Type 1 diabetes and exercise

Rob Andrews

University of Exeter/ Somerset NHS trust

Declaration of interest

Investigator on number of lifestyle studies

- Early ACTID, EXTOD, EXTOD education, Motivate T2DM, EXTOD immune, EXTOD sedentary,

Positions

- Founding member of EXTOD
- Recent chair of Diabetes UK clinical study group 3 – prevention and treatment of type 2 diabetes

Commercial interactions

- Paid to do educational talks by Novonordisk, AstraZeneca, and Lilly

ABCD Diabetes update meeting 2026

Overview

- What are the benefits of exercising regularly for people with T1D?

- Who is safe to exercise?

- Why is glucose control around exercise so difficult if have T1D?

- What is the advice to help control glucose during exercise?

- What is the advice to help control glucose after exercise?

- Where can I get more information?
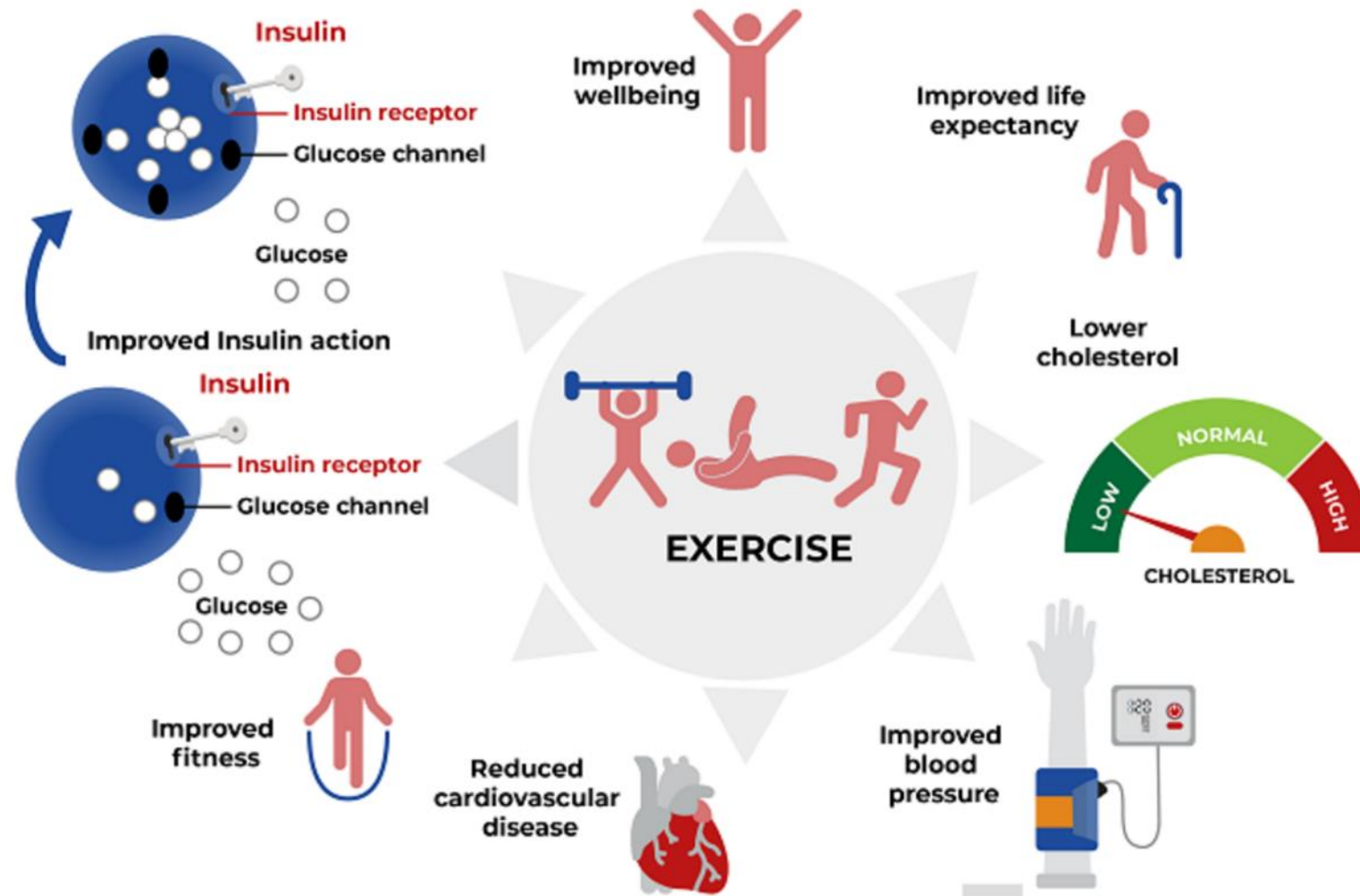
ABCD Diabetes update meeting 2026

