Type 1 Diabetes and Exercise: Optimizing the Medtronic MiniMed® Veo™ Insulin Pump and Continuous Glucose Monitoring (CGM) for Better Glucose Control [1,2] for Healthcare Professionals

Presented by

Dr. Bruce Perkins, MD MPH

Dr. Michael Riddell, PhD

1. Bergenstal RM, Tamborlane WV, Ahmann A, et al. Effectiveness of sensor-augmented insulin-pump therapy in type 1 diabetes. N Engl J Med. 2010;363(4):311-320
2. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Continuous glucose monitoring and intensive treatment of Type 1 diabetes. N Engl J Med. 2008;359:1464-1476

Agenda

Welcome	Josh Tarini, Sr Clinical Specialist, Medtronic Diabetes
Clinical Evidence Update	Dr. Bruce Perkins, MD, MPH
Physiology of Type 1 Diabetes and Exercise	Dr. Michael Riddell, PhD
Case Studies	Dr. Perkins and Dr. Riddell
Questions from On-line Attendees	Josh Tarini, RD.

Learning Objectives

Participants will gain further perspective and understanding of:

- The recent clinical evidence.
- Distinguishing patterns in blood glucose data that can help identify challenges in achieving optimal glycemic control before, during, and after exercise.
- Applying strategies that will allow for better glucose control and performance.
- Optimizing the Medtronic MiniMed® Veo™ Insulin Pump and CGM technology features to achieve better glucose control during exercise.

Key Clinical Evidence to Support CGM and to Guide Exercise in Type 1 Diabetes

Bruce A Perkins MD MPH

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Dr. Bruce Perkins –Dualities of Interest Disclosure

Speaker Fees:

- Glaxo Smith Kline, Inc; Medtronic Minimed, Inc; Johnson and Johnson-Animas; Eli Lilly Canada; Novo Nordisk; Sanofi

Research Support

- Medtronic Minimed, Inc; Boehringer Ingelheim.

Advisory Panel

- Neurometrix, Inc.

CGM/Exercise in Context

Hypo Prevention Tools

Intro to Exercise Strategies.

Step 1: Identify Barriers to Care

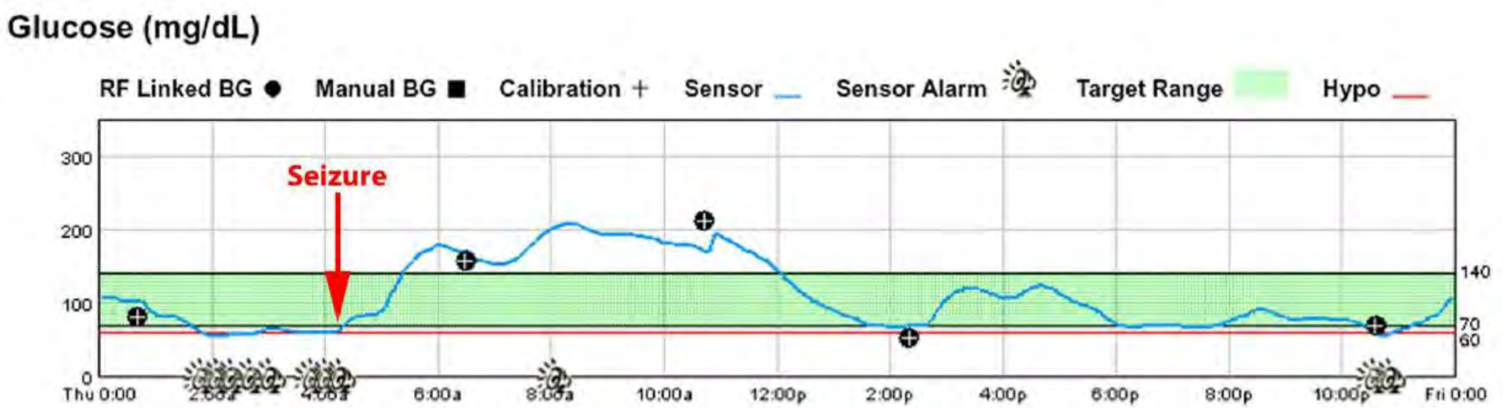
Step 2: Establish Physiological Insulin

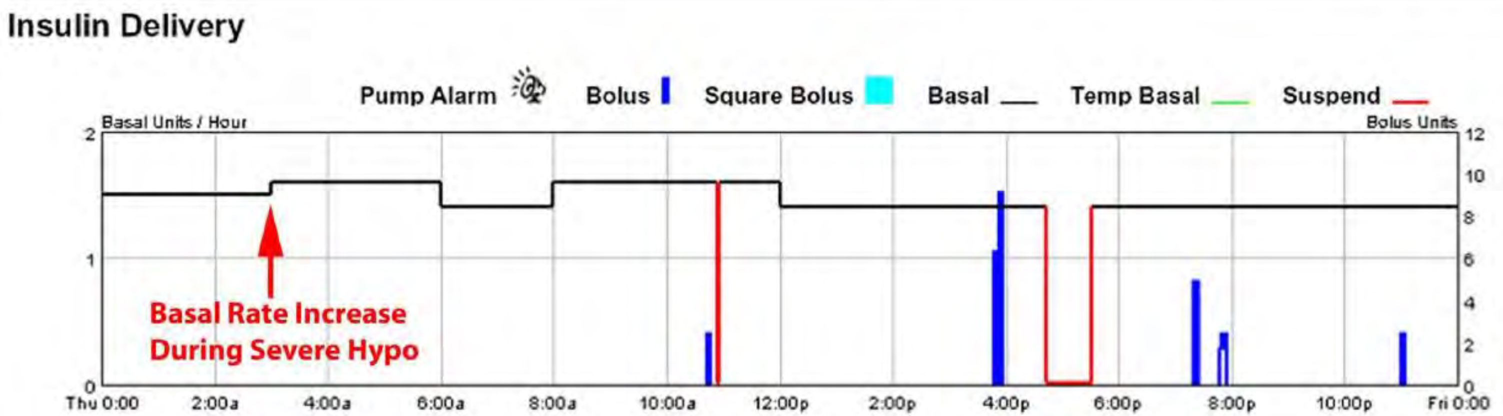
STEP 3: Estimate "ExCarbs"

Step 4: Adjust Insulin

Step 5: Understand Anaerobic Exercise

Can we implement "Technological Awareness" now?





Courtesy of Richard Bergenstal.

