



Exercise- A Type 1 Perspective

Sponsored by Medtronic Diabetes Canada

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Objectives

1. Update the health benefits of regular PA/exercise for diabetes
2. Describe the reasons for exercise-associated dysglycemia in T1D
3. Present some strategies that can help minimize dysglycaemia and maximizing exercise performance for patients



Questions

- ▶ I) Most of the questions about "exercise" (management of glucose or the types of exercise to do) come from my patients living with
 - ▶ A) type 1
 - ▶ B) type 2
 - ▶ C) when expressed as a percentage of who I see, both my patient populations struggle with exercise
-

Questions

- ▶ 2) In your clinical practice, how often do you get questions about managing glucose control with exercise in your patients living with diabetes (type 1 , type 2)?
 - ▶ A) weekly
 - ▶ B) On occasion
 - ▶ C) rarely
-

Questions about exercise and T1D

- ▶ Does it ever get easier to manage Type I and exercise?
 - ▶ I'm experiencing very large drops in blood sugar during exercise. Any suggestions?
 - ▶ Are there any tricks to avoiding a post-exercise spike in blood sugar?
 - ▶ Do you have any advice for managing a pump during exercise?
 - ▶ Is it possible for people to reverse the complications of Type I with exercise?
 - ▶ How do you deal with unpredictable blood sugar changes during predictable workouts?
 - ▶ How do you deal with unsupportive friends, teachers or coaches?
 - ▶ Should I scale back my long-acting basal insulin for exercise?
 - ▶ My son continues to stay very low for hours after a practice. Do you have any advice for him?
 - ▶ When is the best time of day to exercise?
 - ▶ How do I balance the snacks need for exercise and my desire to cut calories?
 - ▶ Before every race, my pre-race adrenaline sends my blood sugar sky-rocketing. Do you have any advice?
 - ▶ My daughter is a competitive swimmer, but on meet days, she has a hard time controlling her blood sugar due to removing her pump. What are her options?
 - ▶ Any suggestions on how to keep blood sugar up during exercise when you're doing something that makes it difficult to eat while on-the-go, like swimming, or cross country skiing?
-

How would you answer this one?

- ▶ *‘Does it ever get easier? I’m new to exercise and I find that the threat of random bouts of hypoglycemia really stop me from working as hard or as long as I should. How long before my body will get used to it?’*
 - ▶ Do you think the body of a person with T1D ever gets used to exercise?
 - ▶ Does it ever get any easier?
-

Problems with exercise do not appear to disappear with training?

DIABETICMedicine

DOI: 10.1111/dme.13070

Short Report: Metabolism

Association of aerobic fitness level with exercise-induced hypoglycaemia in Type 1 diabetes

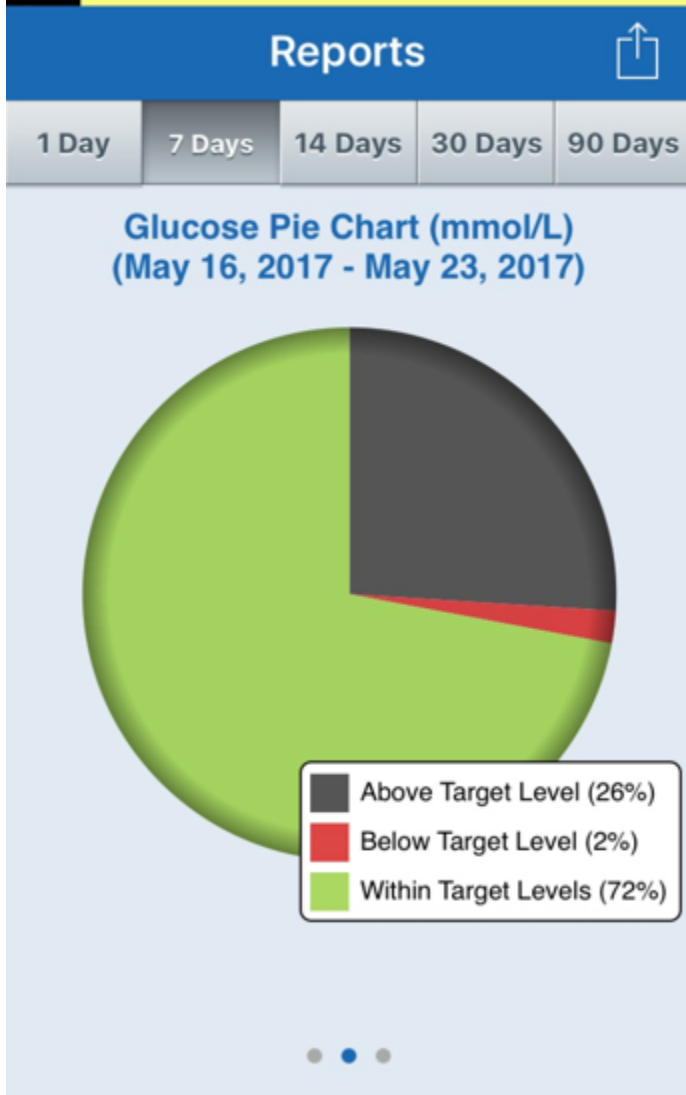
R. A. Al Khalifah^{1,2}, C. Suppère³, A. Haidar^{3,4}, R. Rabasa-Lhoret^{3,4,5,6}, M. Ladouceur⁷ and L. Legault¹

74% risk of developing hypo in the good fitness group vs. 38% in the poor fitness level group. Both groups had similar pre-exercise blood glucose levels.”

What's new?

- Patients with Type 1 diabetes who have a good fitness level are at more risk of developing exercise-associated hypoglycaemia.
- Patients with good physical fitness levels may need to be more cautious when planning physical activity and implement hypoglycaemia prevention strategies early in the activity.

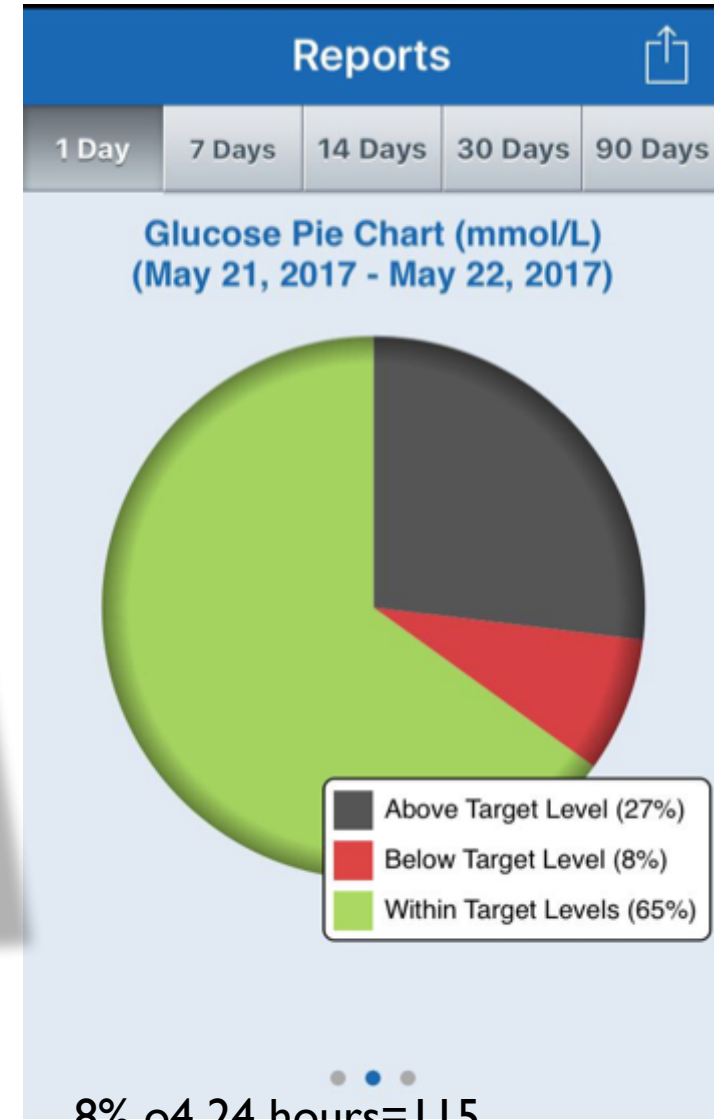
Inactive day



2% of 24 hours = 29 minutes/day below target



Active day



8% of 24 hours = 115 minutes/day below target



Glucose Within Target Levels

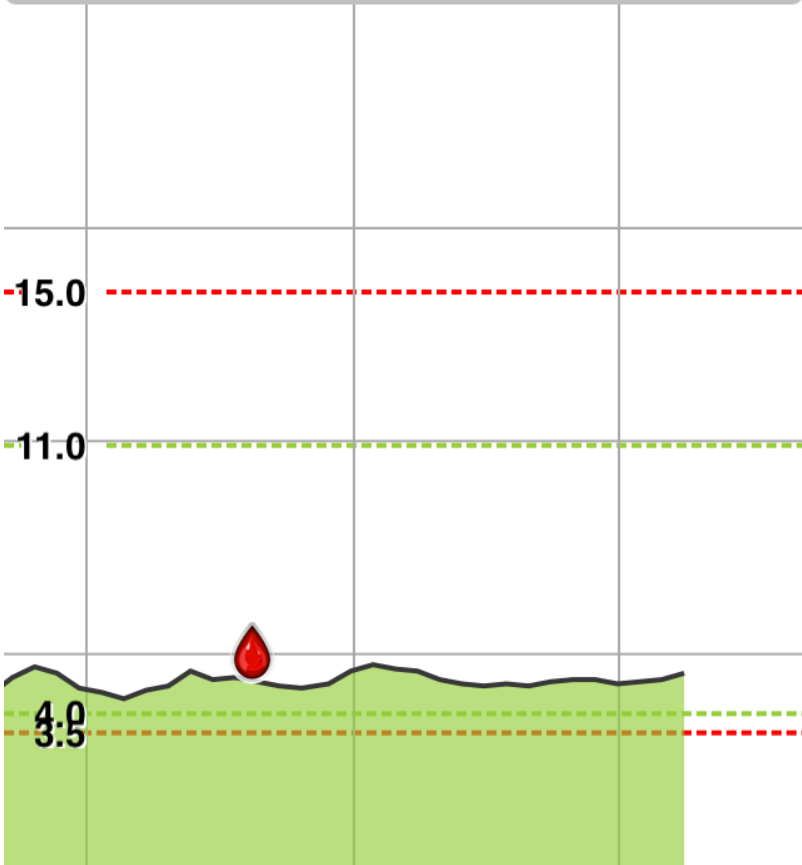
MCR0136

5.0

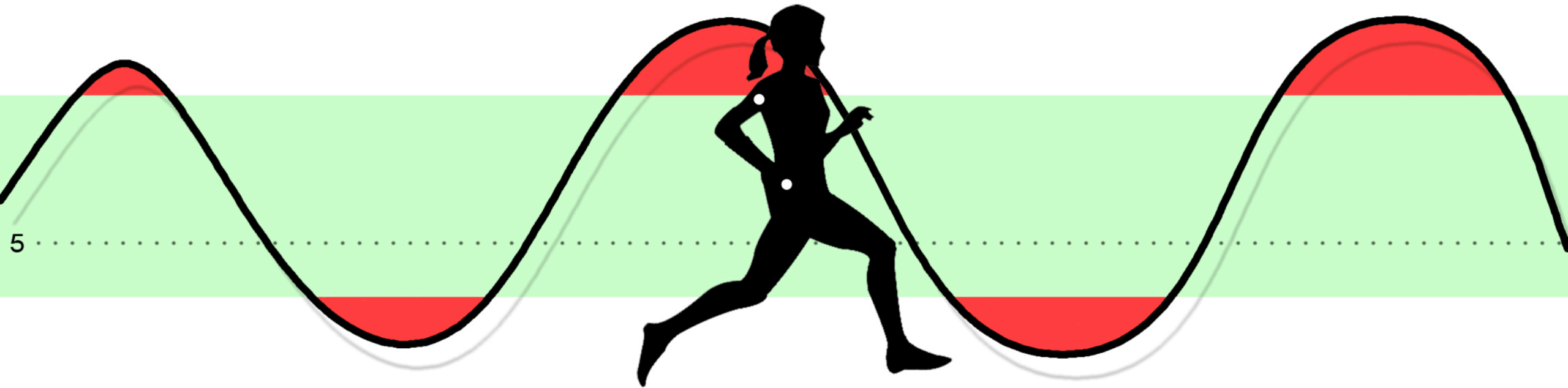


mmol/L

TODAY
8AM 9AM 10AM

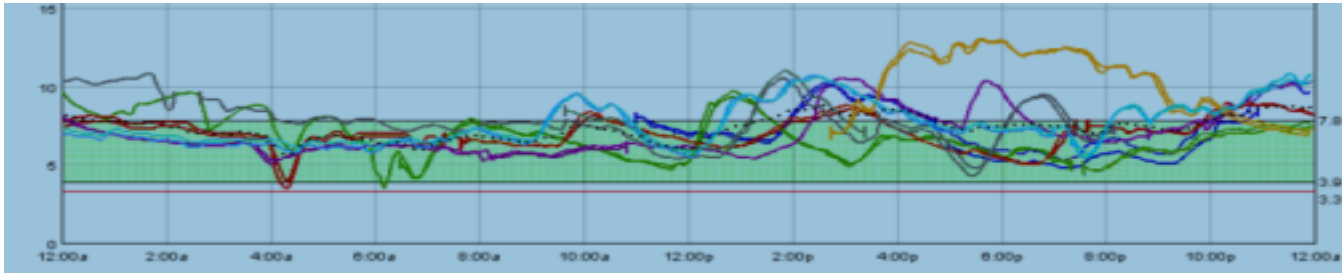


Exercise causes dysglycemia in T1D...



Mike's 7 tools that should make exercise control easier:

1. Knowledge (downloads), experience and education
 2. CGM
 3. Being on a sensor-augmented insulin pump
 - ▶ Not being on NPH insulin
 - ▶ Not being on insulin degludec
 4. A predictable activity routine
 5. Choosing the activity you do based on your glucose concentration
 - ▶ Selecting interval-type exercise
 6. Consume a moderate CHO intake diet
 7. Being careful about vigorous exercise in the late afternoon (see number 2)
-



Glucose control during and after exercise is challenging...

- CGM can reveal problems
- CGM allows for proactive adjustments
- A sensor-augmented pump helps overnight



Questions

- ▶ 3) In your clinical experience, you find glucose management for exercise in type I diabetes
 - ▶ A) reasonably easy to deal with for your patients
 - ▶ B) challenging to deal with overall
 - ▶ C) impossible (brutal) to deal with
-

Questions:

- ▶ 4) In your experience, the majority of clinical challenges related to type I diabetes, physical activity, exercise and sport are related to
 - ▶ A) hypoglycemia during exercise
 - ▶ B) hyperglycemia before or after exercise
 - ▶ C) post exercise late-onset hypoglycemia overnight
 - ▶ D) all of the above are equally common challenges
-

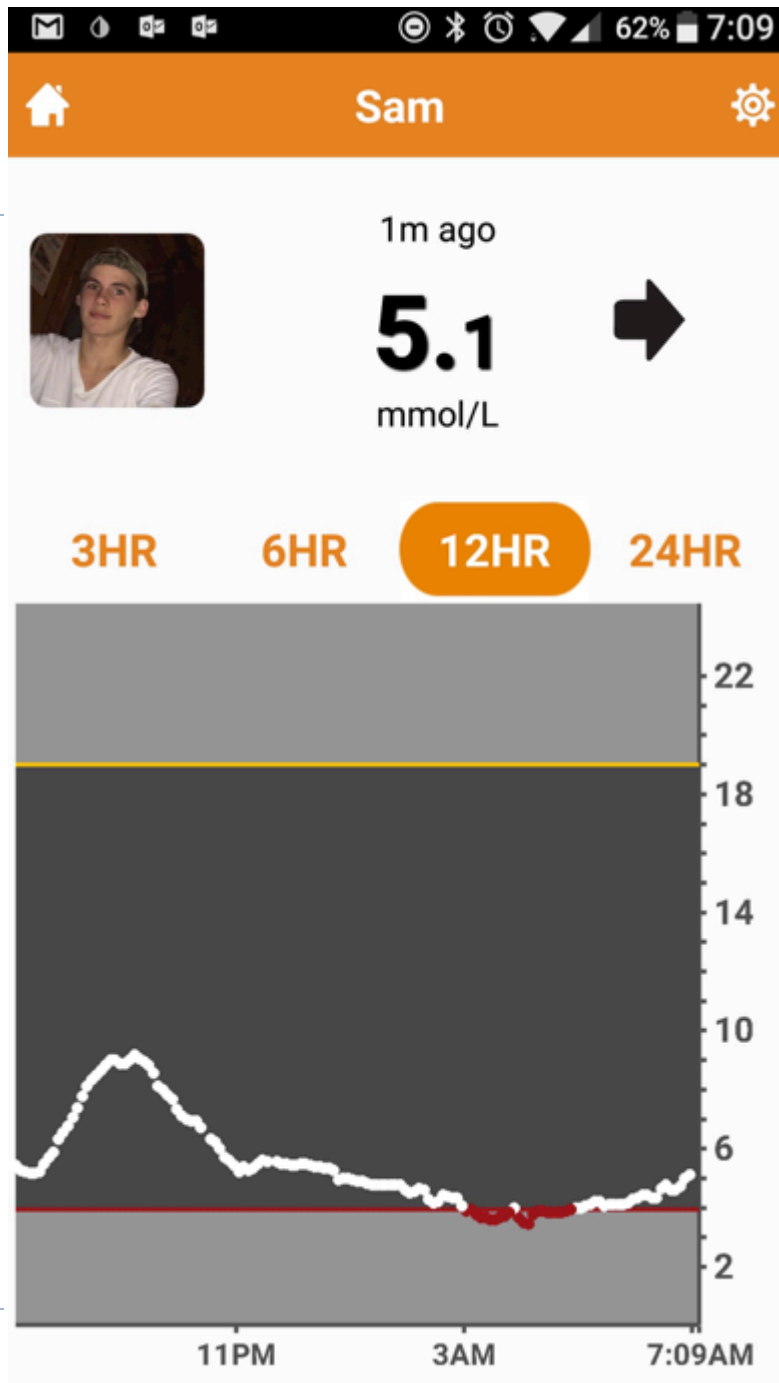
How are we doing with managing
type 1 diabetes at present?



