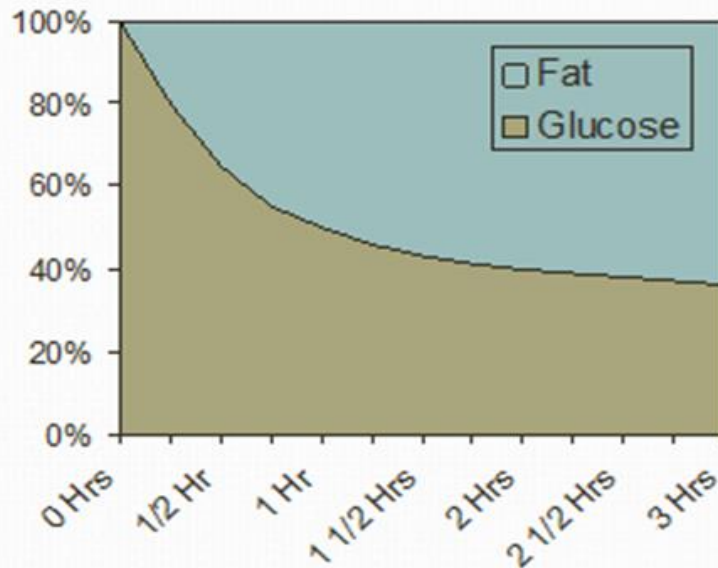
Likelihood of Hypoglycemia:
very low
moderate
very high
low
high

Scheiner, Gary, MS CDE

Source: Source: Brooks & Fahey: Exercise Physiology: Human Bioenergetics and its Applications, Macmillan Pub., NY, 1985.

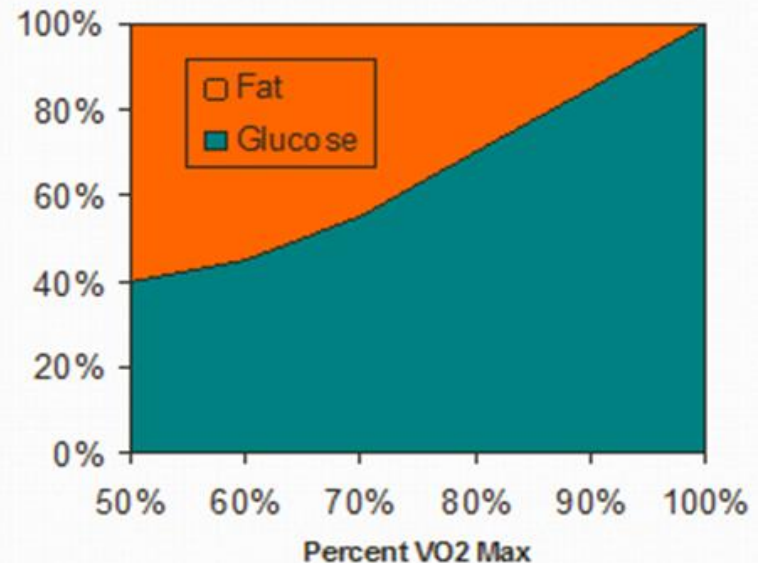
Energy Sources During Exercise

Substrate vs. Duration



BG drops more rapidly during 15-60 minute phase of prolonged exercise

Substrate vs. Intensity

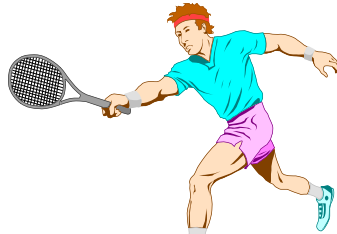


BG drops more rapidly as exercise intensity increases

Scheiner, Gary, MS CDE

Source: Source: Brooks & Fahey: [Exercise Physiology: Human Bioenergetics and its Applications](#), Macmillan Pub., NY, 1985.

Hormonal Responses to Exercise (non-diabetic)