What are the benefits of exercising regularly?

What are the benefits of exercising regularly?

Lower HbA1c – only in children

Reduced retinopathy

Reduced Nephropathy

Reduced Neuropathy
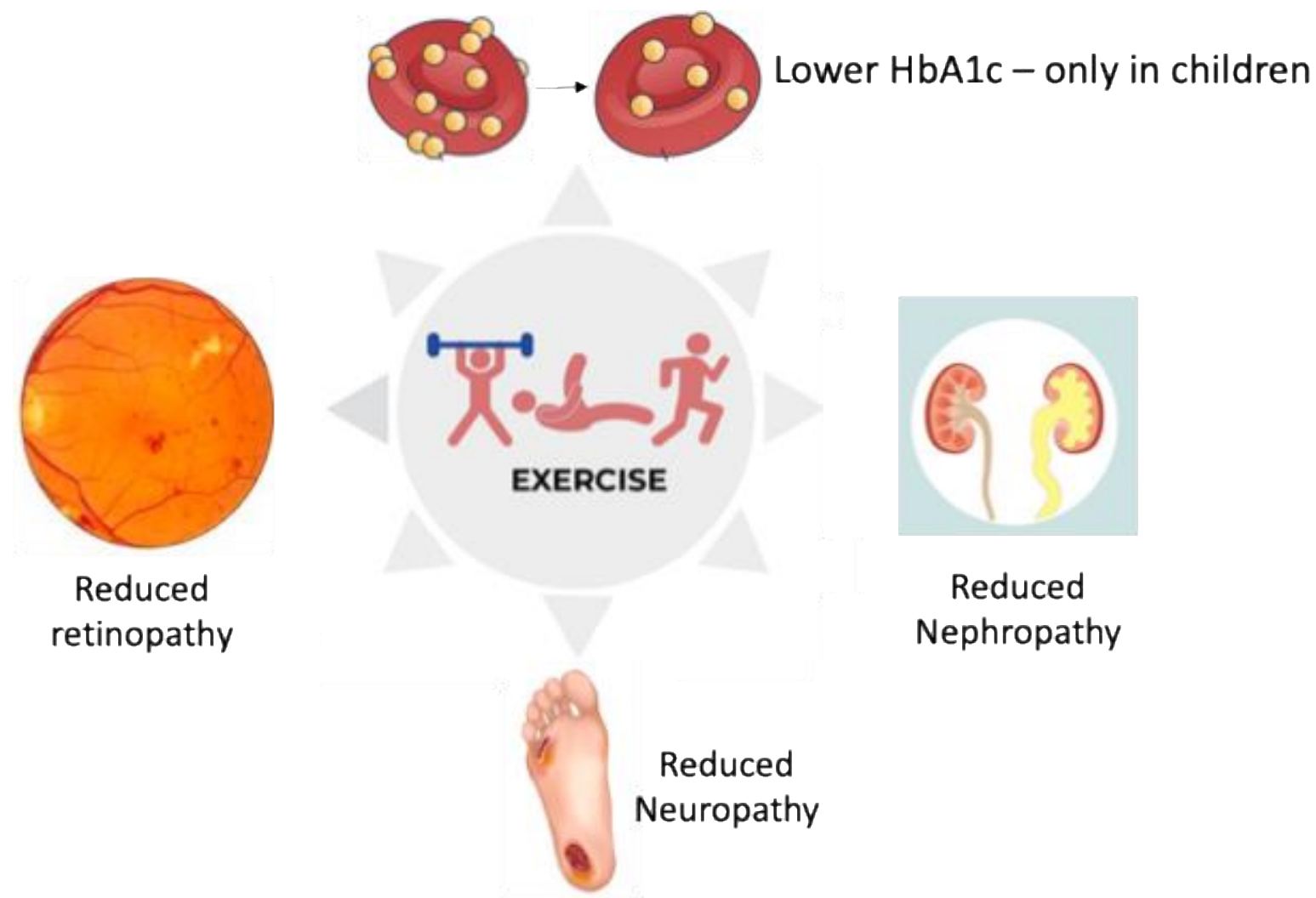
EXERCISE
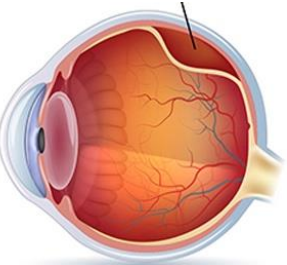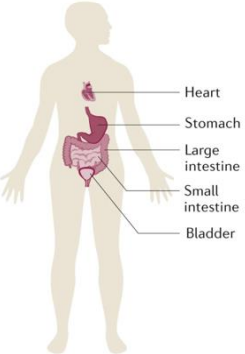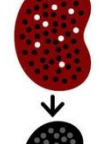
ABCD Diabetes update meeting 2026

