

Exercise & Type 1 Diabetes

Birmingham Women's & Childrens Hospital

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By your side

What today is about!

- Why activity & exercise is important
- The key guidelines papers
- Guiding principles and starting algorithms
- Having a go!
- CGM and exercise
- Use the good stuff and reference – don't re-invent!

Must Read Papers!

Diabetologia
<https://doi.org/10.1007/s00125-020-05263-9>

POSITION STATEMENT



Glucose management for exercise using continuous glucose monitoring (CGM) and intermittently scanned CGM (isCGM) systems in type 1 diabetes: position statement of the European Association for the Study of Diabetes (EASD) and of the International Society for Pediatric and Adolescent Diabetes (ISPAD) endorsed by JDRF and supported by the American Diabetes Association (ADA)

Othmar Moser^{1,2} • Michael C. Riddell³ • Max L. Eckstein¹ • Peter Adolfsson^{4,5} • Rémi Rabasa-Lhoret^{6,7,8,9} • Louisa van den Boom¹⁰ • Pieter Gillard¹¹ • Kirsten Nørgaard¹² • Nick S. Oliver¹³ • Dessi P. Zaharieva¹⁴ • Tadej Battelino^{15,16} • Carine de Beaufort^{17,18} • Richard M. Bergenstal¹⁹ • Bruce Buckingham¹⁴ • Eda Cengiz^{20,21} • Asma Deeb²² • Tim Heise²³ • Simon Heller^{24,25} • Aaron J. Kowalski²⁶ • Lalantha Leelarathna^{27,28} • Chantal Mathieu¹¹ • Christoph Stettler²⁹ • Martin Tauschmann³⁰ • Hood Thabit²⁷ • Emma G. Wilmot^{31,32} • Harald Sourij¹ • Carmel E. Smart^{33,34} • Peter G. Jacobs³⁵ • Richard M. Bracken³⁶ • Julia K. Mader¹

Moser et al (2020)

Moser, O., Riddell, M.C., Eckstein, M.L. *et al.* Glucose management for exercise using continuous glucose monitoring (CGM) and intermittently scanned CGM (isCGM) systems in type 1 diabetes: position statement of the European Association for the Study of Diabetes (EASD) and of the International Society for Pediatric and Adolescent Diabetes (ISPAD) endorsed by JDRF and supported by the American Diabetes Association (ADA). *Diabetologia* (2020). <https://doi.org/10.1007/s00125-020-05263-9>

WILEY

ISPAD CLINICAL PRACTICE CONSENSUS GUIDELINES

ISPAD Clinical Practice Consensus Guidelines 2018: Exercise in children and adolescents with diabetes

Peter Adolfsson¹ • Michael C. Riddell² • Craig E. Taplin³ | Elizabeth A. Davis⁴ | Paul A. Fournier⁵ | Francesca Annan⁶ | Andrea E. Scaramuzza⁷ | Dhruvi Hasnani⁸ | Sabine E. Hofer⁹

Adolfsson et al (2018)

Pediatric Diabetes October 2018; 19 (Suppl. 27): 205–226.

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, Inigo San Millán, Tim Heise, Anne L Peters, Andreas Petz, Lori M Laffel

RIDDELL ET AL (2017)

THE LANCET DIABETES & ENDOCRINOLOGY, 5 (5), P377-390



DH (2011) recommendations?

Sport England interpretation

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

- Recommendation 1** The UK guidelines on physical activity for children and young people should include a recommendation for physical activity in general, an overall guideline.
- Recommendation 2** The UK guidelines on physical activity for children and young people should recommend “daily physical activity”.
- Recommendation 3** 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.
- Recommendation 4** The UK guidelines for children and young people should include a specific recommendation for vigorous activity ($\geq 6-7$ METS) on at least 3 days a week.
- 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

Country	Boys	Girls
England (aged 2–15)	32%	24%
Northern Ireland (Years 8–12)	19%	10%
Wales (aged 4–15)	63%	45%
Scotland (aged 2–15)	76%	67%

Two meta-analysis show **0.5% HbA1c** improvement

Quirk ET AL., (2014)
Diabet Med J Br Diabet Assoc 31:1163–1173

Kennedy A et al (2013)
PLoS One 8:e58861

Beneficial

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

Beneficial

- Fitness
- Insulin requirement
- Lipids
- Endothelial function
- Mortality
- Blood pressure
- Beta cell function
- Glycaemic control

Uncertain / Limited data

- Microvascular complications
- Osteoporosis
- Cancer
- Beta cell function
- Blood pressure
- Glycaemic control

Uncertain / Limited data

- Microvascular complications
- Osteoporosis
- Cancer
- CVD
- Wellbeing

Type 1 diabetes

Type 2 diabetes



Physical activity

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

Activity tactics

60 mins moderate activity a day, try three 20 minutes:

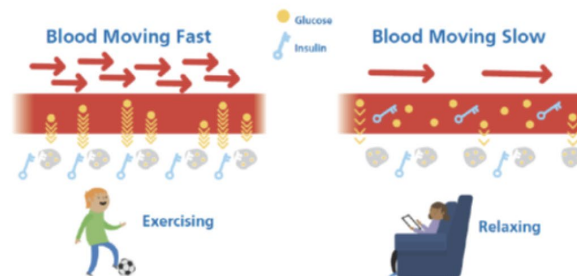
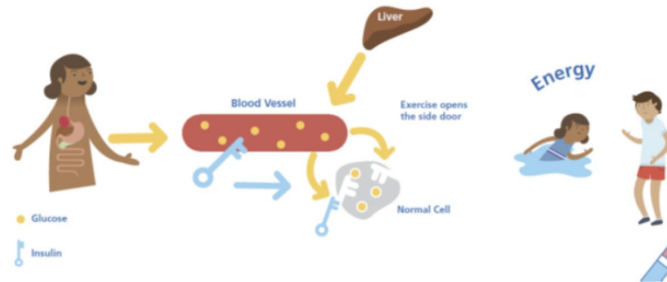
"Opens a side door to muscle cells to let more glucose in"

10 mins of moderate activity after meals:

"Gets insulin to the muscles faster to speed up its action"

Low to moderate intensity activity:

walking, playing in the playground, jogging, shopping



Self - Assessment

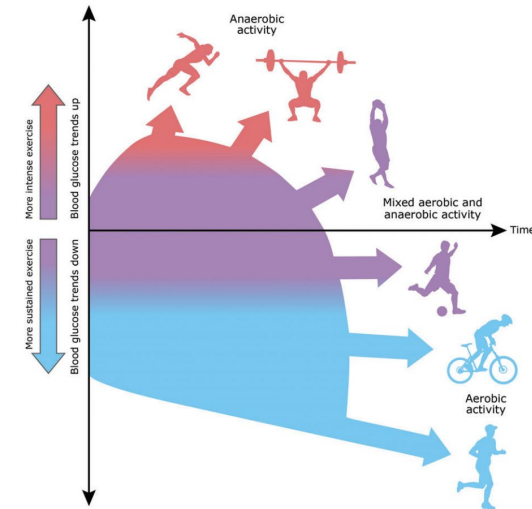
	Type 1:	Type 2:	Type 3:
What are the different modalities/types of exercise?	Aerobic / Continuous	Intermittent / Mixed	Anaerobic / Short-sharp
Examples of those activities			
What usually happens to BG during?			
What metabolic changes cause this ?			
Management Options?			