630G, Enlite CGM, Dexcom G5



Sensonic



Islet, bionic pancreas

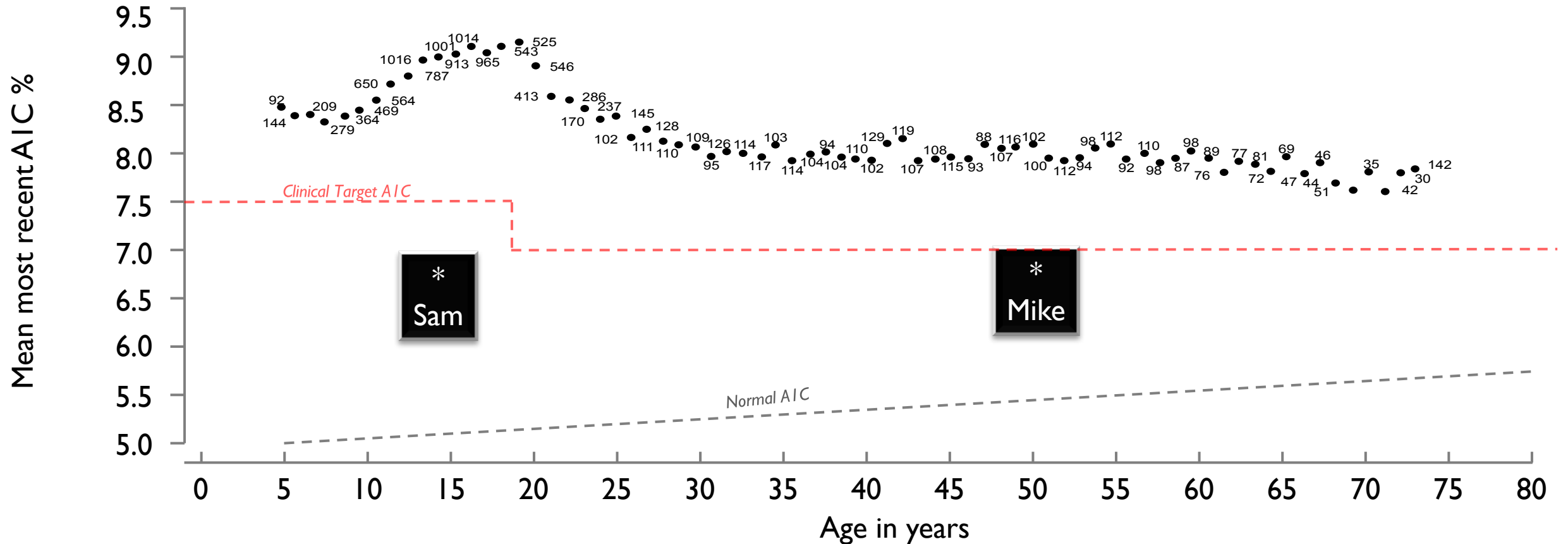


Dexcom/Verily



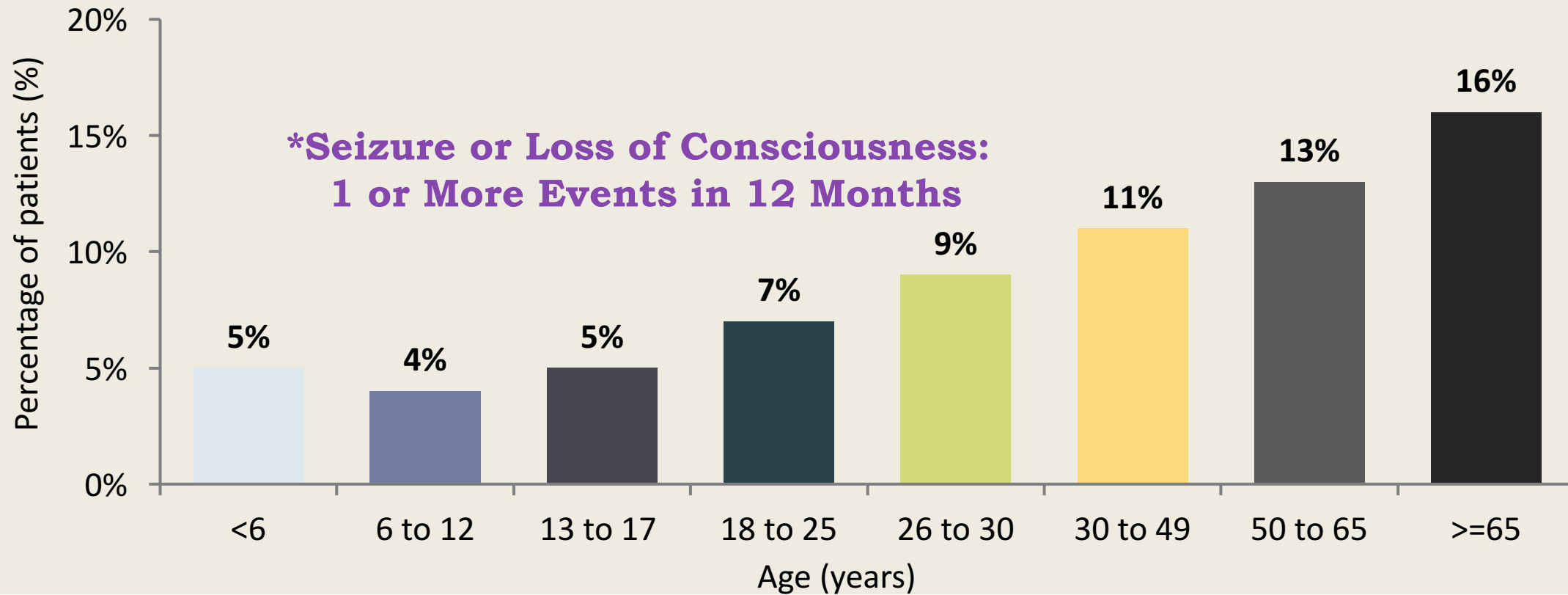
Dexcom G6

Despite advances in care, glycemic control is still challenging in T1D, particularly in youth...



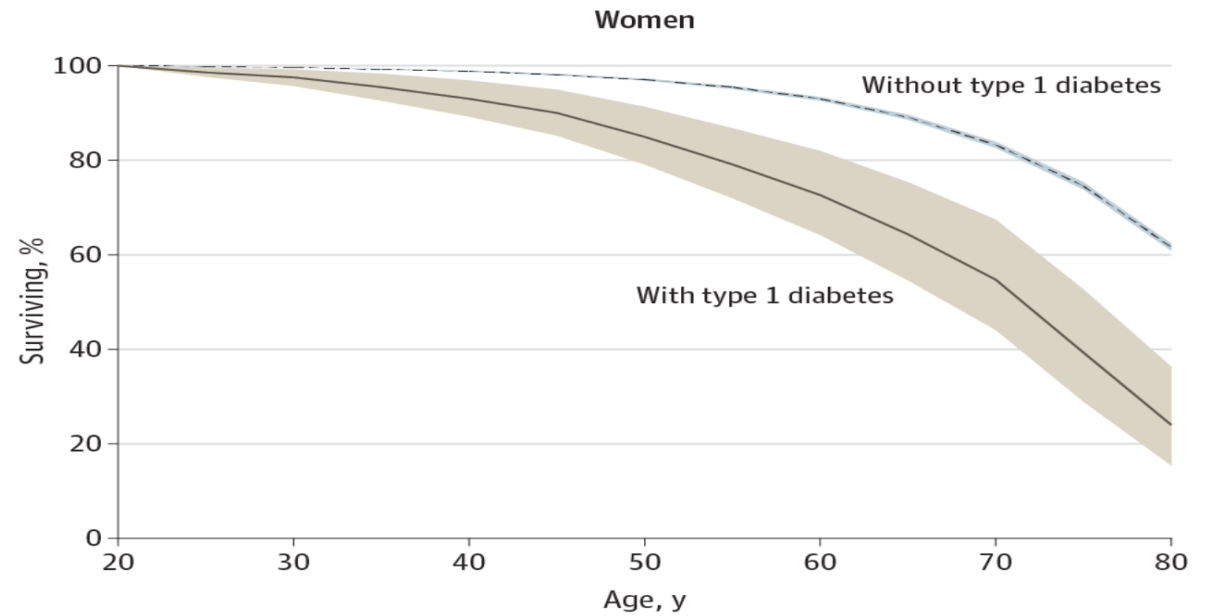
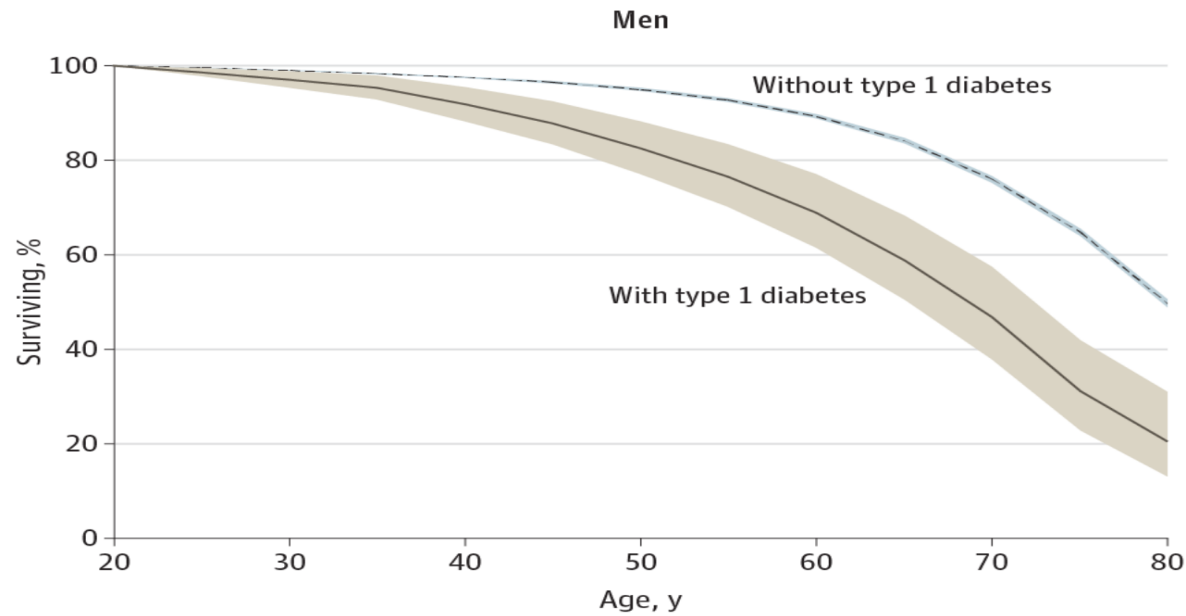
Episodes of Severe Hypoglycaemia are Common (US Data)

1/6 to 1/20 persons with type 1 diabetes experience severe hypoglycaemia each year



From: **Estimated Life Expectancy in a Scottish Cohort With Type 1 Diabetes, 2008-2010**

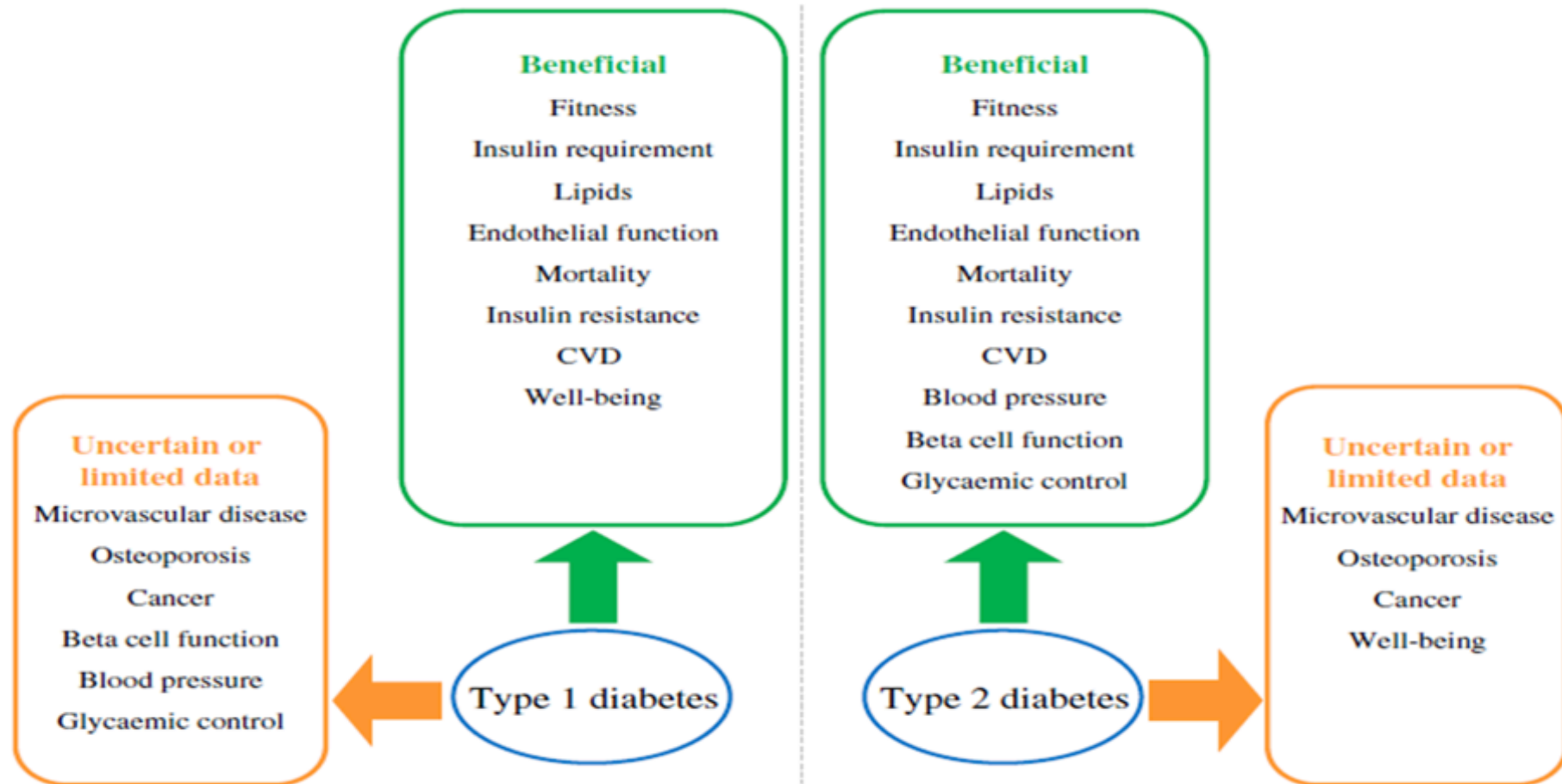
JAMA. 2015;313(1):37-44. doi:10.1001/jama.2014.16425



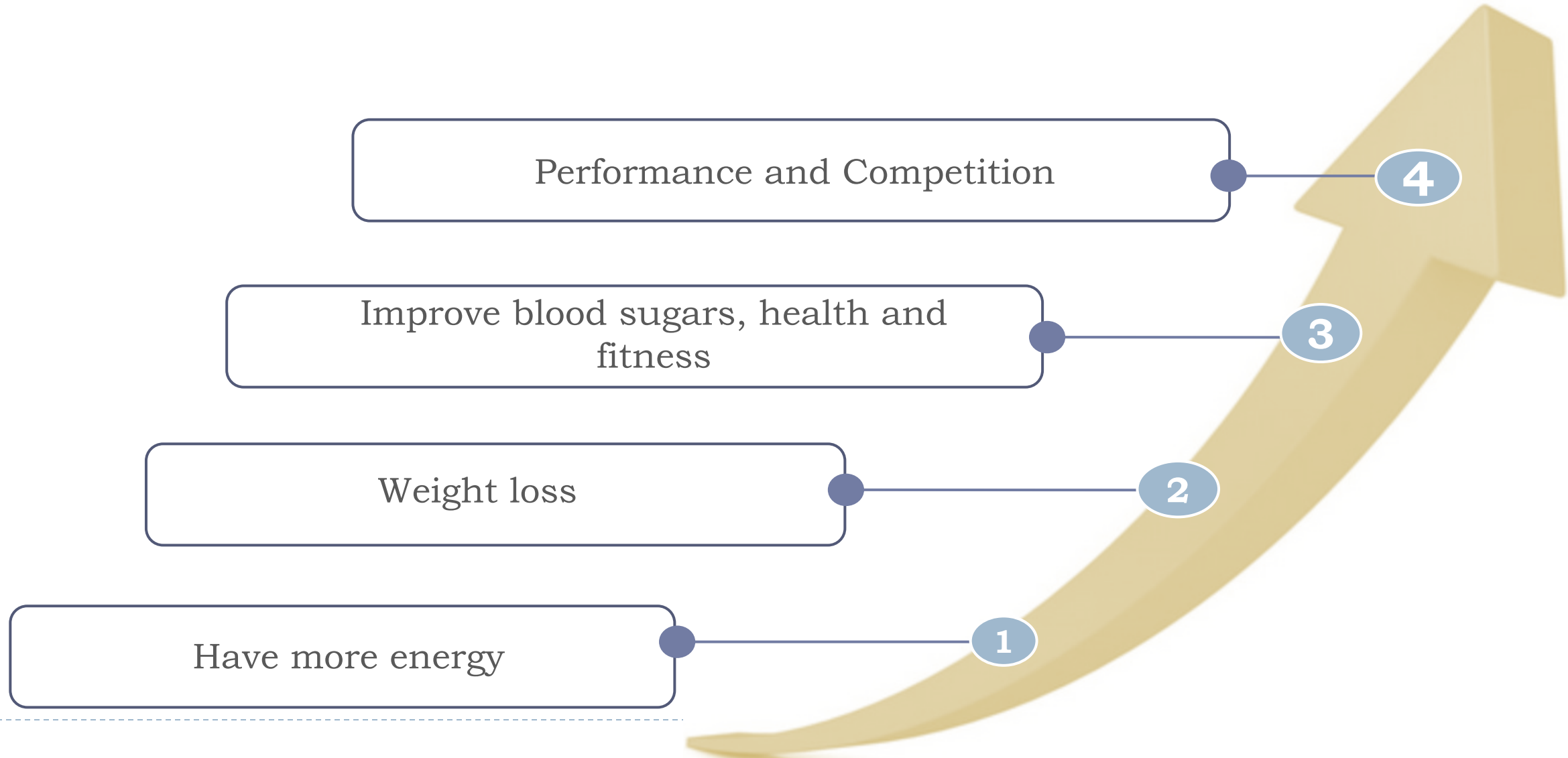
Percentage Surviving by Age Among Those With Type 1 Diabetes Compared With the General Population Without Type 1 Diabetes See the Methods section for life table calculations.



Effects of regular exercise on type 1 and type 2 diabetes



Typical T1D Patient Goals for Exercise



Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association

Sheri R. Colberg,¹ Ronald J. Sigal,² Jane E. Yardley,³ Michael C. Riddell,⁴ David W. Dunstan,⁵ Paddy C. Dempsey,⁵ Edward S. Horton,⁶ Kristin Castorino,⁷ and Deborah F. Tate⁸

Diabetes Care 2016;39:2065–2079 | DOI: 10.2337/dc16-17

Can J Diabetes 37 (2013) S40–S44



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journal homepage:
www.canadianjournalofdiabetes.com



Clinical Practice Guidelines

Physical Activity and Diabetes

Canadian Diabetes Association Clinical Practice Guidelines Expert Committee

Exercise management in type 1 diabetes: a consensus statement

Michael C Riddell, Ian W Gallen, Carmel E Smart, Craig E Taplin, Peter Adolfsson, Alistair N Lumb, Aaron Kowalski, Remi Rabasa-Lhoret, Rory J McCrimmon, Carin Hume, Francesca Annan, Paul A Fournier, Claudia Graham, Bruce Bode, Pietro Galassetti, Timothy W Jones, Iñigo San Millán, Tim Heise, Anne L Peters, Andreas Petz, Lori M Laffel



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

Lancet Diabetes Endocrinol 2017

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January 23, 2017

Recommendations

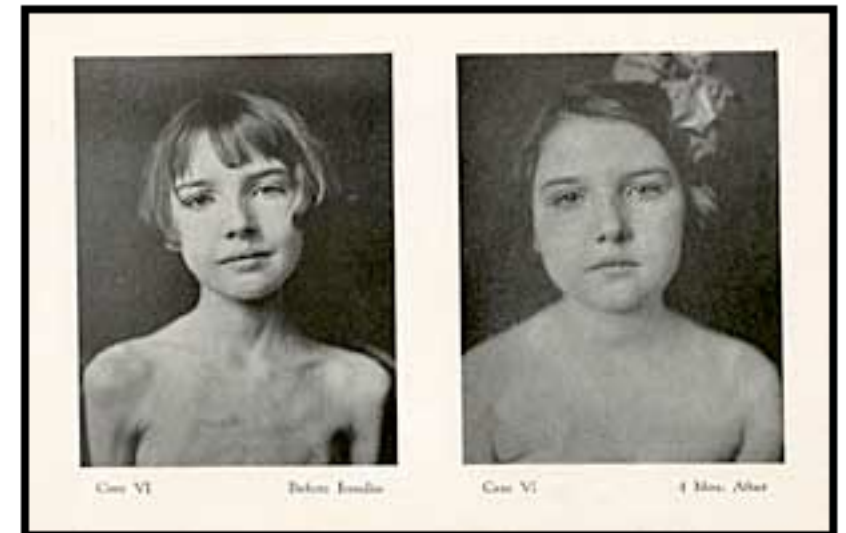
- All adults with diabetes should decrease the amount of time spent in daily sedentary behavior. B
- Prolonged sitting should be interrupted with bouts of light activity every 30 min for blood glucose benefits. C
- Daily physical activity, or at least not allowing more than 2 days to elapse between exercise sessions, is recommended to enhance insulin action. B
- Adults should ideally perform both aerobic and resistance exercise for optimal glycemic and health outcomes (**150 min/week or more**). C
- Children and adolescents with diabetes should be encouraged to meet the same physical activity goals set for youth in general (**60 minutes/day of physical activity**). C
 - Vigorous-intensity activities **at least 3 days per week**.
 - Activities that strengthen muscle and bone at least 3 days per week.