Who is safe to exercise?
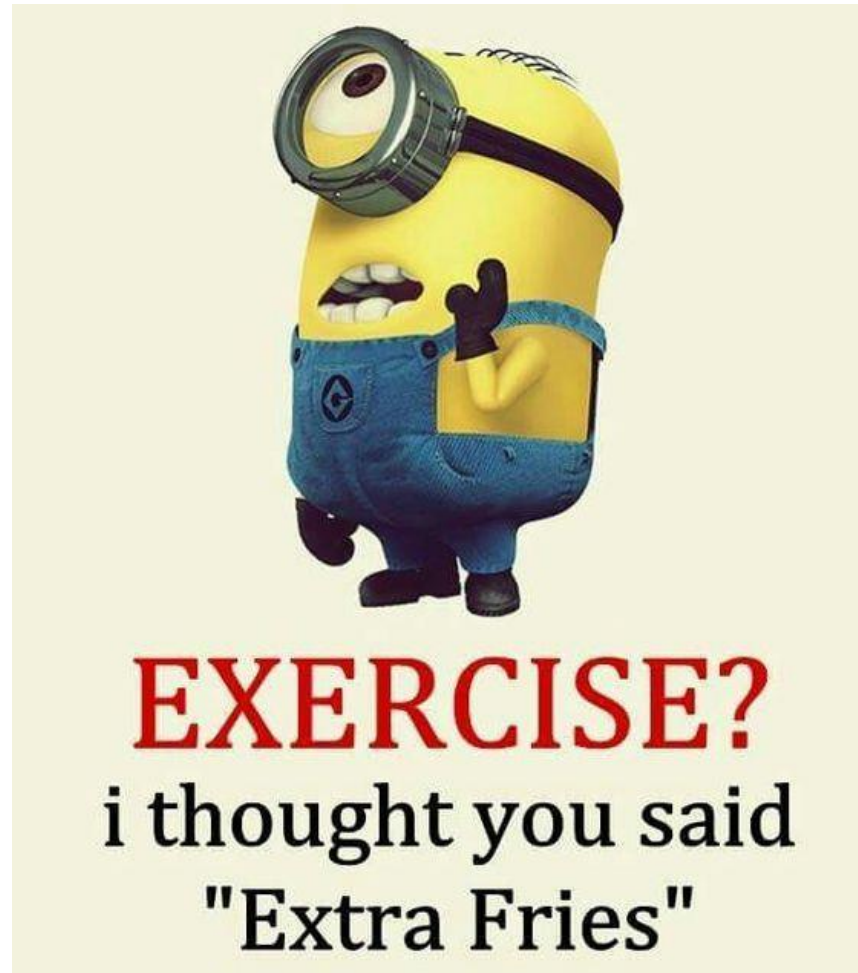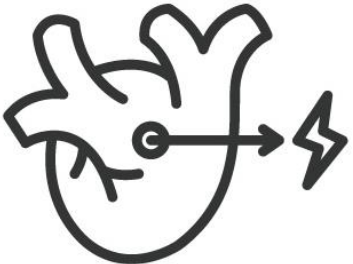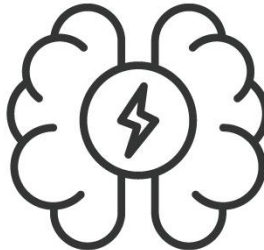
ABCD Diabetes update meeting 2026