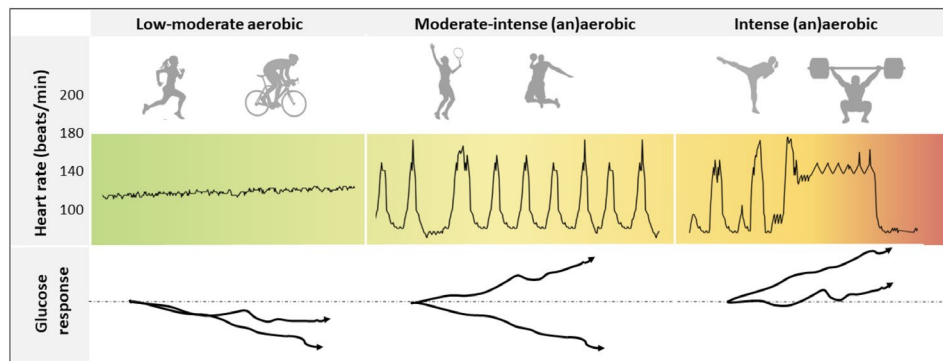
Exercise types

	Aerobic	Mixed	Anaerobic
Work rate			
Glucose trends			
Main variables	Intensity and duration of exercise, insulin to glucagon ratio, fitness, nutrition, initial glucose concentration	Intensity and duration of exercise, insulin to glucagon ratio, counter-regulatory hormones, lactate concentration, fitness, nutrition, initial glucose concentration	Intensity and number of intervals, insulin concentration, counter-regulatory hormones, lactate concentration, fitness, nutrition, initial glucose concentration

RIDDELL ET AL (2017)



Adolfsson et al (2018)

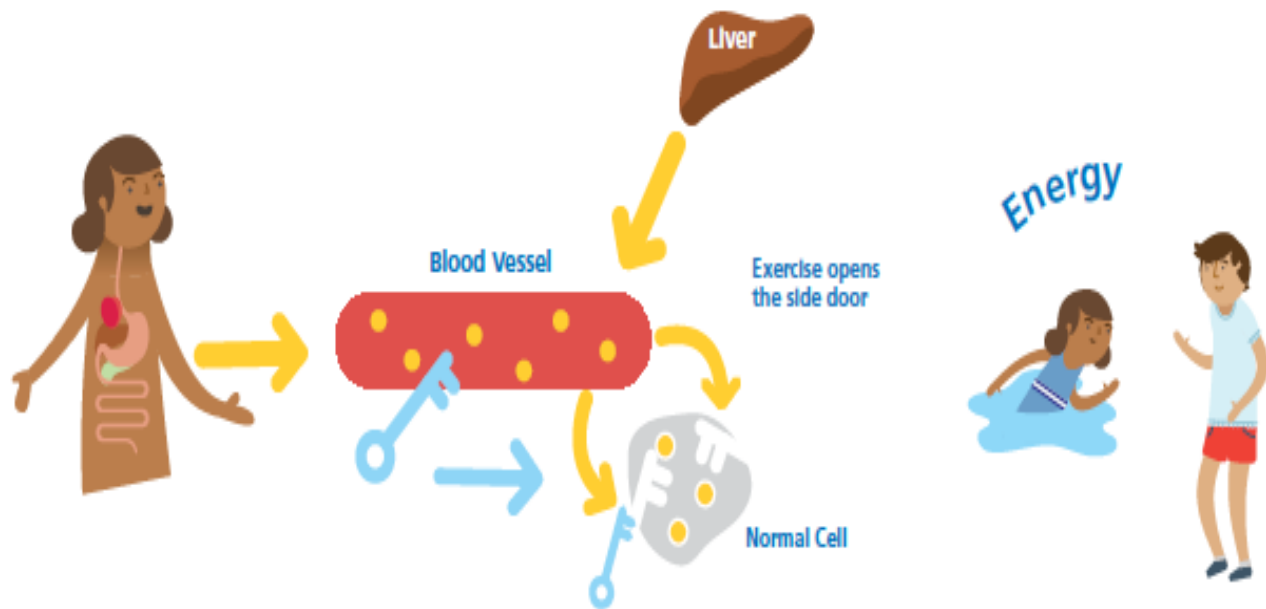


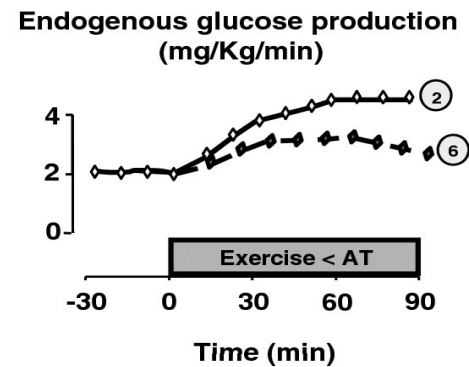
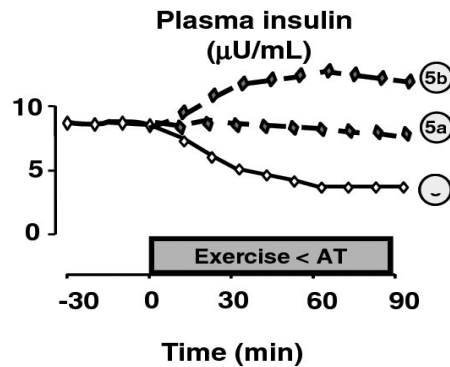
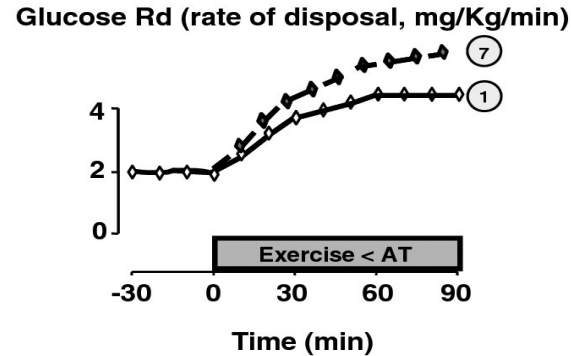
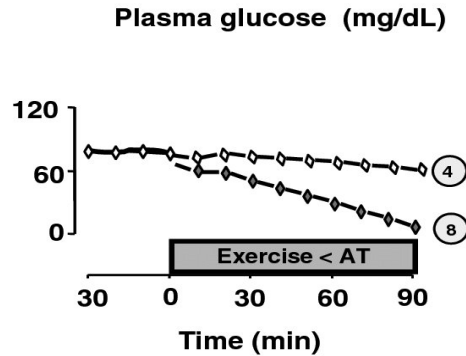
Moser et al (2020)



Aerobic / Continuous Exercise

Low to moderate intensity activity: walking, playing in the playground, jogging, shopping



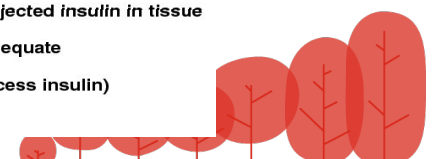


◇◇◇ Control

◆◆◆ T1DM

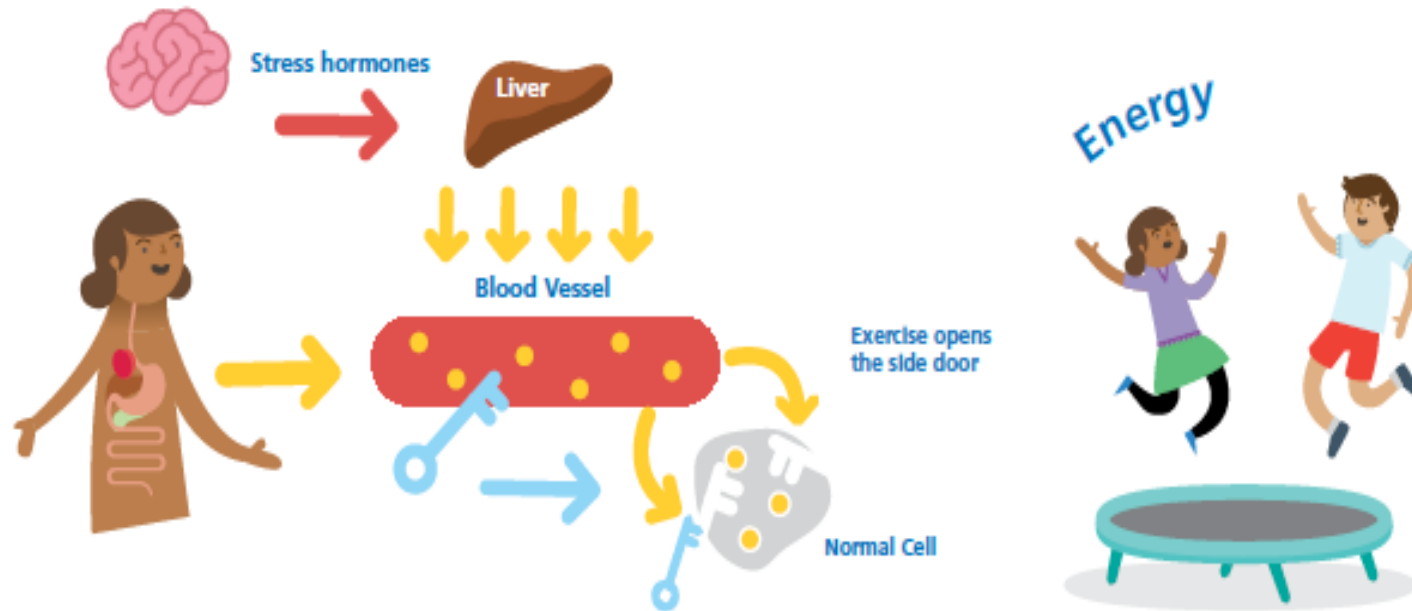
- ① Glucose uptake rises during exercise
- ② Endogenous glucose production in controls rises during exercise
- ③ Plasma insulin decreases during
- ④ Plasma glucose level stays constant

