Exercise & Type 1 Diabetes

Birmingham Women's & Childrens Hospital

Dietitians: John Pemberton
What today is about!

- Learning is doing and keeps you awake!
- Every person with T1DM is a n=1
- Guiding principles and starting algorithms not dogmatic rules
- CGM and exercise
- Use the good stuff and reference, do not re-invent the wheel
DH (2011) recommendations? Sport England interpretation

B. Final recommendations on physical activity guidelines for Children and Young People

<table>
<thead>
<tr>
<th>Recommendation 1</th>
<th>The UK guidelines on physical activity for children and young people should include a recommendation for physical activity in general, an overall guideline.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation 2</td>
<td>The UK guidelines on physical activity for children and young people should recommend “daily physical activity”.</td>
</tr>
<tr>
<td>Recommendation 3</td>
<td>The UK guidelines on physical activity for children and young people should recommend at least 60 minutes of moderate to vigorous physical activity (MVPA) daily.</td>
</tr>
<tr>
<td>Recommendation 4</td>
<td>The UK guidelines for children and young people should include a specific recommendation for vigorous activity (≥6–7 METS) on at least 3 days a week.</td>
</tr>
</tbody>
</table>

**Recommendation for supporting commentary**
The commentary which accompanies the guidelines should indicate that vigorous intensity activity will form part of the daily 60 minute recommendation for children and young people.

| Recommendation 5 | The UK guidelines on physical activity for children and young people should recommend physical activity for the promotion of musculoskeletal health and flexibility at least 3 days per week. |

Table 3. The percentage of children meeting previous physical activity guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>England (aged 2–15)</td>
<td>32%</td>
<td>24%</td>
</tr>
<tr>
<td>Northern Ireland (Years 8–12)</td>
<td>19%</td>
<td>10%</td>
</tr>
<tr>
<td>Wales (aged 4–15)</td>
<td>63%</td>
<td>45%</td>
</tr>
<tr>
<td>Scotland (aged 2–15)</td>
<td>76%</td>
<td>67%</td>
</tr>
</tbody>
</table>
Two meta-analysis show 0.5% HbA1c improvement


**Beneficial**
- Fitness
- Insulin requirement
- Lipids
- Endothelial function
- Mortality
- Insulin resistance
- CVD
- Wellbeing

**Uncertain / Limited data**
- Microvascular complications
- Osteoporosis
- Cancer
- Beta cell function
- Blood pressure
- Glycaemic control

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Riddle and Taplin (2016) Exercise in children with type 1 diabetes in A. Scaramuzza et al. (eds.), Research into Childhood-Onset Diabetes, DOI 10.1007/978-3-319-40242-0_7

A fantastic infographic
Weightlifting, Track cycling, Track (sprinting & field events), Diving (Platform & springboard)
American football, Swimming (sprints), Gymnastics, Fencing
Wrestling, Volleyball, Ice hockey, Tree/rock climbing,

Basketball, Soccer, Racquet sports, Lacrosse
Speed skating (500-1000m)
Skiing (slalom & downhill), Field hockey
Jumping rope, Rowing (middle distance)
Gymnastics, Martial arts, Horseback ridding
Running (middle distance), Games like tag

Skateboarding
Road cycling
In-line skating
Cross country skiing
Brisk walking
Marathon running
Triathlon
Aerobic / Continuous Exercise

Low to moderate intensity activity: walking, playing in the playground, jogging, shopping
What are your options for aerobic / continuous exercise?

12 year old boy – 50kg

Brisk walking to school 30 minutes morning after breakfast.

Brisk walking home after school 30 minutes

14 year old girl – 50kg

60 minutes swimming before breakfast
Anaerobic / Short Sharp Exercise

Very high intensity activity: sprinting, jumping, lifting weights, martial arts & gymnastics
What are your options for Supra-maximal exercise during activity?

17 year old boy – 60kg
Weights session after school 16:30, no meal before

14 year old girl – 50kg
60 minute sprint training session 18:00 after evening meal 17:00
Mixed / Intermittent Exercise

Glucose Trend T1D:

Lots of high intensity with little low intensity bursts, glucose is more likely to increase: Judo, sprint training, competitive football & netball, competition dancing, gymnastics.

or

Lots of low intensity with little high intensity bursts, glucose is more likely to decrease: school P.E recreational football & netball, bike riding, trampoline.
What are your options for intermittent exercise?

13 year old boy – 40kg

Football Match “Big Game” 60 minutes at 11:00, breakfast at 08:00

13 year old girl – 40kg

Netball after school practice 15:30 “easy practice” after school 60 minutes, last meal 12:30 - Lunch
Possible ‘Post exercise whip’ 0 - 60 minutes
Anaerobic HIIT Sprint finish

With thanks to Francesca Annan RD

- Adrenaline, Cortisol, Glucagon = “Glucose release & insulin resistance”
- Anaerobic or hard intermittent
- Disconnected pump
- Cool Down
Effect of exercise on blood glucose after activity

Exercise of 45 minutes or more keeps the side door open for up to 11 hours.
If Blood Glucose is...

