“Exercise in the recreational and competitive athlete with type 1 diabetes- the benefits, the risks and management strategies”

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Quotes from leader of Seattle area JDRF Ride team

• “My glucose levels seem to vary widely with exercise”

• “It seems to depend upon:
  – What I eat
  – How much insulin I have given
  – How hard I ride
  – How long I ride
  – The day of the week
  – How I slept last night
  – The color of my cycling jersey
  – The Dow Jones Industrial Average...”
• In other words- there a lot of variables, and every day is different.

• It’s hard, but how can we help?
  ...because it’s important for mental and physical wellbeing
How much do children with T1DM actually exercise?

Table 1  Time spent in minutes/day at different levels of physical activity in diabetic and healthy age matched children

<table>
<thead>
<tr>
<th>Levels of activity</th>
<th>Diabetic preschoolchildren</th>
<th>Healthy preschoolchildren</th>
<th>Diabetic schoolchildren</th>
<th>Healthy schoolchildren</th>
<th>Diabetic teenagers</th>
<th>Healthy teenagers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>192.7 (78.1)</td>
<td>184.3 (54.2)</td>
<td>168.9 (76.7)</td>
<td>165.6 (74.6)</td>
<td>166.3 (67.5)</td>
<td>159.2 (68.3)</td>
</tr>
<tr>
<td>Moderate</td>
<td>39.1 (24.3)</td>
<td>40.7 (16.1)</td>
<td>37.9 (15.9)*</td>
<td>32.1 (12.1)</td>
<td>45.6 (26.9)*</td>
<td>32.1 (23.5)</td>
</tr>
<tr>
<td>Vigorous</td>
<td>21.3 (9.4)</td>
<td>21.8 (12.3)</td>
<td>19.0 (14.8)</td>
<td>22.9 (11.5)</td>
<td>25.2 (15.3)*</td>
<td>19.1 (11.3)</td>
</tr>
</tbody>
</table>

Data are given as mean (SD).
*Significant difference between diabetic and healthy children.
Compliance with physical activity recommendations - SEARCH for Diabetes in Youth

![Bar chart showing compliance with MVPA standards for different groups and time points.](chart.png)
So, youth with type 1 diabetes may exercise at least as much as their non-diabetic peers.

This is a huge success story in and of itself!

But... Is physical fitness affected by T1DM in children? What about the role of exercise specifically with regard to overall glycemic control?

What does recent data tell us?
How does physical activity and fitness influence glycaemic control in young people with Type 1 diabetes?

M. Cuenca-García¹,², R. Jago², J. P. H. Shield³ and C. P. Burren³

- 2012 UK study - 60 young people with T1DM, mean age 12.5 years, mean HbA1c 8.4% and 37 controls (siblings)
  - no difference in fitness at baseline
  - no difference in degree of physical activity

- Moderate–vigorous physical activity (but not fitness) predicted 1/3 of the variance in HbA1c, even when accounting for confounding variables such as insulin dose, age, weight, puberty stage...
“Eurofit physical fitness test”
  – Nine tests- motor and cardiorespiratory fitness tests (VO2 max estimated by shuttle run test**)

106 youth with T1DM, 130 controls
  – Mean HbA1c 8.2-8.9% (depending on group)

T1DM group just as active as the controls

Decreased fitness (VO2 max) in
  – girls
  – pubertal boys with T1DMs

** not validated in T1DM
Is Glycemic Control a/w Aerobic Capacity in Subjects with Type 1 Diabetes?

- Adult (trained) athletes
  - A1c <7% were as fit or fitter than those without T1DM
  - A1c>7% less fit

Hoffman group, Auckland NZ
So... in T1DM?

High blood glucose levels

Decreased physical fitness
• Big question – exercise as an intervention in youth with T1DM

This has not been at all clear, as most data was cross-sectional, and individual RCTs small
Is exercise associated with HbA1c in youth?