- ⑤a Plasma insulin is constant due to exogenous insulin administration
- ⑤b Plasma insulin rises due to release of residual injected insulin in tissue
- ⑥ Endogenous glucose production in T1DM is inadequate
- ⑦ Glucose uptake may rise more than controls (excess insulin)
- ⑧ Plasma glucose levels may decrease

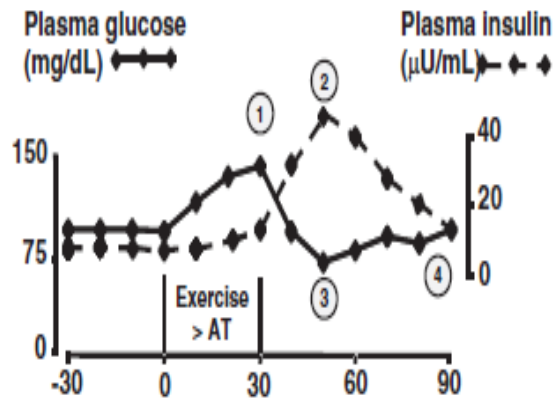


Anaerobic / Short Sharp Exercise

Very high intensity activity:
sprinting, jumping, lifting weights, martial arts & gymnastics

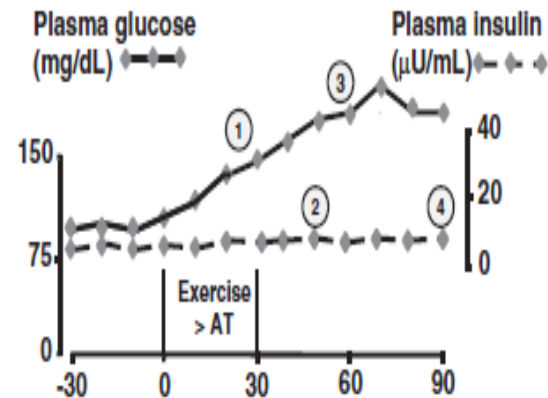


Healthy subjects



- ① Mild hyperglycemia occurs due to intense sympathetic activity
- ② Insulin rises in response to hyperglycemia
- ③ Mild hypoglycemia may occur (transient in insulin + increased insulin sensitivity)
- ④ Return to baseline condition

T1DM subjects



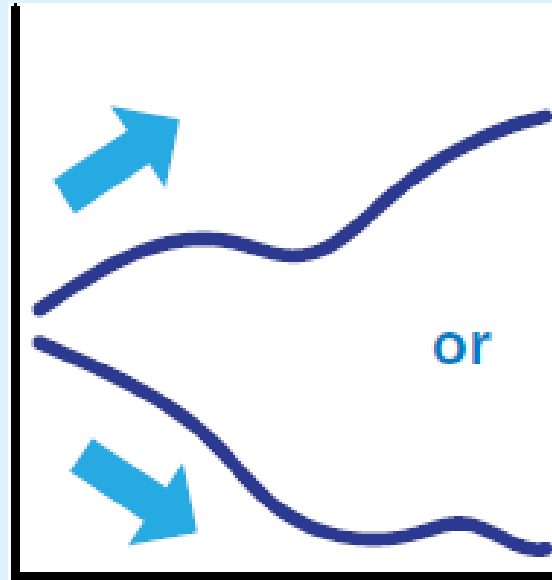
- ① Mild hyperglycemia occurs due to intense sympathetic activity
- ② Insulin cannot spontaneously increase
- ③ Hyperglycemia increases even further
- ④ Hyperglycemia may persist unless insulin is administered

Figure 3 Schematic of sequence of homeostatic events affecting carbohydrate metabolism during and immediately after intense exercise (above the anaerobic threshold, AT) in healthy and T1DM subjects, showing the possible causes of postexercise hyperglycemia in T1DM.



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.

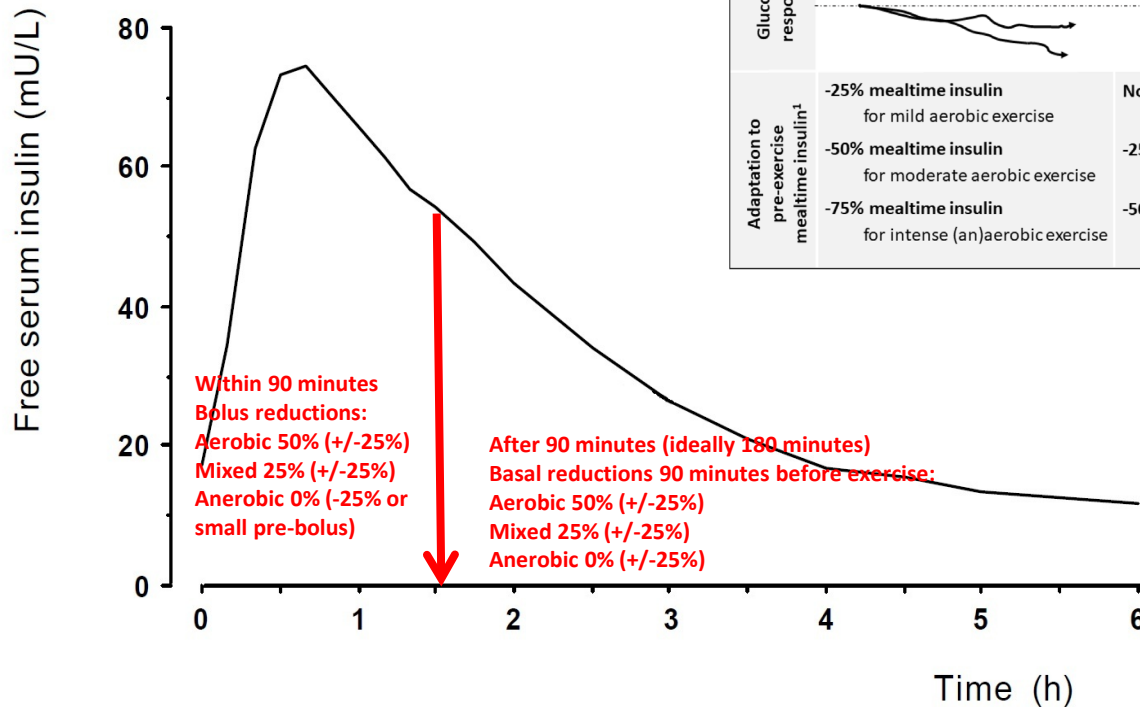
Lots of low intensity with little high intensity bursts, glucose is more likely to decrease: school P.E recreational football & netball, bike riding, trampoline.