Adherence to PA- Adults

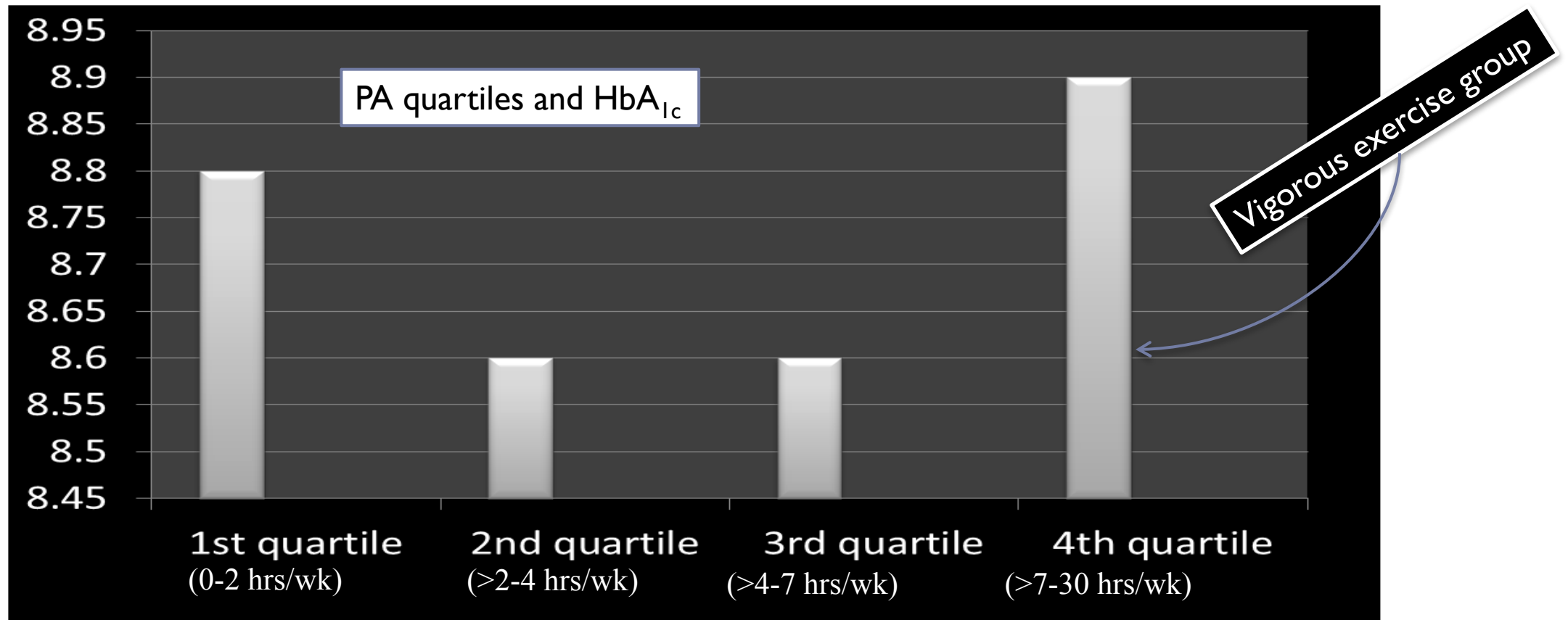
- ▶ Most adults with T1D do not engage in regularly physical activity.
 - ▶ Two longitudinal studies of adults with T1D (Canada, UK) show that **~60% of patients are inactive** (~50% of the general population are inactive)
 - ▶ Adherence to recommendations generally **decreases with age** and is **lower in females**
 - ▶ **People with type 1 diabetes now tend to be more obese than non diabetics!**

Adherence to PA -Youth

- ▶ In the global TEENS study, about $\frac{2}{3}$ ^{rds} of youth with T1D were not participating in 30 min of exercise daily
- ▶ In a Canadian study, adolescents with T1D were shown to spend **more time lying down and resting** than non diabetic peers (2.0 vs. 1.3 h/day)



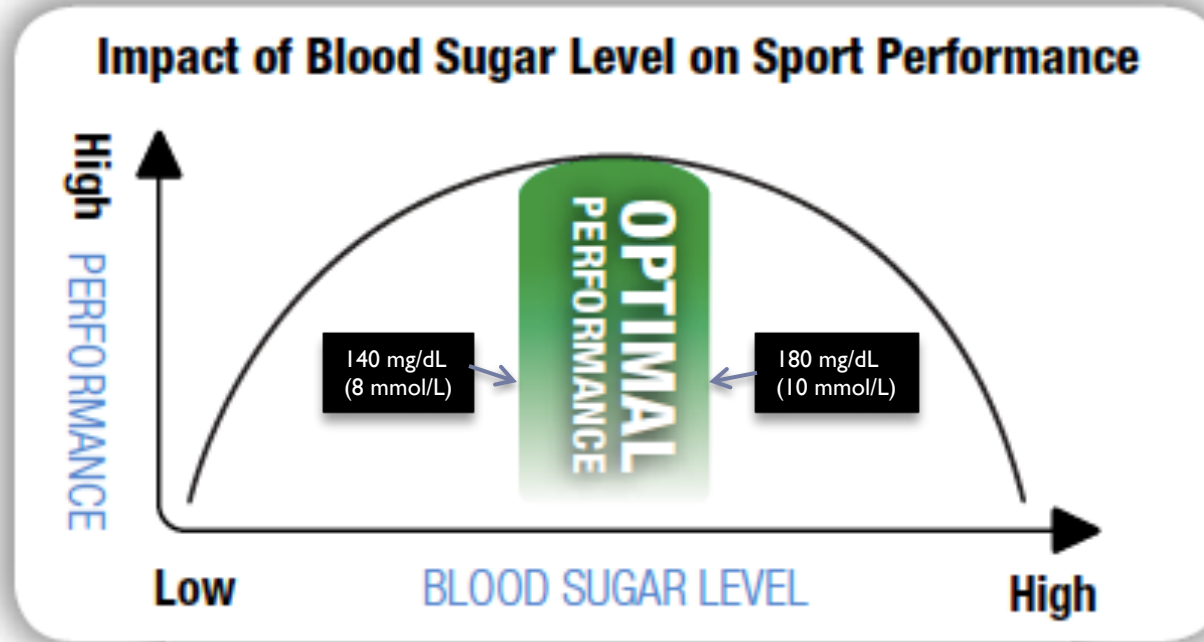
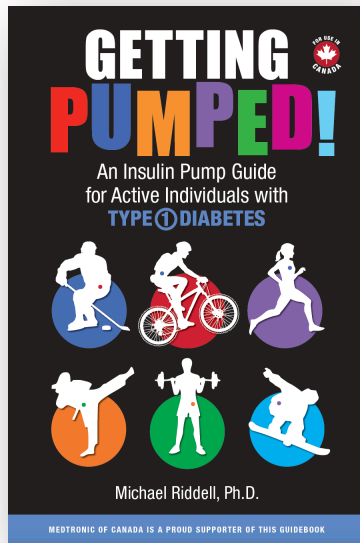
Associations between physical activity and glycemic control in children, adolescents, and young adults with type 1 diabetes.



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

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

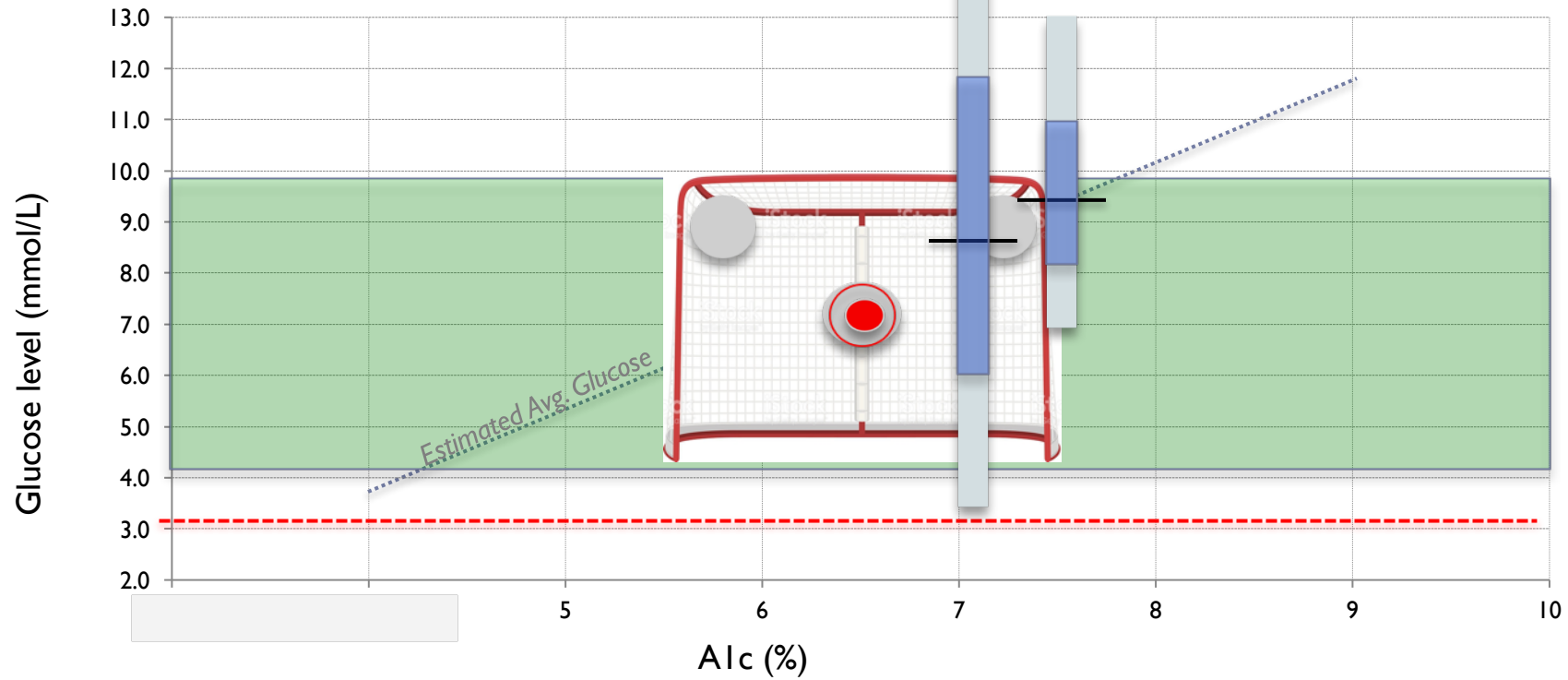
Does glucose control impact
exercise performance in T1D?



CONSEQUENCES OF BLOOD SUGAR LEVEL

Too Low	Too High
▼ Coordination	Endurance ▼
▼ Skill Level	Muscle Strength ▼
▼ Mental Performance	Glycogen Reserves ▼
▲ Fatigue	Fatigue ▲
▲ Risk of Injury	Dehydration ▲

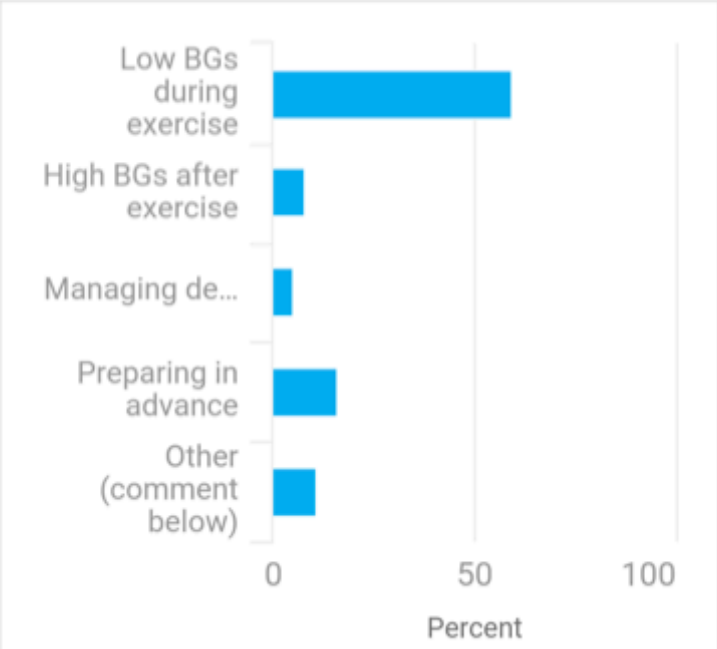
- CSII and CGS
- MOTIVATION!
- Regular predictable physical activity
- Moderate carb diet (nuts, seeds, fruits, vegetables, protein, milk...)
- An SGLT2 antagonist

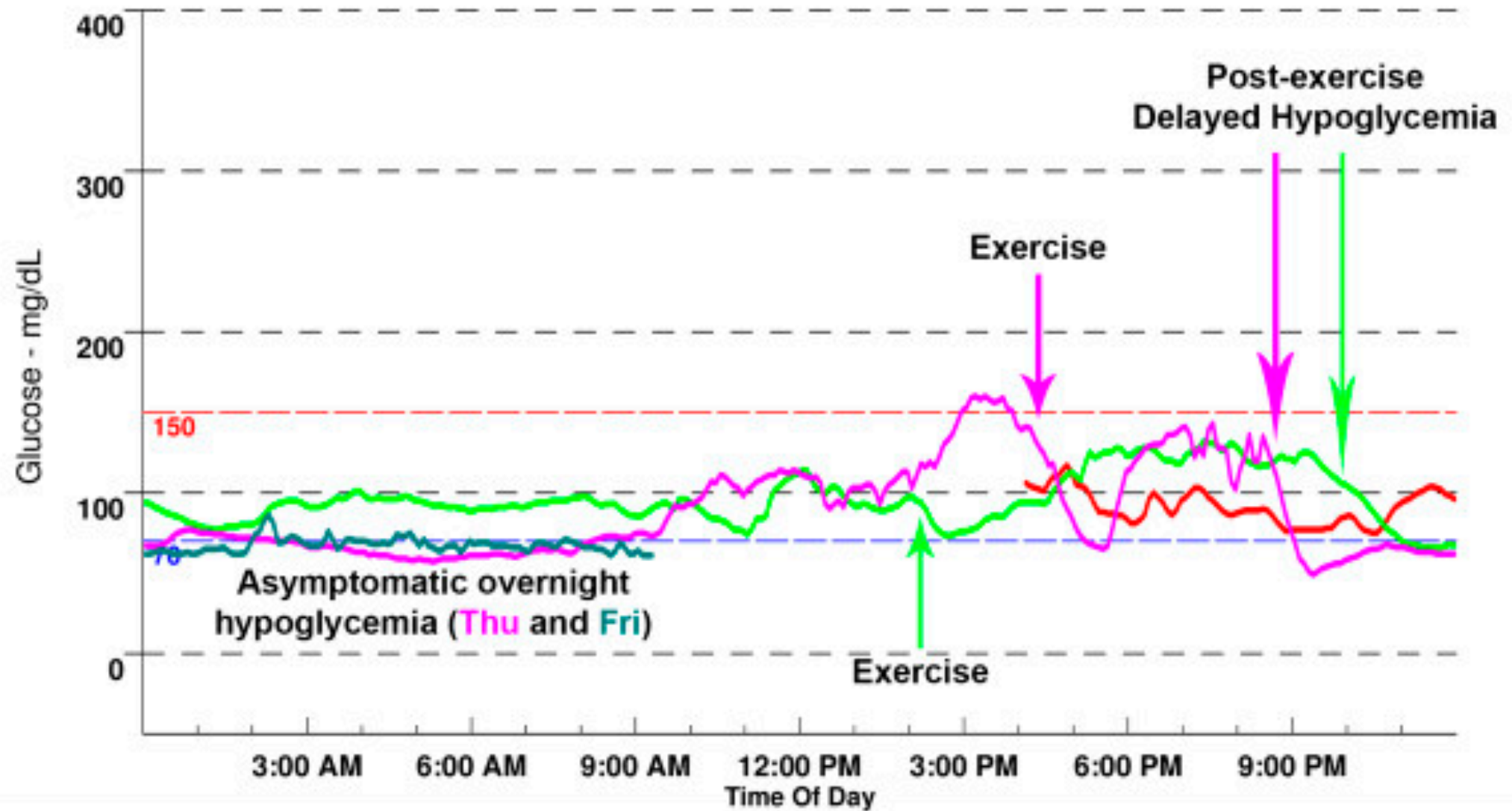


May 24

- **ANSWERED:** What is your biggest challenge when managing type 1 and exercise?

Your answer: High BGs after exercise





Legend

Sunday

Tuesday

Thursday

Saturday

Monday

Wednesday

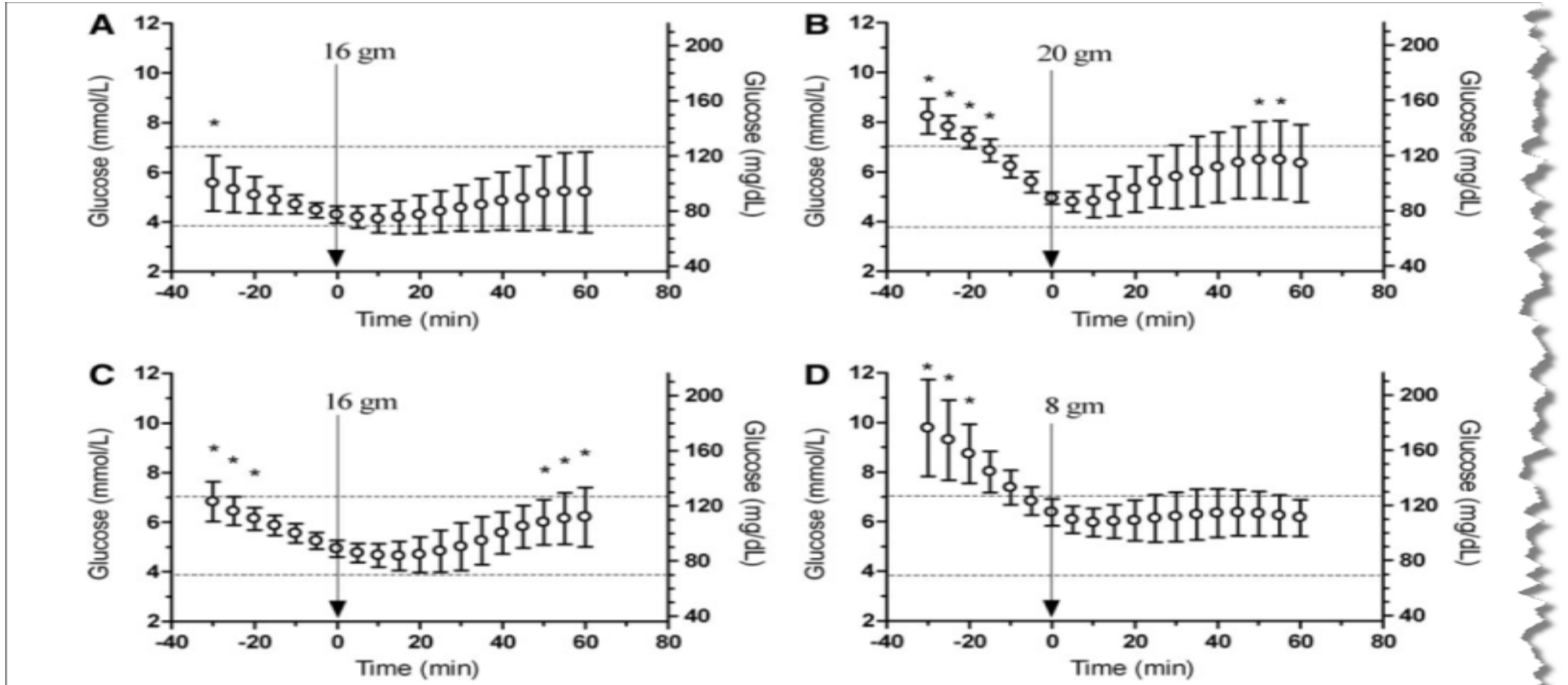
Friday

The fear of hypoglycemia in T1D is a major barrier to exercise

- ▶ Adolescents with T1D were shown to spend **more time lying down and resting** than non diabetic peers (2.0 vs. 1.3 h/day)
- ▶ In the global TEENS study, about **$\frac{2}{3}$ ^{rds} of youth with T1D were not participating in 30 min of exercise daily**