Insulin
Secretion ↓↓

Counterregulatory Hormone Secretion ↑
• Epi/Nepi • Glucagon • GH, Cortisol



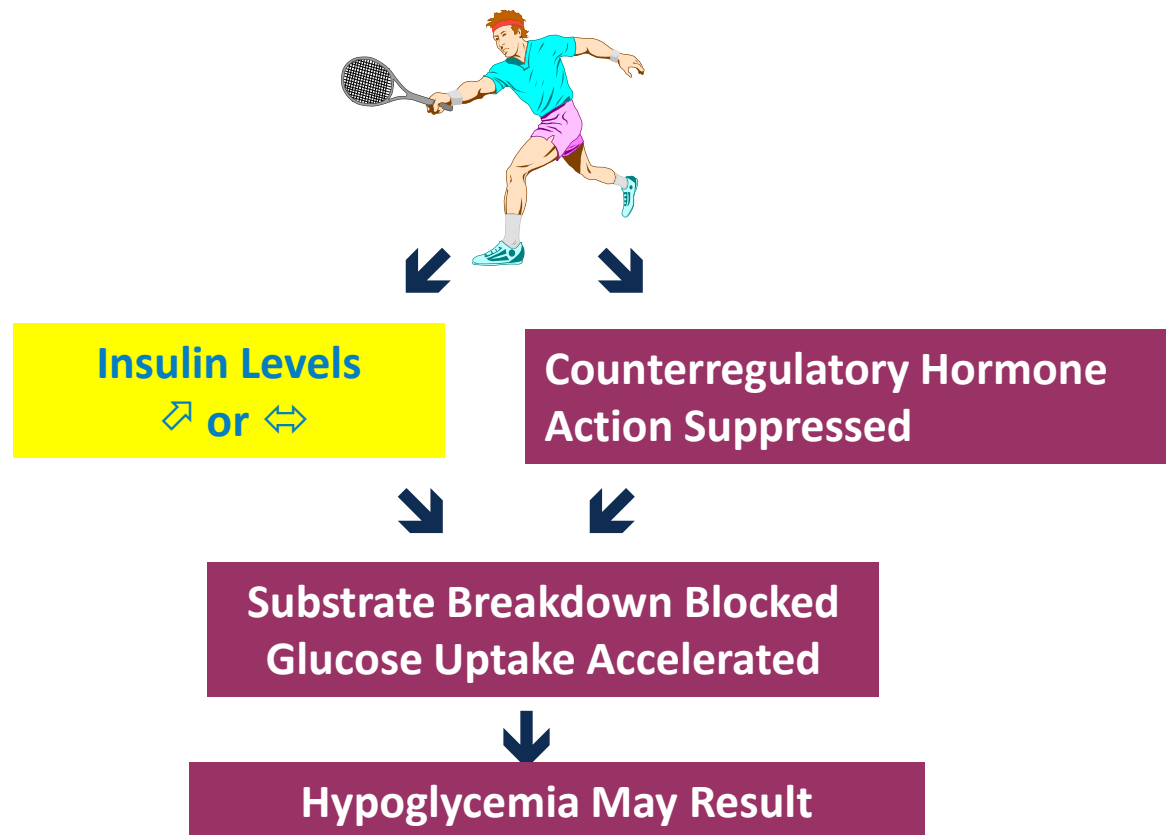
Substrate Breakdown

- Glycogenolysis
- Lipolysis
- A.A. Utilization



BG Holds *Steady* Despite
↑ Glucose Utilization by Muscle

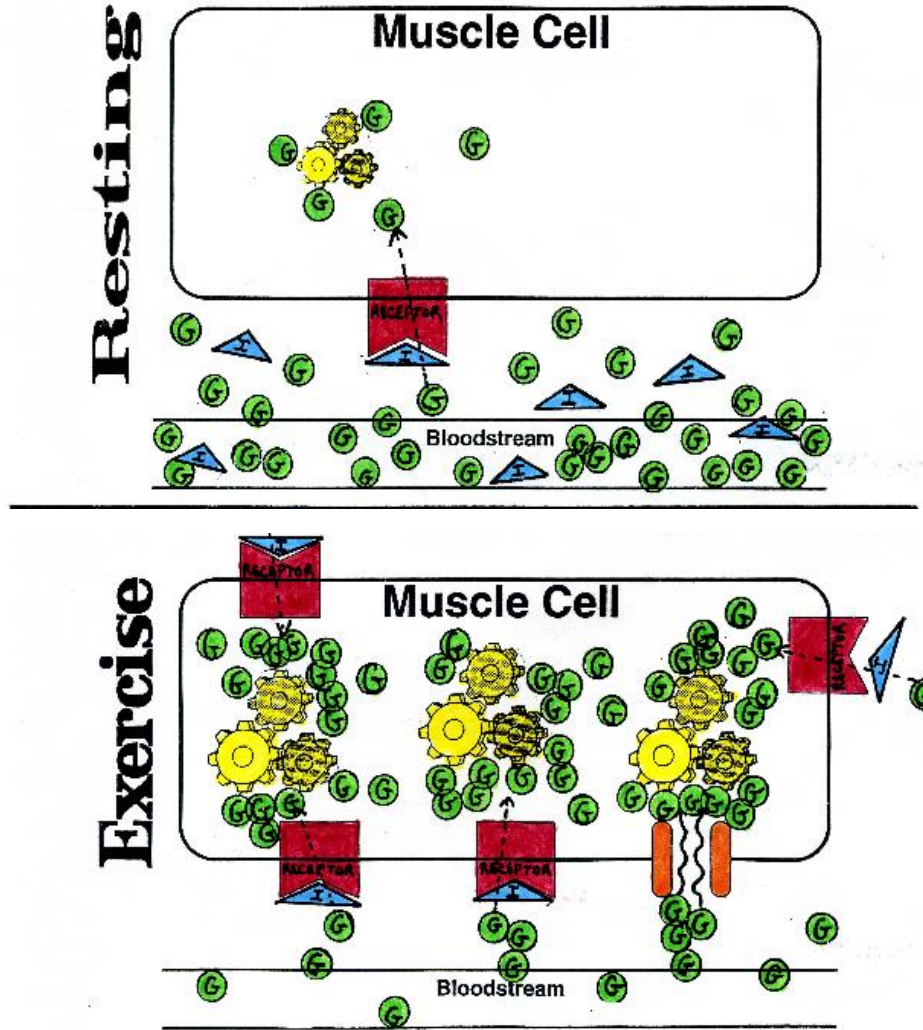
Hormonal Responses to Exercise (diabetes, using insulin)



Scheiner, Gary, MS CDE

Source: Brooks & Fahey: [Exercise Physiology: Human Bioenergetics and its Applications](#), Macmillan Pub., NY, 1985.

How Is Glucose Uptake Accelerated?



Who Is At Risk of Hypoglycemia?

Premixed Insulin Users

MDI/Pump Users

Basal Insulin (Only) Users

Meglitinide Users

Sulfonylurea Users

Combination Med Users

Insulin Adjustment Based on Timing and Duration

	Activity Within 2 Hours After Meal	Activity Before or Between Meals
Short Duration (<90 Minutes)	↓ Mealtime Bolus (Omit Meglitinide)	Snack Prior to Activity

Derived from: [Diabetes Care](#), vol. 24, no. 4, 4/2001, 625-630.

Which is better for promoting weight loss?

- Exercise **BEFORE** eating?
- Exercise **AFTER** eating?



Insulin Adjustment Based on Timing and Duration

	Activity Within 2 Hrs After Meal	Activity Before or Between Meals
Long Duration (>90 Minutes)	<p>↓ Mealtime Bolus (omit meglitinide)</p> <p>↓ Basal Rate</p> <p>Snack at regular intervals</p> <p>Watch for delayed-onset hypoglycemia</p>	<p>Snack Prior to Activity</p> <p>↓ Basal Rate (if using pump)</p> <p>Snack at regular intervals</p> <p>Watch for delayed- onset hypoglycemia</p>

Insulin Adjustments

Meal Bolus Adjustment

(for post-meal activity)

- ▶ Low Intensity Cardio ↓ 25%
- ▶ Mod. Intensity Cardio ↓ 33%
- ▶ High Intensity Cardio ↓ 50%
- ▶ **Competitive/Anaerobic ???**

Derived from: [Diabetes Care](#), vol. 24, no. 4, 4/2001, 625-630.

Source: Scheiner, Gary: [Think Like A Pancreas](#), Marlowe Publishing, NY, 2005

Insulin Adjustments

Basal Adjustment

(for > 90 min. activity)

- ▶ CSII: ↓ Basal rate 50% starting 1 hr pre-activity, *or*:
- ▶ CSII: Disconnect 1-hr prior, but reconnect hourly and bolus 50% of usual basal rate

(for day-long activity)

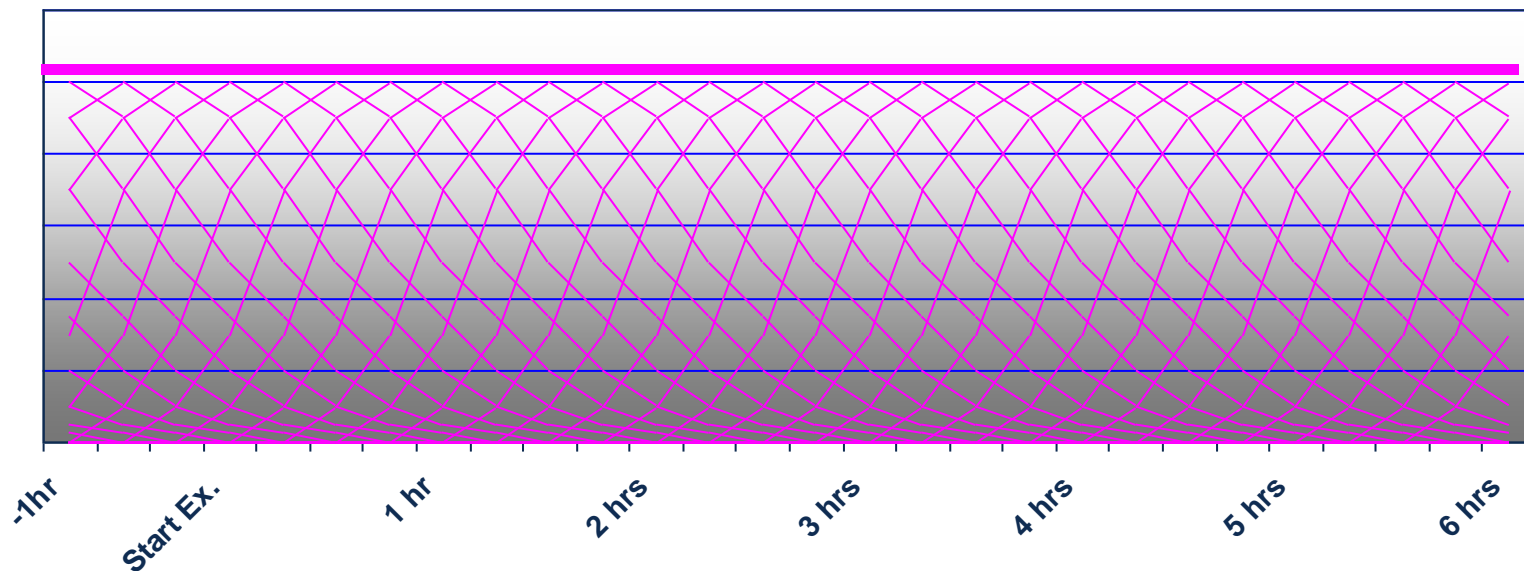
- ▶ CSII: ↓ basal 50% daytime, 25% nighttime
- ▶ Shots: ↓ basal insulin 25%

Derived from: [Diabetes Care](#), vol. 24, no. 4, 4/2001, 625-630.