19,143 patients

![Graph showing the association between exercise frequency and HbA1c levels in youth.](image)

A systematic review of physical activity and sedentary behavior intervention studies in youth with type 1 diabetes: study characteristics, intervention design, and efficacy

Different interventions (aerobic/strength), settings (home/supervised), schedules (days per week), goals (A1c vs fitness)
Is HbA1c the right (or only useful) construct when considering T1D and exercise?

- Perhaps we should consider cardiovascular health as well as HbA1c when considering the data on physical activity and exercise?
- What does that data tell us?
  - Not surprisingly (!) better lipids, lower insulin dose, lower BMI in youth and young adults with T1D, in addition to lower HbA1c, in systematic reviews of exercise

  *Physical activity interventions in children and young people with Type 1 diabetes mellitus: a systematic review with meta-analysis. Diabetic Medicine Volume 31, Issue 10, pages 1163-1173*
Nineteen adolescents with T1DM, ages 14 - 19 years
• Maximal aerobic capacity (VO2 max)
• 1-hour treadmill exercise session for accumulated metabolic workload
• Mean amplitude of glycemic excursion (MAGE) calculated from CGM data

\[ \text{VO2 max} \propto \frac{1}{\text{MAGE}} \]

\[ \text{Aerobic work} \propto \frac{1}{\text{MAGE}} \]

Which leads to what? Or again, is it circular/bidirectional?
Fig. 1. Physiologic responses to exercise in the diabetic and non-diabetic individual (square brackets denote plasma concentration).

Pediatric Diabetes 2014: 15 (Suppl. 20): 203–223
Glucose Provision During Exercise Requires Glycogen Mobilization

Glucose ~ 90 mg/dL
What are the acute effects of different *types* of exercise

- Resistance versus Aerobic
- High Intensity vs low intensity
- Early vs Late effects
Change in glucose concentrations during exercise (n = 48).

**No insulin adjustment**

The Diabetes Research in Children Network (DirecNet)
Study Group Dia Care 2006;29:20-25
Nadir glucose during exercise versus baseline concentration (n = 48).

The Diabetes Research in Children Network (DirecNet) Study Group Dia Care 2006;29:20-25

©2006 by American Diabetes Association
Resistance vs Aerobic

Diabetes Care 2013;36:537-542

• 12 adults, mean HbA1c 7.1%
• 45 minutes of weight lifting or 45 minutes of cardio

Higher sugars during and immediately after resistance exercise
Practice vs. Race/Competition

- Kris Freeman, national ski champion and Olympian
- “In practice events, I try to dial in the basal rate I need, but adrenaline changes things”
- “In training, without the adrenaline working, my BG tends to drop. For races, I've started changing basal rates up to 2 hours in advance, in anticipation of the adrenaline spike. I know it's coming.”
- “I can lie bed and see my BG rise 80 points just from race nerves.”
“So what was your dosing strategy?”

What I ended up doing is .7 units/hr 24/7, and then leading up to the race, three hours before, I upped my basal to 1.0 units/hr to cover the sugar I release from being nervous. Twenty minutes prior to the 15k race, I actually upped to 7 units/hr, and then took a half-unit bolus, because the amount of sugar I release in an event like that is incredible.

I only take a bolus before a race if I'm in an upward trend. If I get much over 200, I'm putting myself at a disadvantage, because my lactate levels go up and that creates that heavy, nasty feeling people sometimes get when exercising. It hurts. I don't want that.

So what's your strategy for Saturday's Gold Medal (30k) event?

This next race is going to be interesting. I had more confidence in my insulin strategy going into the 15k than into the 30k.
USA's Freeman has blood sugar crash in cross-country pursuit

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."
Training effect on fuel utilization

Fuel Utilization: Muscle Glycogen Demand Increases with Intensity

- Lower intensity exercise
  - High lipid (fat) utilization
- Higher intensity exercise
  - High muscle glycogen use
  - High plasma glucose use
Intermittent high intensity vs steady state-What do our kids play?

Elite soccer players during European Champions League and UEFA Cup matches- Sprinting analysis.