Microvascular complications and exercise

Eyes	Feet	Kidney	Nerves
Proliferative eye disease			Neuropathy

Eyes

Proliferative eye disease

Avoid high intensity exercise

Detached retina

Avoid exercise until given go ahead

Feet

Active ulcer or Charcot then avoid weight bearing exercise. Fine to exercise and can help healing

Kidney

Stage   eGFR

1   More than 90

2   60–89

3   30–59

4   15–29

5   under 15 or on dialysis

Safe to exercise. In fact protects against progression

Nerves

Neuropathy

Safe to exercise. Check feet regularly.

Autonomic neuropathy

Heart
Stomach
Large intestine
Small intestine
Bladder

Cardiac investigation should be carried out.

University of Exeter

ABCD Diabetes update meeting 2026

NHS Somerset NHS Foundation Trust

Macrovascular complications and exercise

IHD	Hypertension	Peripheral Vascular disease	Heart failure	Stroke
New See doctor **MI** 3 months cardiac rehab then any exercise **Stable** Any form of exercise	**BP> 180/120** See doctor **BP high** Start with moderate aerobic or anaerobic exercise	**Exercise is as good as revascularization**. Walking best form of exercise	**New** See doctor **Stable** Low intensity exercise Avoid exercise that increases HR too much	**New** 3 months stroke rehab then any exercise **Stable** Any form of exercise

University of Exeter

ABCD Diabetes update meeting 2026

NHS Somerset NHS Foundation Trust

Why is glucose control around exercise so difficult if have T1D?

It's all down to hormonal responses.

The Normal response is, "I do", Not, " I suppose so"