ORIGINAL ARTICLE

N ENGL J MED 369;3 NEJM.ORG JULY 18, 2013

Threshold-Based Insulin-Pump Interruption for Reduction of Hypoglycemia

The ASPIRE In-Home trial (Automation to Simulate Pancreatic Insulin Response)

Average Patient: 43yo with 27years of T1DM, A1c 7.2%, no recent severe hypo or hospitalization, and wore a sensor ≥80% of the time in a run-in period.
Design: 3-month (2w run-in) randomized, controlled, multi-center, open-labelled trial N= 247.
Primary Endpoint (Efficacy): $AUC_{10p\text{-}8a\ HYPO}$

INTERVENTION
SAP with Low Glucose Suspend
- LGS set at $\leq$ 3.9 mmol/L

CONTROL
Standard SAP
- No LGS

Bergenstal RM, Klonoff DC, Garg SK, et al for the ASPIRE In-Home Study Group. N Engl J Med 2013;369:224-32

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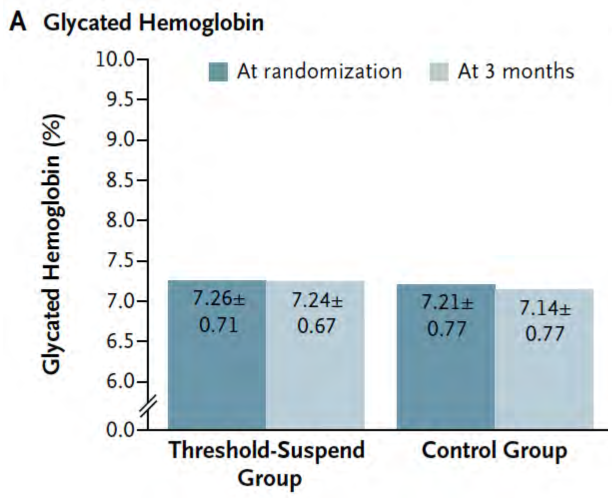
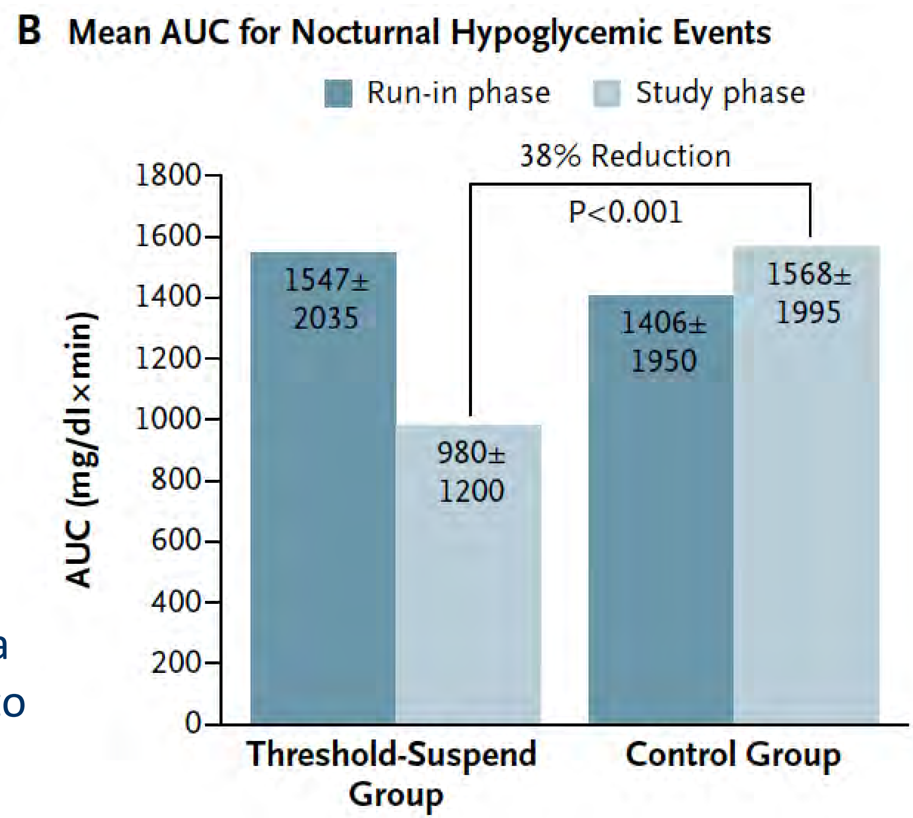
Safety



Extent & duration of hypoglycemia in LGS/TS was a third (38%) lower compared to Control

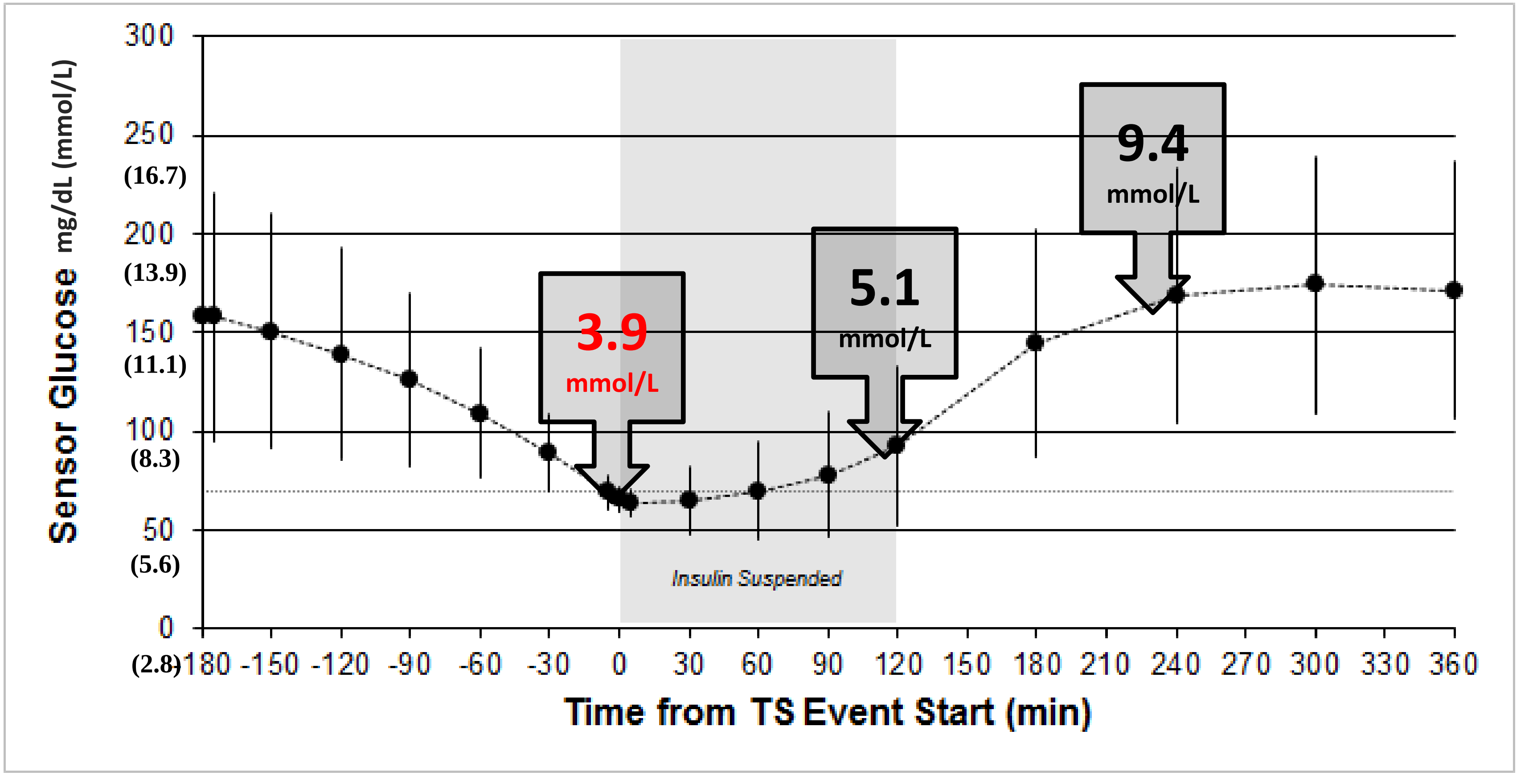
Efficacy



Number of Discrete Events decreased by 30%:
Nocturnal 1.5 vs. 2.2 events per patient·week
Combined 3.3 vs. 4.7 events per patient·week

Bergenstal RM, Klonoff DC, Garg SK, et al for the ASPIRE In-Home Study Group. N Engl J Med 2013;369:224-32.