Insulin reductions Before exercise

	Low-moderate aerobic	Moderate-intense (an)aerobic	Intense (an)aerobic
Heart rate (beats/min)			
Glucose response			
Adaptation to pre-exercise mealtime insulin ¹	-25% mealtime insulin for mild aerobic exercise -50% mealtime insulin for moderate aerobic exercise -75% mealtime insulin for intense (an)aerobic exercise	No mealtime insulin reduction if stable glucose is expected -25% mealtime insulin if slight glucose drop is expected -50% mealtime insulin if moderate glucose drop is expected	No mealtime insulin reduction required Consider micro-bolus insulin correction ²

Moser et al (2020)

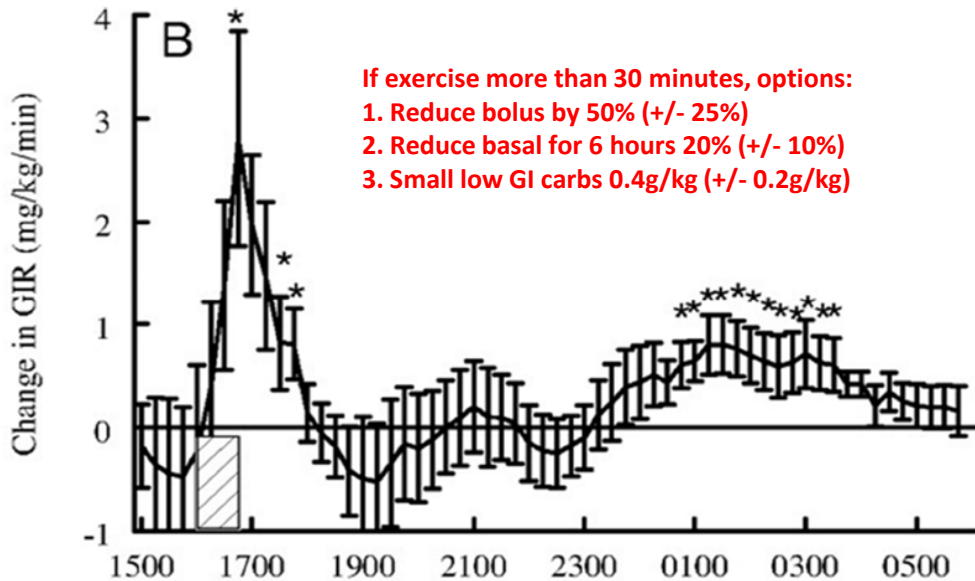


Quick recap – After Exercise

Table 4 General insulin therapy and carbohydrate recommendations for exercise in children and adolescents with type 1 diabetes

Type of therapy	Type/intensity of exercise Duration 30–45 min	Type/intensity of exercise Duration >45 min
MDI/CSII: mealtime bolus insulin dose reduction	-25% for mild aerobic -50% for moderate aerobic -50% for intense aerobic -25% for mixed aerobic/anaerobic Up to -50% post exercise	-50% for mild aerobic -75% for moderate aerobic -75% for intense aerobic -50% for mixed aerobic/anaerobic Up to -50% post exercise
MDI: basal insulin ^a	-20% for evening/late afternoon exercise	-20% for evening/late afternoon exercise -30 to -50% for all-day/unusual activities ^a
CSII: basal insulin rate	Up to -50% 90 min pre exercise Insulin pump suspension (<60 min) -20% for post-exercise night time ^b	Up to -80% 90 min pre exercise Insulin pump suspension (<60 min) -20% for post-exercise night time ^b
General CHO intake ^c	10–15 g CHO depending on IOB and sensor glucose level 1.5 g CHO per kg BW/h for intense exercise (regular IOB) 0.25 g CHO per kg BW/h for intense exercise (less IOB) 0.4 g CHO/kg BW pre-bed snack for evening/late afternoon exercise	10–15 g CHO depending on IOB and sensor glucose level 1.5 g CHO per kg BW/h for intense and/or long-lasting exercise (regular IOB) 0.25 g CHO per kg BW/h for intense exercise (less IOB) 0.4 g CHO/kg BW pre-bed snack for evening/late afternoon exercise

Moser et al 2020.



- If exercise more than 30 minutes, options:**
- 1. Reduce bolus by 50% (+/- 25%)**
 - 2. Reduce basal for 6 hours 20% (+/- 10%)**
 - 3. Small low GI carbs 0.4g/kg (+/- 0.2g/kg)**

McMahon et al (2007) JCEM 92: 963-968

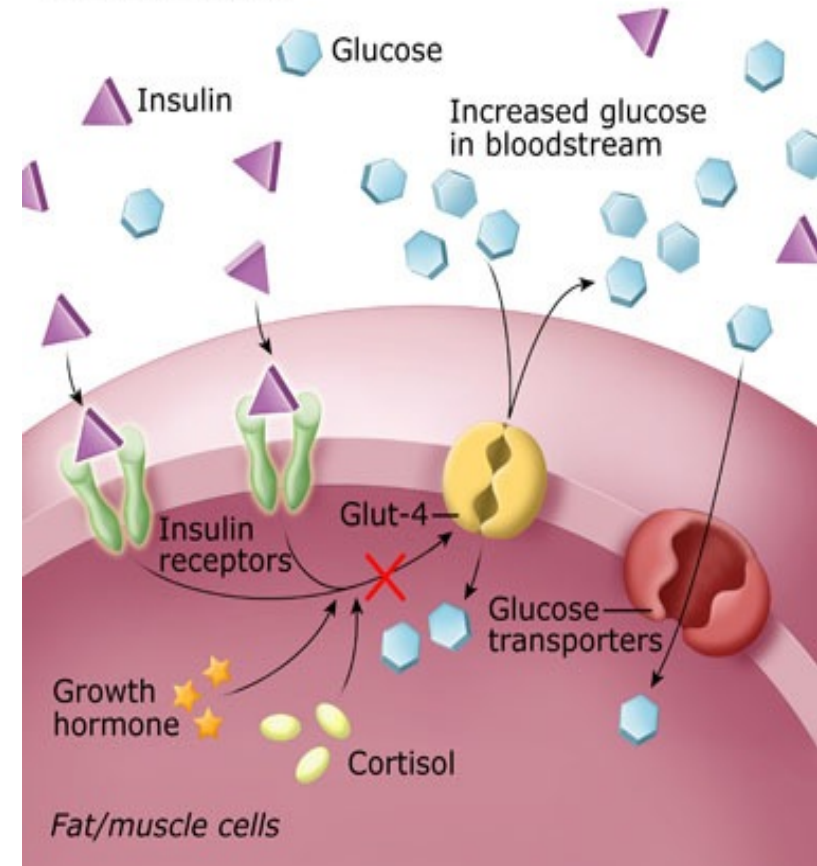


Possible 'Post exercise whip' 0 - 60minutes Anaerobic HIIT Sprint finish

With thanks to Francesca Annan RD

- Adrenaline, Cortisol, Glucagon = "Glucose release & insulin resistance"
- Anaerobic or hard intermittent
- High lactate + Cori Cori cycle
- Disconnected pump
- Options:
 - 50% correction dose
 - Effective warm down

Glucose Counter-regulatory Hormones: Effect on Fat and Muscle Cells



Algorithm

		Before exercise				During exercise	After exercise		
		Meal insulin		Basal insulin		Carbs	Maximum of two options		
Exercise type	Plan execution	Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)	See carbs chart for glucose level and trend arrows. Capped at 60kg dur to 1g/min max glucose absorption	Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
Aerobic	Went low first time	-75%	No change	No change	-75% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-50%	No change	No change	-50% (No change)	0.5g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	-25%	No change	No change	-25% (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Mixed	Went low first time	-50%	No change	No change	-50% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-25%	No change	No change	-25% (No change)	0.3g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Anaerobic	Went low first time	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Starting plan	No change	No change	No change	No change (No change)	0.0g/kg/hr	-25%	-10% for 6 hrs (-10%)	0.2g/kg
	Went high first time	No change and small bolus 15 mins pre-exercise	No change	No change	No change and small bolus 15 mins pre-exercise		no change	No change	0g/kg

Algorithm

17 year old boy
50kg on MDI(Lantus 20u)
Weights 16:30 for 60 mins
Last meal 13:00
100g carbs after (1u:10g)

Before

During

After

		Before exercise				During exercise	After exercise		
Exercise type	Plan execution	Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
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Algorithm