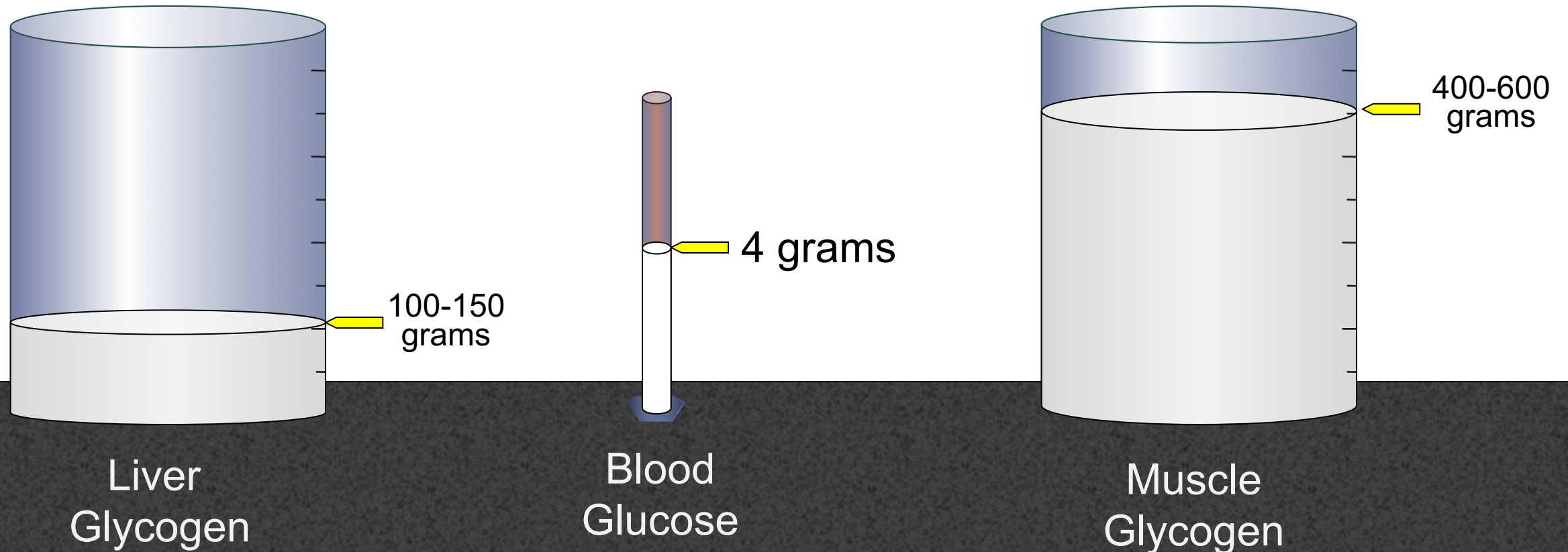


Benefits of RT CGM and CHO feeding for activity in T1D

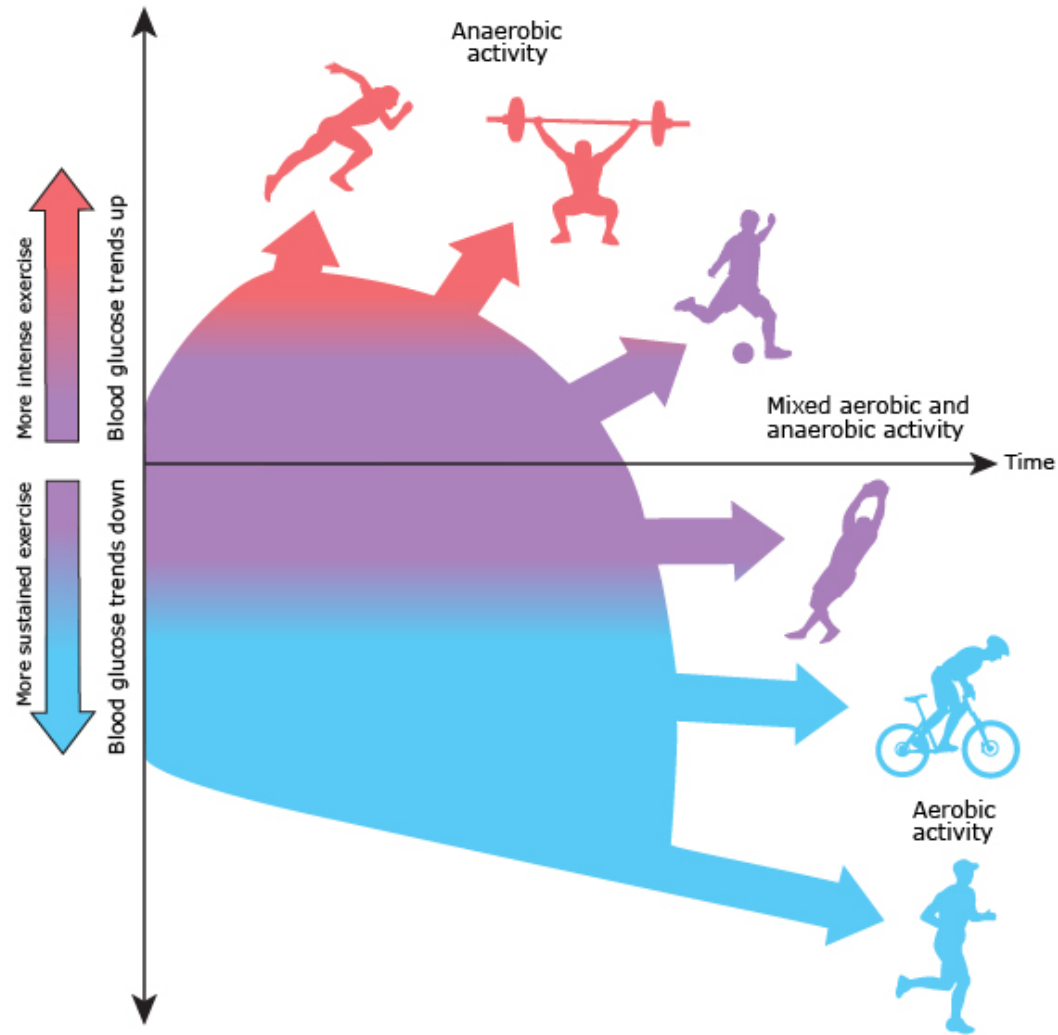


The main challenge with T1D and exercise is the limited glucose storage in blood...

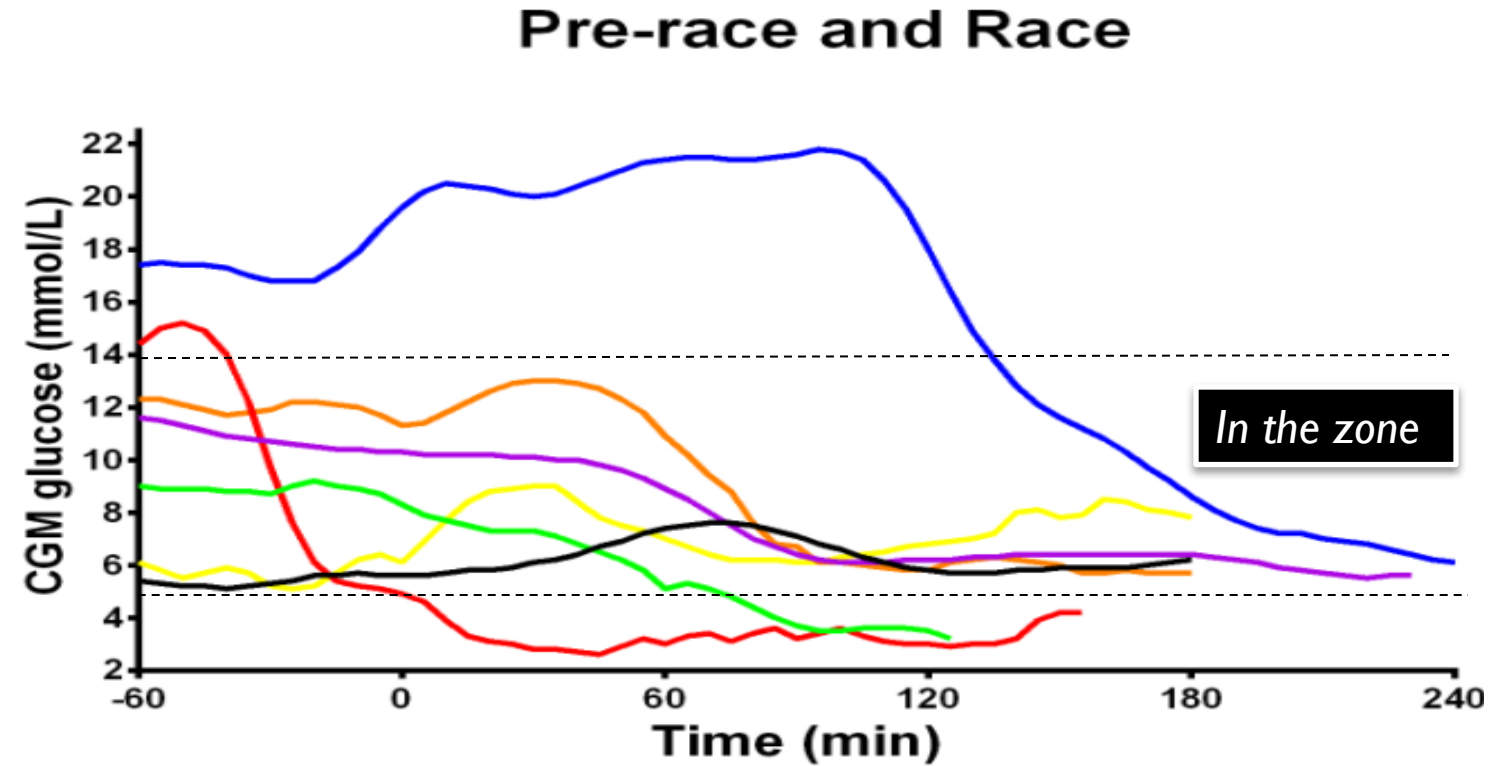
Typical Carbohydrate Stores of a 170lb male "athlete"



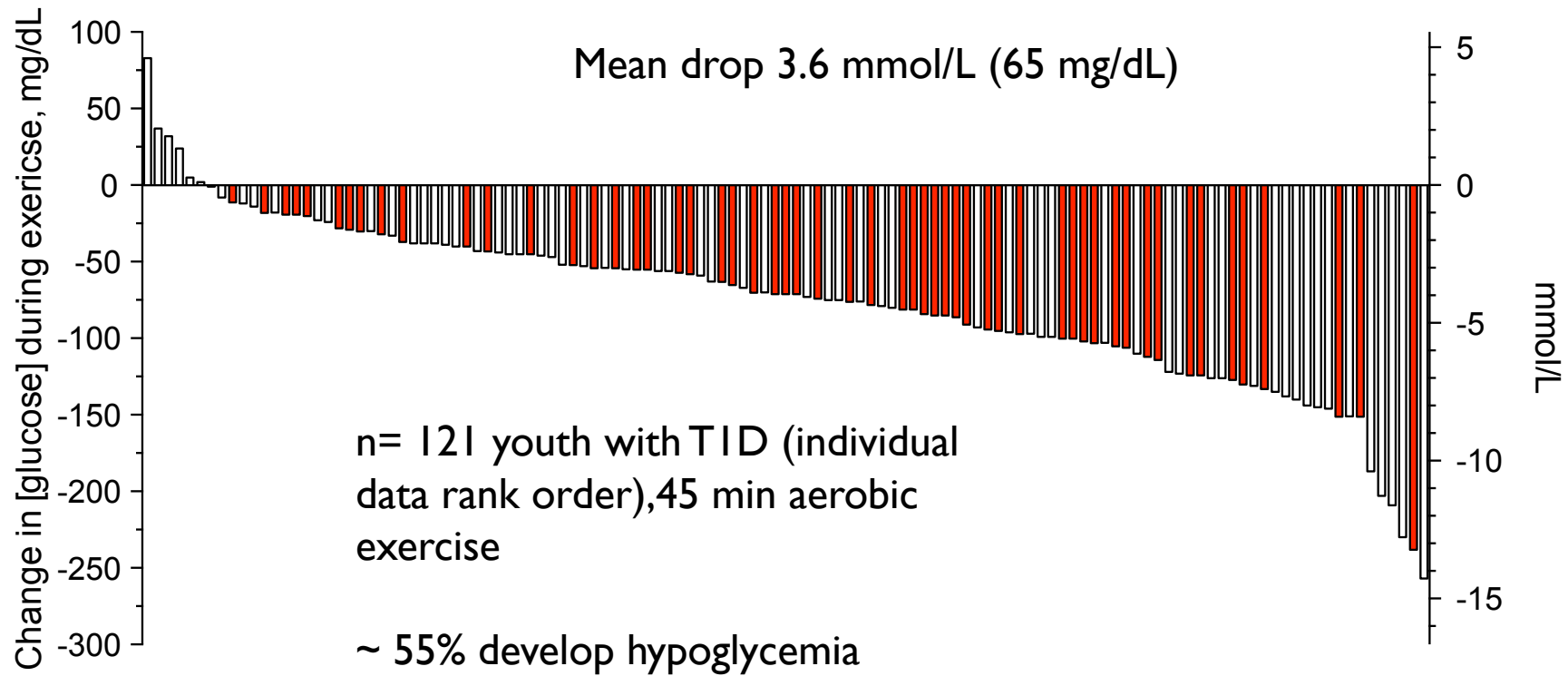
Various types of exercise can do different things to blood glucose...



Glycemic responses to prolonged aerobic exercise is variable in T1D...



Individuality in the blood glucose response to aerobic exercise with no CHO snack or change in insulin...

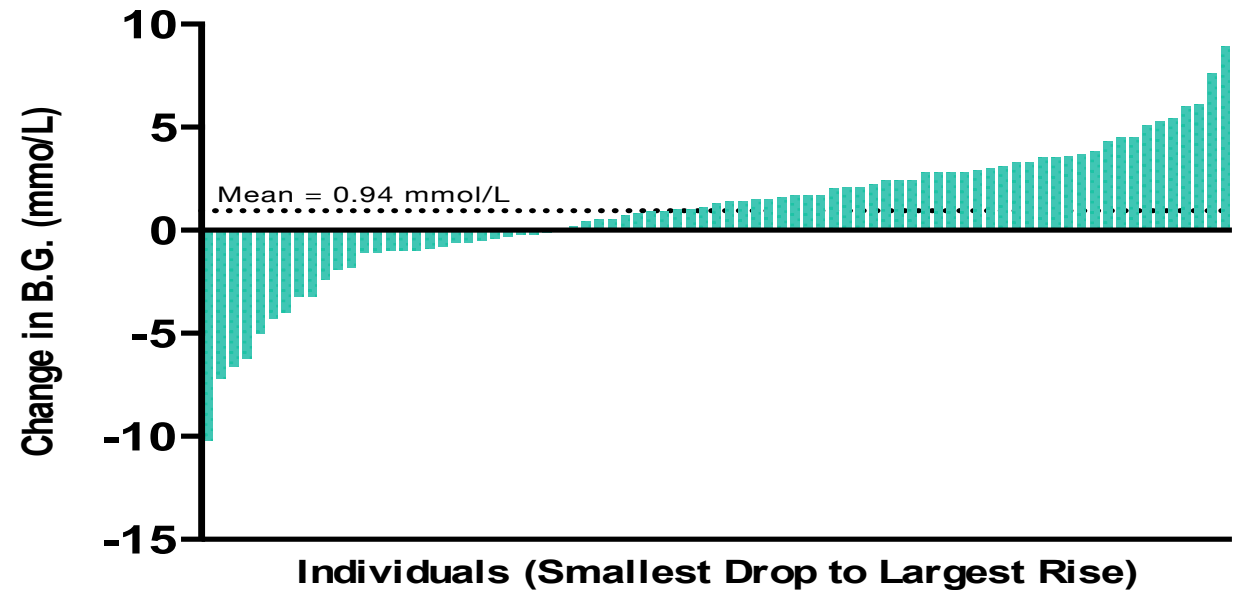


Individuality in the blood glucose response to intense anaerobic exercise with no CHO snack or change in insulin...

~90 kids with T1D performed pre and post blood sugars with sprinting . Each participant was ranked from largest decrease to greatest rise in glycemia...

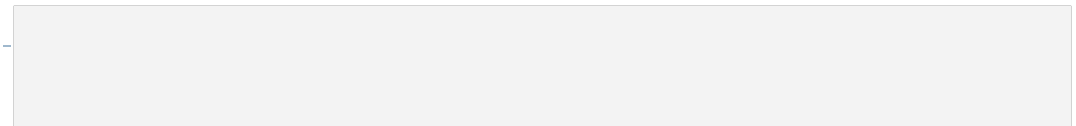


The Sprint Challenge - Change Post 30 Minute Recovery

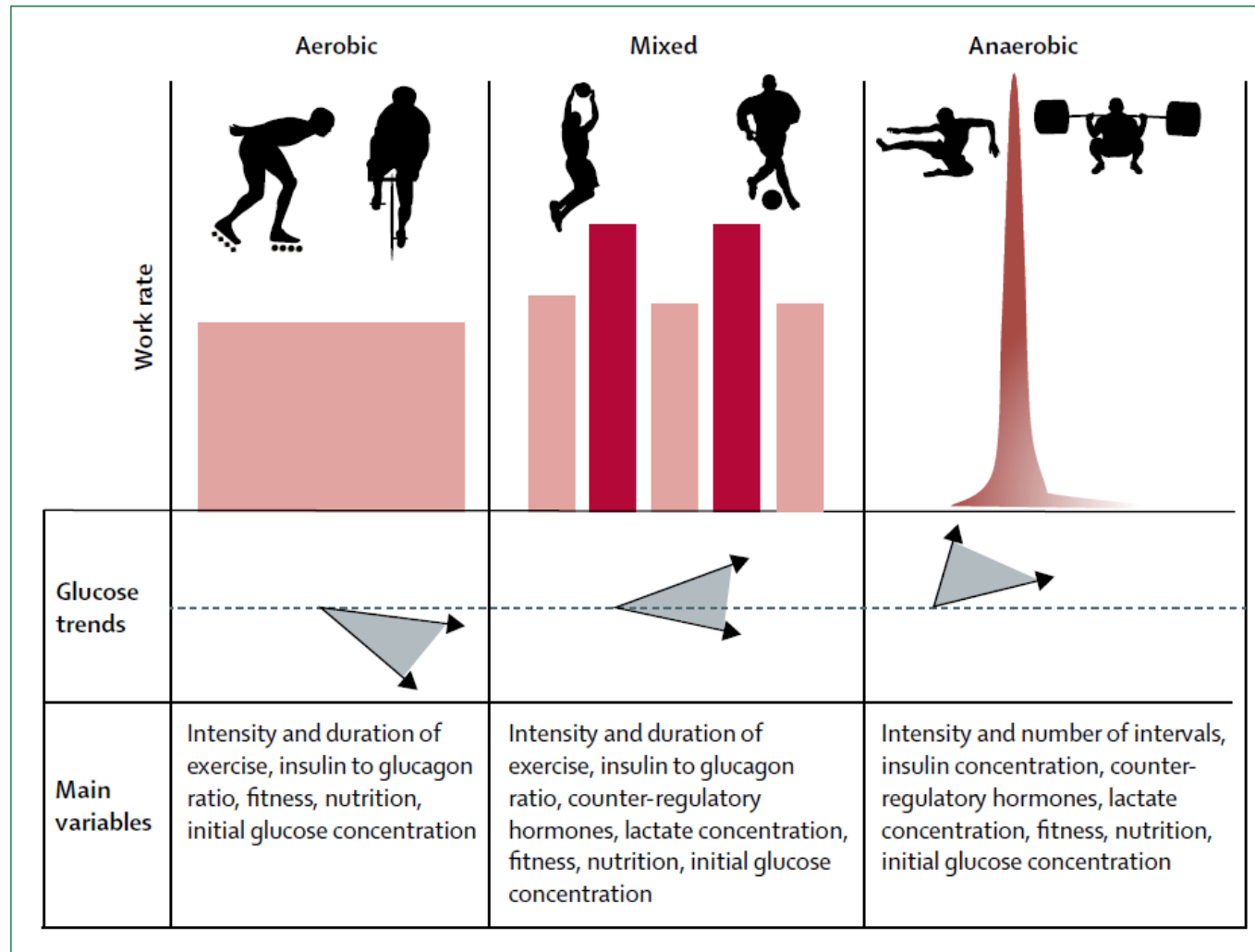


The Dskate Camp Sprint Study (Milton 2016)