Sensor Glucose Values Before, During and After the 2-Hour Nocturnal Suspends



There were no DKA events.

There were no severe hypoglycemic events in the intervention group, 4 in the control.

Bergenstal RM, Klonoff DC, Garg SK, et al for the ASPIRE In-Home Study Group. Threshold-based insulin-pump interruption for reduction of hypogylycemia. N Engl J Med 2013;369:224-32.

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Original Investigation

Effect of Sensor-Augmented Insulin Pump Therapy and Automated Insulin Suspension vs Standard Insulin Pump Therapy on Hypoglycemia in Patients With Type 1 Diabetes

A Randomized Clinical Trial

Average Patient: 18yo with 11years of T1DM, A1c 7.5%, on pump and with **NEAR-TOTAL LOSS OF HYPOGLYCEMIA AWARENESS**.

Design: 6-month randomized, controlled, multi-center, open-labeled trial N= 95.

Primary Endpoint (Efficacy): moderate (assistance) to severe (seizure/coma)hypoglycemia episodes

Ly et al. JAMA Sept 26, 2013

Incidence Rates of Moderate-Severe Hypoglycemia *(Adjusted to baseline rates)

	Insulin Pump (n = 49)	Sensor-Augmented Pump With Low-Glucose Suspension (n = 46)
Sum of Severe and Moderate Hypoglycemia		
Baseline		
Rate per 100 patient-months (95% CI)[a]	20.7 (13.8 to 30)	129.6 (111.1 to 150.3)
No. of events (total No. of patients)	28 (45)	175 (45)
End point		
6-Month rate per 100 patient-months (95% CI)[a]	11.9 (6.8 to 19.3)	28.4 (19.8 to 39.6)
No. of events (total No. of patients)	13 (45)	35 (4
Incidence rate per 100 patient-months (95% CI)[b]	34.2 (22.0 to 53.3)	9.5 (
Patients modeled	45	41
Incidence rate ratio per 100 patient-months (95% CI)[b]		3.6 (1.7 to 7.5)
P value		<.001

70% lower

Average Percentage of hours spent in SG <3.9

Nocturnal 4.4 vs. 11.8 %   Daytime 4.1 vs. 6.9 %

Ly et al. JAMA Sept 26, 2013

Considerations

1. How much exercise should we recommend to our patients with diabetes?

2. A 70kg man plans on an intense 1-hour hike on the Grouse Mountain – without changing his insulin regimen, how much extra carbohydrates for exercise ("ExCarbs") would you suggest that he take to avoid hypoglycemia?

3. For those on insulin pump therapy, at what point would you suggest that basal insulin be reduced relative to the start of a jog in order to help prevent hypoglycemia?

Case History

Jeff is a 28yo man with a 16-year history of T1DM

- MDI Therapy recently changed to pump.
- Historical A1c's: 7.0 to 8.8%
- Cardiac Functional Enquiry negative.
- Normotensive, Height 175cm Weight 80kg BMI = 26.1 kg/m^2

He has made efforts to run and do resistance training in the early mornings, but his motivation has been curbed by recurrent hypoglycemia during (and after) his exercise.

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Step 1: Acknowledge (and Work to Reconcile) the Barriers to Effective Diabetes Management

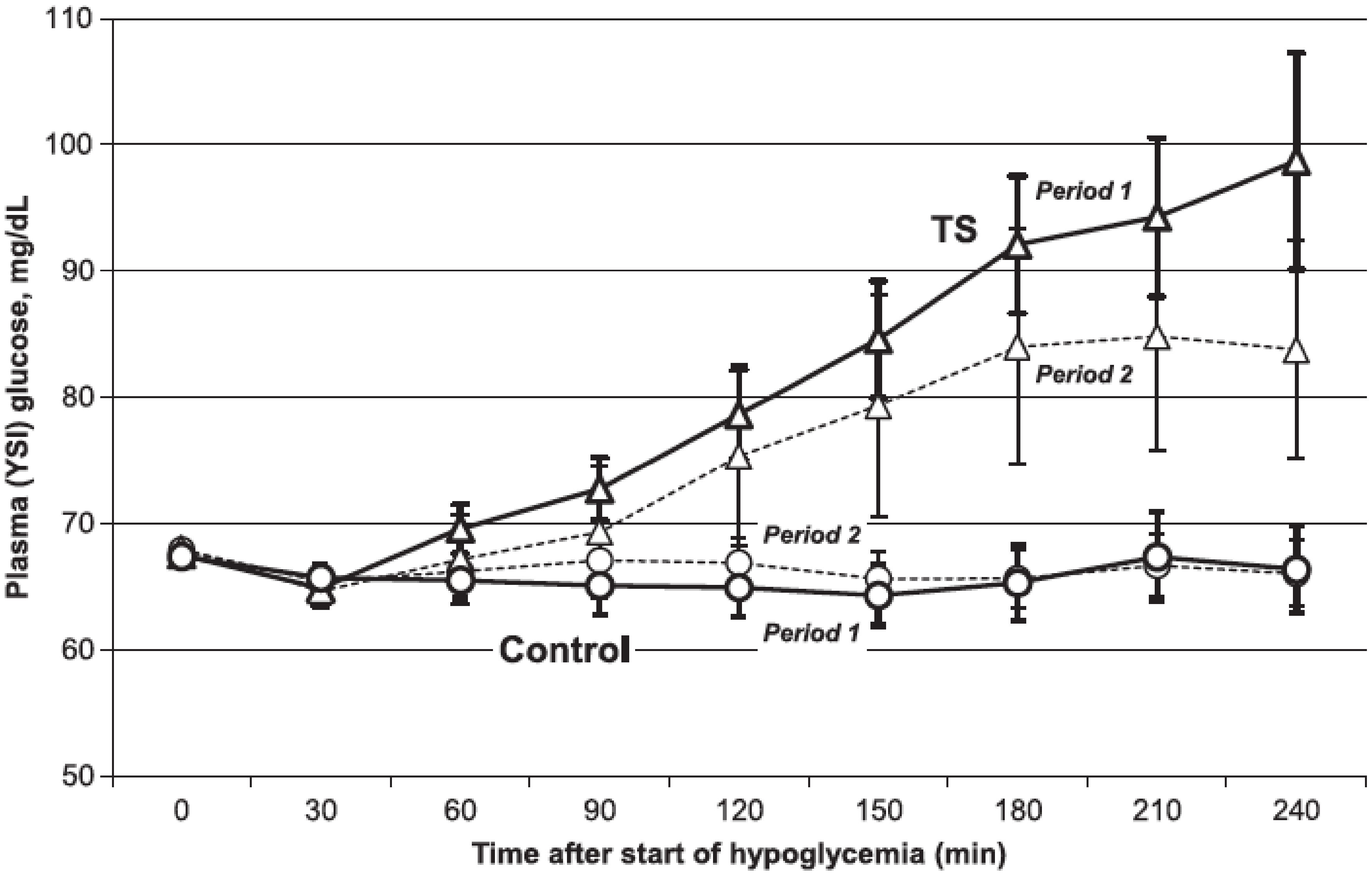
- Has the patient accepted the complexity and demands of day-to-day management?
- Is the patient adherent to treatment and troubleshooting?
- Is there a lack of social support and access to care?
- Are there psychological barriers?
- **How profound is the Fear of Hypoglycemia?**

Aschner P et al. Global Partnership for Effective Diabetes Management. *Int J Clin Pract 2001*

What are the risk factors for the development of hypoglycemia unawareness (Hypoglycemia-Associated Autonomic Failure ‘HAAF’)?