**Below 4**
Treat hypo wait 15 mins before re checking and give follow up snack (10-15g carbohydrate) once BG above 4

**Between 4-8**
Give 10g of fast acting carbohydrate at the start of exercise such as 60mls Lucozade

**Between 9-13**
Do not give any fast acting carbohydrate before exercise (a small correction can be given - please discuss individual patients)

**14+ check for Ketones**
If Ketones are above 0.6, do not exercise
First 90 minutes peak insulin action
90-180 minutes moderate insulin action
>180 minutes low insulin action

For most consistent results
Remember the 3 hour exercise rule!
Studies on aerobic moderate intensity exercise and the reductions are likely to be less for intermittent and high intensity activities.
BWCH: Insulin reductions within 90 minutes of exercise

<table>
<thead>
<tr>
<th></th>
<th>Anaerobic Short-Sharp</th>
<th>Intermittent Mixed</th>
<th>Aerobic Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE 3-5</td>
<td>N/A</td>
<td>-35%</td>
<td>-25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-50%</td>
</tr>
<tr>
<td>RPE 5-7</td>
<td>N/A</td>
<td>-25%</td>
<td>-35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-65%</td>
</tr>
<tr>
<td>RPE 7-10</td>
<td>N/A</td>
<td>-15%</td>
<td>-50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-75%</td>
</tr>
</tbody>
</table>
Recommendations: Carbohydrate during activity

- Aerobic exercise extra carbohydrate:
  - If no adjustment to pre-meal insulin delivery has occurred:
    - 1.0g/kg of carbohydrate per kg per hour
  - Where pre-exercise insulin has been reduced
    - 0.5 g/kg of carbohydrate per hour

- Mixed / intermittent the carbohydrate requirement will be less.
  - If no adjustment to pre-meal insulin delivery has occurred:
    - 0.5 g of CHO per kg per hour
  - Where pre-exercise insulin has been reduced:
    - 0.25 g/kg per hour
## Carbohydrate Requirement g/kg/hr (grams per kilogram per hour)

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<thead>
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<th>Anaerobic Short-Sharp</th>
<th>Intermittent Mixed</th>
<th>Aerobic Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insulin reduction</td>
<td>No insulin reduction</td>
<td>Insulin reduction</td>
</tr>
<tr>
<td>RPE 3-5</td>
<td>0.075</td>
<td>0.01</td>
<td>0.15</td>
</tr>
<tr>
<td>RPE 5-7</td>
<td>0.125</td>
<td>0.15</td>
<td>0.225</td>
</tr>
<tr>
<td>RPE 7-10</td>
<td>0.15</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**BWCH: Carbohydrate during activity**

If glucose in target
Recommendations: After exercise

- 50% of the usual correction dose for post-exercise hyperglycaemia and only if hyperglycaemia persists for >60 min post exercise.

- Activity >45min:
  - Reduce meal insulin after exercise 25-50%
  - lower the basal rate by 20% between 9 p.m. and 3 a.m.
  - 20g protein before bed (Increase Glucagon)
  - Carbohydrate snack before bed
Six Key questions

- Therapy: Pump or MDI?
- What type of activity will they be doing?
  - Aerobic/ Anaerobic/ Intermittent
- When eating and bolusing prior to activity?
  - Within 90 mins/ >90 minutes
- How long?
  - Minutes
- How intense will they be working out of 10?
  - Light: 3 – 5
  - Medium: 5 – 7
  - High: 7 – 10
- Are they eating after the activity?
- Live Example
CGM - it's the future!
Where Sensors and Meters Measure

Sensor measures interstitial glucose continuously

Meter

Meter measures blood glucose as a snap shot

Lag time: est. 10 minutes
Differences – blood glucose vs sensor glucose

Lag Time is about 10 minutes
**Libre:**

What do the arrows mean?

<table>
<thead>
<tr>
<th>Trend Arrow</th>
<th>Description</th>
<th>Where the blood glucose is now (10 minutes ahead)</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑</td>
<td>Rising quickly</td>
<td>2 mmol/l higher</td>
</tr>
<tr>
<td>←</td>
<td>Rising</td>
<td>1 mmol/l higher</td>
</tr>
<tr>
<td>→</td>
<td>Stable</td>
<td>Same</td>
</tr>
<tr>
<td>↓</td>
<td>Falling</td>
<td>1 mmol/l lower</td>
</tr>
<tr>
<td></td>
<td>Falling quickly</td>
<td>2 mmol/l lower</td>
</tr>
</tbody>
</table>
# What's on offer?