Source: Scheiner, Gary: [Think Like A Pancreas](#), Marlowe Publishing, NY, 2005

Pump disconnection: Effect on basal insulin level

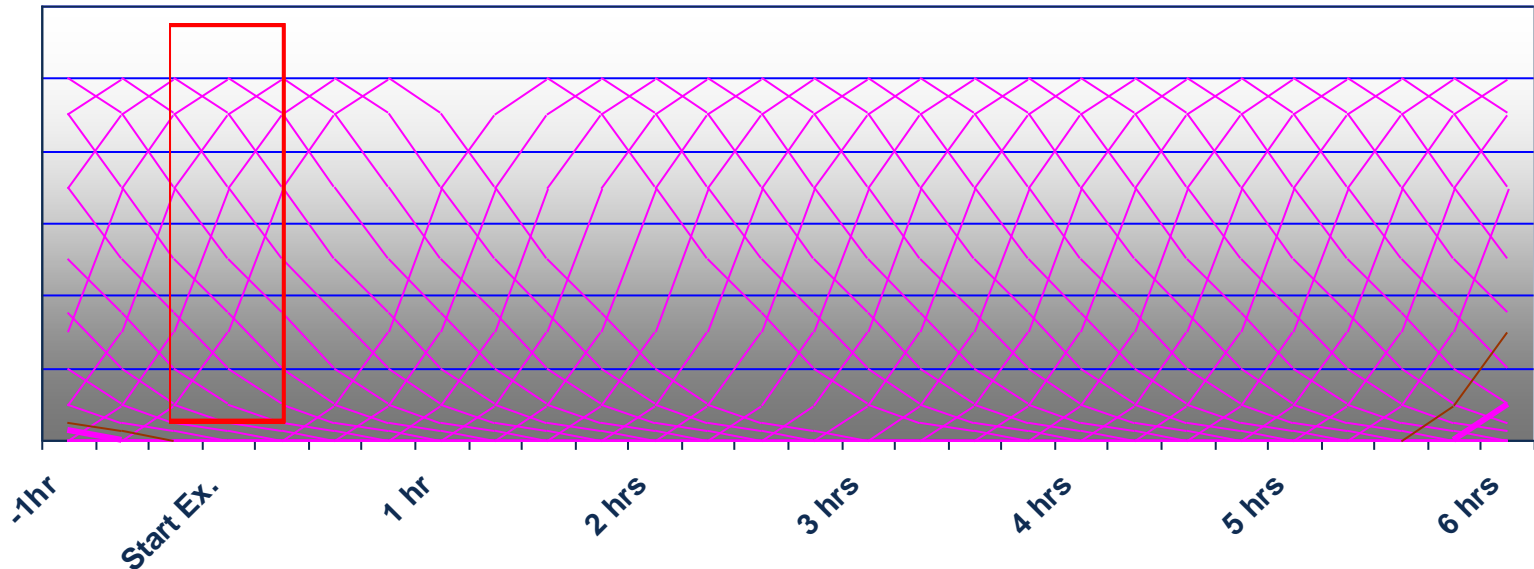
Basal insulin is a series of minute boluses.



Based on observed pharmacodynamics of rapid-acting insulin analogs

Pump disconnection: Effect on basal insulin level

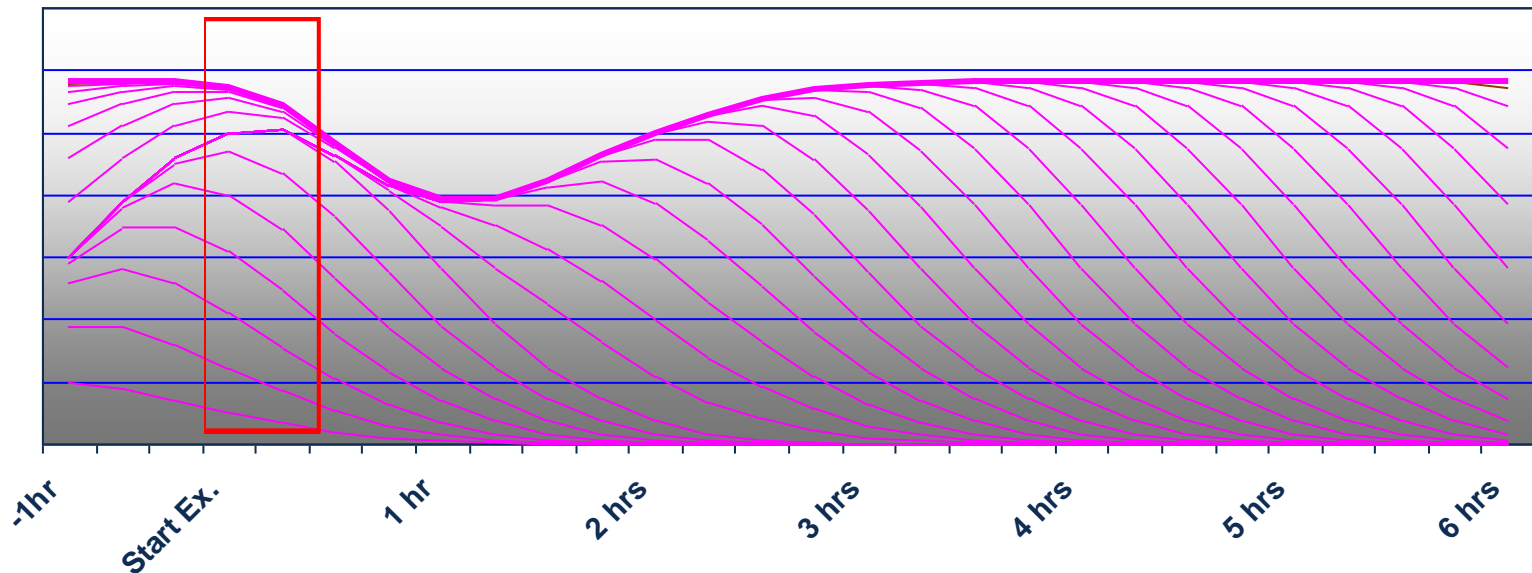
Disconnection during 30 min. exercise (red box)
eliminates bolus pulses for 30 minutes



Based on observed pharmacodynamics of rapid-acting insulin analogs

Pump disconnection: Effect on basal insulin level

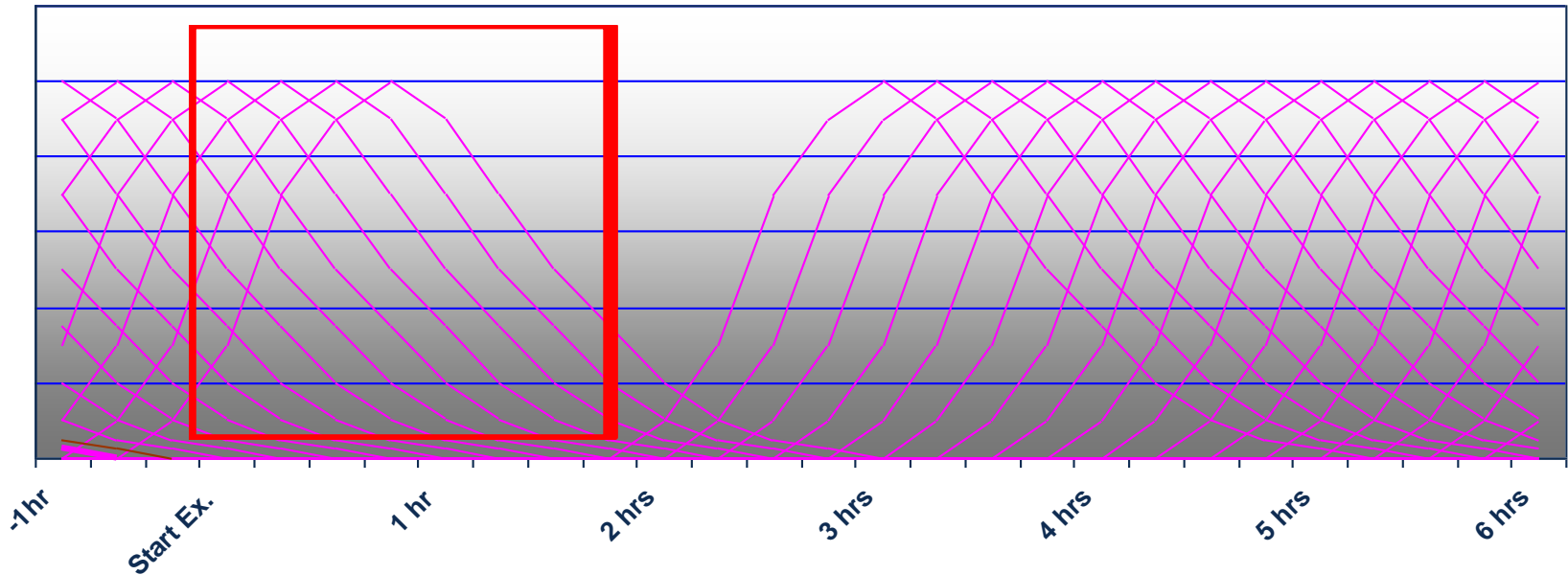
Level of active basal insulin resulting from 30 minutes disconnection during exercise



Disconnection during a short exercise session has minimal effect !