Cryer PE. Diabetes. 2009

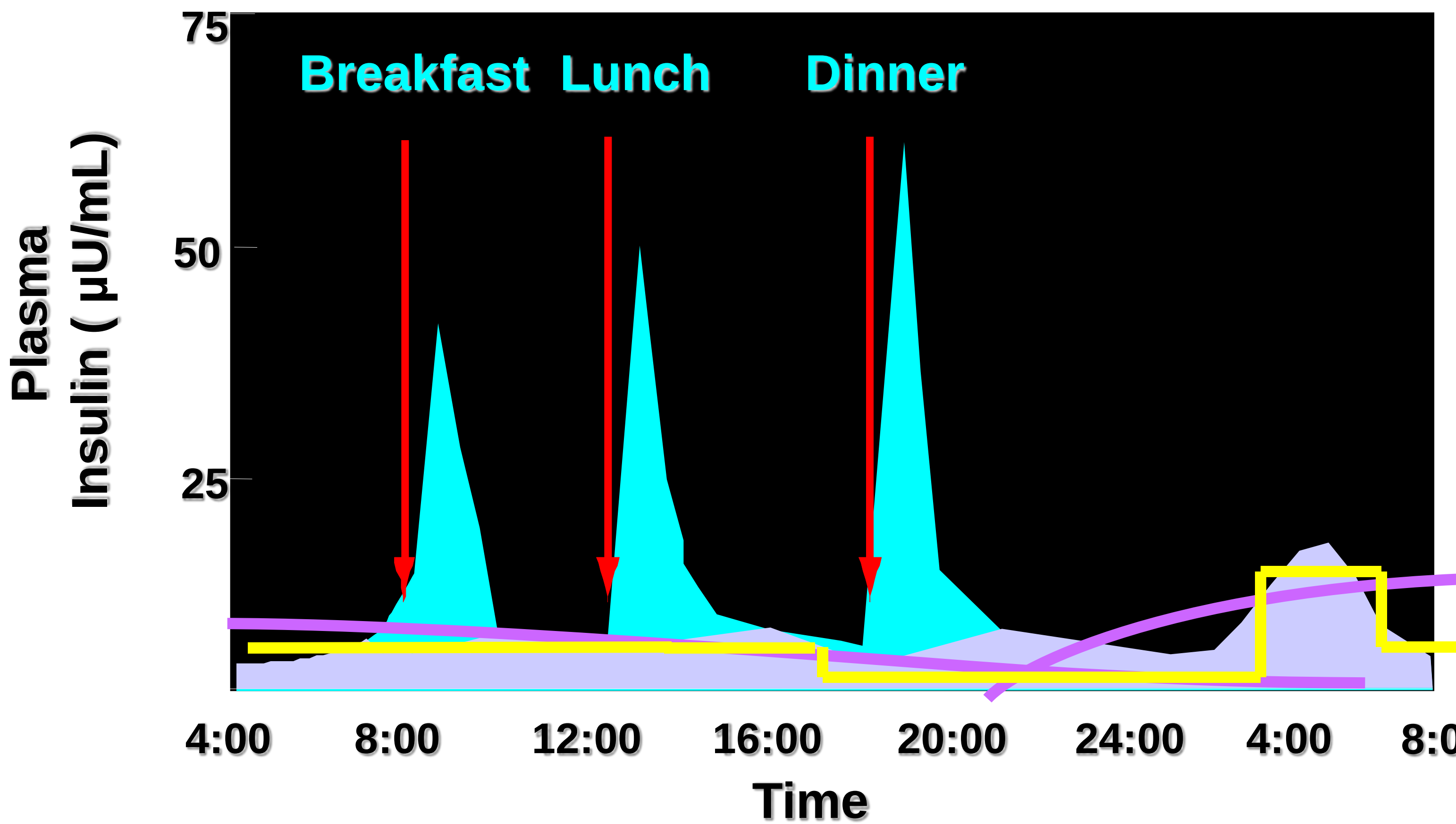
Antecedent Hypoglycemia Challenges Both Physiological and Technological Awareness.



Garg et al. The Order Effect in the ASPIRE In-Clinic Study. DT&T 2014

Step 2: Establish an Insulin Regimen that is *Physiological.*

That is, a regimen that does not sabotage efforts to be active.



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At this point, while working on evaluating his insulin regimen, he…

- ✓ Understands risk periods for lows.
- ✓ Is engaged in frequent self-glucose monitoring.
- ✓ Adheres to consistently-timed basal injections.
- ✓ Trusts his carb ratio, sensitivity, and his approach to troubleshooting highs.
- ✓ Has a healthy "exercise environment".

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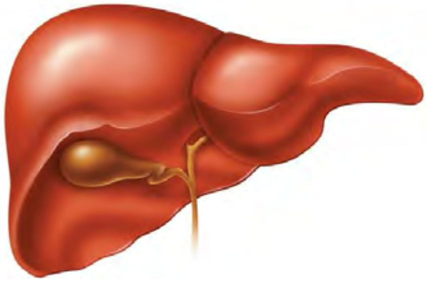
Further considerations,

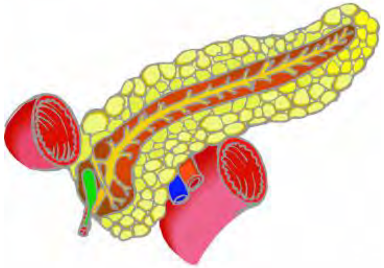
While establishing "Physiological Insulin", he takes additional steps to prevent hypoglycemia on exercise days:

1. ½ correction doses for post-exercise hyperglycemia
2. Further ½ corrections for bedtime hyperglycemia

For days with exercise in excess of his usual experience:

1. Bedtime 15-30g snack without aspart.
2. 25% overnight basal decrease.
3. 3 am BG check for days with exercise in excess of usual activity.