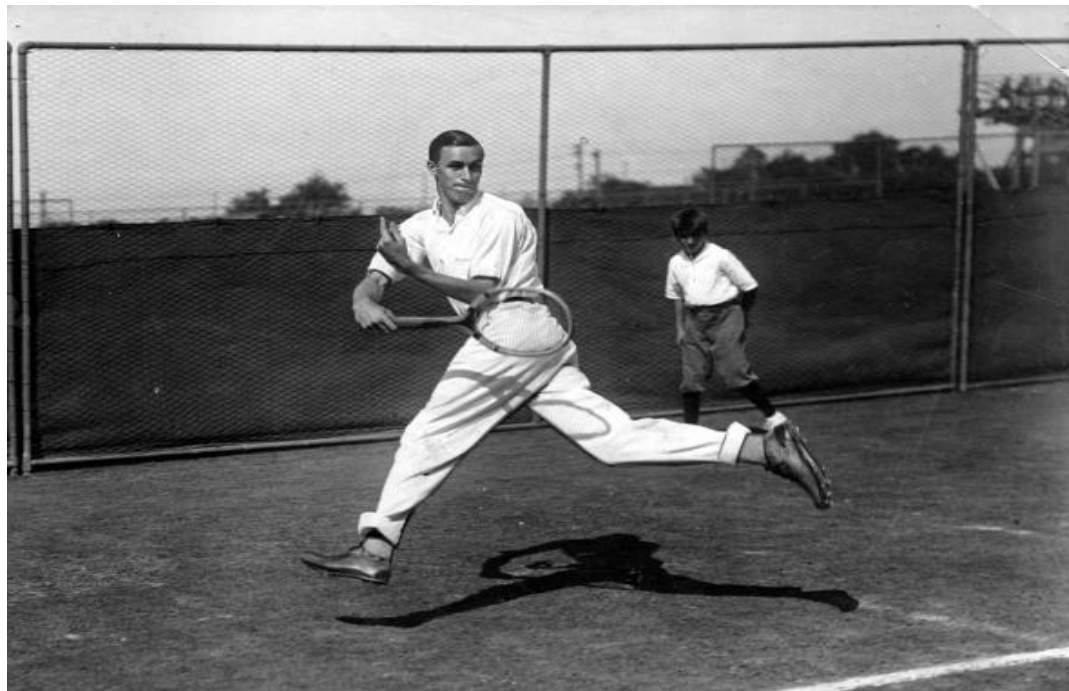
Riddell et al., in preparation



Identifying general trends and reasons for patient variability in blood glucose responses to exercise in T1D



Aerobic exercise has long been known to act like insulin to lower blood glucose levels

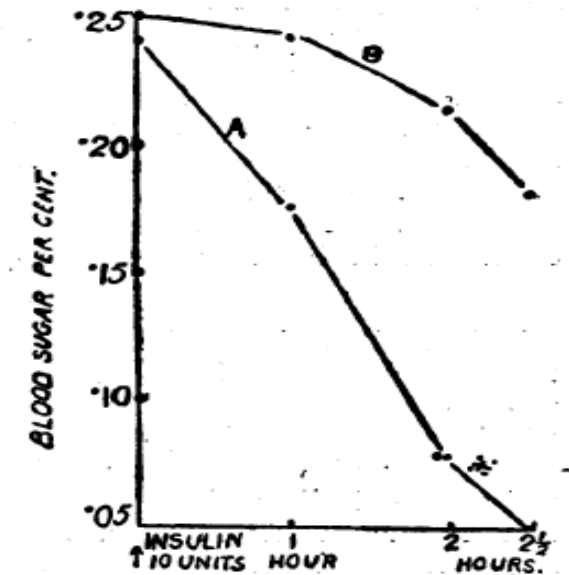


THE EFFECT OF EXERCISE ON INSULIN ACTION IN DIABETES.*

BY

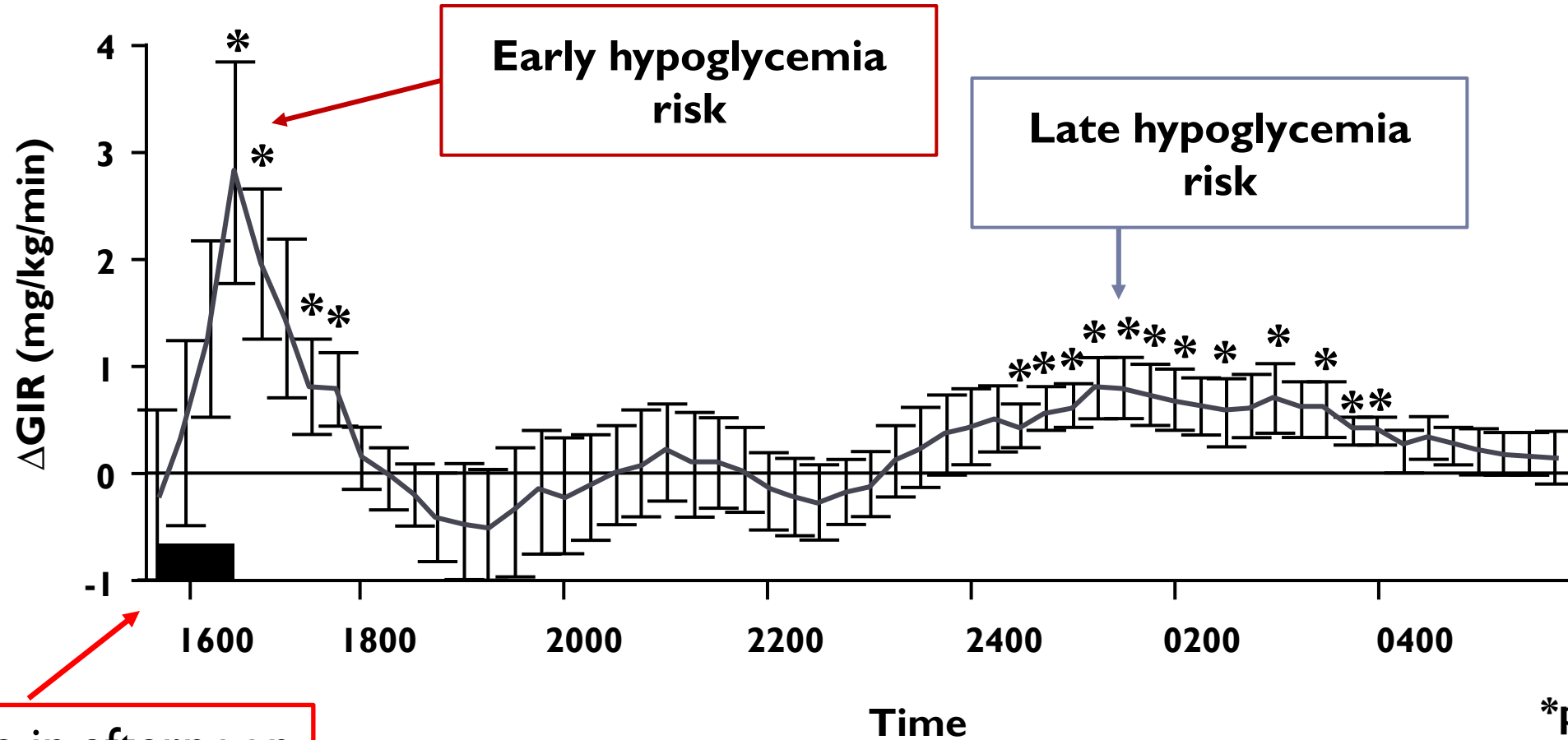
R. D. LAWRENCE, M.D.,
CHEMICAL PATHOLOGIST, KING'S COLLEGE HOSPITAL.

Time. Minutes.	A. Insulin + Exercise.	B. Insulin, no Exercise.
2 p.m.	240 Insulin 10 units	254 Insulin 10 units
20	245	—
30	—	242
45	219	—
60	175	239
90	116	230
120	73*	211
150	51*	181
4.30 p.m.		



The British Medical Journal 1926

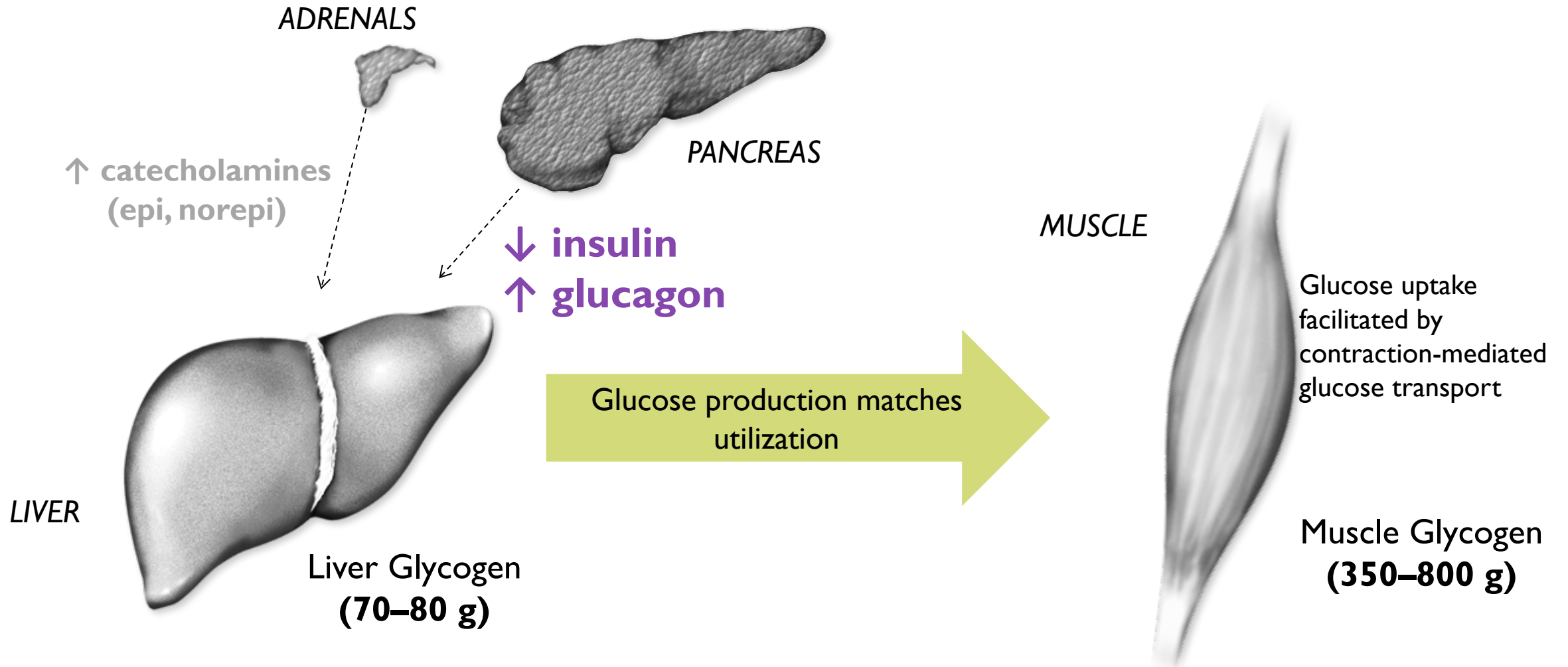
Insulin sensitivity changes in response to afternoon aerobic exercise in a biphasic manor in T1D



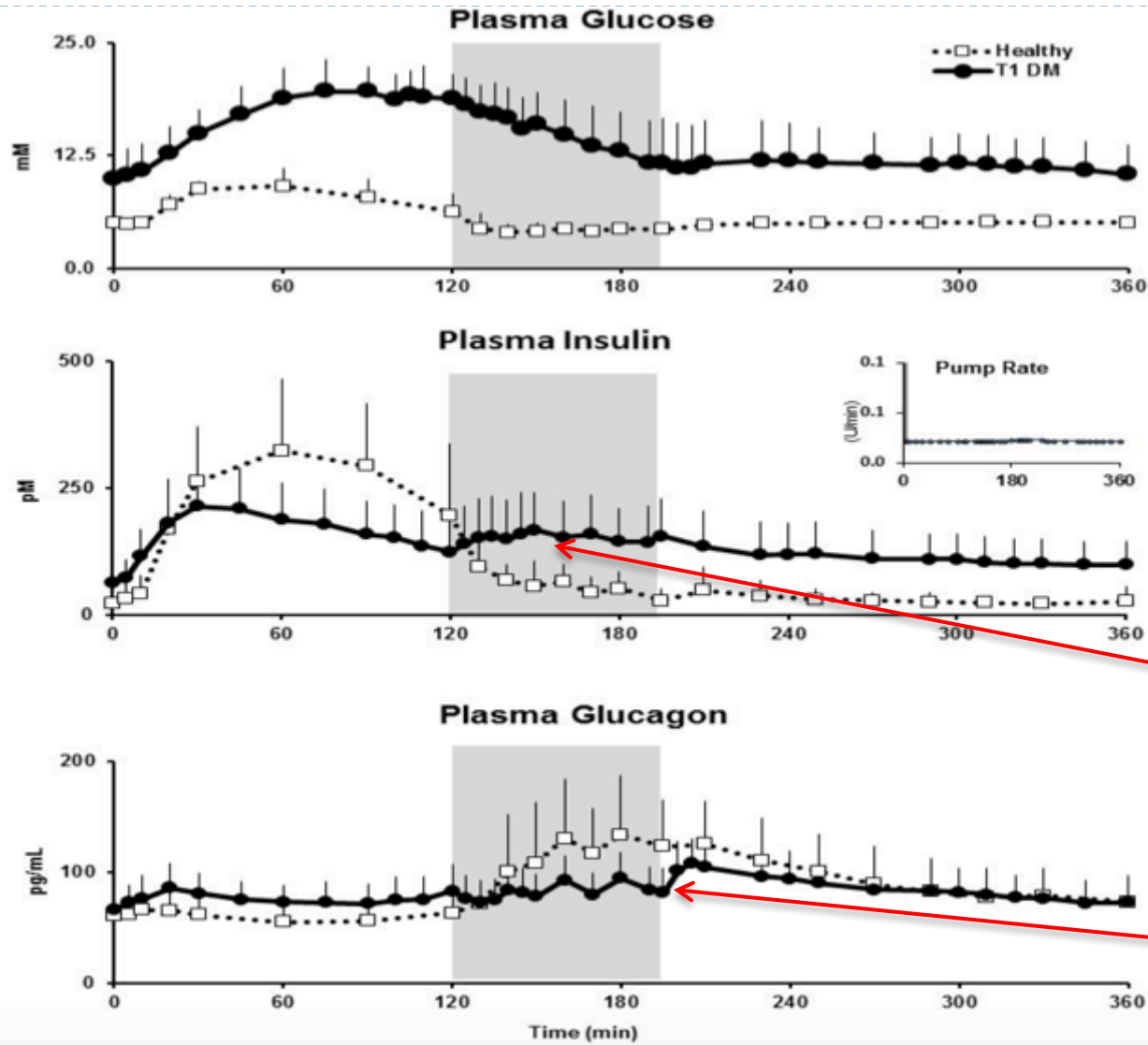
Exercise in afternoon

* $p < 0.05$

Normal Mechanisms of Glucose Provision For Aerobic Exercise



Aerobic Exercise-Post Prandial Dysfunction in Insulin and Glucagon levels in T1D

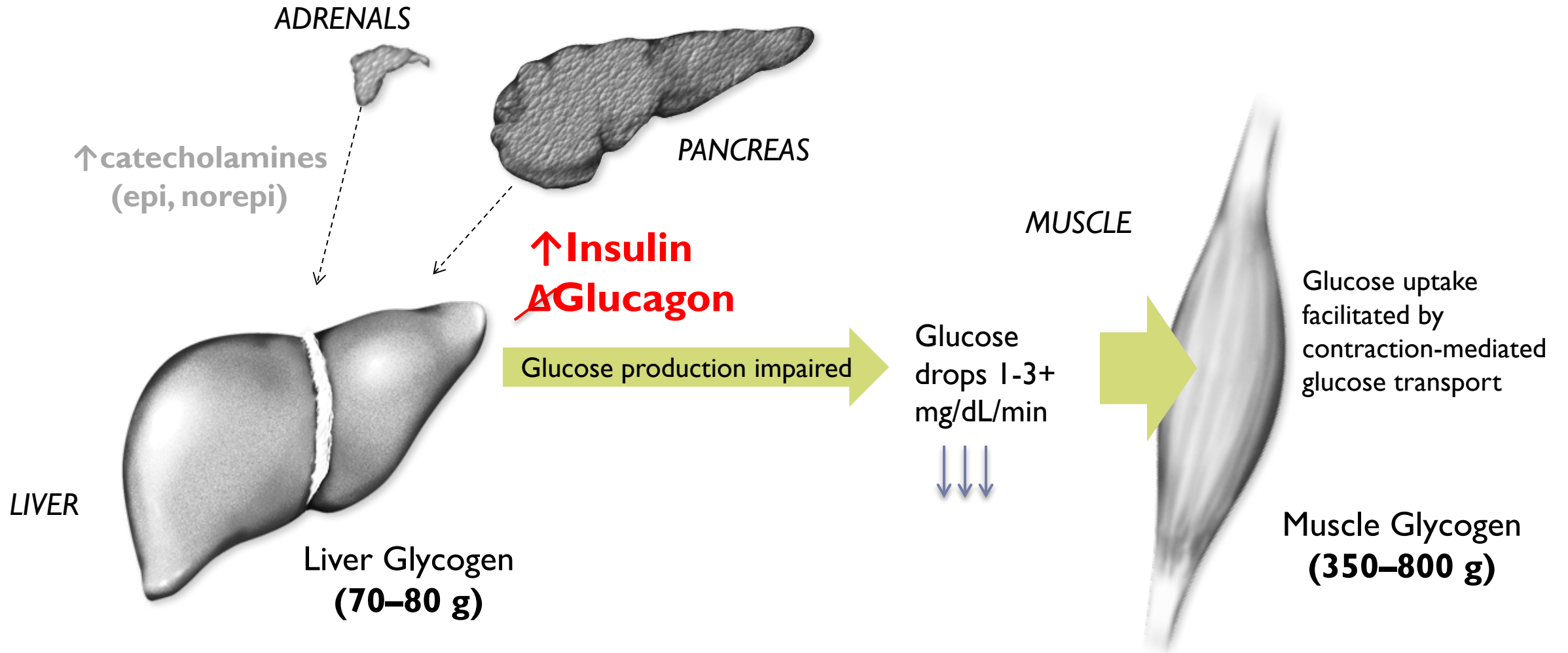


16 T1D “pumpers”
exercising 120 minutes
after a meal (75g CHO)
with usual basal/bolus
insulin

Basal insulin pump rates
were not changed during
the study duration

Glucagon response flat?

Mechanisms of Exercise-Induced Hypoglycemia in T1D



Exercise management in type 1 diabetes: a consensus statement



Michael C Riddell, Ian W Gallen, Carmel E Smart, Craig E Taplin, Peter Adolfsson, Alistair N Lumb, Aaron Kowalski, Remi Rabasa-Lhoret, Rory J McCrimmon, Carin Hume, Francesca Annan, Paul A Fournier, Claudia Graham, Bruce Bode, Pietro Galassetti, Timothy W Jones, Iñigo San Millán, Tim Heise, Anne L Peters, Andreas Petz, Lori M Laffel

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.