<table>
<thead>
<tr>
<th>Medtronic 640G with smart guard and VEO with Low Glucose Suspend</th>
<th>Dexcom CGM G4</th>
<th>Dexcom CGM G5</th>
<th>Freestyle Libre</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>This is an integrated system where insulin pump acts as a receiver of CGM data. The auto suspend feature helps in suspending the pump if glucose level hits a threshold (VEO) or is predicted to hit a threshold in the next 30 minutes (640G)</td>
<td>Continuous Glucose monitoring system which can be used alone or integrated with animas pump where CGM data can be viewed on the pump. A Newer version G5 is available in the market which is the first and only remote glucose monitoring system.</td>
<td>Continuous Glucose monitoring system which can be used alone. It can send data wirelessly to a compatible smart phone. It is FDA approved to make treatment decisions upon it’s results.</td>
<td>Flash glucose monitoring system. Monitor when scanned over transmitter gives the current sugar reading. It provides the glucose history for previous 8 hours</td>
</tr>
<tr>
<td>13.6%</td>
<td>13.0%</td>
<td>10% - Paediatrics</td>
<td>11.4%</td>
</tr>
<tr>
<td>Every 5 mins</td>
<td>Every 5 mins</td>
<td>Every 5 mins</td>
<td>Every second (when flashed)</td>
</tr>
<tr>
<td>Age 2 and above</td>
<td>Age 2 and above</td>
<td>Age 2 and above</td>
<td>Age 4 and above</td>
</tr>
<tr>
<td>6 days</td>
<td>7 days</td>
<td>7 days</td>
<td>14 days</td>
</tr>
</tbody>
</table>
Solutions to make CGM more reliable during exercise:

- Last meal insulin 3hrs before exercise – Check IOB???
- Set low alarm at 6.0mmol/l
- Hydrate effectively
- Set rate of change alarms: if goes off use BG not SG
  - 0.17mmol/l per min
  - 1.7mmol/l in 10 mins
  - One arrow down (Libre & Dexcom)
  - Two Arrows down (Medtronic)
- Sensor placed away from exercising muscle
<table>
<thead>
<tr>
<th>Medtronic Minimed 640G &amp; VEO</th>
<th>Dexcom G4 &amp; G5</th>
<th>Abbott Libre &amp; Navigator</th>
<th>Change in glucose mmol/l in 15 minutes</th>
<th>Real life speak</th>
<th>SG 6.0 mmol/l expected SG range mmol/l in 15 minutes</th>
<th>SG 12mmol/l expected SG range mmol/l in 15 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down</td>
<td>Down</td>
<td>Down</td>
<td>0.0 - 0.8</td>
<td>Stable</td>
<td>5.2 - 6.8</td>
<td>11.2 - 12.8</td>
</tr>
<tr>
<td>Down</td>
<td>Down</td>
<td>Down</td>
<td>0.8 - 1.7</td>
<td>Falling slowly</td>
<td>4.3 - 5.2</td>
<td>10.3 - 11.2</td>
</tr>
<tr>
<td>Down</td>
<td>Down</td>
<td>Down</td>
<td>&gt;1.7</td>
<td>Falling quickly</td>
<td>&lt;4.3</td>
<td>&lt;10.3</td>
</tr>
<tr>
<td>Down</td>
<td>Down</td>
<td>Down</td>
<td>&gt;2.5</td>
<td>Falling rapidly</td>
<td>&lt;3.5</td>
<td>&lt;9.5</td>
</tr>
<tr>
<td>Up</td>
<td>Up</td>
<td>Up</td>
<td>0.8 - 1.7</td>
<td>Rising slowly</td>
<td>6.8 - 7.7</td>
<td>12.8 - 13.7</td>
</tr>
<tr>
<td>Up</td>
<td>Up</td>
<td>Up</td>
<td>1.7 - 2.5</td>
<td>Rising quickly</td>
<td>&gt;7.7</td>
<td>&gt;13.7</td>
</tr>
<tr>
<td>Up</td>
<td>Up</td>
<td>Up</td>
<td>&gt;2.5</td>
<td>Rising rapidly</td>
<td>&gt;8.5</td>
<td>&gt;14.5</td>
</tr>
</tbody>
</table>
How much carbohydrate for 45 minutes of football?

- Blood Glucose 6.0 mmol/l
The BCH CGM Calculator

Example
Monitoring

- Dexcom Clarity
- Libre Software
- Diasend CGM and insulin data - All but Medtronic
- CareLink Personal & Pro
- Telephone clinic
- Skype style clinic
- Teach the patients how to use the algorithms for self-management
What I was hoping?

- Know your types of exercise
- Know your insulin reductions
- Know your CGM arrows ROC
- Know advice that increases CGM accuracy during exercise
- Give plans according to 6 key questions – Standardise!
- Review, adapt, improve
References Exercise


- Yardley & Sigal (2015) Exercise Strategies for Hypoglycemia Prevention in Individuals With Type 1 Diabetes. DOI: 10.2337/diaspect.28.1.32
References CGM


• Danne et al – CGM Concencuses from ATTD - *Diabetes Care* 2017;40:1631–1640 | https://doi.org/10.2337/dc17-1600