CGM/Exercise in Context

- Hypo Prevention Tools
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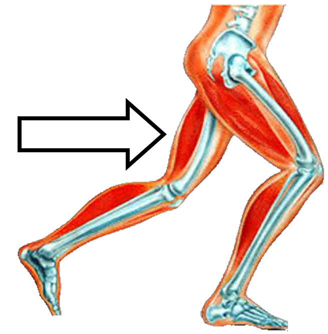
Extra Carbohydrates for Exercise: "ExCarbs"

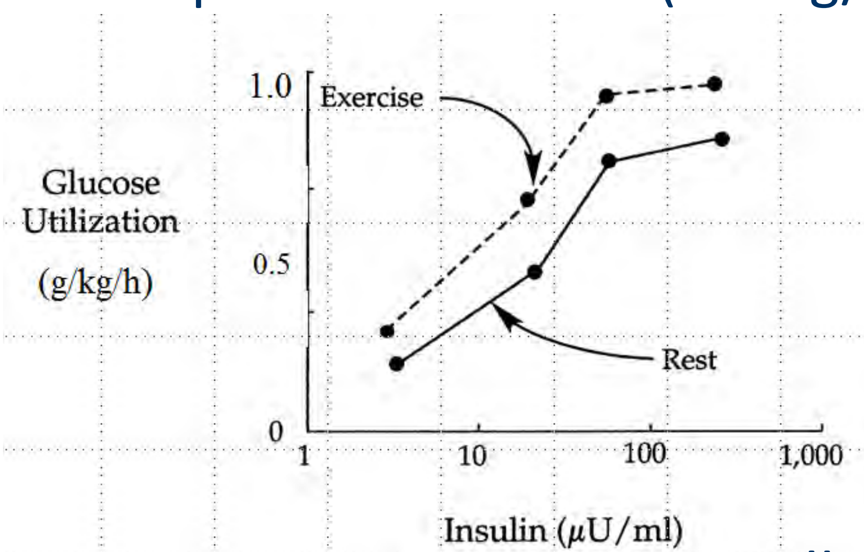


1. Universal recommendation of 15-30g every 30-60 minutes.
2. Quantitative method based on the type of activity.
3. Estimation of maximal glucose disposal into muscle (0.5-1g/kg/h).

Table 1. Estimation of ExCarbs According to Type of Activity and Weight *

Activity		Weight 100 lbs.	150 lbs.	200 lbs.
baseball		25	38	50
basketball	moderate	35	48	61
	vigorous	59	88	117
bicycling	6 mph	20	27	34
	10 mph	35	48	61
	14 mph	60	83	105
	18 mph	95	130	165
	20 mph	122	168	214
dancing	moderate	17	25	33
	vigorous	28	43	57
digging		45	65	83
eating		6	8	10
golf (pullcart)		23	35	46
handball		59	88	117
jump rope 80/min		73	109	145
mopping		16	23	30
mountain climbing		60	90	120
outside painting		21	31	42
raking leaves		19	28	38
running	5 mph	45	68	90
	8 mph	96	145	190
	10 mph	126	189	252
	shoveling	31	45	57
skating	moderate	25	34	43
	vigorous	67	92	117
skiing	crosscountry 5 mph	76	105	133
	downhill	52	72	92
	water	42	58	74
soccer		45	67	89
swimming	slow crawl	41	56	71
	fast crawl	69	95	121
tennis	moderate	23	34	45
	vigorous	59	88	117
volleyball	moderate	23	34	45
	vigorous	59	88	117
walking	3 mph	15	22	29
	4.5 mph	30	45	59

Walsh and Roberts. Using Insulin and Pumping Insulin



Wasserman et al. and Riddell et al. Handbook of Exercise and Diabetes, 2002

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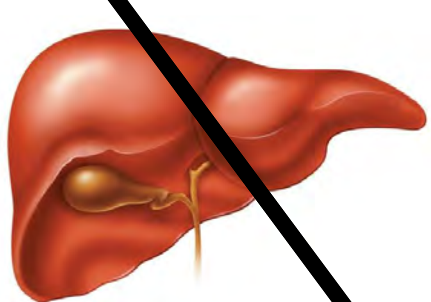
Jeff

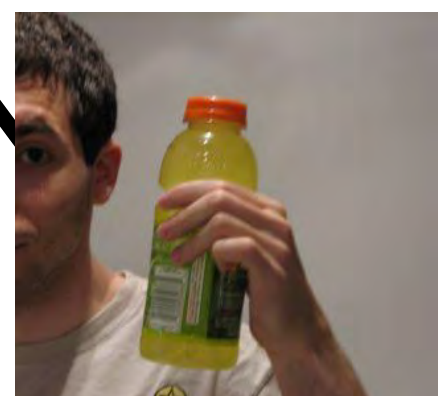


↑ Insulin

1. **Eat More**

0.5-1.0 g/kg/h

0.5g/kg X 80kg = 40g/h of mod. to intense aerobic activity



~ 15 g Carb per 250 mL.

One Bottle ~ 750 ml.

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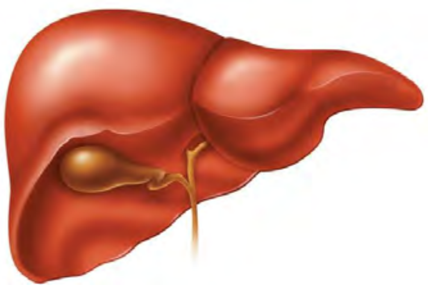
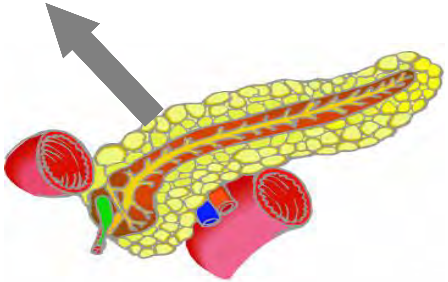
STEP 4. Educate the Patient about Translating "ExCarbs" into Insulin Dose Adjustments

1. Eat More



2. Adjust Bolus Insulin
3. Adjust Basal Insulin (Pumpers)

↓Insulin



ExCarbs Needed for Exercise: 40g

Meal: 90g

Bolus for 50g

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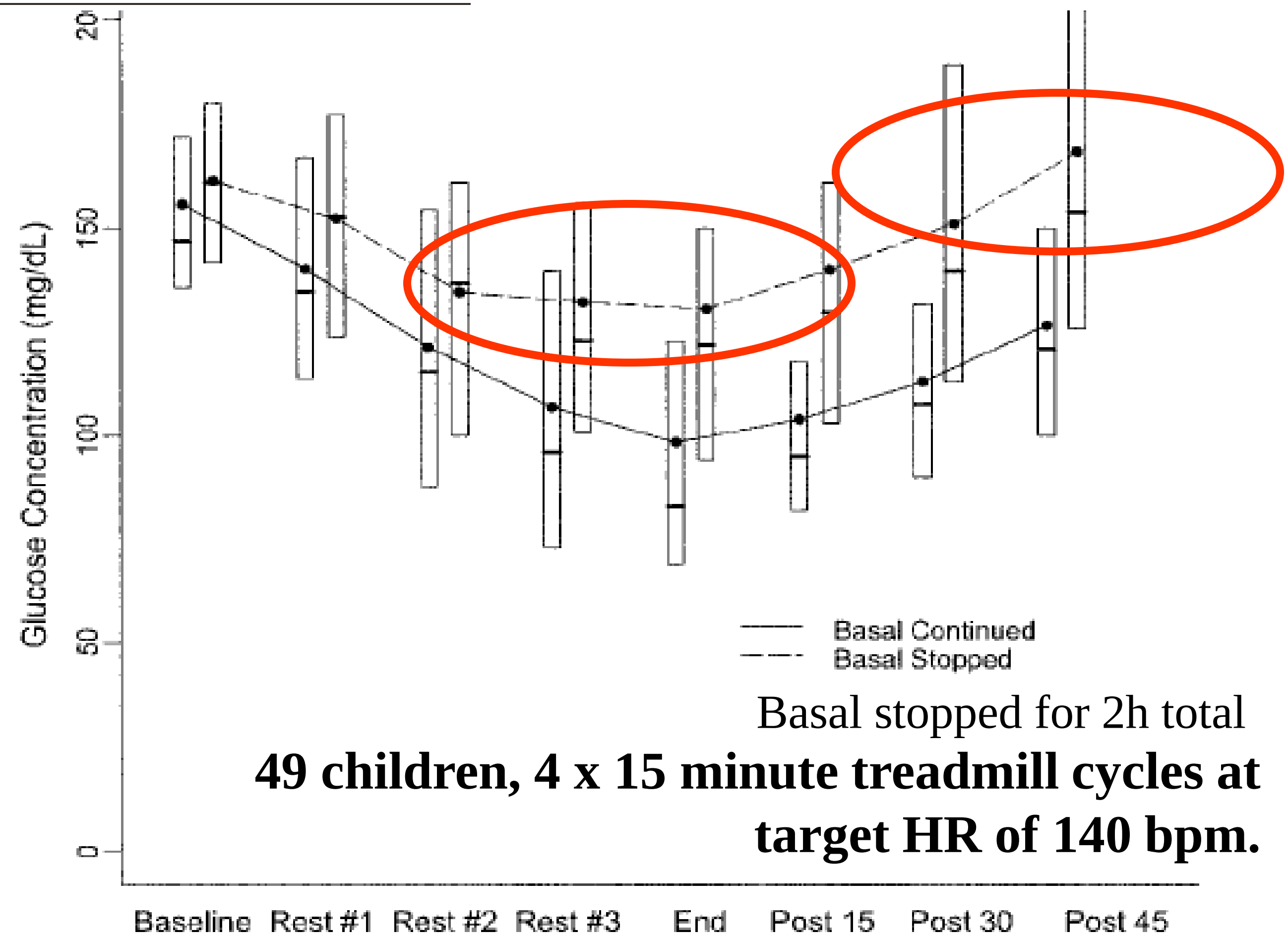
Prevention of Hypoglycemia During Exercise in Children With Type 1 Diabetes by Suspending Basal Insulin