17 year old boy
50kg on MDI(Lantus 20u)
Weights 16:30 for 60 mins
Last meal 13:00
100g carbs after (1u:10g)

Before
No change

During
No carbs

After
-25% = 7.5 units
10g low GI before bed
OR
Lantus 18units (-10%)

		Before exercise				During exercise	After exercise		
Exercise type	Plan execution	Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
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Algorithm

12 year old girl –
40kg on Pump
Football 09:00 for 60 mins
Breakfast 08:00
60g (1u:10g)
No meal until 13:00

Before

During

After

		Before exercise				During exercise	After exercise		
Exercise type	Plan execution	Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
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Algorithm

12 year old girl –
40kg on Pump
Football 09:00 for 60 mins
Breakfast 08:00
60g (1u:10g)
No meal until 13:00

Before
-25% (4.5units)

During
12g (0.3*40)

After
-20% basal for 6 hrs

		Before exercise				During exercise	After exercise		
Exercise type	Plan execution	Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
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Algorithm

15 year old girl–
50kg on pump
Jogging 16:30 for 60 mins
no meal before
50g after (1u:20g)

Before

During

After

		Before exercise				During exercise	After exercise		
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Aerobic	Went low first time	-75%	No change	No change	-75% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-50%	No change	No change	-50% (No change)	0.5g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	-25%	No change	No change	-25% (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Mixed	Went low first time	-50%	No change	No change	-50% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-25%	No change	No change	-25% (No change)	0.3g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Anaerobic	Went low first time	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Starting plan	No change	No change	No change	No change (No change)	0.0g/kg/hr	-25%	-10% for 6 hrs (-10%)	0.2g/kg
	Went high first time	No change and small bolus 15 mins pre-exercise	No change	No change	No change and small bolus 15 mins pre-exercise		no change	No change	0g/kg

Algorithm

15 year old girl–
50kg on pump
Jogging 16:30 for 60 mins
no meal before
50g after (1u:20g)

Before
-50% basal 15:00

During
25g (0.5*50)

After
-50% bolus (1.25 units)
20g low GI before bed
OR
-20% basal 6 hours

		Before exercise				During exercise	After exercise		
Exercise type	Plan execution	Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
Aerobic	Went low first time	-75%	No change	No change	-75% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-50%	No change	No change	-50% (No change)	0.5g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	-25%	No change	No change	-25% (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Mixed	Went low first time	-50%	No change	No change	-50% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-25%	No change	No change	-25% (No change)	0.3g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Anaerobic	Went low first time	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Starting plan	No change	No change	No change	No change (No change)	0.0g/kg/hr	-25%	-10% for 6 hrs (-10%)	0.2g/kg
	Went high first time	No change and small bolus 15 mins pre-exercise	No change	No change	No change and small bolus 15 mins pre-exercise		no change	No change	0g/kg

Algorithm

15 year old girl–
50kg on pump
Jogging 16:30 for 60 mins
no meal before
50g after (1u:20g)

Went low during
Went High after

Before

During

After

		Before exercise				During exercise	After exercise		
Exercise type	Plan execution	Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
Aerobic	Went low first time	-75%	No change	No change	-75% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-50%	No change	No change	-50% (No change)	0.5g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	-25%	No change	No change	-25% (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Mixed	Went low first time	-50%	No change	No change	-50% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-25%	No change	No change	-25% (No change)	0.3g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Anaerobic	Went low first time	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Starting plan	No change	No change	No change	No change (No change)	0.0g/kg/hr	-25%	-10% for 6 hrs (-10%)	0.2g/kg
	Went high first time	No change and small bolus 15 mins pre-exercise	No change	No change	No change and small bolus 15 mins pre-exercise		no change	No change	0g/kg

Algorithm

15 year old girl–
50kg on pump
Jogging 16:30 for 60 mins
no meal before
50g after (1u:20g)

**Went low during
Went High after**

Before
-75% basal at 15:00

During
25g (0.5*50)

After
-25% bolus (1.8 units)
10g low GI before bed
OR
-10% basal 6 hours

Exercise type	Plan execution	Before exercise				During exercise	After exercise		
		Meal insulin		Basal insulin		Carbs	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
Aerobic	Went low first time	-75%	No change	No change	-75% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-50%	No change	No change	-50% (No change)	0.5g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	-25%	No change	No change	-25% (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Mixed	Went low first time	-50%	No change	No change	-50% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-25%	No change	No change	-25% (No change)	0.3g/kg/hr	-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Anaerobic	Went low first time	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Starting plan	No change	No change	No change	No change (No change)	0.0g/kg/hr	-25%	-10% for 6 hrs (-10%)	0.2g/kg
	Went high first time	No change and small bolus 15 mins pre-exercise	No change	No change	No change and small bolus 15 mins pre-exercise		no change	No change	0g/kg

BWC Calculator



**Birmingham Women's
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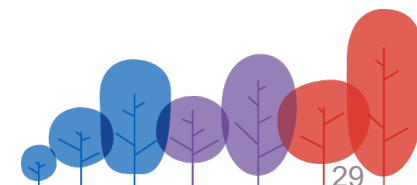
A man in a purple shirt is shouting into a microphone. He is holding a tray of food. The background is dark with some balloons. A speech bubble contains the text 'CGM - it's the future!'.

CGM - it's
the future!

What do the arrows mean?

Trend Arrow Receiver	Trend Arrow APP	Description	Where the blood glucose is now (10 minutes ahead)
		Rapidly rising	>2.0mmol/l higher
		Rising	1.5mmol/l higher
		Slowly rising	1mmol/l higher
		Stable	Same
		Slowly falling	1 mmol/l lower
		Falling	1.5mmol/l lower
		Rapidly Falling	>2.0mmol/l lower

Device	Trend Arrow	Interpretation within 15 min	Conforms with generic trend arrow as used in the position statement
Abbott Devices Senseonics Devices	↑	Increase >1.7 mmol/l (30 mg/dl)	↑
	↗	Increase 0.8–1.7 mmol/l (15–30 mg/dl)	↗
	→	Increase/decrease <0.8 mmol/l (15 mg/dl)	→
	↘	Decrease 0.8–1.7 mmol/l (15–30 mg/dl)	↘
	↓	Decrease >1.7 mmol/l (30 mg/dl)	↓
Dexcom Devices	↑↑	Increase >2.5 mmol/l (45 mg/dl)	↑
	↑	Increase 1.7–2.5 mmol/l (30–45 mg/dl)	
	↗	Increase 0.8–1.7 mmol/l (15–30 mg/dl)	↗
	→	Increase/decrease <0.8 mmol/l (15 mg/dl)	→
	↘	Decrease 0.8–1.7 mmol/l (15–30 mg/dl)	↘
	↓	Decrease 1.7–2.5 mmol/l (30–45 mg/dl)	↓
	↓↓	Decrease >2.5 mmol/l (45 mg/dl)	
Medtronic Devices ¹	↑↑↑	Increase >2.5 mmol/l (45 mg/dl)	↑
	↑↑	Increase 1.7–2.5 mmol/l (30–45 mg/dl)	
	↑	Increase 0.8–1.7 mmol/l (15–30 mg/dl)	↗
		Increase/decrease <0.8 mmol/l (15 mg/dl)	→
	↓	Decrease 0.8–1.7 mmol/l (15–30 mg/dl)	↘
	↓↓	Decrease 1.7–2.5 mmol/l (30–45 mg/dl)	↓
	↓↓↓	Decrease >2.5 mmol/l (45 mg/dl)	

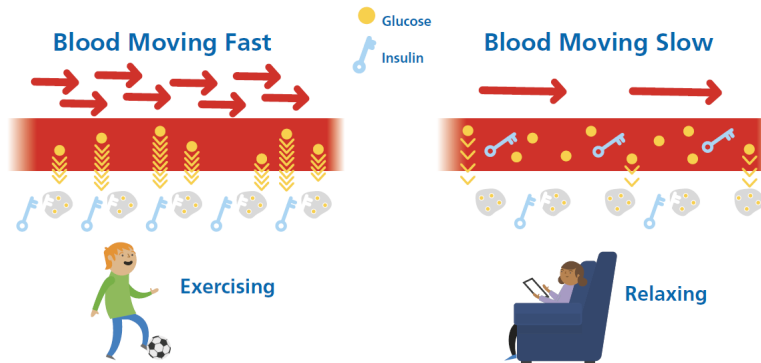


Using activity to lower glucose - DynamicGM

DynamicGM: Short bouts of activity to make meal time insulin work faster

How quickly insulin takes glucose from the blood into the muscle cells is determined by the amount of blood supplied to the muscles.