Healthy people

People with T1D

Exercise

Adrenal Gland

Pancreas

Brain

↑ Catecholamines

↑ Cortisol

↑ Glucagon

↓ Insulin

↑ Growth hormone

Liver

Glucose

Normal glucose

Glucose

Muscle

↑ Catecholamines

FFA s

Blood

Adipose tissue

Exercise

Adrenal Gland

Subcut Insulin

Pancreas

Brain

↑ Catecholamines

↑ Cortisol

↔ Insulin

↑ Glucagon

↑ Growth hormone

Liver

Glucose

Low glucose

Glucose

Muscle

↑ Catecholamines

FFA s

Blood

Adipose tissue

Cockcroft EJ et al Exp Physiol 2019

University of Exeter

ABCD Diabetes update meeting 2026

NHS Somerset NHS Foundation Trust

Endocrine imbalance seen in T1DM during exercise

A. Euglycaemia
- ⬇ Insulin
- ⬆ counterregulation (glucagon, growth hormone, cortisol, catecholamines)

B. Hypoglycaemia
- Relative hyperinsulinaemia
- Impaired counterregulation

C. Hyperglycaemia
- Relative hypoinsulinaemia
- ⬆Catecholamines
- Anaerobic metabolism (lactate production)

Courtesy M Riddell

ABCD Diabetes update meeting 2026

Glucose responses to different exercises

Flexibility / Stretching

Aerobic

Anaerobic

Mixed
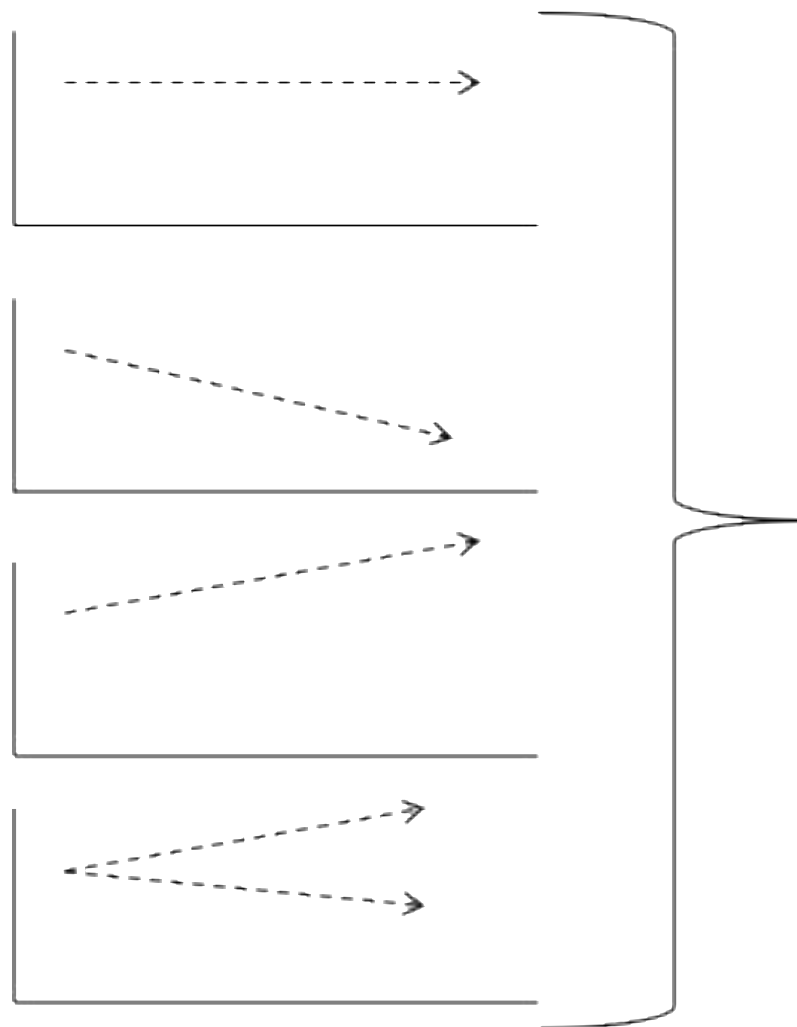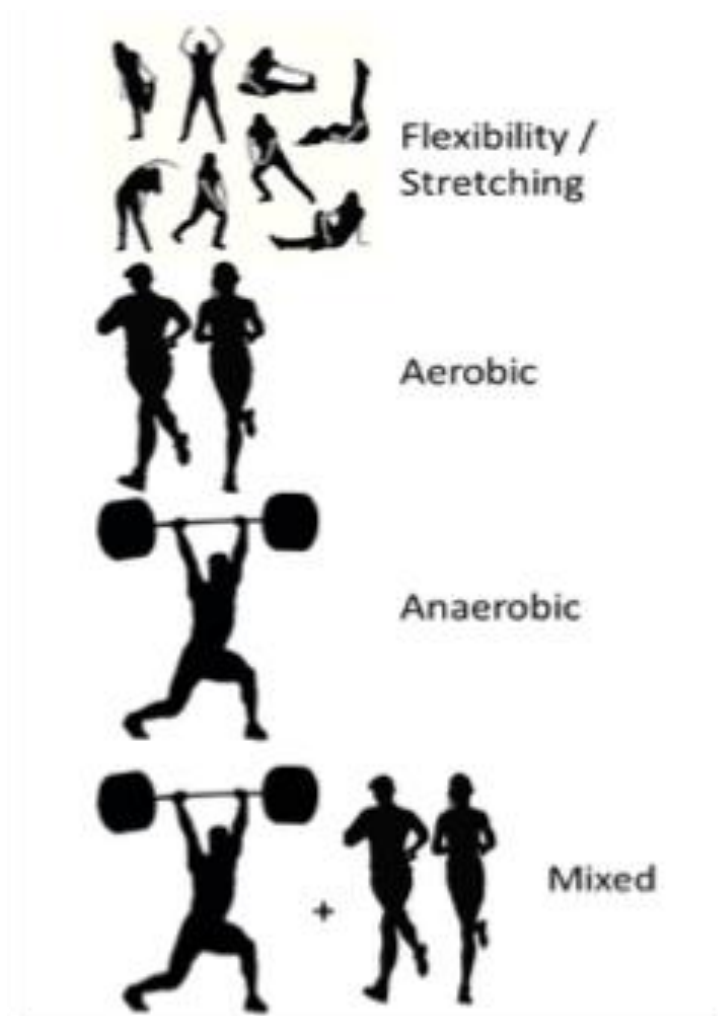
Initial blood glucose change