• Team sports are often “on and off”
  – Soccer
  – LaCrosse
  – Football
  – Basketball

Figure 1. Ratio of explosive to leading sprints by playing position.

Effect of 30 min (represented by box) of IHE (▪) or MOD (□) on normalized blood glucose levels.

40% VO$_2$ max +/- 4 second sprints every 2 minutes

Kym J. Guelfi et al. Dia Care 2005;28:1289-1294
Effect of 30 min (represented by box) of IHE (●) or MOD (□) on epinephrine (A), norepinephrine (B), growth hormone (C), cortisol (D), glucagon (E), and the glucagon-to-insulin ratio (F).

Kym J. Guelfi et al. Dia Care 2005;28:1289-1294

©2005 by American Diabetes Association
So:
1. Aerobic exercise at submaximal effort causes a slow and steady drop in blood glucose

2. Intense exercise such as all out efforts, or intervals, or resistance (weights) doesn’t have the same effect, and may raise blood sugar acutely

3. But there is still a risk later on of a low blood sugar (overnight)
Responses of glucose infusion rate (A)

Difference in glucose infusion rate (GIR) between exercise and rest studies (B)

Overnight glucose levels after afternoon aerobic exercise

Exercise Timing?

Midday Exercise in Adolescents – higher risk for low glucose for the next 11 hours

45 minutes cycling at 95% lactate threshold starting at noon

Glucose uptake remained elevated for many hours... but biphasic pattern not seen

Tim Jones et al, JCEM 2013
Interventions to address exercise-related glycemic excursions in youth with T1DM

Insulin adjustments
Nutritional strategies
?both
Effects of Exercise on Blood Glucose in T1DM during exercise without extra snacks- basal continued vs basal suspended

Nutritional Strategies to Prevent Hypoglycemia at Exercise in Diabetic Adolescents

Glycemic excursions according to exercise conditions.

Normal bolus

Standardized breakfast
16% protein, 34% fat, 50% CHO
(+/- approx 30g of protein)

50% VO2 max cycle ergometer

PL, standardized breakfast + placebo snack;
CHO, standardized breakfast + CHO snack ~30g
PROT, protein supplemented breakfast + placebo snack).

DUBÉ, MARIE-CHRISTINE; LAVOIE, CAROLE; GALIBOIS, ISABELLE; WEISNAGEL, S. JOHN
Medicine & Science in Sports & Exercise.
44(8):1427-1432, August 2012.
doi: 10.1249/MSS.0b013e3182500a35
In absence of insulin adjustments (ie. during peak action)

1-1.5 g/kg/hr of CHO may be required depending on CHO utilization (sport and insulin dependent)

Where pre-exercise bolus has been reduced, or no active rapid acting, then consider 0.3-0.5 g/kg/hr CHO

ISPAD guidelines 2014

Table 2. Exercise exchanges of 100 kcal (420 kJ) in children of various body masses. Assuming that, on average, 60% of total energy is provided by carbohydrate, one exchange is equivalent to 60 kcal or 15 g carbohydrate

<table>
<thead>
<tr>
<th>Activity</th>
<th>Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Basketball (game)</td>
<td>30</td>
</tr>
<tr>
<td>Cross-country skiing</td>
<td>40</td>
</tr>
<tr>
<td>Cycling</td>
<td></td>
</tr>
<tr>
<td>10 km/h</td>
<td>65</td>
</tr>
<tr>
<td>15 km/h</td>
<td>45</td>
</tr>
<tr>
<td>Figure skating</td>
<td>25</td>
</tr>
<tr>
<td>Ice hockey (ice time)</td>
<td>20</td>
</tr>
<tr>
<td>Running</td>
<td></td>
</tr>
<tr>
<td>8 km/h</td>
<td>25</td>
</tr>
<tr>
<td>12 km/h</td>
<td>—</td>
</tr>
<tr>
<td>Snowshoeing</td>
<td>30</td>
</tr>
<tr>
<td>Soccer</td>
<td>30</td>
</tr>
<tr>
<td>Swimming</td>
<td></td>
</tr>
<tr>
<td>30 m/min breast stroke</td>
<td>55</td>
</tr>
<tr>
<td>Tennis</td>
<td>45</td>
</tr>
<tr>
<td>Walking</td>
<td></td>
</tr>
<tr>
<td>4 km/h</td>
<td>60</td>
</tr>
<tr>
<td>6 km/h</td>
<td>40</td>
</tr>
</tbody>
</table>
Exercise Timing?