- The more blood supplied, the quicker the insulin moves glucose from the blood to the muscle cells. This prevents glucose spiking after eating
- The less blood supplied, the slower insulin moves glucose from the blood to the muscle cells. It is more likely the glucose will spike after eating.



DynamicGM: Using short burst of activity to prevent glucose spikes

Practical tip: use short bouts of activity if your glucose level is spiking 1-2 hours after eating

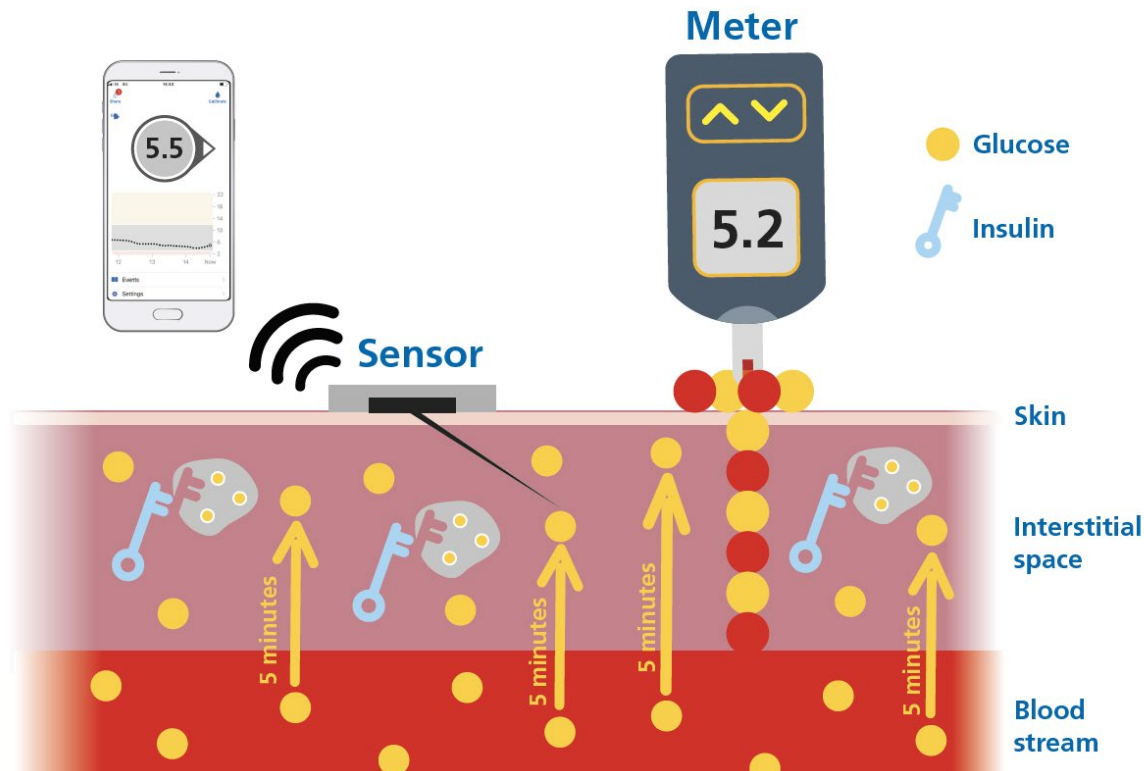
Dexcom sensor glucose Levels	Trend arrow	How many minutes of activity
8.0 - 10.0 mmol/l		5
		10
		15
10.0 - 14.0 mmol/l		15
		20
		25
		30
More than 14.0 mmol/l		15
		20
		25
		30
		40

<https://screencast-o-matic.com/watch/cYf3iBA6qY>

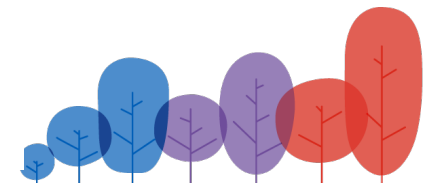
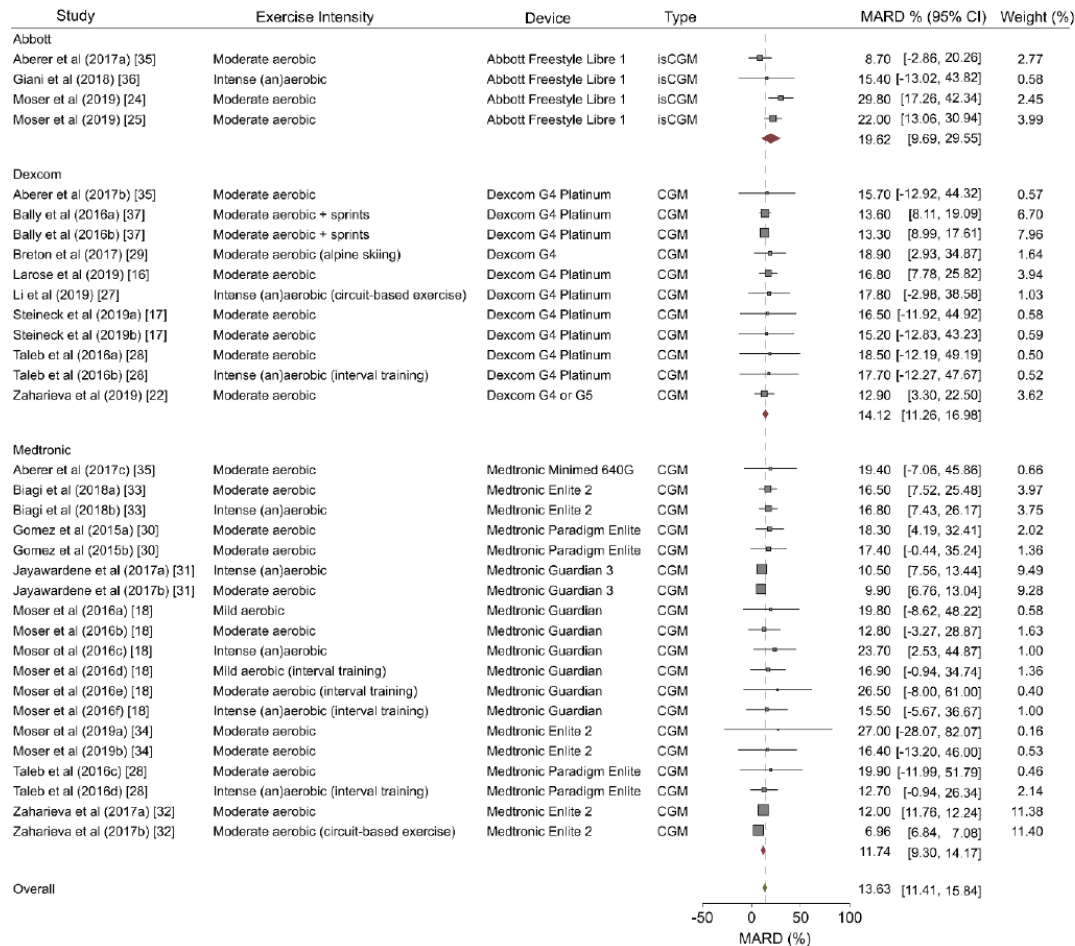