The Diabetes Research in Children Network (DirecNet) Study Group*

Diabetes Care, volume 29, number 10, October 2006

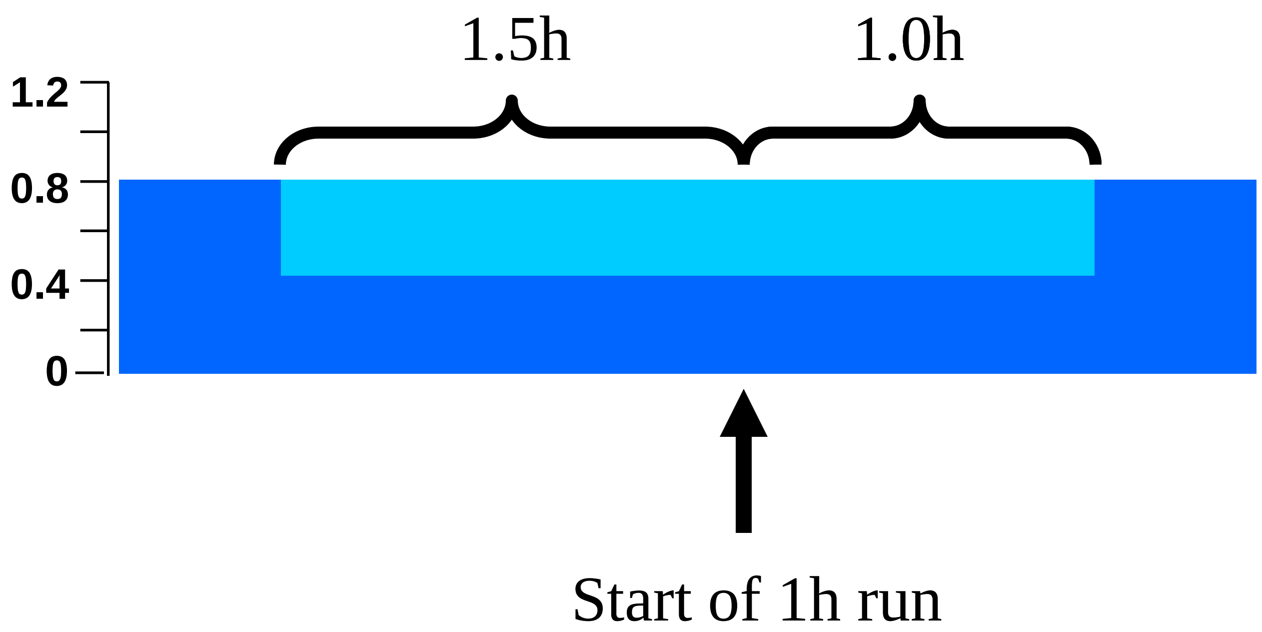


Basal stopped for 2h total

49 children, 4 x 15 minute treadmill cycles at target HR of 140 bpm.

Also Sonnenberg, 1990

Jeff's Morning Runs.



(Be aware of the timing of the last bolus)

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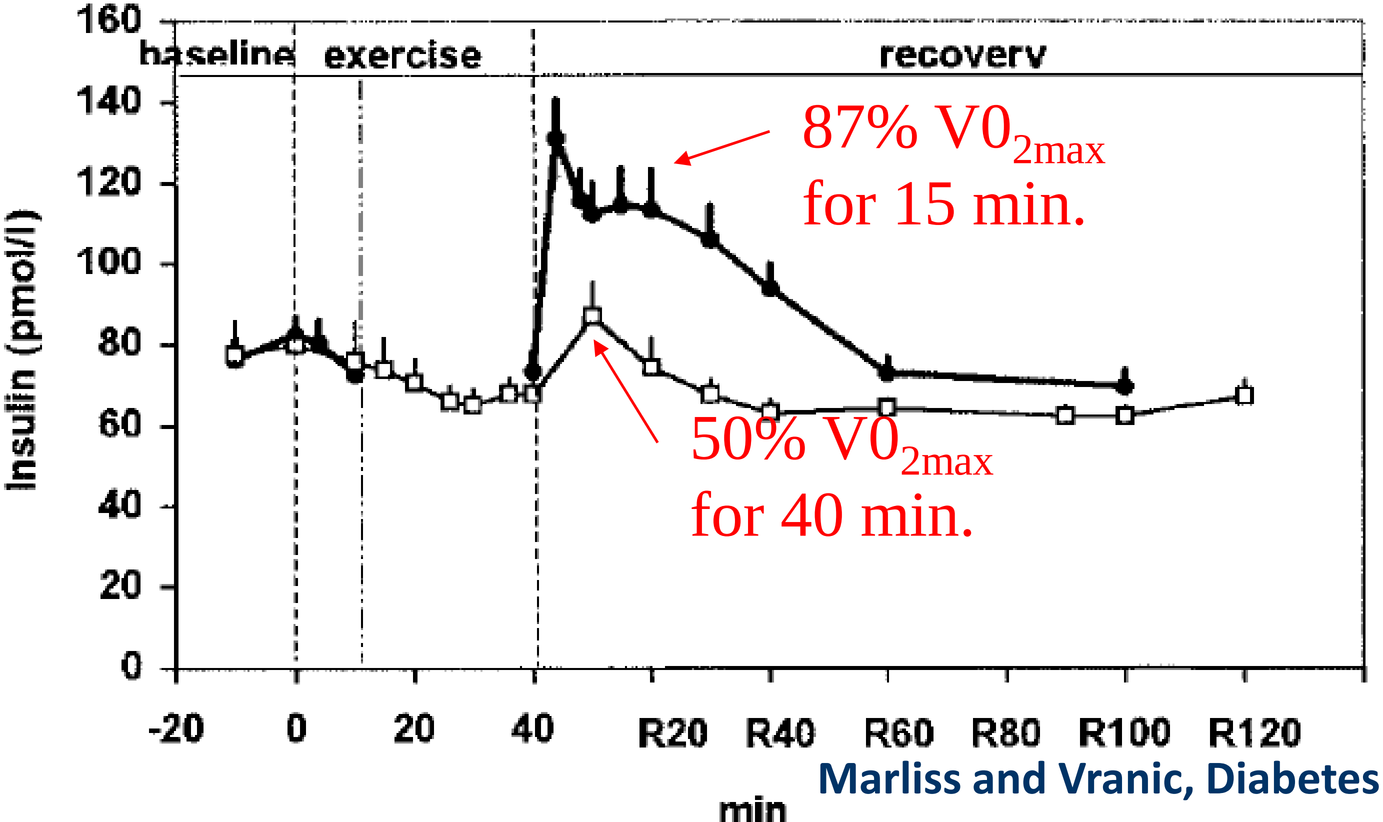
- **Step 5: Understand Anaerobic Exercise**