Midday Exercise in Adolescents – higher risk for low glucose for the next 11 hours

45 minutes cycling at 95% lactate threshold starting at noon

11pm

Higher GIR

Glucose uptake remained elevated for many hours
Midday bought of exercise – 45 minutes at 95% lactate threshold

- 20 grams of glucose more was needed for the hour of exercise, and 2-3 grams more per hour up until 11 hours later

- If insulin:carb ratio is 1:10g, then this would be equivalent to ~ 0.2 units/hr. If basal rate is 1 unit/hr, then this would represent ~ a 20% reduction in basal rate for up to 11 hours if no extra carbs eaten
Adjusting post-exercise meal bolus - how much?

Diabetes Care 2013 Campbell et al
Autonomic failure in T1DM

• Hypoglycemia unawareness is common
  *Sleep itself is a state of impaired counter-regulation

• Antecedent exercise and antecedent hypoglycemia are known risk factors (Cryer, Diab Care 2008)

• Avoidance of hypoglycemia during exercise may be all that is required to prevent later hypoglycemia in some cases
Preventing Post-Exercise Nocturnal Hypoglycemia in Children with Type 1 Diabetes

Craig E. Taplin, MD, Erin Cobry, BS, Laurel Messer, MPH, RN, CDE, Kim McFann, PhD, H. Peter Chase, MD, and Rosanna Fiallo-Scharer, MD
Effect of Exercise Session Glycemia on Nocturnal BGL Nadir by Visit Type

*\( p = 0.02 \)

BGL Event During Exercise

- **BGL < 80**
- **BGL > 80**

**Overnight BGL Nadir**

- **Control**
- **Terbutaline**
- **BRR**

*\(*\) denotes statistical significance.
Original Article

Do youth with type 1 diabetes exercise safely? A focus on patient practices and glycemic outcomes


Objective: Insulin adjustments have been shown to reduce glycemic excursions during and after exercise, but little is known about their use in youth with type 1 diabetes (T1D). We aimed to assess practices in youth with T1D around exercise, assess factors that influence practices, and examine associations between key behaviors and glycemic outcomes.

Research design and methods: We developed the Type 1 Diabetes Report of Exercise Practices Survey (T1D-REPS) and piloted this tool in 100 youth.

Alissa J. Roberts¹, Joyce P. Yi-Frazier², Karen E. Aitken³, Connor A. Mitrovich⁴, Michael F. Pascual⁵ and Craig E. Taplin⁶,⁷

¹Seattle Children's Hospital Division of Endocrinology and Diabetes,
²Seattle, WA, USA, ³University of Washington, Seattle, WA, USA, and
⁴Seattle Children's Research Institute.
So what are patients actually doing??