Normal lag time: 5 minutes
Exercise lag time: 12-24mins

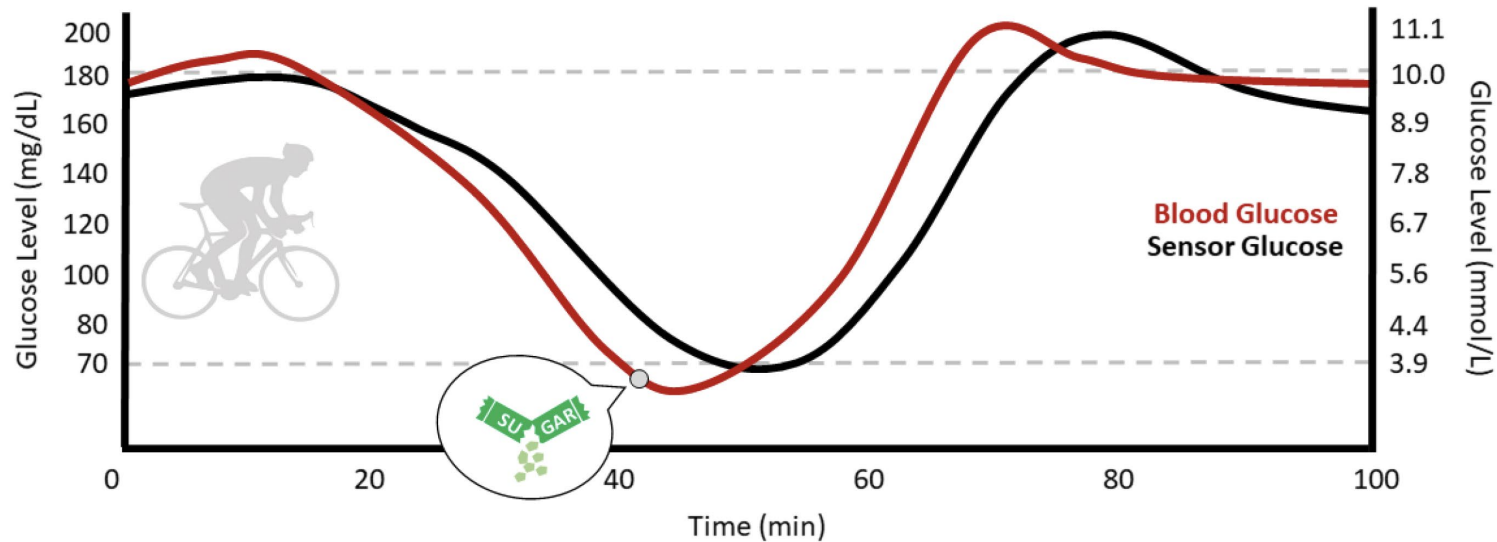
Sensors and meters measure glucose in different places



Moser et al 2020



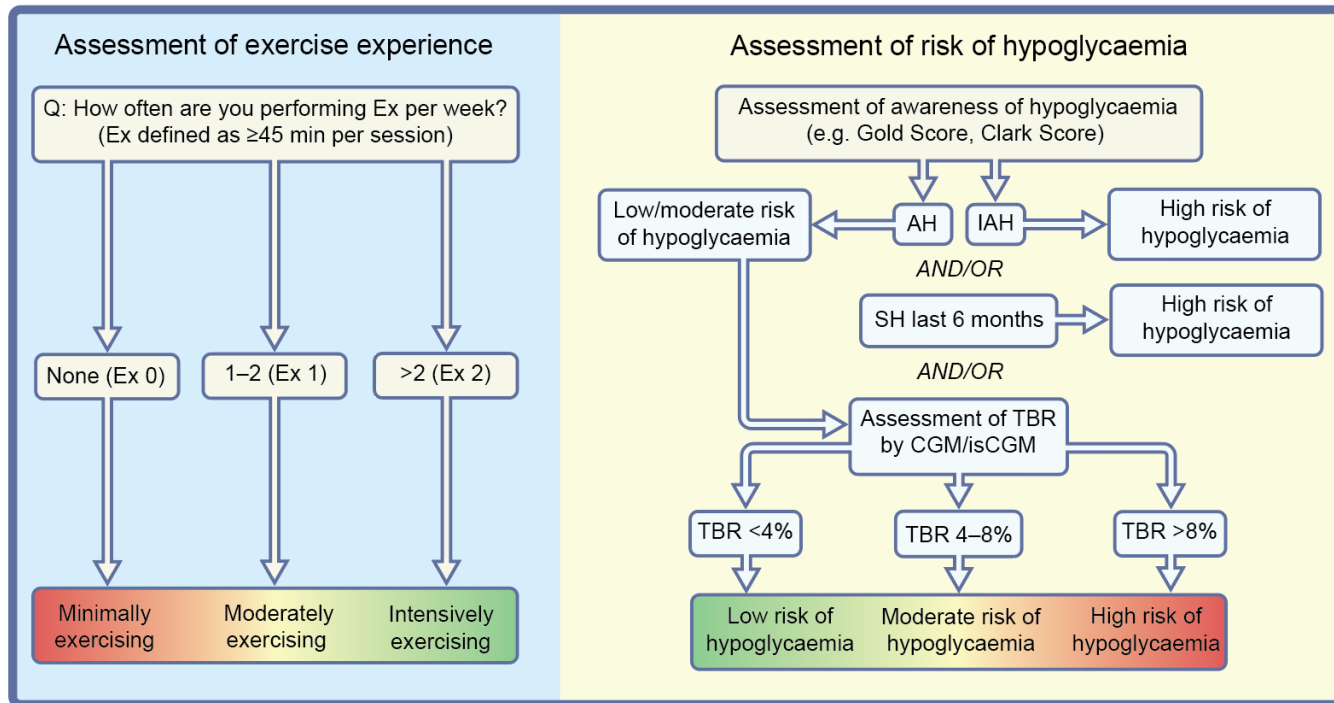
Be ware of rapidly moving glucose!



Moser et al (2020)



Hypoglycaemia risk



Moser et al (2020)



Carbohydrate just before & during exercise

20 minutes before

Pre-exercise sensor glucose for different groups in T1D			Trend arrow	Action	
Ex 2 and/or low hypo risk	Ex 1 and/or moderate hypo risk	Ex 0 and/or high hypo risk	Direction	Increase in sensor glucose expected	Decrease in sensor glucose expected
>15.0 mmol/l (>270 mg/dl) AND >1.5 mmol/l blood ketones			↗↘↔↙↕	No Ex, Insulin correction	
>15.0 mmol/l (>270 mg/dl) AND ≤1.5 mmol/l blood ketones			↗↗	Consider insulin correction ^a , Can start AE	Consider insulin correction ^a , Can start all Ex
			→	Consider insulin correction ^a , Can start AE	Can start all Ex
			↘↘	Can start all Ex	
10.1–15.0 mmol/l (181–270 mg/dl)	11.1–15.0 mmol/l (199–270 mg/dl)	12.1–15.0 mmol/l (217–270 mg/dl)	↗↗	Can start AE	Can start all Ex
			→	Can start all Ex	
			↘↘	Can start all Ex	
7.0–10.0 mmol/l (126–180 mg/dl)	8.0–11.0 mmol/l (145–198 mg/dl)	9.0–12.0 mmol/l (162–216 mg/dl)	↗↗	Can start all Ex	
			→	Can start all Ex	
			↘↘	~5 g CHO (0.2 g/kg), Can start all Ex	~10 g CHO (0.3 g/kg), Can start all Ex
5.0–6.9 mmol/l (90–125 mg/dl)	5.0–7.9 mmol/l (90–144 mg/dl)	5.0–8.9 mmol/l (90–161 mg/dl)	↗↗	Can start all Ex	~5 g CHO (0.2 g/kg), Can start all Ex
			→	~5 g CHO (0.2 g/kg), Can start all Ex	~10 g CHO (0.3 g/kg), Can start all Ex
			↘	~10 g CHO (0.3 g/kg), Delay all Ex ^b	~15 g CHO (0.4 g/kg), Delay all Ex ^b
			↓	Individual amount CHO ingestion, Delay all Ex ^b	
<5.0 mmol/l (<90 mg/dl)				Individual amount CHO ingestion, Delay all Ex ^b	

Moser at al (2020)