Pump disconnection: Effect on basal insulin level

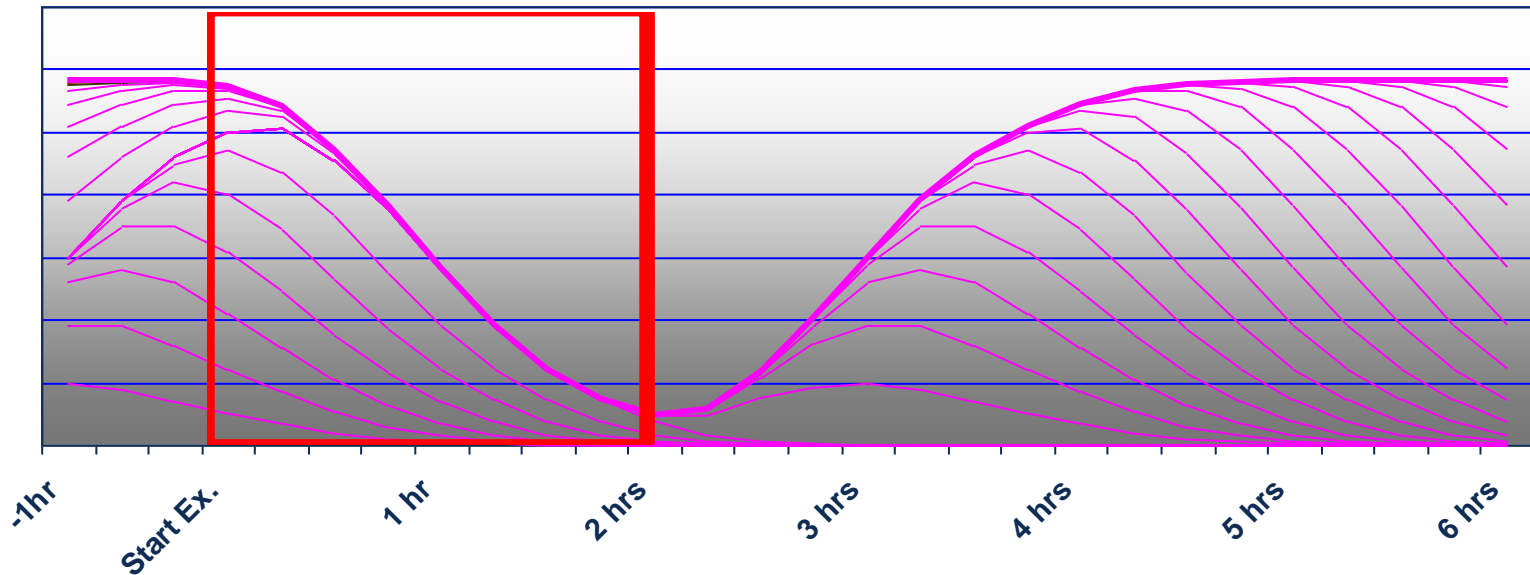
Disconnection during 2 hours of exercise (red box) eliminates bolus pulses for 120 minutes



Based on observed pharmacodynamics of rapid-acting insulin analogs

Pump disconnection: Effect on basal insulin level

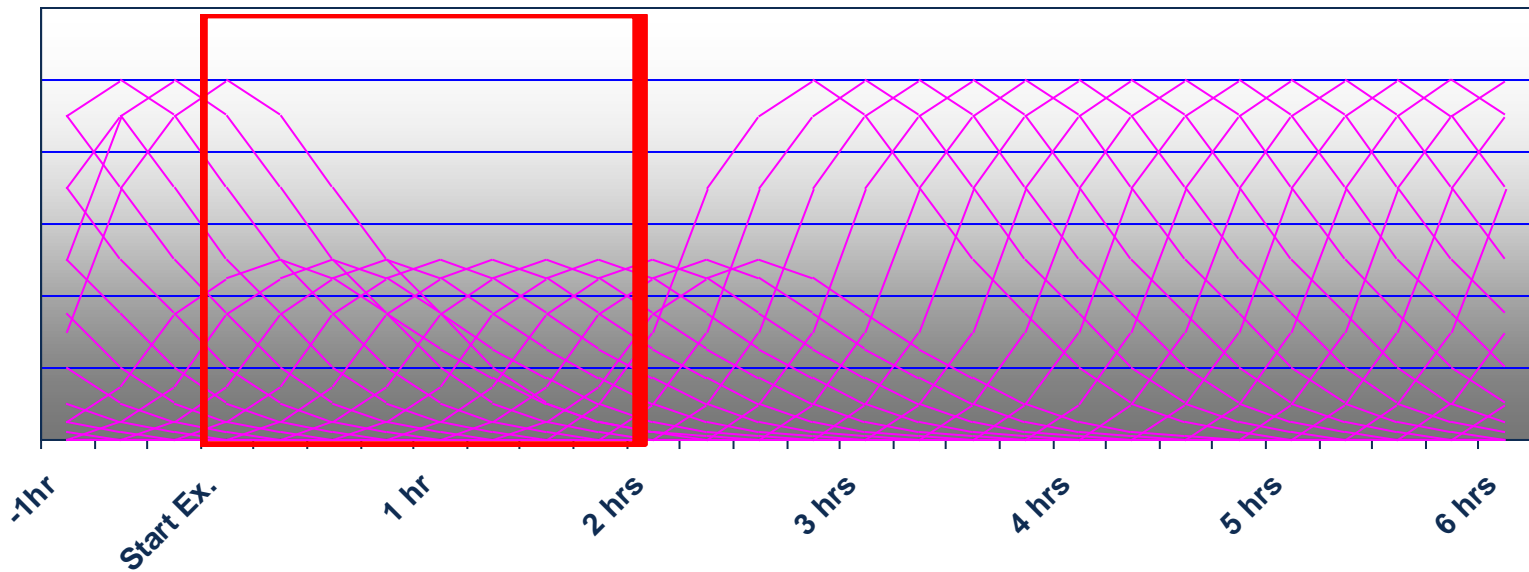
Level of active basal insulin resulting from 2 hrs disconnection during exercise:



Disconnection for > 90 minutes has little benefit early on, and can result in a serious insulin deficiency later!