Lancet Diabetes Endocrinol 2017

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Muscle Health Research Centre,
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Diabetes and Endocrinology,
Royal Berkshire Hospital,
Reading, UK (I W Gallen FRCP);
Hunter Medical Research

NEW (CONSENSUS) EXERCISE DECISION TREE FOR T1D

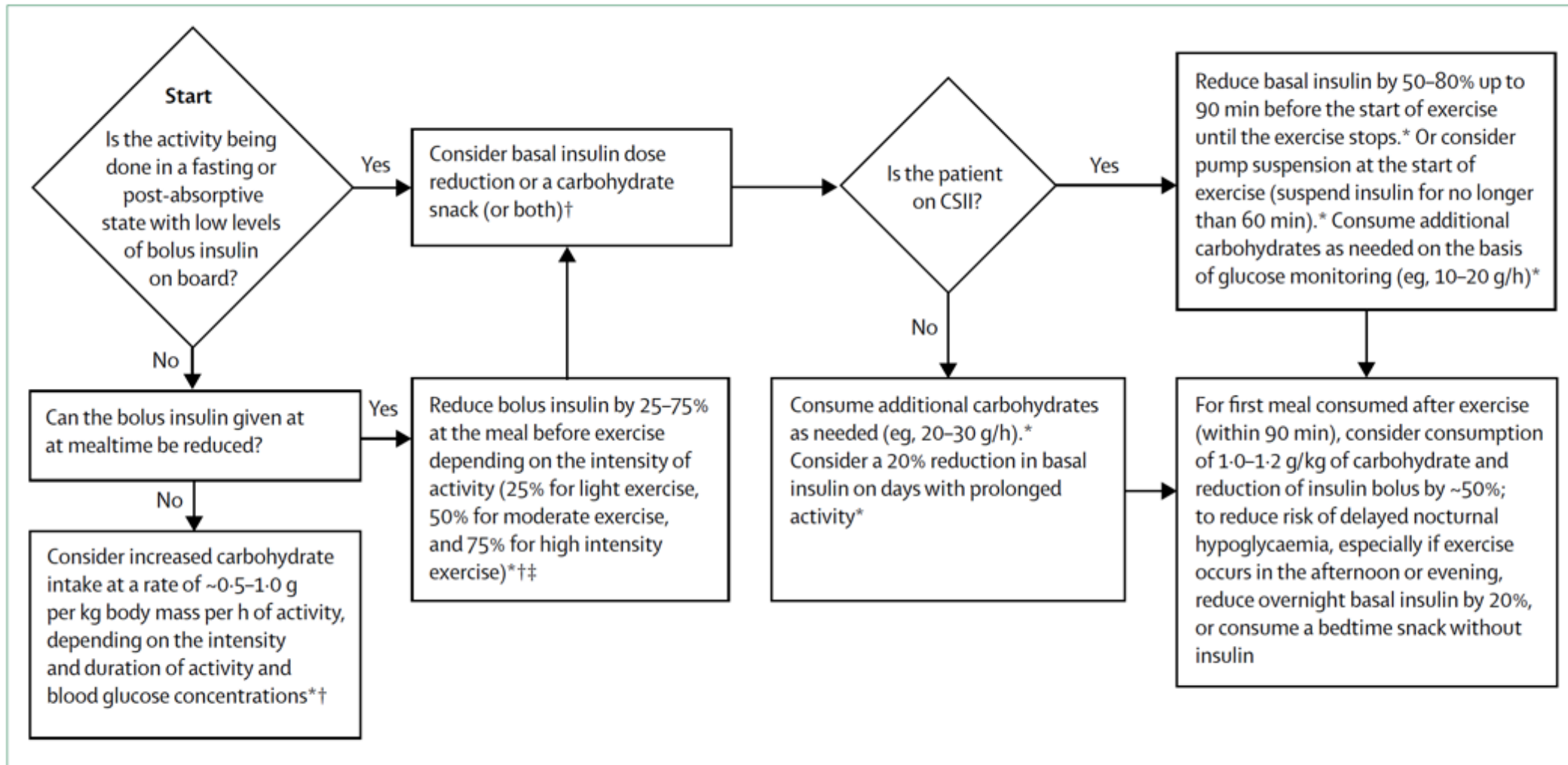


Figure 2: Decision tree for aerobic exercise and mixed aerobic and anaerobic activities lasting 30 min or longer in people with type 1 diabetes

PRESENTING SPONSOR



Riddell MC et al., Lancet Diabetes Endocrinol. 2017





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Canadian Journal of Diabetes

journal homepage:
www.canadianjournalofdiabetes.com

**DIABETES
CANADA**



Review

Insulin Management Strategies for Exercise in Diabetes



Dessi P. Zaharieva MSc^a, Michael C. Riddell PhD^{a,b,*}

^a School of Kinesiology & Health Science, Faculty of Health, Muscle Health Research Centre and Physical Activity & Chronic Disease Unit, York University, Toronto, Ontario, Canada

^b LMC Diabetes & Endocrinology, Toronto, Ontario, Canada

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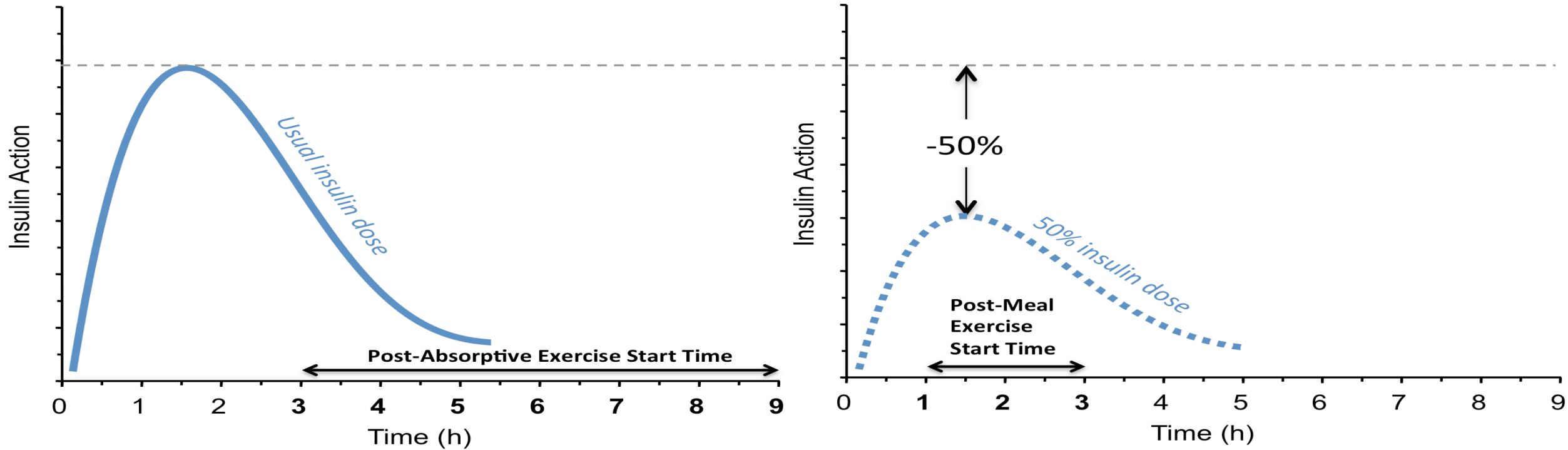
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Accepted 31 July 2017

ABSTRACT

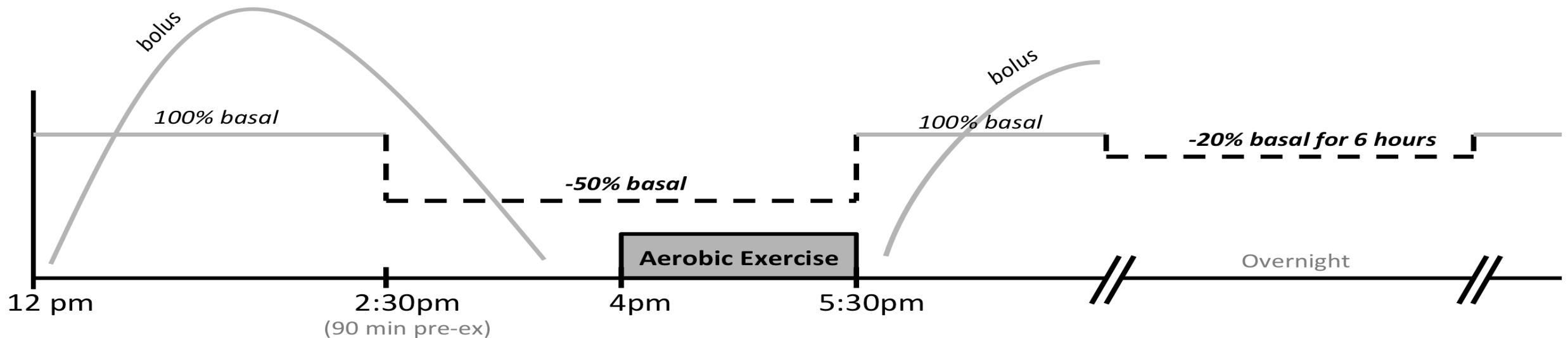
There is no question that regular exercise can be beneficial and lead to improvements in overall cardiovascular health. However, for patients with diabetes, exercise can also lead to challenges in maintaining blood glucose balance, particularly if patients are prescribed insulin or certain oral hypoglycemic agents. Hypoglycemia is the most common adverse event associated with exercise and insulin therapy, and the fear of hypoglycemia is also the greatest barrier to exercise for many patients. With the appropriate insulin dose adjustments and in some cases carbohydrate supplementation, blood glucose levels can

Bolus reductions for post meal aerobic exercise



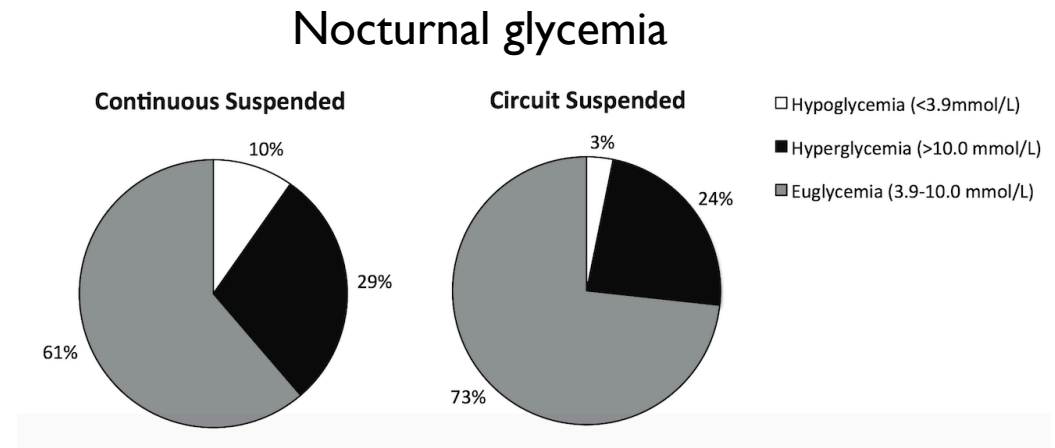
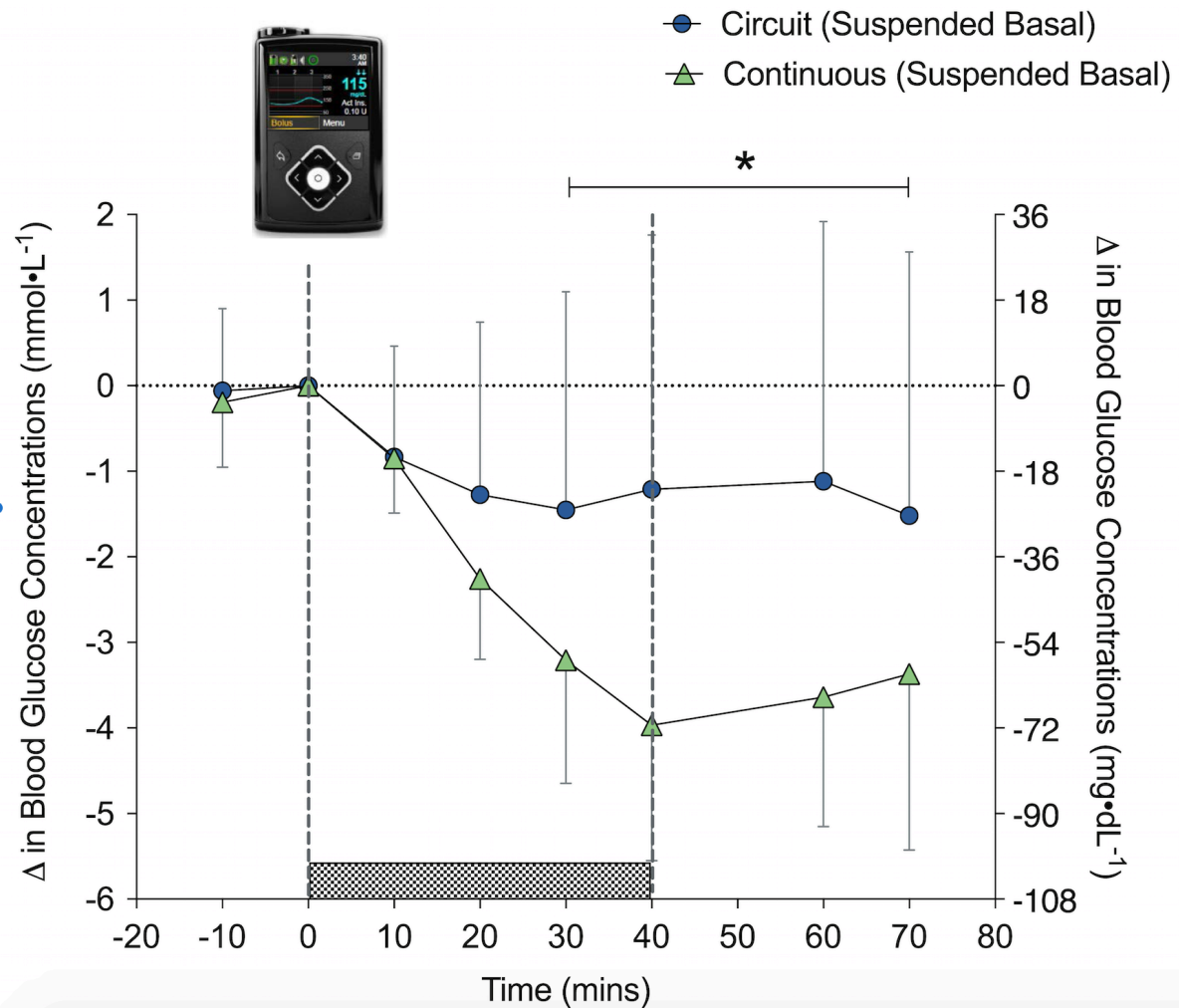
For aerobic exercise to be performed after a meal, take ~50% less insulin.

Recommended timing of basal rate reductions (pump)

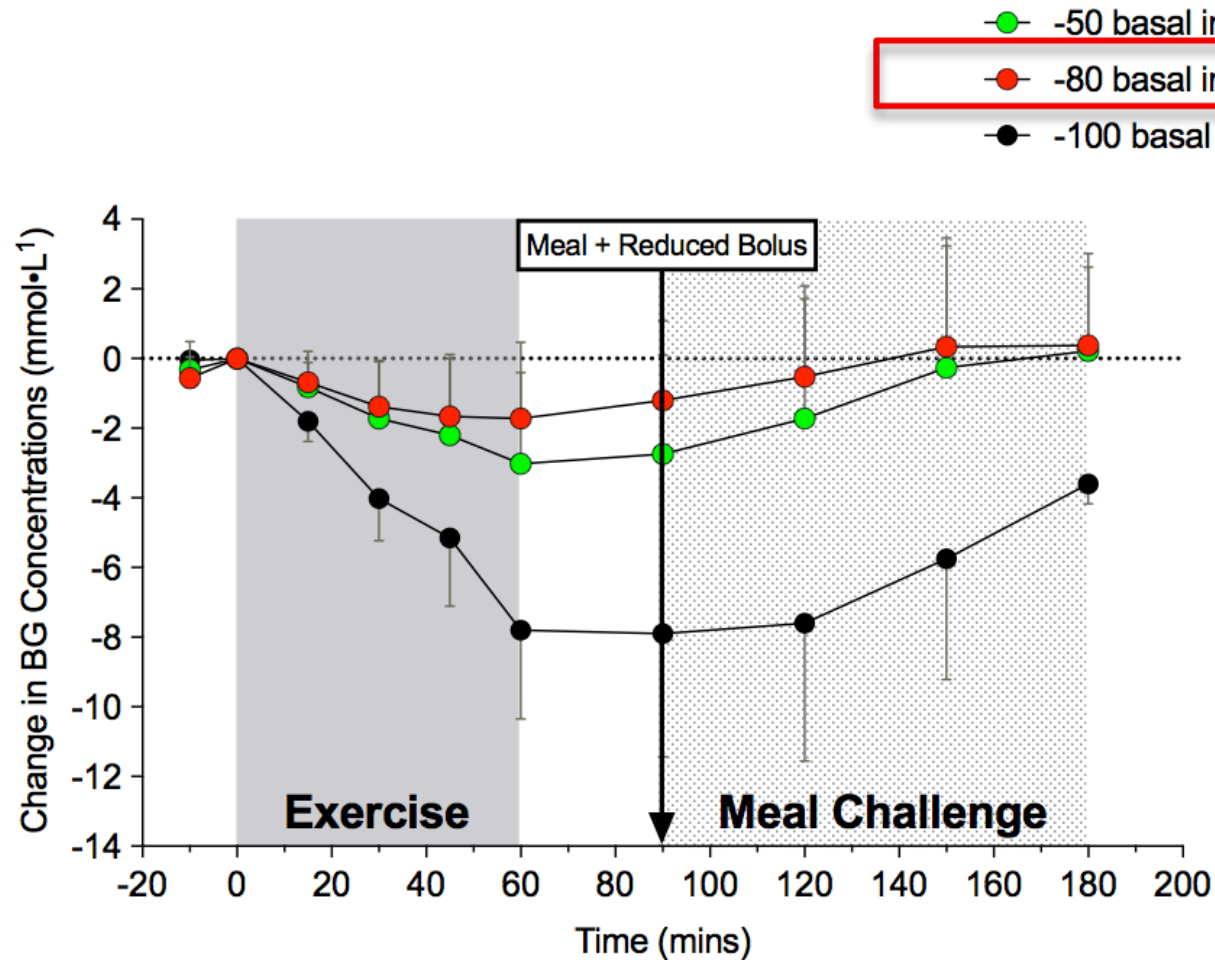


For aerobic exercise performed before meals, reduce basal insulin by 50-80% well in advance of exercise (60-90 min pre exercise).

Suspending insulin delivery on a pump does not sufficiently prevent the drop in glucose during aerobic exercise



Efficacy of insulin basal rate reductions for exercise in T1D



What if you don't bother with
changing insulin delivery- can you
still exercise?

Carbohydrate (CHO) Intake for Aerobic Exercise



Brief, mild exercise performed soon after a meal

- No additional CHO needed



Prolonged exercise

- CHO intake may be needed (15-30 g)

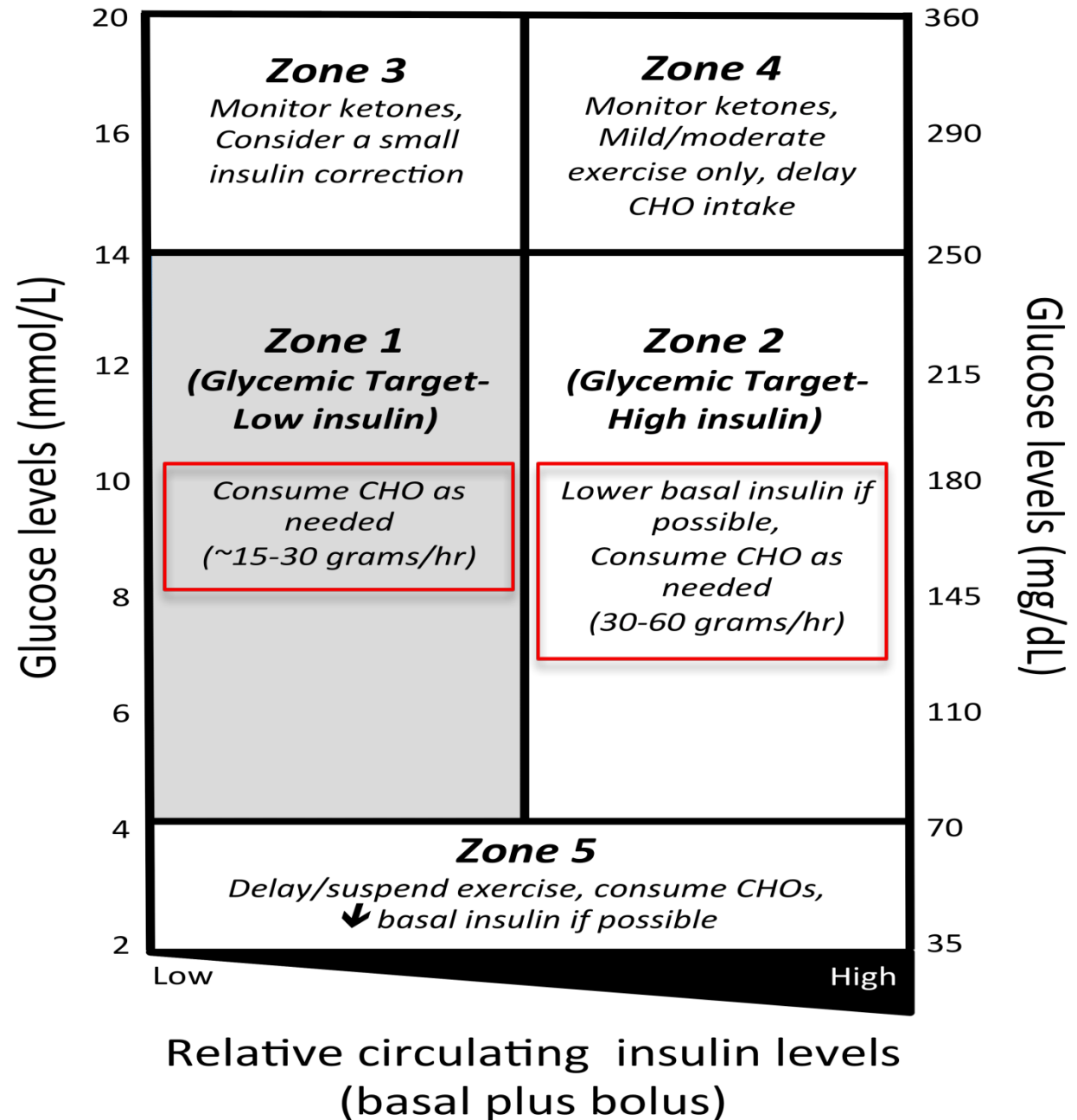


Endurance/performance activities

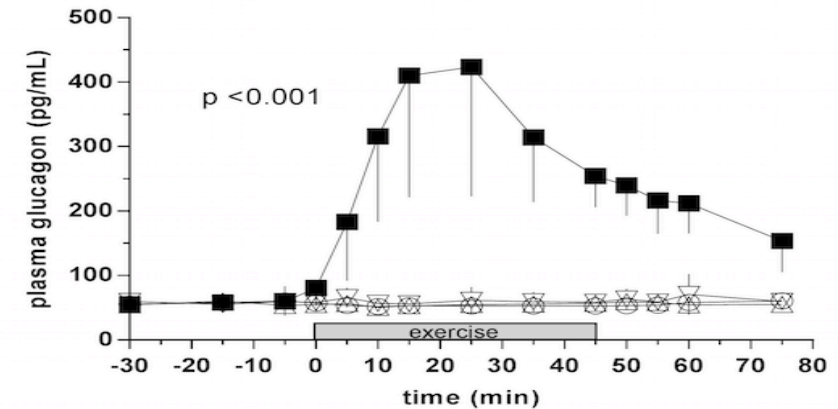
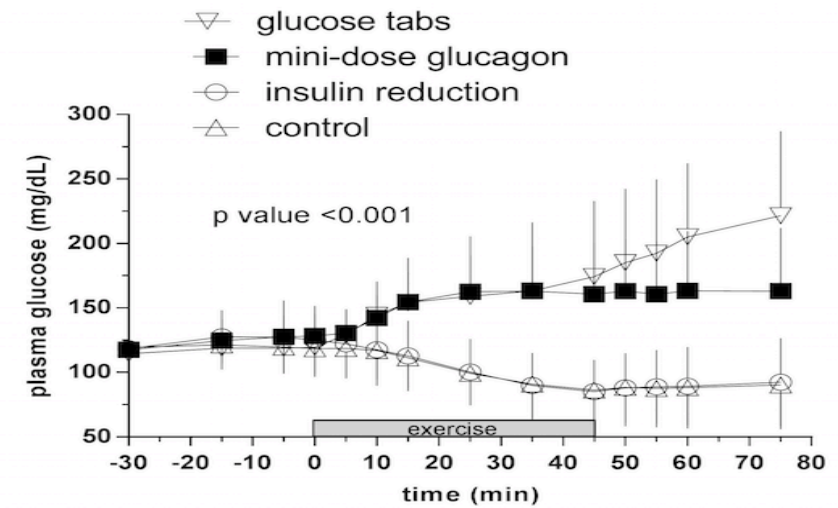
- CHO intake needed (30-60 g/hour)

When it comes to exercise and
T1D, on board insulin matters!