Table 2. Rates of insulin adjustments around exercise

<table>
<thead>
<tr>
<th>Rate of Insulin Adjustments</th>
<th>Percent</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any modification of insulin regimen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No modification</td>
<td>16%</td>
<td>14</td>
</tr>
<tr>
<td>Insulin adjustment</td>
<td>84%</td>
<td>73</td>
</tr>
<tr>
<td>Pre-exercise meal insulin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No insulin adjustment</td>
<td>60%</td>
<td>48</td>
</tr>
<tr>
<td>Less insulin</td>
<td>40%</td>
<td>32</td>
</tr>
<tr>
<td>Basal insulin rate during exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No insulin adjustment</td>
<td>32%</td>
<td>28</td>
</tr>
<tr>
<td>Basal rate decrease or suspension</td>
<td>68%</td>
<td>59</td>
</tr>
<tr>
<td>Overnight basal insulin rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No or rare insulin changes overnight</td>
<td>90%</td>
<td>65</td>
</tr>
<tr>
<td>Always or often decrease basal rate overnight</td>
<td>10%</td>
<td>7</td>
</tr>
<tr>
<td>Overnight basal rate or bedtime carbohydrate insulin adjustments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No insulin changes at bedtime or overnight</td>
<td>69%</td>
<td>60</td>
</tr>
<tr>
<td>Less insulin at bedtime or overnight</td>
<td>31%</td>
<td>27</td>
</tr>
</tbody>
</table>
Youth with T1DM may be frequently picking the wrong intervention.
Future Studies needed

• What to recommend for those not on a pump?
• What are patients actually doing in the real world?
• Where are we headed with technology?

• Predictive alarms and closed loop systems
  – The role of modern glucose monitoring
Closed loop systems and Exercise in T1DM
FIG. 2. Reference YSI values for all 98 successful sessions. Tracings are centered at the time when the YSI glucose value fell below 70 mg/dL. Solid black line represents the mean of low glucose suspend (LGS)-On sessions, the dashed black line represents the mean of LGS-Off, and the gray lines represent mean±SEM values.

ASPIRE study of threshold suspend in exercise-induced hypoglycemia
“PILGRIM” study – feasibility study

Next steps in monitoring for exercise-associated hypoglycemia

- Predictive low glucose suspend

16 separate experiments performed until predictive pump suspension

- In 12 hypoglycemia was prevented
- Mean BGL at time of suspension 92 mg/dL
- Mean time of suspension was 90 mins
Diagrammatic representation of clinical study procedures.

48-hour evaluation period
2 overnights

Closed-Loop

Open-Loop

Closed-Loop

Open-Loop

Subject recruitment, consent, enrollment

Key

Meals  Exercise

Plasma BG every 30 min, insulin every 30 min overnight

Sherr J L et al. Dia Care 2013;36:2909-2914
Episodes of overnight treatable hypoglycemia (reference blood glucose <60 mg/dL) during OL and CL.

Sherr J L et al. Dia Care 2013;36:2909-2914
A: Overnight insulin delivery in units/h 7–11 h postexercise (10:00 p.m. to 2:00 a.m.), with CL associated with lower insulin delivery (P = 0.008).

Again about 20-30% less basal delivery overnight
Closed Loop Systems for Exercise Depend on CGM accuracy during Exercise - Dexcom G4 Platinum vs Medtronic Enlite System, at Rest and During Exercise

MARD 13.8%

MARD 22.5%

MARD 12.4%

MARD 20.4%

Adapted from Taleb et al, Diabetes Technology & Therapeutics. September 2016, 18(9)
Exercise with Single Hormonal Closed Loop Control may still be challenging...

Figure 1—Plasma glucose (A), insulin infusion rates (B), and plasma insulin (C) for conventional insulin pump therapy and closed-loop basal insulin delivery (median [interquartile range]). Meals (M), snacks (S), and exercise sessions are indicated. A: Episodes of hypoglycemia requiring treatment (○, insulin pump therapy; ●, closed-loop delivery).

FROM:
Closed-Loop Basal Insulin Delivery Over 36 Hours in Adolescents With Type 1 Diabetes Randomized clinical trial. Elleri et al. Diabetes Care 2013 Apr; 36(4): 838–844
Light cycling 30 mins > 4 hrs post-meal (minimal IOB)

Other Physiologic signals such as Heart Rate may help closed loop control around Exercise

Breton et al. Diabetes Technol Ther. 2014 Aug 1; 16(8): 506–511

12 adults
Heart rate informed artificial pancreas system enhances glycemic control during exercise in adolescents with T1D

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Funding Information
Grant/Award Number: JDRF 17-2013-498

Objective: To evaluate the safety and performance of using a heart rate (HR) monitor to inform an artificial pancreas (AP) system during exercise among adolescents with type 1 diabetes (T1D).