Pump Temp Basal: Effect on basal insulin level

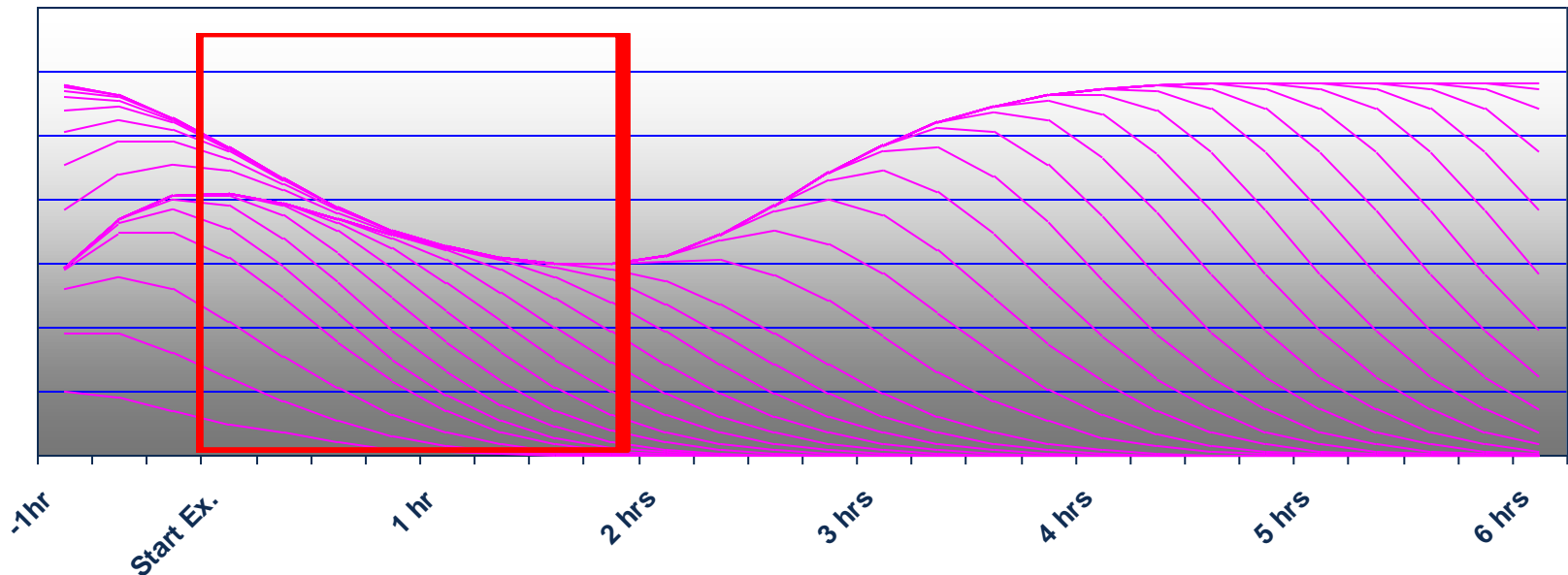
Temp Basal -50% starting 1-hr prior to 2-hr exercise until 30 minutes before completion:



Based on observed pharmacodynamics of rapid-acting insulin analogs

Pump temp basal: Effect on basal insulin level

Level of active basal insulin from temp basal - 50% starting 1-hr prior until 30 minutes before completion of 2-hour exercise:



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

Insulin Adjustment: Case Study

2-Hour Lacrosse Practice
(after dinner)

↓ Dinner bolus 50%

↓ Disconnect 1-hr pre-practice,
re-connect hourly & bolus 50%
of usual basal

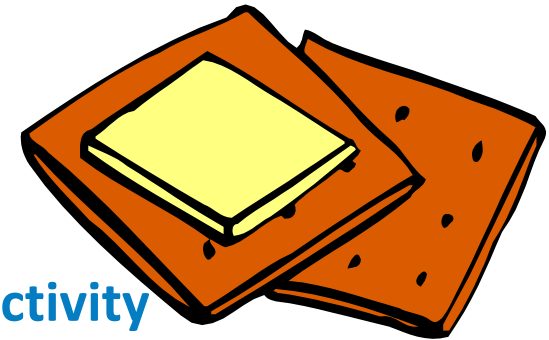
Snack at midpoint (if BG appears
to be dropping)



Snacking to prevent hypoglycemia

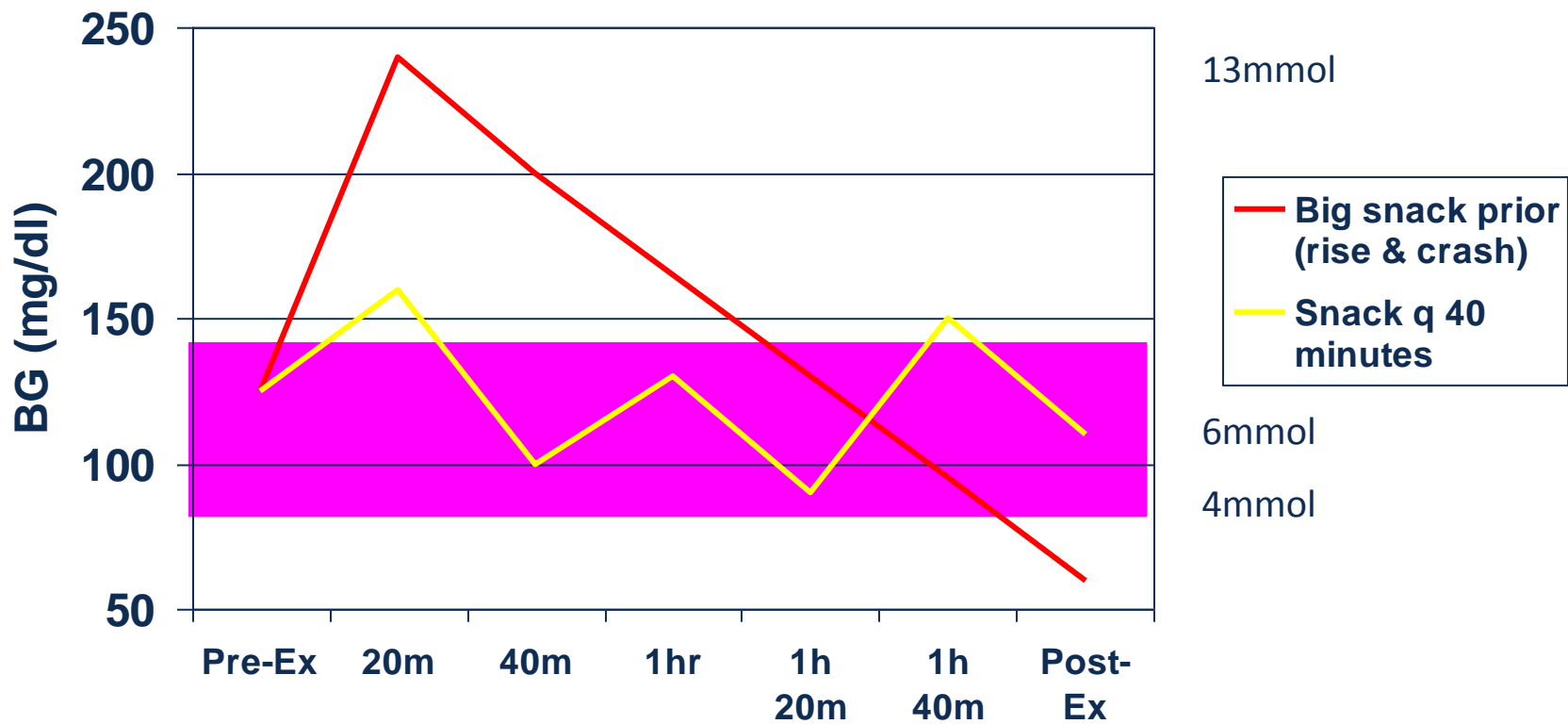
Basic Rules:

- ① **Snack *prior* to activity to *prevent* hypoglycemia**
- ② **Adjust quantity based on pre-activity BG or *direction* of BG**
 - BG low or dropping: ↑ usual carbs
 - BG OK or stable: usual carbs
 - BG High or rising: ↓ usual carbs
- 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



Source: Scheiner, Gary: [Think Like A Pancreas](#), Marlowe Publishing, NY, 2005

Which approach keeps BG in range for the majority of the workout?



Source: Scheiner, Gary, MS CDE

Snacking to prevent a low

	Carbohydrate Requirement Per <u>60 Minutes</u> of Activity (if no insulin adjustments are made)				
	50 lbs (24 kg)	100 lbs (48 kg)	150 lbs (71 kg)	200 lbs (95 kg)	250 lbs (119 kg)
Dancing or Gymnastics	8-12g	17-23g	25-35g	34-46g	42-57g
Tennis (singles)	18-22g	37-43g	55-65g	74-86g	92-107g
Swimming (fast pace)	22-25g	44-50g	65-75g	88-100g	110-125g

Sources: Scheiner, Gary: Think Like A Pancreas, Marlowe Publishing, NY, 2005

Walsh, John and Roberts, Ruth: Pumping Insulin, 4th ed., Torrey Pines Press, San Diego, 2006.

Heyward, Vivian: Designs for Fitness, Macmillan Publishing, NY, 1984.