Starting blood glucose levels and relative 'on board' or 'active' insulin levels and what to do for prolonged aerobic exercise



In the very near future, we will be able to take minidose glucagon (prefilled needle) before exercise to prevent hypoglycemia during exercise



Rickels et al., ADA 2017

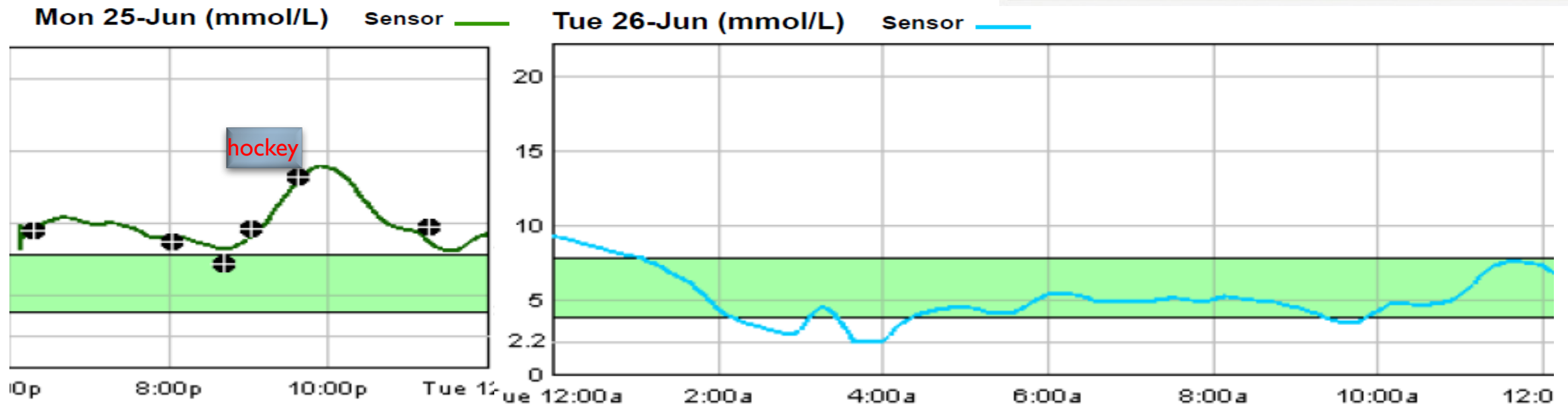


Nocturnal Hypoglycemia

- ▶ In children, ~75% of severe hypoglycemia occurs during sleep
- ▶ Increased physical activity and hypoglycemia during the activity increases risk
- ▶ Real-time CGM provides nocturnal alarms
 - ▶ But 71% of alarms are not responded to

DCCT, Diabetes Care 18:1415, 1995
Davis, Diabetes Care 20:22, 1997
Buckingham, DTT 7:440, 2005

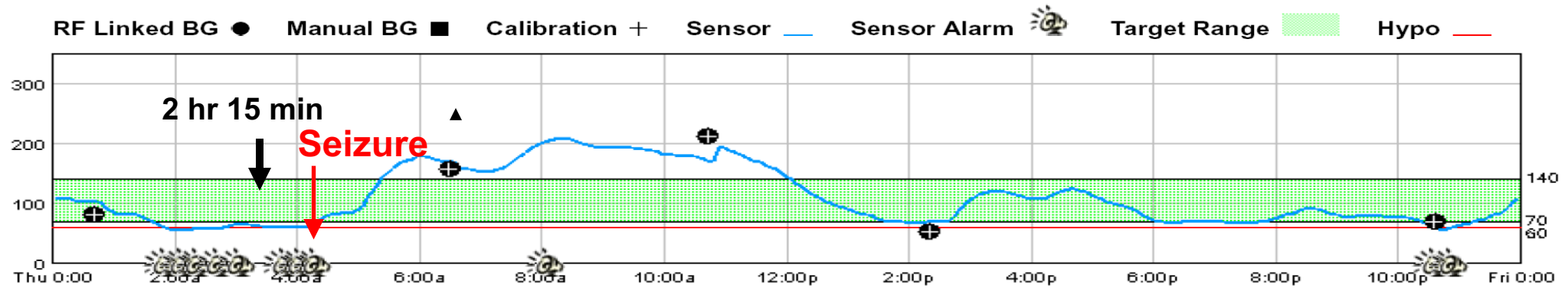
Exercise can transiently cause hyperglycemia.....
Then late-onset hypoglycemia....



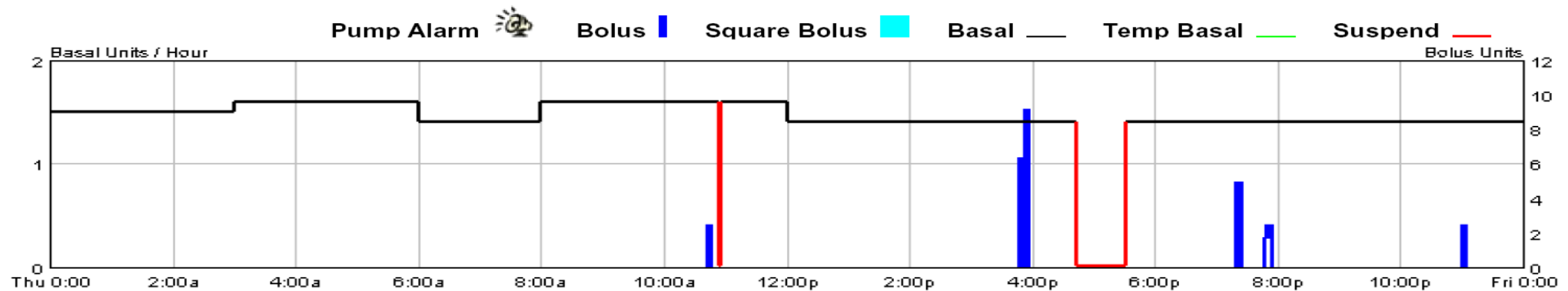
Nocturnal Hypoglycemia Prior to a Seizure - 16 year old

Buckingham. Diabetes Care 31:2110. 2008

Glucose (mg/dL)



Insulin Delivery



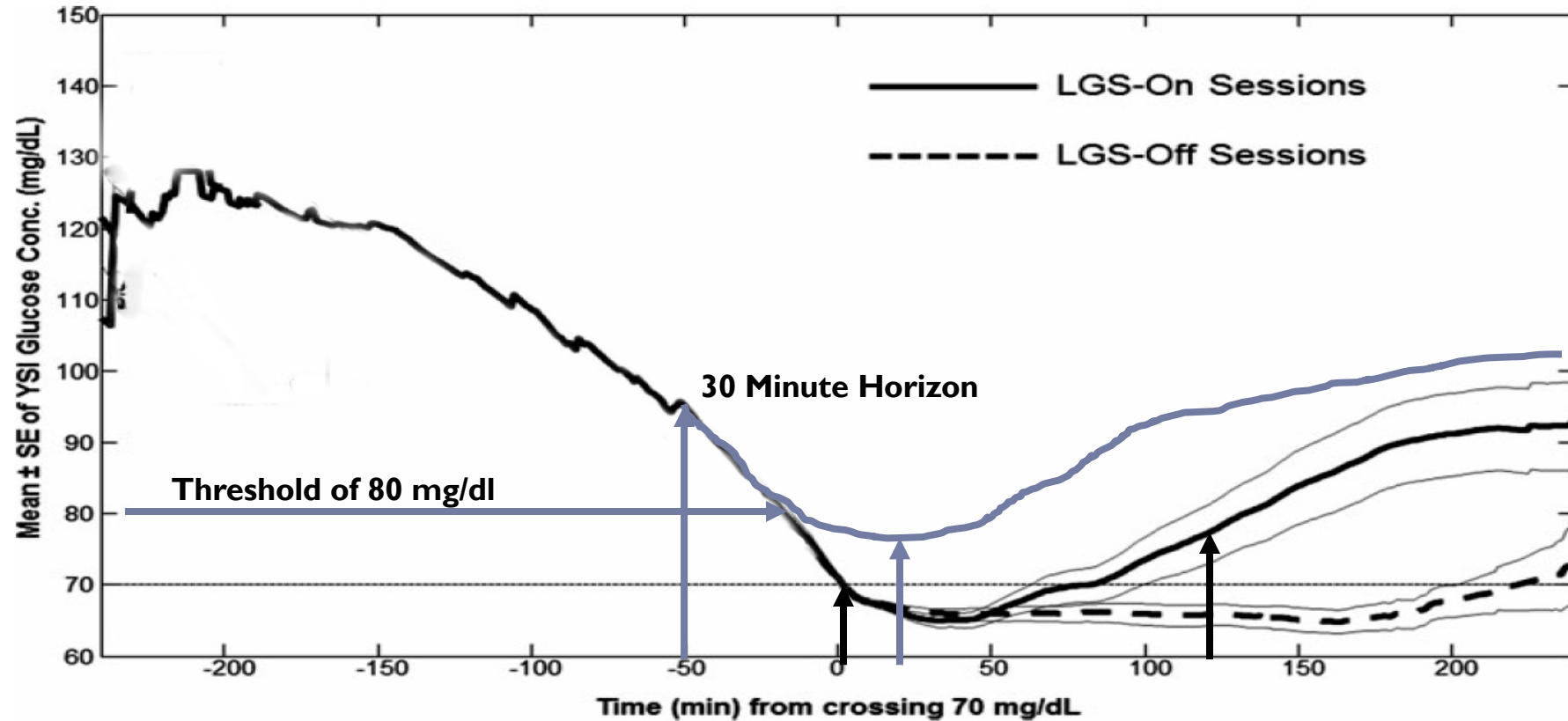
Overnight Glucose Control

- ▶ Medtronic pumps and preventing lows
 - ▶ Threshold suspend on low (suspend on low) (Medtronic 630G)
 - ▶ Predictive low glucose suspend (Medtronic 640G)
 - ▶ Full Closed-loop at night (Medtronic 670G)



Low Glucose Suspend overnight (after usual day and after exercise day, n= 50 subjects)

DTT (2012) 14:205



Medtronic 670G



Glucometer



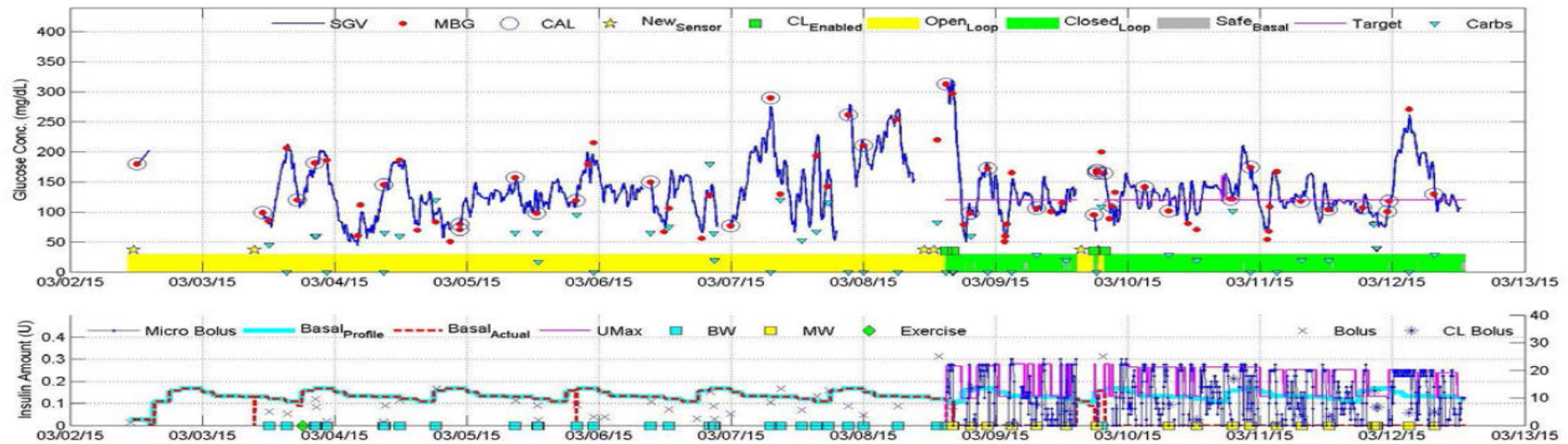
Enlite 3 sensor

Open Loop Compared to Closed-Loop



Overall Patient (304-NG1008908U) Summary [From CL Start]

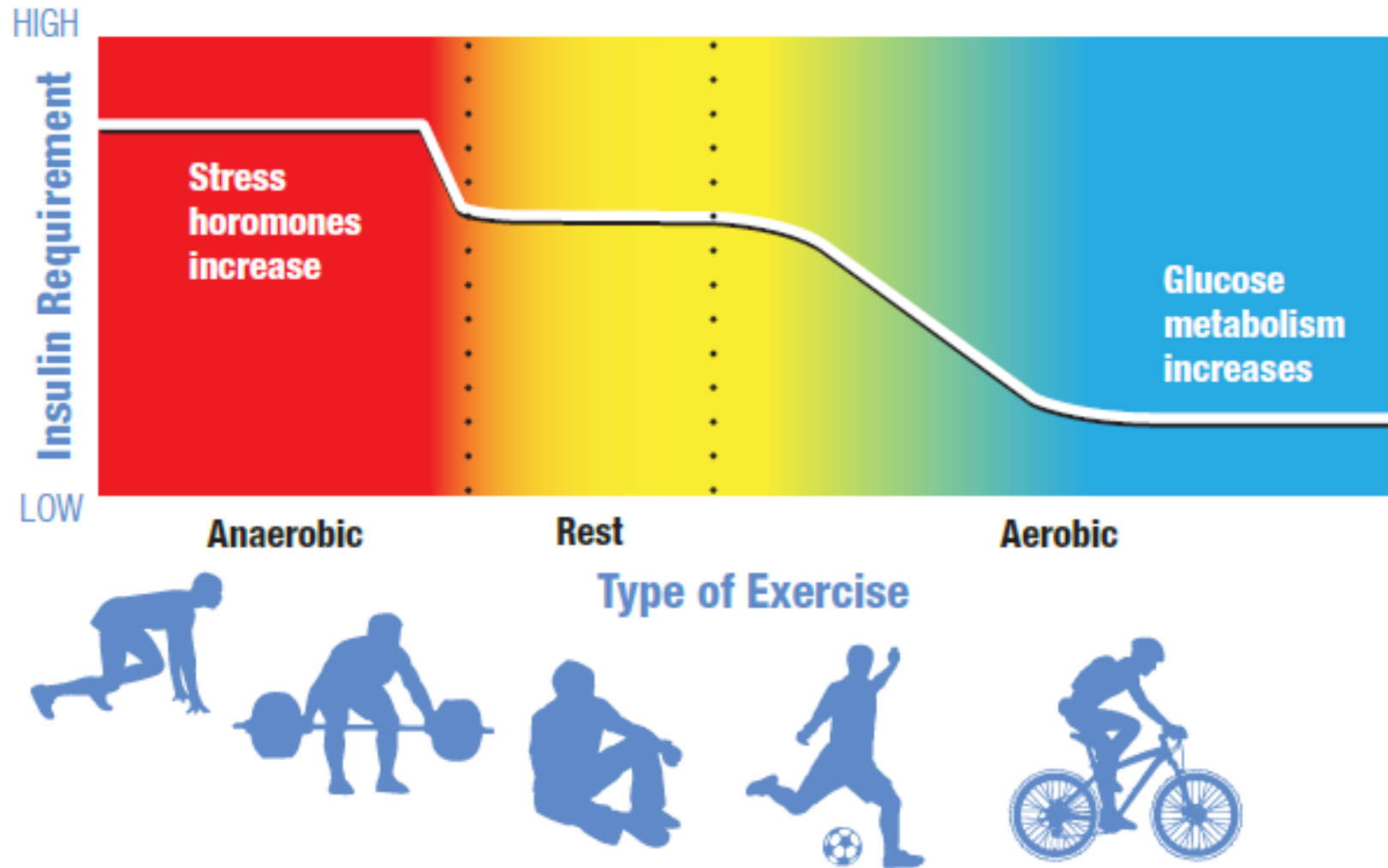
3/12/15



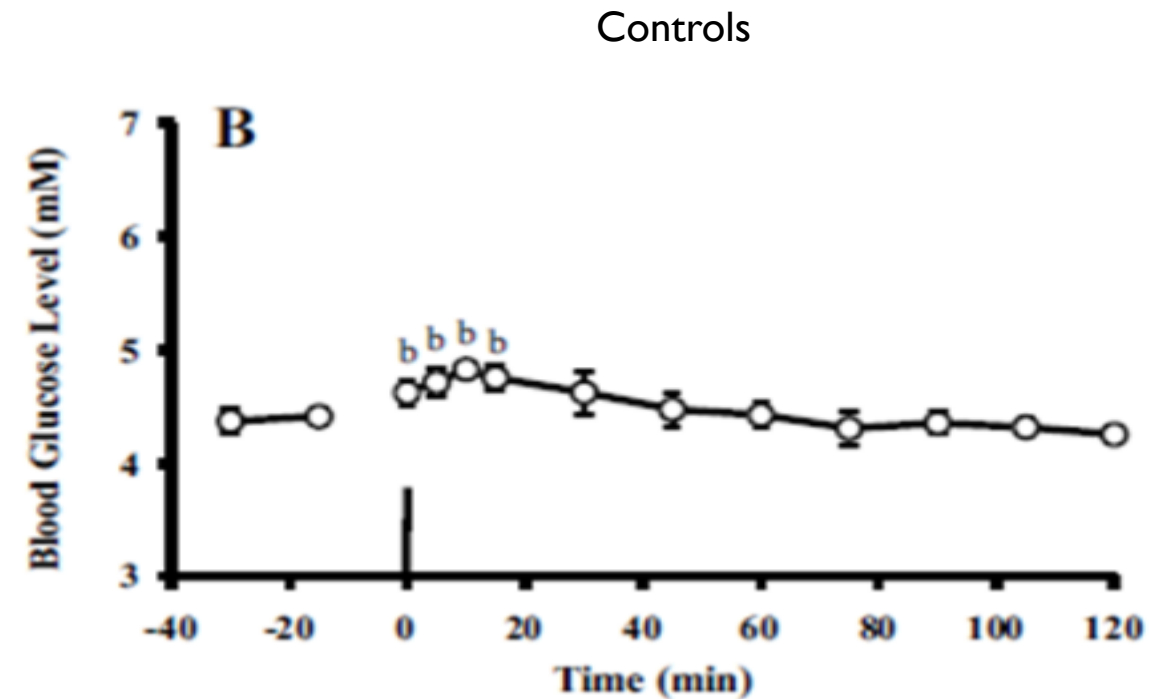
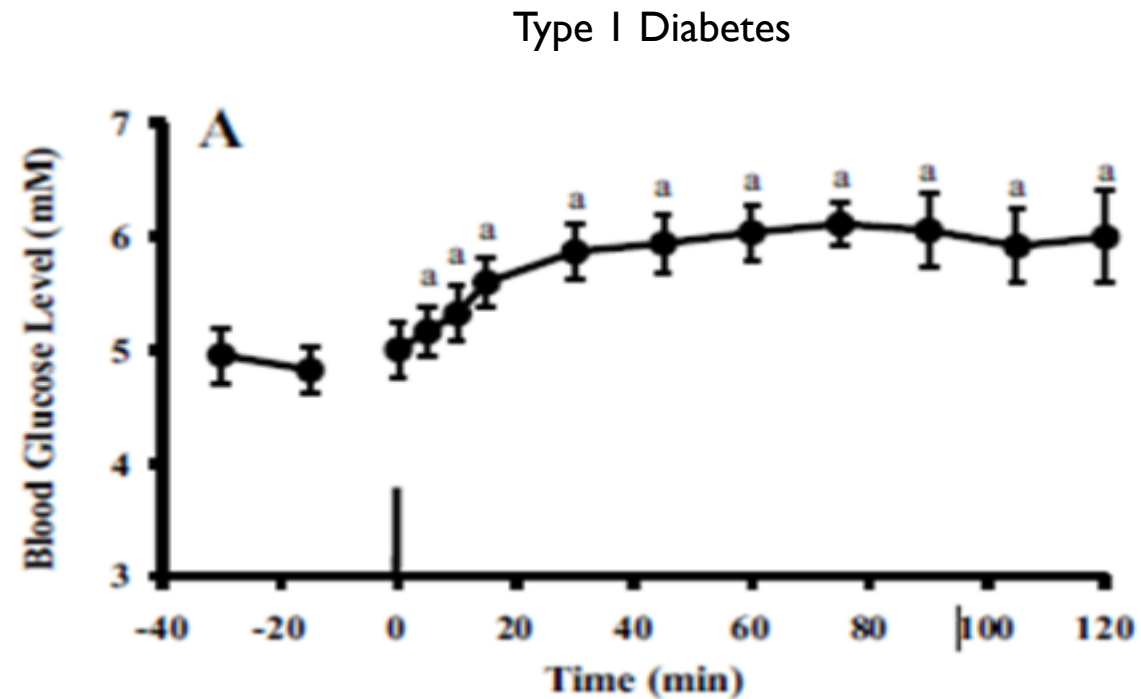
Exercise of different types...