Materials and Methods: In a randomized, cross-over trial, adolescents with T1D aged 13-18 years were enrolled to receive on separate days either the unmodified UVA AP (stdAP) or an AP system connected to a portable HR monitor (AP-HR) that triggered an exercise algorithm for blood glucose (BG) control. During admissions, participants underwent a structured exercise regimen. Hypoglycemic events and CGM tracings were compared between the two admissions, during exercise and for the full 24-hour period.

Results: Eighteen participants completed the trial. While number of hypoglycemic events during exercise and rest was not different between visits (0.39 AP-HR vs 0.50 stdAP), time below 70 mg dL⁻¹ was lower on AP-HR compared to stdAP, 0.5±2.1% vs 7.4±12.5% (P = 0.028). Time with BG within 70-180 mg dL⁻¹ was higher for the AP-HR admission vs stdAP during the exercise portion and overall (96% vs 87%, and 77% vs 74%), but these did not reach statistical significance (P = 0.075 and P = 0.366).

Conclusions: Heart rate signals can safely and efficaciously be integrated in a wireless AP system to inform of physical activity. While exercise contributes to hypoglycemia among adolescents, even when using an AP system, informing the system of exercise via a HR monitor improved time <70 mg dL⁻¹. Nonetheless, it did not significantly reduce the total number of hypoglycemic events, which were low in both groups.
No food after 11am

3 x 15 mins @ HR 140
with 5 min rest

4pm
Heart rate informed artificial pancreas system enhances glycemic control during exercise in adolescents with T1D

A

Percent time <70 mg/dL

Percent time with BG <70 mg/dL

p<0.05

Standard AP AP-HR

B

Percent time 70-180 mg/dL

Percent time with BG 70-180 mg/dL

Standard AP AP-HR

C

Mean glucose

Mean BG (mg/dL)

Standard AP AP-HR

D

Mean Low BG Index

LBGI

Mean Low BG Index

Standard AP AP-HR

Pediatric Diabetes
13 OCT 2016 DOI: 10.1111/pedi.12454
Other Closed Loop Options to Safely Exercise? 
- would a bi-hormonal model have an advantage?

• Continuous exercise - 60 min session at 60% VO₂peak
• Interval exercise - 2 min alternating periods of 85% and 50% VO₂peak for 40 min
• Both exercises were matched for energy expenditure
Continuous aerobic exercise
- a dual hormonal AP system

Insulin only

Insulin + Glucagon

Adapted from:
Continuous aerobic exercise - a dual hormonal AP system

No difference between groups in overnight lows

Discuss the advantages and disadvantages of insulin dose reduction and carbohydrate intake for exercise. Activities that include anaerobic exercise will require less carbohydrate intake and/or less insulin adjustments. If both resistance/anaerobic and aerobic are to be performed, suggest performing resistance/anaerobic first.

Is the patient willing and able to lower insulin levels for exercise?

Is the activity ≤ 3 hours after a meal?

Consider increased carbohydrate intake at a rate of ~0.5 grams/kg body mass/hour of activity.

Is the activity ≥60min in duration?

Reduce bolus insulin by 25-75% at the meal before exercise depending on the intensity (i.e. light=25%; moderate=50%; heavy=75% reduction).

Is the activity ≥60min in duration?

Reduce bolus insulin by 50-75% at the meal before exercise (i.e. light=50%; moderate/heavy 75%)

Is the activity prolonged resistance exercise (weight lifting for >30 minutes)?

Discuss the possibility that intense anaerobic sprint-based exercise may increase glucose levels and require conservative insulin correcting in recovery if hyperglycemia exists.

Consider bolus insulin reduction

Is the patient on CSII?

Consider basal insulin reduction

Is the patient on CSII?