Snacking to prevent a low

	Carbohydrate Requirement Per <u>60 Minutes</u> of Activity (if no insulin adjustments are made)				
	50 lbs (24 kg)	100 lbs (48 kg)	150 lbs (71 kg)	200 lbs (95 kg)	250 lbs (119 kg)
Cleaning Up	3-7g	7-13g	10-20g	14-26g	17-32g
Brisk Walking (mall/theme park)	8-12g	17-23g	25-35g	34-46g	42-57g
Mowing (push- mower)	13-17g	27-33g	40-50g	54-66g	67-82g

Sources: Scheiner, Gary: [Think Like A Pancreas](#), Marlowe Publishing, NY, 2005

Walsh, John and Roberts, Ruth: [Pumping Insulin, 4th ed.](#), Torrey Pines Press, San Diego, 2006.

Heyward, Vivian: [Designs for Fitness](#), Macmillan Publishing, NY, 1984.

Snacking to prevent low: Case Study



After School Tennis (85 lb/40 kg)

- ✓ Check BG prior
- ✓ Snack 20g (if BG 161-200 / 9-11mmol)
- ✓ Snack 30g (if BG 100-160 / 5-9mmol)
- ✓ Snack 40g (if BG <100 / 5mmol)
- ✓ No snack (if BG >200 / 11mmol)
- ✓ Addl. 20g snack after each hr of play

V^a®i@bLΣ\$:

Just a Few Factors that affect Blood Glucose During Exercise

- Active Insulin
- Infusion Site
- What You Ate
- Time of Day
- Emotional State
- Temp/Humidity
- Familiarity w/Activity
- Amt. Of Prior Activity
- Size/Number of Muscles Involved
- Duration
- Intensity

Sources: Walsh J et al: Using Insulin, Torrey Pines Press, San Diego, 2003.
Scheiner, Gary: Think Like A Pancreas, Marlowe Publishing, NY, 2005.

Watch Out for *D'OH!* (*Delayed Onset Hypoglycemia*)

- Following high-intensity exercise
- Following extended duration activity
- Due to replenishment of muscle glycogen stores, enhanced insulin sensitivity
- May occur up to 24 hours afterwards (typically 6-12 hours later)



Source: Colberg, Sheri: [The Diabetic Athlete](#), Human Kinetics, Champaign, IL, 2001.

D'OH! Prevention

- **Keep records – track the patterns**
- **Decrease basal insulin (modestly) or meal/snack boluses post-activity**
- **“Free” Snacks (slow-acting carbs) following activity**

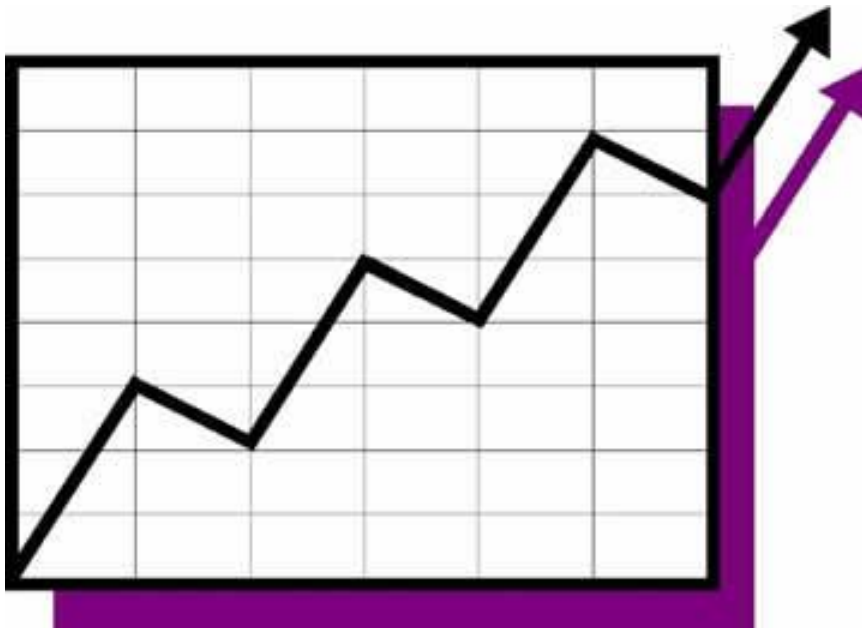


D'OH! Prevention

- **Check BGs more frequently**
 - ✓ q 2 hrs during “high risk” period
 - ✓ 3am night following activity
- **Wear a continuous glucose monitor**



Can Exercise *Cause*



Rise in BG?

Ketoacidosis?

Blood Glucose Homeostasis: The Grand Balancing Act



Adrenaline Raises BG!

Adrenaline Raises BG!

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

- ➔ **Weight lifting** (high weight, low reps)
- ➔ **Sports w/ “bursts” of activity** (golf, baseball, martial arts)
- ➔ **Sprints** (running, swimming)
- ➔ **Judged performances** (gymnastics, skating)
- ➔ **Events in which WINNING is the primary objective**



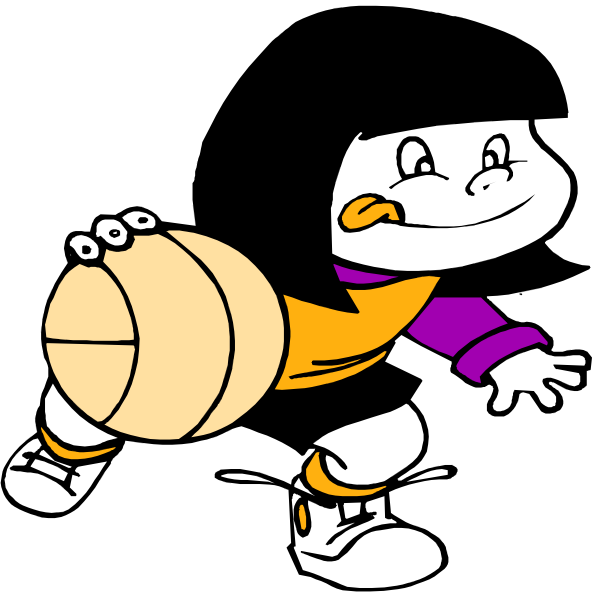
Sources: Colberg, Sheri: [The Diabetic Athlete](#), Human Kinetics, Champaign, IL, 2001.

Preventing / Offsetting BG Rise

- ✓ **Keep Records to determine avg. BG rise**
- ✓ **Check BG 30-60 Min. Pre-Activity**
 - ✓ **Bolus 30-60 min. prior to activity to offset rise (give 50% of usual amount required)**
 - ✓ **Take 50% of Usual “Correction Dose” If High (reduce based on insulin-on-board)**

Sources: Scheiner, Gary: [Think Like A Pancreas](#), DaCapo Press, 2012

Snacking to prevent high: Case Study



Late-Morning Basketball; disconnects for 1 hour; BG typically rises from 100 to 300mg/dl (5.5 to 16.6 mmol).

- ✓ Check BG 30 min prior
- ✓ Bolus 50% of amount required to cover current BG (including IOB)
- ✓ Bolus 50% of amount needed to offset 200 mg/dl (11 mmol) rise
- ✓ Check BG at halftime; keep sugared drinks handy.

Post-Workout Rise?

Possible Causes:

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

Possible Solutions:

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



How High is Too High?

No Such Number.

- ✓ Performance may suffer
 - ✓ Hydrate
- ✓ Administer Rapid-Acting Insulin (i.m.?)