ABCD Diabetes update meeting 2026

Hypo risk on different treatments

% Hypoglycaemia with exercise
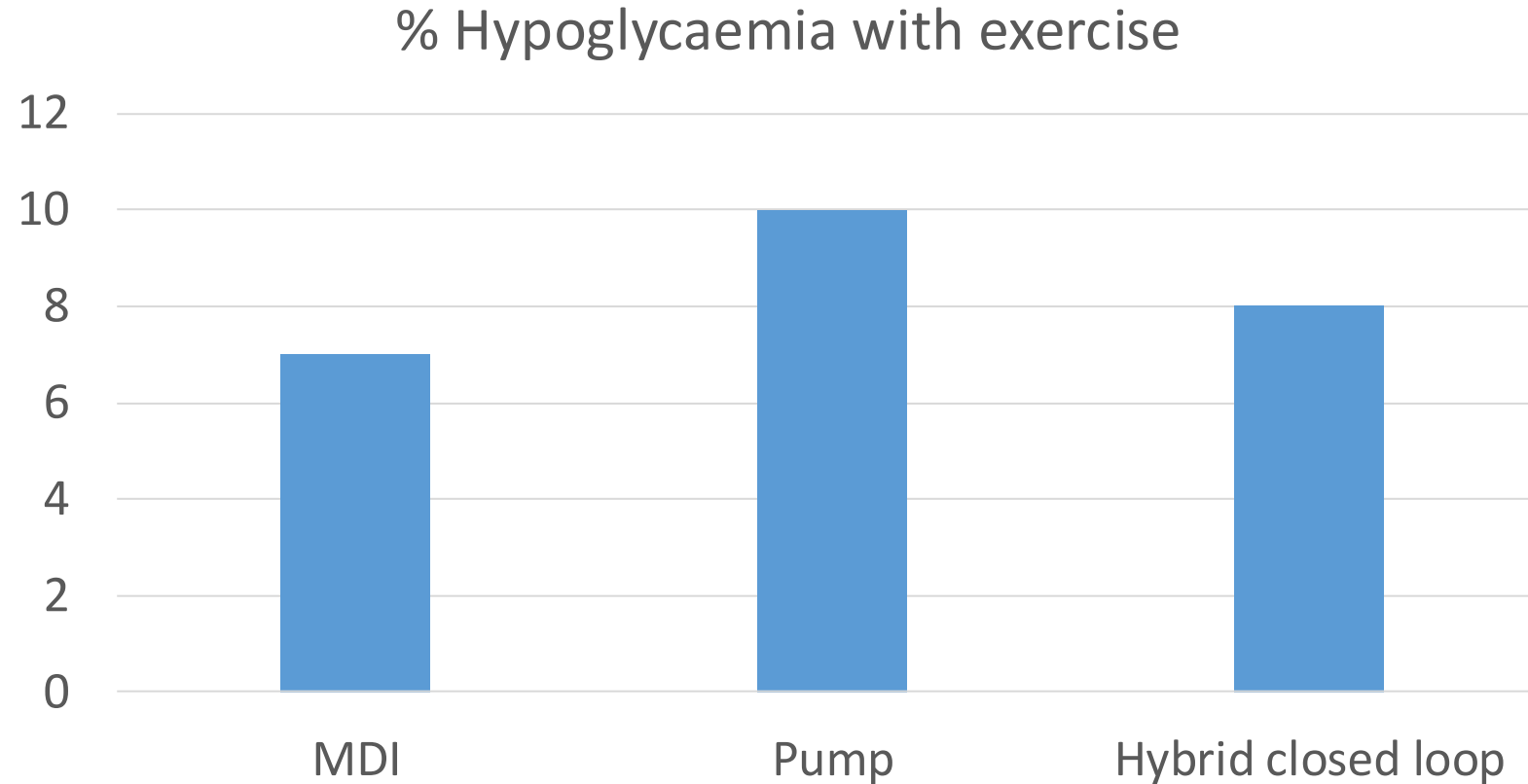
Bergford S et al Diabetes Technol Ther. 2023 Sep;25(9):602-611. doi: 10.1089/dia.2023.0140.