Consider the timing of exercise relative to the last meal

Consider a 20% reduction in basal insulin on days with prolonged activity. Consider CSII therapy if repeated hypo- or hyperglycemia persists

Reduce basal insulin by 50-90% 60-90 minutes before the start of exercise until the exercise stops. Or consider pump suspension at the start of exercise.

Riddell, Taplin et al. Ped Diab 2015

Other notes: 1) Pump suspension at the onset of aerobic exercise may require initial carbohydrate intake (15-20g); 2) Consider CGM where patient or parent preference dictates, or with history of nocturnal or severe hypoglycemia; 3) Downward trending arrows on CGM during exercise should be responded to by the ingestion of 8-20 grams of rapidly acting carbohydrate; 4) consider overnight basal rate reduction of 1-40% on the evenings after prolonged aerobic exercise or resistance training.
Frequent Monitoring of BGL and/or CGM

- Exercise Type, intensity, duration
- Time since last meal and insulin dose
- Time of Day
- Physical Fitness
- Recent hypoglycemia, hypo unawareness
- Emotional/stress hormone factors

Factors affecting risk of hypoglycemia

Possible Actions

- Reduce insulin bolus
- Reduce basal insulin
- Resume basal insulin
- Reduce insulin bolus
- Reduce basal insulin

Risk of delayed hypoglycemia

Preceding meal

Following meal

Night

snack

snack +/- max effort

Adapted from Nadine Taleb and Rémi Rabasa-Lhoret. 
Diabetologia August 2016,59(8),1632–1635
Different Kinds of Exercise do Different Things to Blood Glucose *acutely*

- But *all increase risk of lows many hours later*

Consider pump suspension or reduction before and during exercise as one option to prevent lows (and/or basal rate reduction beforehand)

- But beware of highs if this is done with intense or interval exercise

Minimizing the amount of rapid acting insulin on board during exercise and then snack to maintain sugar level

- Planning is important but children and adolescents are spontaneous!

Beware of hormonal responses (excitement/nerves) that might quickly wane (highs followed by lows)

Consider use of protein before exercise to attenuate risk of hypoglycemia

Replenish CHO stores quickly post-exercise... but don’t over-bolus!

Consider decreasing the post-meal bolus, and *also* night time insulin to prevent night time low blood sugars (this is what the artificial pancreas seems to do)

Check blood glucose often – this is the best management strategy of all!

Strongly consider CGM and available technology for threshold suspend and in future predictive low glucose suspend
The psychology of exercise and diabetes

Acta Paediatr Scand 1980

• “Many patients mean that is easy to be theoretically positive, but quite another thing to really exercise regularly.”

• Too often physical exercise becomes a “medicine” instead of a natural pleasant habit.

• “It is important that the hospital staff inform the patients without nagging, and then support and stimulate the patients, and give them adequate responsibility.”
Barriers to exercise participation

• Teenage girls with T1DM are less active then teenage boys, and less active than non-diabetic girls of the same age (Valerio et al, Nutr Metab Cardiovasc Dis 2007)

• Data supports all of the following in youth:
  – Intrapersonal factors (lack of energy, perceived competence, negative self image, T1DM stigma)
  – Interpersonal factors (family and peer support)
  – Environmental (access, opportunity)
Barriers to exercise participation in adults with T1DM- knowledge and fear

• Better knowledge of insulin pharmacokinetics
• Use of approaches to minimize glycemic excursion around
  – Both associated with less perceived barriers
  – *Higher perceived barriers correlated with HbA1c*
• Fear of hypoglycemia is significant barrier to exercise in T1DM.
  – That fear needs to be addressed in patients and parents.

(Diab Care 2008 2109-9 – most common barrier to regular exercise in adults with T1D is fear of lows)
(Ped Diab 2007 362-8- 63% of parents report fear of nocturnal lows)
• Role modelling, inspiring examples
• Provider comfort with data and technology
• First messages at time of diagnosis (inclusionary vs exclusionary messages?)

Specific strategies to allay parental fear - give them control by having a specific plan!