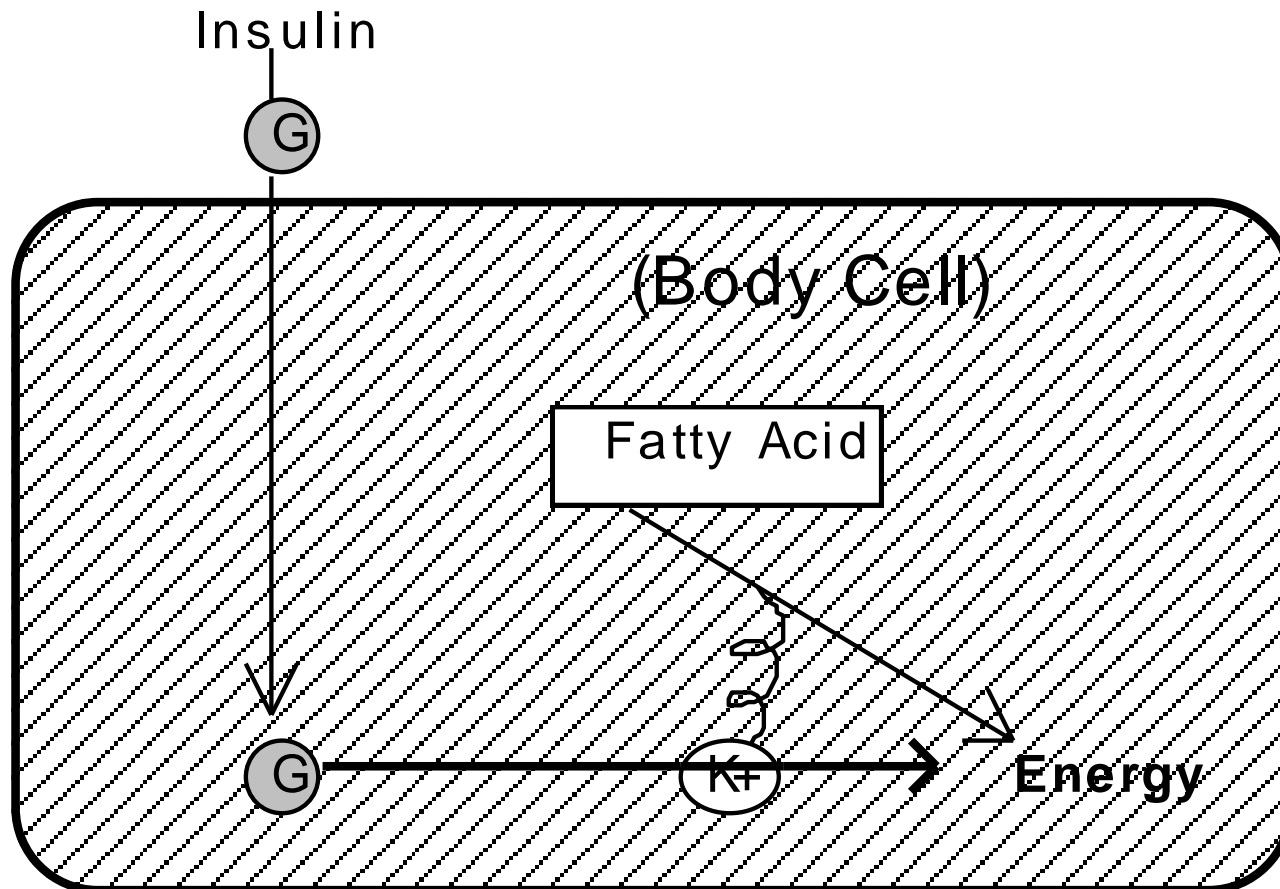
The Exception: Ketosis

What the *&!%#! Is a

KETONE???



Normal (Sufficient Insulin)

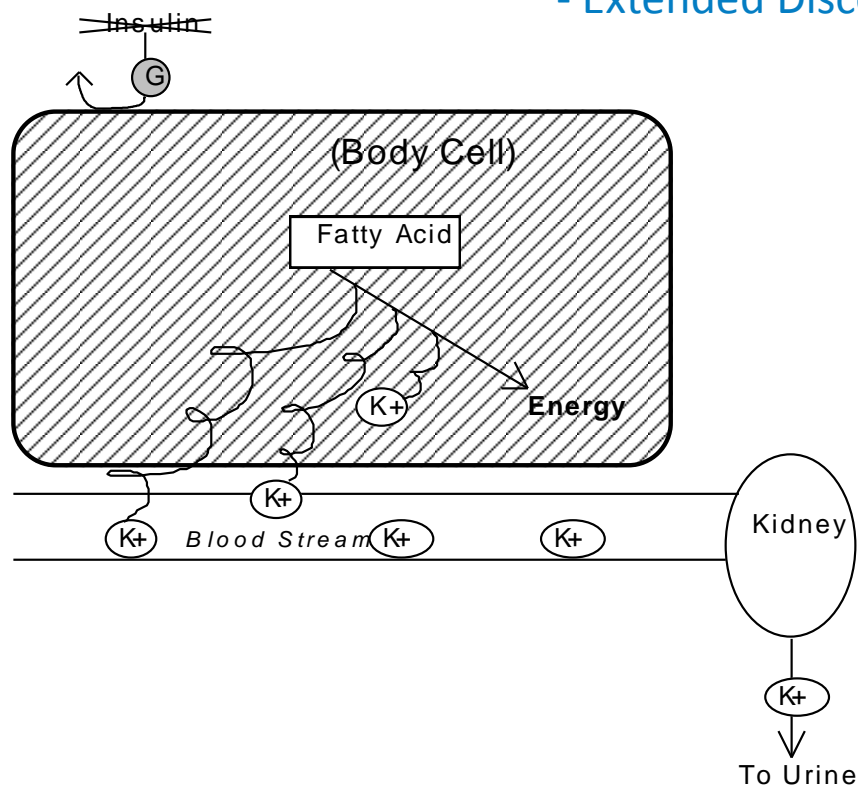


Source: Scheiner, Gary, [Think Like a Pancreas](#), Marlowe Pub., NY, 2005

Abnormal (Insulin Deficiency)

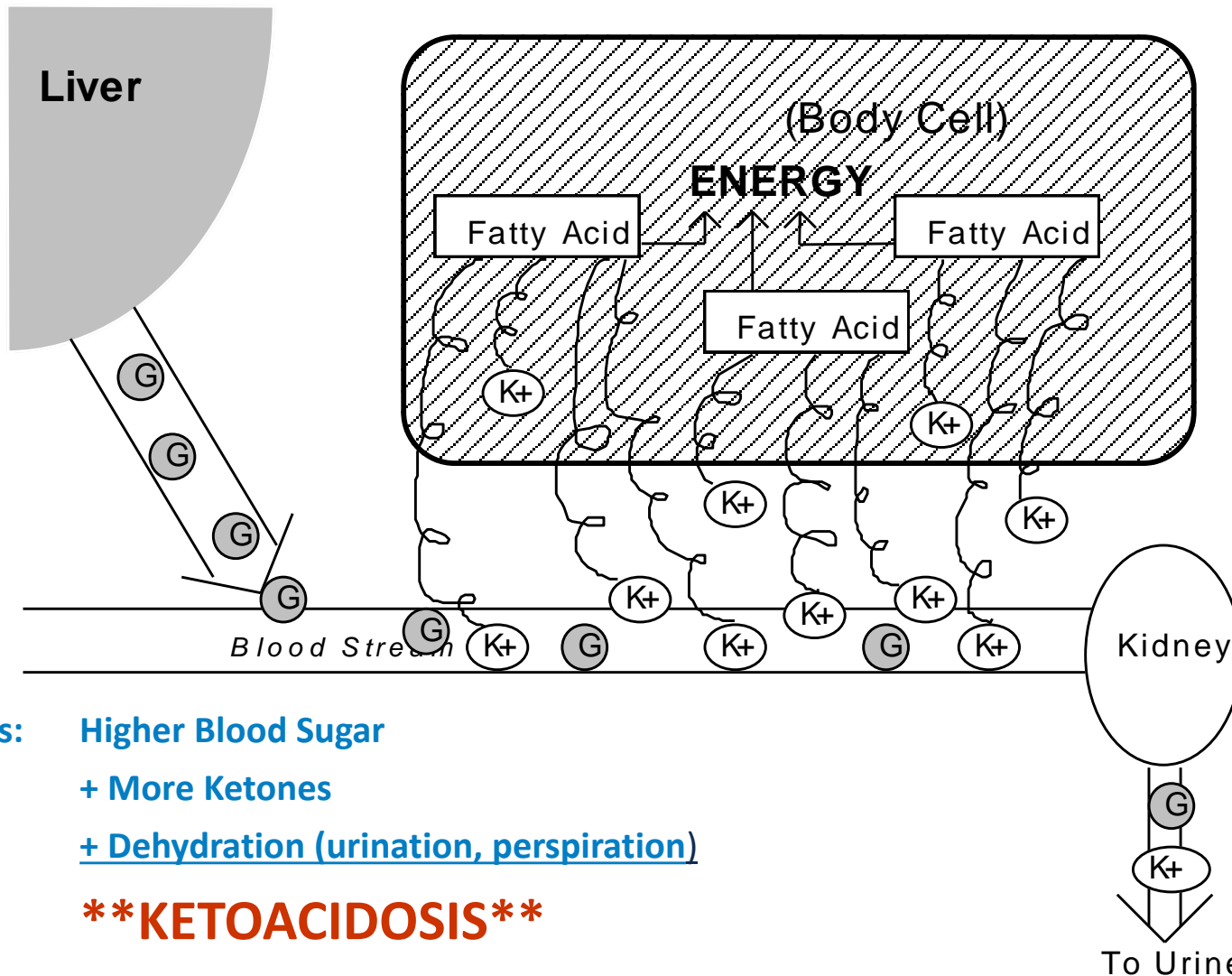
possibly due to:

- Missed Injection
- Spoiled Insulin
- Poor Absorption
- Insufficient Dose
- Illness
- Pump Problem:
 - Occlusion
 - Air in Tubing
 - Canula Dislodgement
 - Extended Disconnection



Source: Scheiner, Gary, [Think Like a Pancreas](#), Marlowe Pub., NY, 2005

Exercise During Insulin Deficiency



results: **Higher Blood Sugar**
+ More Ketones
+ Dehydration (urination, perspiration)
****KETOACIDOSIS****

Source: Scheiner, Gary, [Think Like a Pancreas](#), Marlowe Pub., NY, 2005

To Prevent Ketoacidosis

- ✓ Check urine for ketones prior to exercise with unexplained high BG
- ✓ No exercise w/positive ketones (small or more on urine ketostix; $>.5$ mmol/l on blood β Ketone test)
- ✓ OK to exercise if nonketotic – take 50% of usual “correction” bolus and drink plenty of water
- ✓ Do not disconnect for more than 2 hours

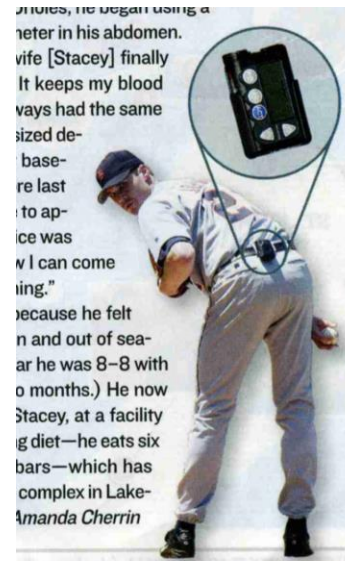


Source: Diabetes Care vol. 30 Supplement 1: ADA Clinical Practice Recommendations 2007

Alternatives to extended pump disconnection

Wear It!

- ✓ Clip to tight clothing
- ✓ Sport Pack
- ✓ Fanny Pack
- ✓ Backpack Harness



Infusion Set Adhesion During Exercise

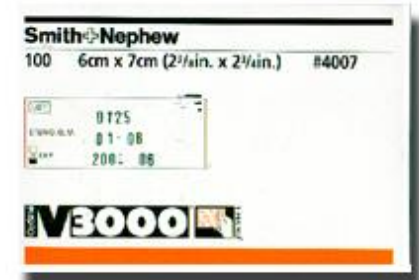
✓ Smart Set Placement

- Under tight clothing
- Body part w/less skin movement

✓ Skin prep agent w/adhesive (IV Prep, Skin Prep, Mastisol)

✓ Tape over site (Smith+Nephew, 3M)

✓ Antiperspirant (Hypercare 20% AlCl solution, Stratus Pharma.)



Pump & Temperature Extremes During Exercise

Cold:

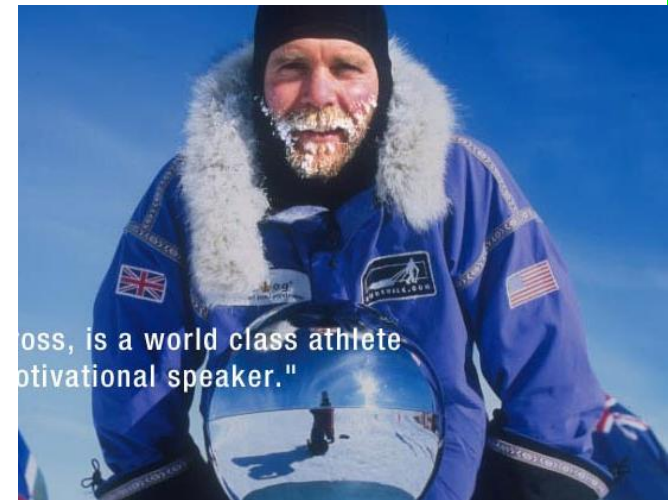
Generally not a concern when pump is worn against body

Heat:

Insulin analogs can denature if:

- Exposed to $> 98^{\circ}\text{F}$ (36C)
- Stored or worn $> 86^{\circ}\text{F}$ (30C) for extended periods

Pump function OK under most conditions



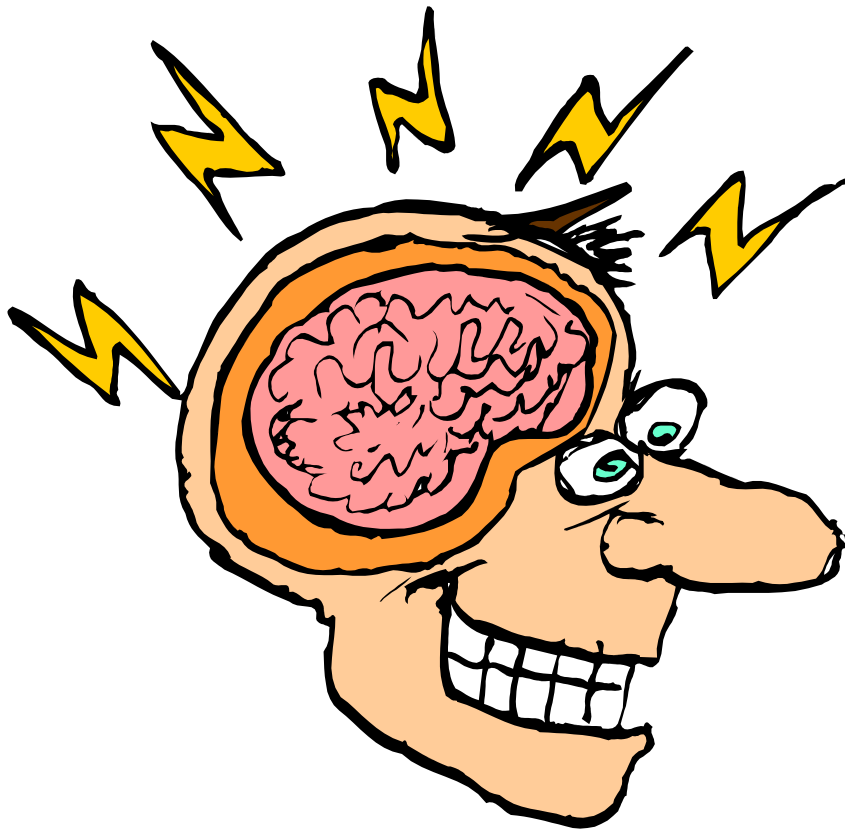
Pump & Temperature Extremes During Exercise

“Cool” Ideas:

- ✓ Keep pump out of direct sunlight
 - Wear under clothing
 - Store in a cool place when disconnected
 - Don't forget the tubing!!!
- ✓ Spend less time in extreme heat
 - Get into a/c and shade periodically
 - Humidity is not a factor
- ✓ FRIO Cooling Case



**There is nothing you can't
accomplish...**



**If you think like
a pancreas!**