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


Presented by
Dr. Bruce Perkins, MD MPH
Dr. Michael Riddell, PhD
## Agenda

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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
Division of Endocrinology
Associate Professor and Clinician-Scientist
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.
Can we implement “Technological Awareness” now?

**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**

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**Glucose (mg/dL)**

- RF Linked BG
- Manual BG
- Calibration
- Sensor
- Sensor Alarm
- Target Range
- Hypo

**Insulin Delivery**

- Pump Alarm
- Bolus
- Square Bolus
- Basal
- Temp Basal
- Suspend

**Basal Rate Increase During Severe Hypo**

Courtesy of Richard Bergenstal.
The ASPIRE In-Home trial (Automation to Simulate Pancreatic Insulin Response)

**Average Patient:** 43yo with 27 years 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):** $\text{AUC}_{10p-8a} \text{HYPO}$

- **INTERVENTION**
  - SAP with Low Glucose Suspend
    - LGS set at ≤ 3.9 mmol/L

- **CONTROL**
  - Standard SAP
    - No LGS

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

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.

**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 11 years 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

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**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**

*Ly et al. JAMA Sept 26, 2013*
Incidence Rates of Moderate-Severe Hypoglycemia *(Adjusted to baseline rates)*

<table>
<thead>
<tr>
<th>Sum of Severe and Moderate Hypoglycemia</th>
<th>Insulin Pump (n = 49)</th>
<th>Sensor-Augmented Pump With Low-Glucose Suspension (n = 46)</th>
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<tr>
<td><strong>Baseline</strong></td>
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<tr>
<td>Rate per 100 patient-months (95% CI)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.7 (13.8 to 30)</td>
<td>129.6 (111.1 to 150.3)</td>
</tr>
<tr>
<td>No. of events (total No. of patients)</td>
<td>28 (45)</td>
<td>175 (45)</td>
</tr>
<tr>
<td><strong>End point</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-Month rate per 100 patient-months (95% CI)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.9 (6.8 to 19.3)</td>
<td>28.4 (19.8 to 39.6)</td>
</tr>
<tr>
<td>No. of events (total No. of patients)</td>
<td>13 (45)</td>
<td>35 (45)</td>
</tr>
<tr>
<td>Incidence rate per 100 patient-months (95% CI)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>34.2 (22.0 to 53.3)</td>
<td>9.5 (6.7 to 12.6)</td>
</tr>
<tr>
<td>Patients modeled</td>
<td>45</td>
<td>41</td>
</tr>
<tr>
<td>Incidence rate ratio per 100 patient-months (95% CI)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.6 (1.7 to 7.5)</td>
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*P value < .001*  

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/m²

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.
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?

*Int J Clin Pract 2001*
What are the risk factors for the development of hypoglycemia unawareness (Hypoglycemia-Associated Autonomic Failure ‘HAAF’)?
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.

![Graph showing Plasma Insulin levels with Breakfast, Lunch, and Dinner peaks at different times.](image)
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”.
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.
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).

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

Walsh and Roberts. 
Using Insulin and Pumping Insulin

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

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

<table>
<thead>
<tr>
<th>Activity</th>
<th>100 lbs</th>
<th>150 lbs</th>
<th>200 lbs</th>
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<tbody>
<tr>
<td>Walking</td>
<td>18 g</td>
<td>27 g</td>
<td>36 g</td>
</tr>
<tr>
<td>Jogging</td>
<td>25 g</td>
<td>37 g</td>
<td>49 g</td>
</tr>
<tr>
<td>Cycling</td>
<td>12 g</td>
<td>18 g</td>
<td>24 g</td>
</tr>
<tr>
<td>Swimming</td>
<td>21 g</td>
<td>31 g</td>
<td>41 g</td>
</tr>
<tr>
<td>Running</td>
<td>35 g</td>
<td>53 g</td>
<td>71 g</td>
</tr>
<tr>
<td>Walking</td>
<td>24 g</td>
<td>34 g</td>
<td>43 g</td>
</tr>
<tr>
<td>Cycling</td>
<td>15 g</td>
<td>22 g</td>
<td>29 g</td>
</tr>
<tr>
<td>Swimming</td>
<td>36 g</td>
<td>54 g</td>
<td>68 g</td>
</tr>
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Wasserman et al. and Riddell et al. 
Handbook of Exercise and Diabetes, 2002
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.
**STEP 4. Educate the Patient about Translating “ExCarbs” into Insulin Dose Adjustments**

1. Eat More
2. Adjust Bolus Insulin
3. Adjust Basal Insulin (Pumpers)

ExCarbs Needed for Exercise: 40g
Meal: 90g
Bolus for 50g
Prevention of Hypoglycemia During Exercise in Children With Type 1 Diabetes by Suspending Basal Insulin

Also Sonnenberg, 1990

Basal stopped for 2h total

49 children, 4 x 15 minute treadmill cycles at target HR of 140 bpm.
Jeff’s Morning Runs.

Start of 1h run

(Be aware of the timing of the last bolus)
STEP 5. Educate the Patient about the Effects of Anaerobic/Resistance Exercise

Insulin Concentration According to “Aerobic” versus “Anaerobic” Exercise.

- 87% VO$_{2\text{max}}$ for 15 min.
- 50% VO$_{2\text{max}}$ for 40 min.

Marliss and Vranic, Diabetes 2002
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
Resistance before **Aerobic** protects against Hypoglycemia

**Managing Exercise**

**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**

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