STEP 5. Educate the Patient about the Effects of Anaerobic/Resistance Exercise

Insulin Concentration According to "Aerobic" versus "Anaerobic" Exercise.



Marliss and Vranic, Diabetes 2002

RETURN TO CASE: JEFF

STEP 1: IDENTIFY BARRIERS TO CARE

STEP 2: ESTABLISH PHYSIOLOGICAL INSULIN

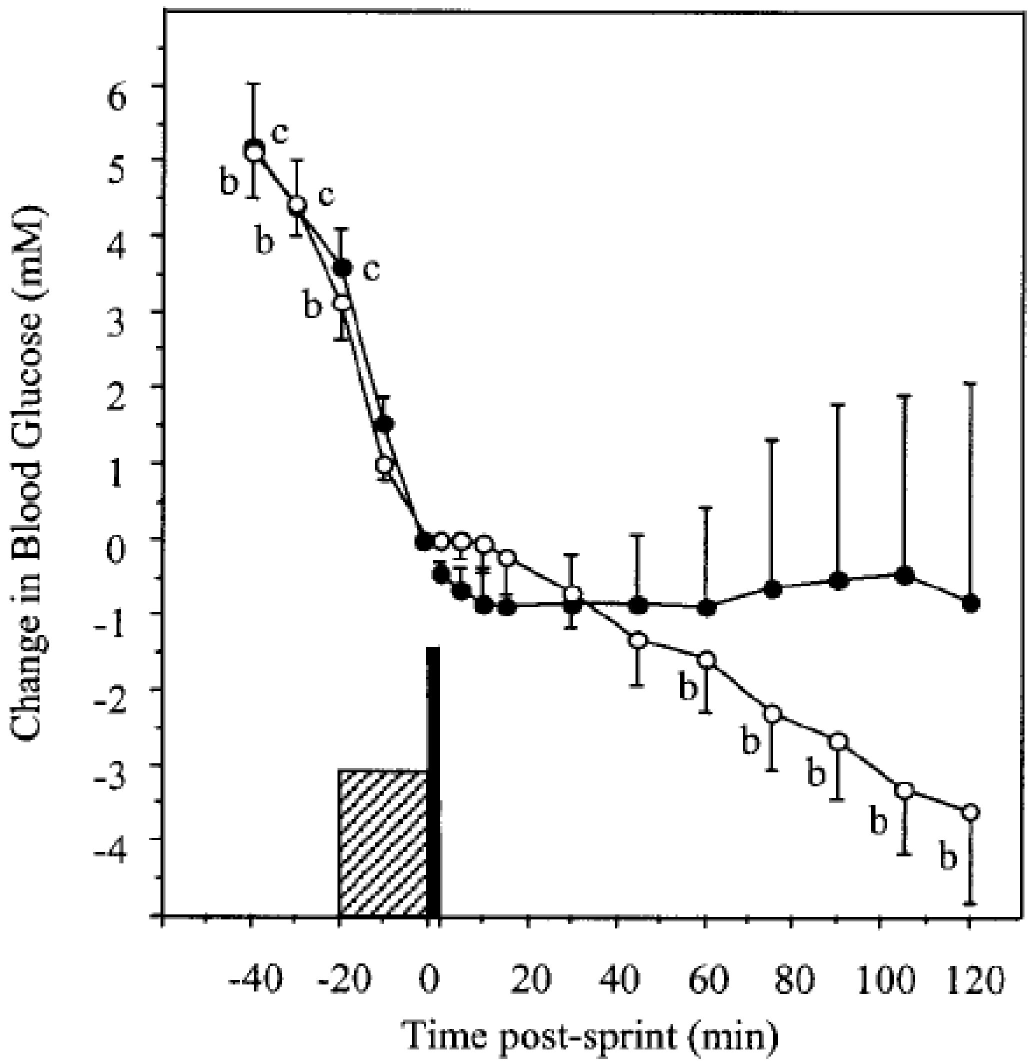
STEP 3: ESTIMATE "EXCARBS"

STEP 4: ADJUST INSULIN

STEP 5: UNDERSTAND ANAEROBIC EXERCISE

SUMMARY

Using Anaerobic Exercise to One's Benefit: The 10s Sprint.