Every 15-20 minutes during

Pre-exercise sensor glucose for different groups in T1D			Trend arrow	Action	
Ex 2 and/or low hypo risk	Ex 1 and/or moderate hypo risk	Ex 0 and/or high hypo risk	Direction	Increase in sensor glucose expected	Decrease in sensor glucose expected
>15.0 mmol/l (>270 mg/dl) AND >1.5 mmol/l blood ketones			↗↘↔↙↕	No Ex, Insulin correction	
>15.0 mmol/l (>270 mg/dl) AND ≤1.5 mmol/l blood ketones			↗↗	Consider insulin correction ^a , Can start AE	Consider insulin correction ^a , Can start all Ex
			→	Consider insulin correction ^a , Can start AE	Can start all Ex
			↘↘	Can start all Ex	
10.1–15.0 mmol/l (181–270 mg/dl)	11.1–15.0 mmol/l (199–270 mg/dl)	12.1–15.0 mmol/l (217–270 mg/dl)	↗↗	Can start AE	Can start all Ex
			→	Can start all Ex	
			↘↘	Can start all Ex	
7.0–10.0 mmol/l (126–180 mg/dl)	8.0–11.0 mmol/l (145–198 mg/dl)	9.0–12.0 mmol/l (162–216 mg/dl)	↗↗	Can start all Ex	
			→	Can start all Ex	
			↘↘	~5 g CHO (0.2 g/kg), Can start all Ex	~10 g CHO (0.3 g/kg), Can start all Ex
5.0–6.9 mmol/l (90–125 mg/dl)	5.0–7.9 mmol/l (90–144 mg/dl)	5.0–8.9 mmol/l (90–161 mg/dl)	↗↗	Can start all Ex	~5 g CHO (0.2 g/kg), Can start all Ex
			→	~5 g CHO (0.2 g/kg), Can start all Ex	~10 g CHO (0.3 g/kg), Can start all Ex
			↘	~10 g CHO (0.3 g/kg), Delay all Ex ^b	~15 g CHO (0.4 g/kg), Delay all Ex ^b
			↓	Individual amount CHO ingestion, Delay all Ex ^b	
<5.0 mmol/l (<90 mg/dl)				Individual amount CHO ingestion, Delay all Ex ^b	

Moser at al (2020)

10 questions

1. What's your name?

John Pemberton

2. What activity are you doing
and what time are you doing it?

Rowing 12:00

3. Are you using an insulin pump
or multiple daily injections?

Insulin pump

4. How many minutes before
exercise are you eating and
giving insulin?

180

5. How many minutes are you
exercising for?

45

6. What is your weight in
kilograms (kg)?

95

7. What is your exercise hypoglycaemia risk?

Low (All of: 1. Exercise more than 2 times a week, 2. TBR less than 4%, 3. Hypo aware)

8. What type of activity are
you doing (see pictures)?

Mixed

9. What glucose units
does your device use?

mmol/L

10. What glucose & ketone level
should stop exercise for you?

≥ 14.0 mmol/L (250mg/dL) & ≥ 0.6 mmol/L



Algorithm

Exercise type	Plan execution	Before exercise				During exercise	After exercise		
		Meal insulin		Basal insulin		Carbohydrate: 20 mins before every 20 mins during	Maximum of two options		
		Within 90mins of exercise	More than 90 minutes before exercise	If exercise is within 90mins of meal insulin	If exercise is more than 90mins since meal insulin. Change basal 90mins before (MDI)		Meal insulin	Basal insulin pump (MDI: Basal insulin if in evening)	Low GI carbs no insulin before bed. Capped at 60kg to prevent excessive intake
Aerobic	Went low first time	-75%	No change	No change	-75% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-50%	No change	No change	-50% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	-25%	No change	No change	-25% (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Mixed	Went low first time	-50%	No change	No change	-50% (No change)		-75%	-30% for 6 hrs (-30%)	0.6g/kg
	Starting plan	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Went high first time	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
Anaerobic	Went low first time	-25%	No change	No change	-25% (No change)		-50%	-20% for 6 hrs (-20%)	0.4g/kg
	Starting plan	No change	No change	No change	No change (No change)		-25%	-10% for 6 hrs (-10%)	0.2g/kg
	Went high first time	No change and small bolus 15 mins pre-exercise	No change	No change	No change and small bolus 15 mins pre- exercise		no change	No change	0g/kg

Carbs 20 min before & every 20 min during

Sensor glucose Levels	Trend arrow & action to take	Grams carb g/kg/20min (60min) - Aerobic	Grams carb g/kg/20min (60min) - Mixed	Grams carb g/kg/20min (60min) - Anaerobic
<4.0mmol/L	Treat hypo, re-check & follow below guidance	0.5/kg	0.5/kg	0.5/kg
4.0-4.9 mmol/L		0.5 (1.5)	0.45 (1.35)	0.4 (1.2)
		0.4 (1.2)	0.35 (1.05)	0.3 (0.9)
		0.3 (0.9)	0.25 (0.75)	0.2 (0.6)
		0.2 (0.6)	0.15 (0.45)	0.1 (0.3)
		0.1 (0.3)	0.05 (0.15)	0 (0)
E2: 5.0-6.9 mmol/L E1: 5.0-7.9 mmol/L E0: 5.0-8.9 mmol/L		0.5 (1.5)	0.45 (1.35)	0.4 (1.2)
		0.4 (1.2)	0.35 (1.05)	0.3 (0.9)
		0.3 (0.9)	0.25 (0.75)	0.2 (0.6)
		0.2(0.6)	0.1 (0.3)	0 (0)
E2: 7.0-10.0mmol/L E1: 8.0-11.0mmol/L E0: 8.0-12.0mmol/L		0.3 (0.9)	0.25 (0.75)	0.2 (0.6)
		0 (0)	0 (0)	0 (0)
		0 (0)	0 (0)	0 (0)
13.9 mmol/L	All Arrows	0 (0)	0.0 (0)	0.0 (0)
>13.9 mmol/L & ketones <0.5mmol/L		Ok to exercise: No carbohydrate needed for 20 minutes		
		Ok to exercise: No carbohydrate needed for 20 minutes, may need 50% of correction dose		
ketones >0.5mmol/L	All Arrows	No exercise: Requires corrective dose of insulin to get ketones less than 0.6mmol/l before starting exercise		

Capped at 60kg due to glucose absorption limit of 1g/min for glucose and 1.5g/kg for mixed fast acting carb sources –
Jeukendrup (2014) *Sports Med* **44**, 25–33

Live demo

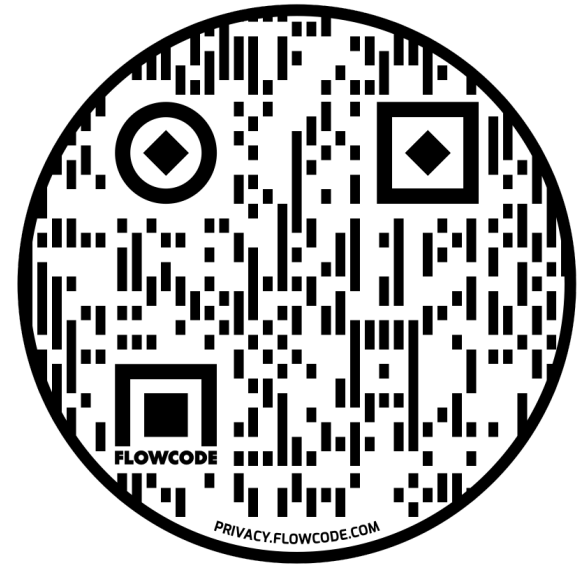


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Competency

- Click the competency link or QR code
 - https://docs.google.com/forms/d/e/1FAIpQLScAkzhquDv0rt3FskE6Mtg-rfsZVy9Bm1_yzW2yovO8Md4CEg/viewform
- Must score 9/10 to get the Type 1 DEC by email
- Make sure you use with Adobe Acrobat Reader
- Use with clinical expertise and experience
- All feedback both good and for improvements welcome:
 - johnpemberton@nhs.net
- Massive thanks to the professionals in creating the guidance:
 - ISPAD
 - EASD
 - ADA



What I was hoping?

- Know your types of exercise
- Know your insulin reductions
- Know your CGM arrows ROC
- Know CGM accuracy deteriorates during exercise
- Give plans according to key questions
- Think about using the calculator
- Plans will need trial and error