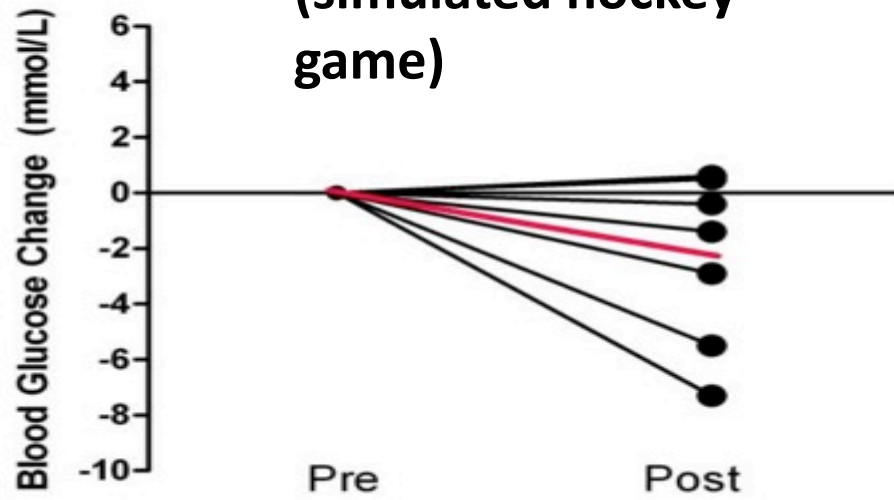
Insulin needs and the exercise spectrum



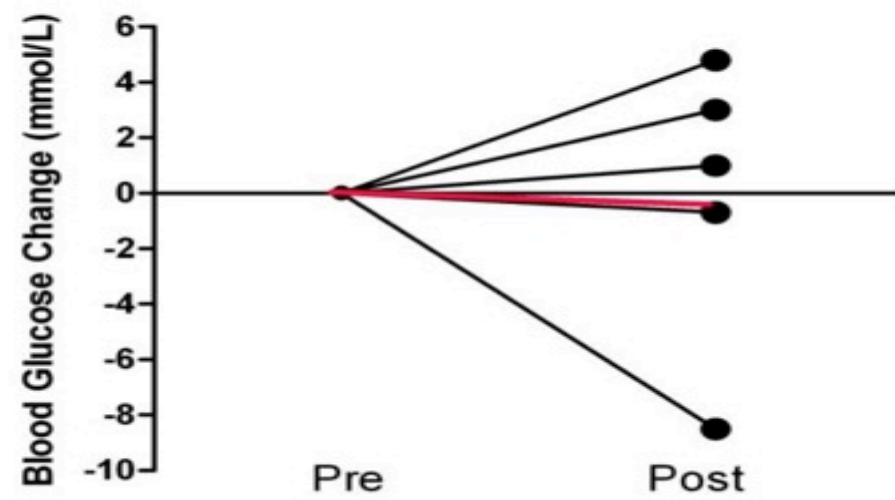
Blood glucose response to a 10s anaerobic sprint in adolescents with and without T1D



Lab Exercise (simulated hockey game)



True Hockey Game



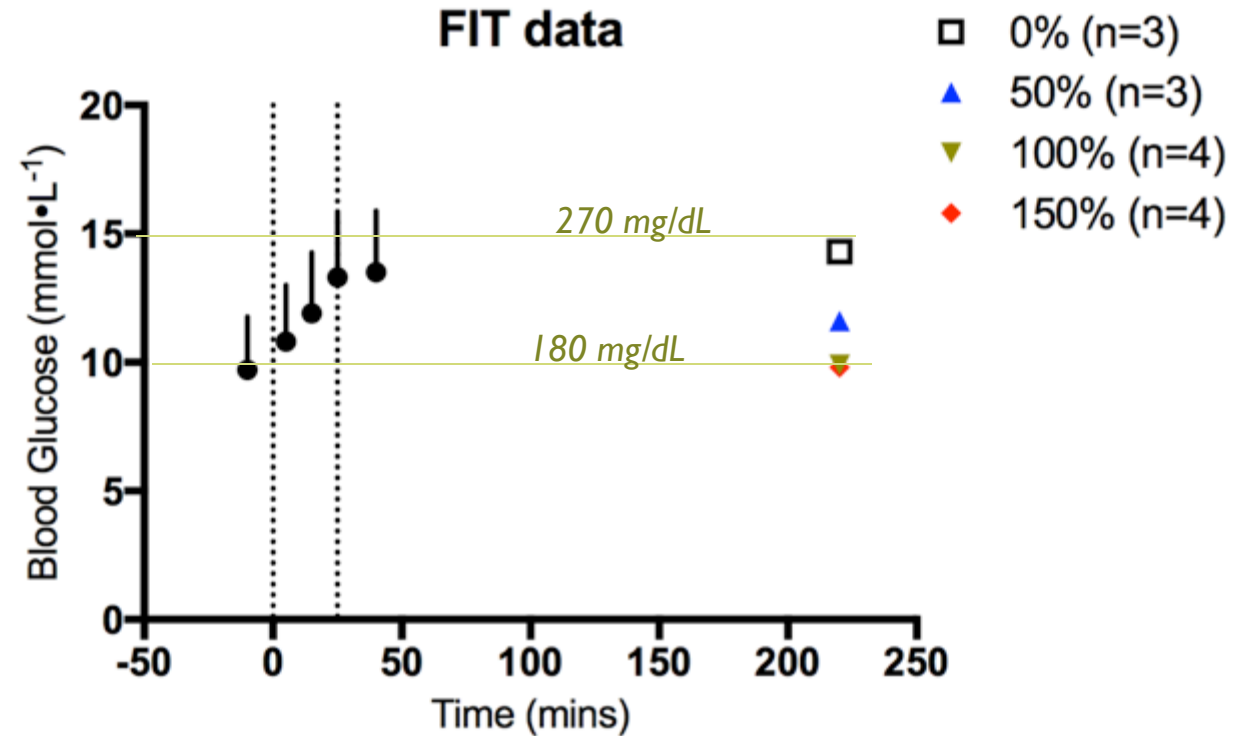
Exercise and Hyperglycemia- the importance of Monitoring



Gary Hall, Jr. (born September 26, 1974, diagnosed T1D in 1999)- US swimmer who competed in the 1996, 2000, and 2004 Olympics and won ten Olympic medals.

“You have to test your blood glucose levels often, the more the better....Nerves will send my levels sky high...When I broke the American record, I tested ten minutes before my race. I was at 140.Ten minutes after the race I tested again. I was at 388.The race lasted 21 seconds.”

What is the “best” post exercise high glucose correction bolus that won't result in recovery hypo?



Before the 2002 Winter Olympics in Salt Lake City, he was diagnosed with Type I diabetes

Kris Freeman Quick Facts

Hometown	Andover, NH
Birthplace	Concord, NH
Birthdate	10/14/1980
Years on Team	10
Club	Ski and Snowboard Club Vail
Olympics	2002, 2006, 2010
Worlds	2001, 2003, 2005, 2007, 2009, 2011



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The 2010 Vancouver Olympics

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USA's Freeman has blood sugar crash in cross-country pursuit

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By Steve Elfers, USA TODAY

The USA's Kris Freeman (21) makes his way down a tricky curve during the men's cross-country 30-kilometer pursuit Saturday in Whistler. Freeman, who is a diabetic, was only about six seconds behind at the 11.25 kilometer mark when he had a blood sugar crisis. He finished 45th.

By Beau Dure, USA TODAY

WHISTLER — Kris Freeman competes in the grueling sport of cross country skiing with Type I diabetes. Most days, he manages it well; some days, he posts exceptional results such as his two fourth-place finishes in World Championship competition.

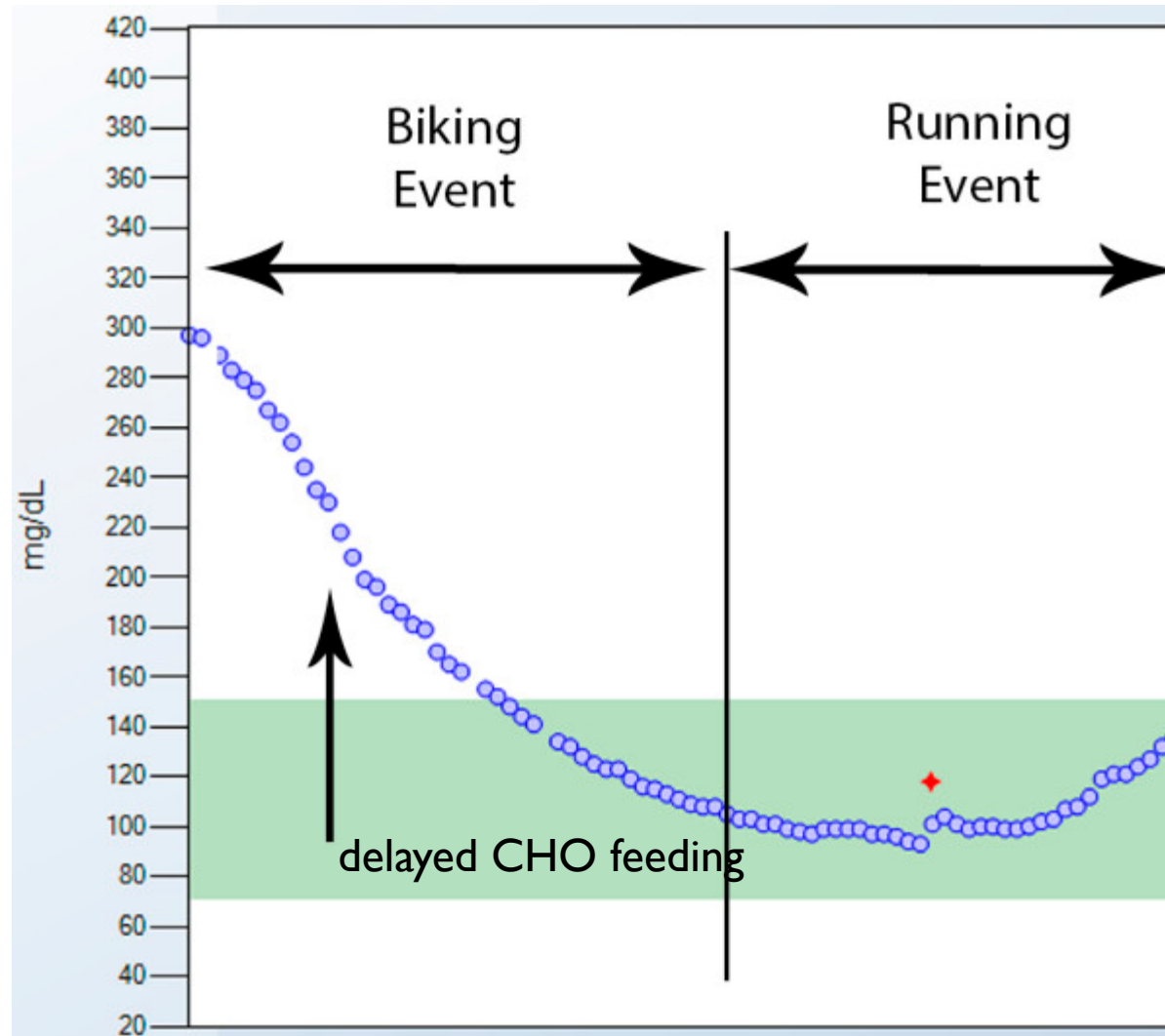
In Saturday's men's 30-kilometer mixed-style pursuit race, his condition caught up with him.

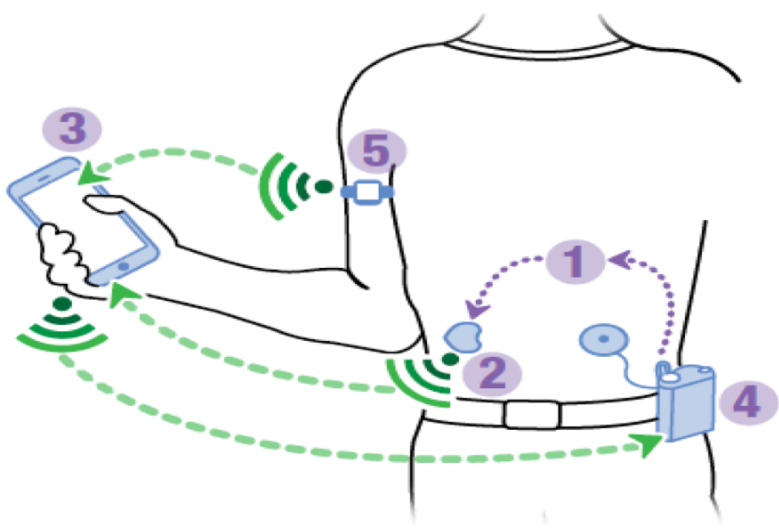
RESULTS: Men's 30K pursuit

"On the fourth lap of the classic race, I had a blood sugar crash," Freeman said. "I stopped and lied on the ground for a minute."

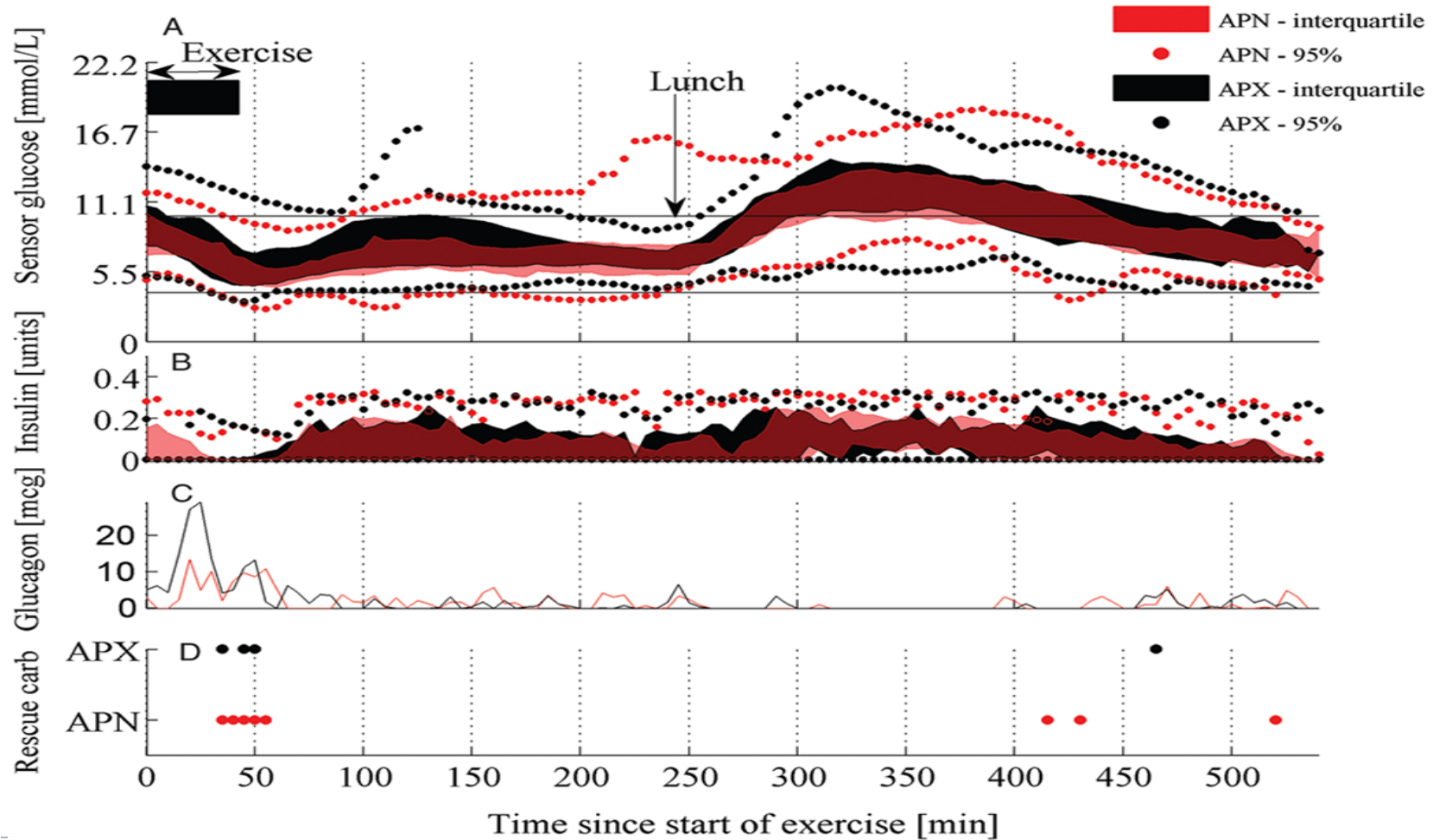
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This 18-year-old male used RT-CGM while training for and competing in a 13h Ironman Triathlon





In the very near future, we will be using “exercise smart” artificial pancreases!



JDRF Performance in Exercise and Knowledge (PEAK) Program



Exercising Safely with Type 1 Diabetes

Do you have type 1 diabetes (T1D) or care for someone who does? Are you a healthcare provider who treats people with T1D? JDRF PEAK's one-day events offer the information you need to manage physical activity and T1D.



PRESENTING SPONSOR



Summary

- ▶ Many patients with T1D remain in suboptimal control and struggle with being physically active
- ▶ Glucose control remains challenging in active patients
 - ▶ Hypoglycemia is the major barrier for exercise in T1D
 - ▶ Hyperinsulinemia and a failure in glucagon to rise contribute to hypo risk
 - ▶ Basal rate insulin reductions do not prevent the drop in glucose if done at the time start of exercise
- ▶ For aerobic exercise done soon after meals, a 50% bolus reduction
- ▶ For aerobic exercise done before meals, an 80% basal rate reduction needs to occur well in advance (-90 min)
- ▶ A sensor-augmented pump with CGM can offer protection, particularly overnight