*** And also the sequence of resistance exercise prior to aerobic exercise.**

Bussau et al. 2006 and 2007

Return to Case: Jeff
Step 1: Identify Barriers to Care
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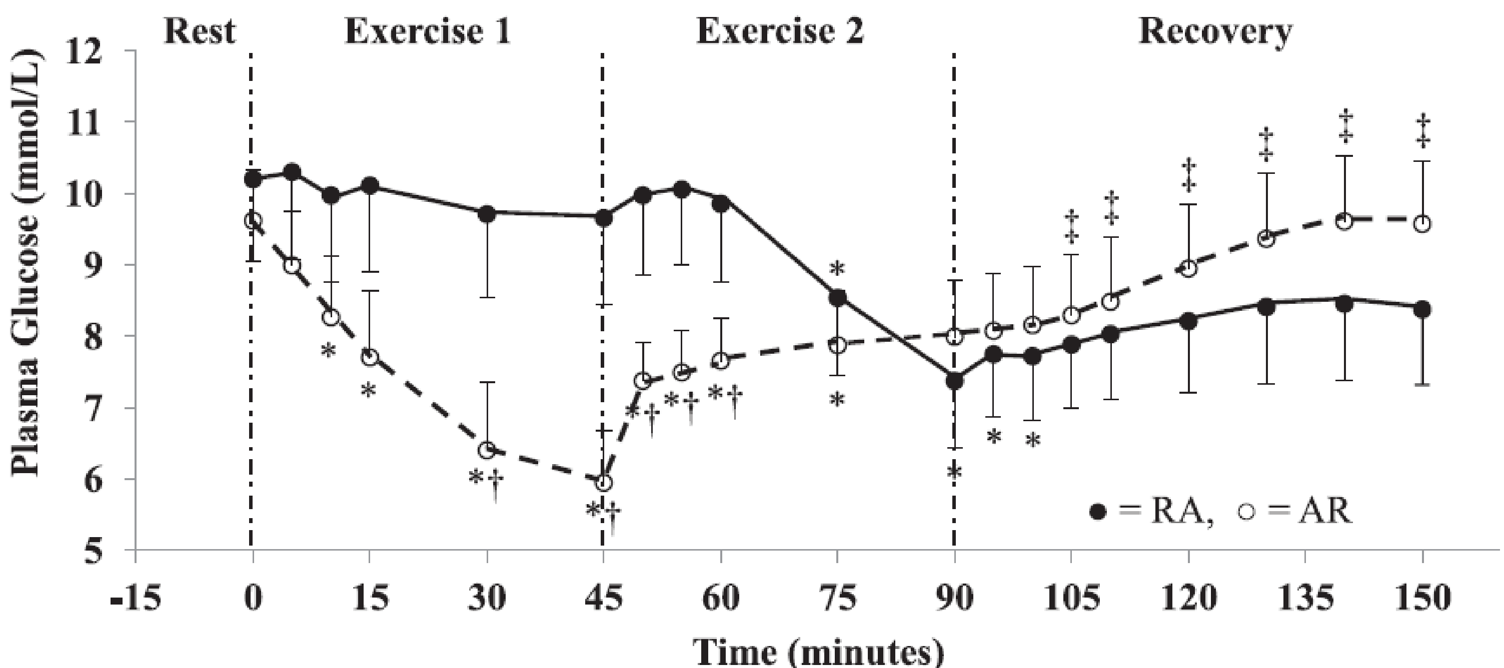
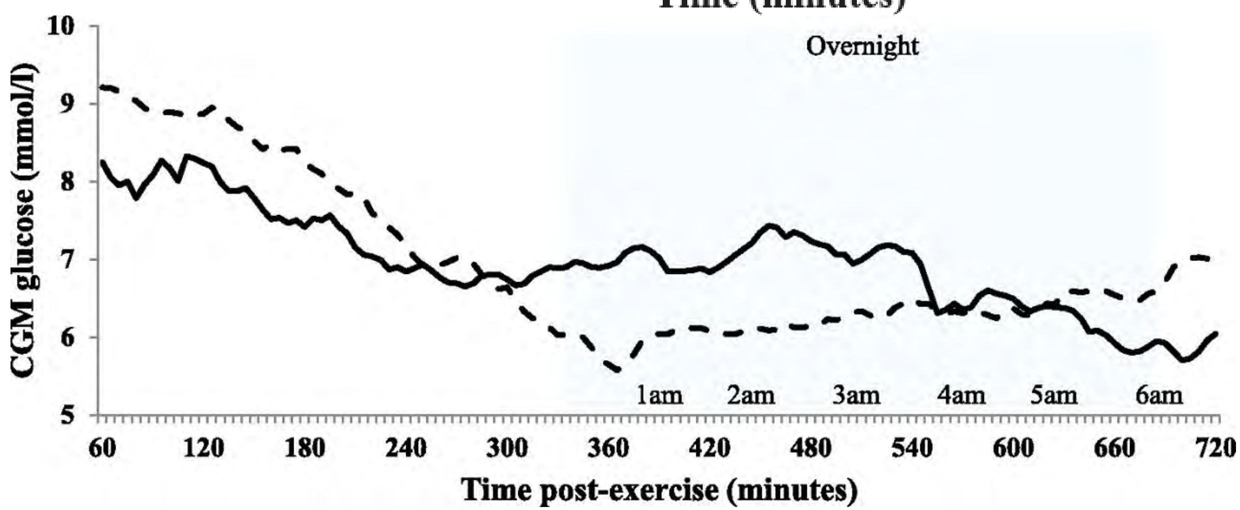
Summary

Resistance before Aerobic protects against Hypoglycemia



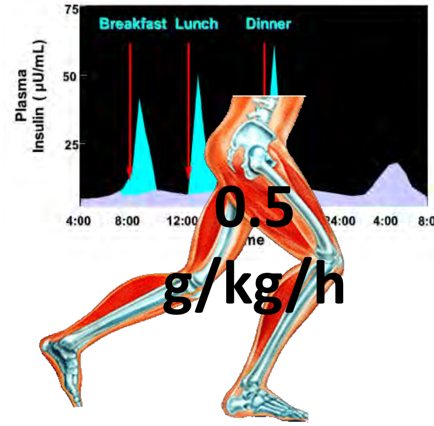


Yardley et al., Diabetes Care, 2012

SUMMARY: The Clinical Steps to "Managing Exercise"

STEP 1. Identify/Reconcile Existing Barriers to Effective Care

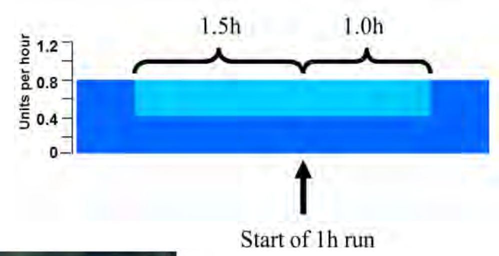
STEP 2. Establish a "Physiological" Insulin Regimen



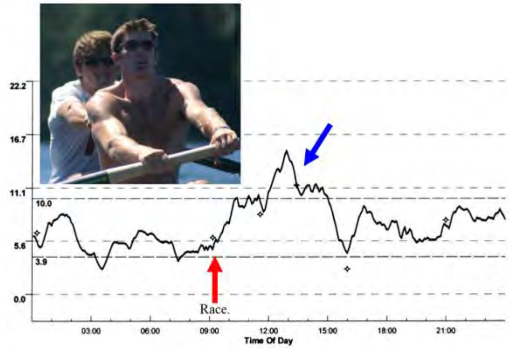
STEP 3. Coach the Patient to Estimate "ExCarbs".

STEP 4. Coach the Patient to Adjust Insulin

A. Exercise with "Bolus on Board": Subtract ExCarbs from the meal bolus



B. Exercise without "Bolus on Board" in pump users: 50% temporary basal 1.5h before until end of exercise.



STEP 5. Educate about effects of Anaerobic/Resistance Exercise.

Considerations

1. How much exercise should we recommend to our patients with diabetes?

2. A 70kg man plans on an intense 1-hour hike in the Gatineau hills – without changing his insulin regimen, how much extra carbohydrates for exercise ("ExCarbs") would you suggest that he take to avoid hypoglycemia?

3. For those on insulin pump therapy, at what point would you suggest that basal insulin be reduced relative to the start of a jog in order to help prevent hypoglycemia?

Conclusion

- **LOW GLUCOSE SUSPEND** represents a new approach to help face the challenge of unpredictable hypoglycemia in the active patient.

- A diabetes health care provider (HCP) can efficiently initiate guidance for safe exercise by **describing and implementing 5 Steps**.

- These 5 steps focus on knowledge of **physiological insulin, "ExCarbs", and consideration of "active insulin**" at the time of exercise.

- An HCP's **knowledge of exercise physiology is fundamental** to the delivery of these 5 Steps.

- **Medtronic Carelink Pro**® represents an efficient means to more **confidently establish physiological insulin.**

diabetes longevity.ca

Toll-free 1-855-808-0150

Have you been living with type 1 diabetes for 50 years?