University of Exeter

ABCD Diabetes update meeting 2026

NHS
Somerset
NHS Foundation Trust

After exercise... 'Whip, Double dip

Immediate high BGs

- Over fuelling with carbs

- Ongoing glucogenesis as muscles stop needing fuel

- Pump removal

Then hypos within 2hrs

- Insulin sensitivity

- Blunted glucagon response

And hypos again 6hr or on sleeping

- Insulin sensitivity

-Blunted glucagon response

- Increased muscle and liver uptake of glucose
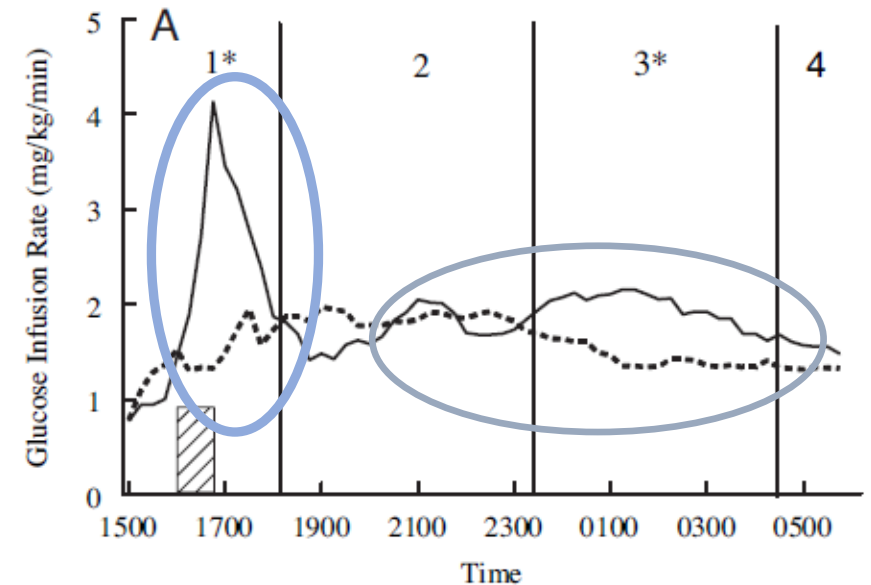
McMahon et al (2007) *JCEM* **92(3)**:963-968

ABCD Diabetes update meeting 2026

Summary

Patients with Type 1 diabetes have two problems

1. Inability to regulate insulin levels automatically
   - So can be too high during exercise resulting in hypos
   - Does not rise if glucose rises before, during or after
   - Is not reduced when becomes more insulin sensitive after exercise so hypos after exercise

2. Reduced hormone response when glucose falls.

But

1. Better fat burners.
2. With Insulin have ability to bulk up and recover quicker.

ABCD Diabetes update meeting 2026

What is the advice to help control glucose during exercise?

Hey Dude when I said "curls might help, that is not what I meant!"

Step 1 – provide with clear glucose targets

ABCD Diabetes update meeting 2026

Blood glucose levels that say "no"

Low blood glucose

- Blood glucose < 3.5 mmol/L

- Severe hypoglycaemia (needed help)
  - Don't exercise for 24 hours

- Self-treated hypoglycaemia
  - Be careful for 24 hours
  - If it occurs before exercise – treat and have stable glucose for 60 minutes before starting
  - If it occurs during exercise – stop, treat, recommence after stable for 45 minutes

High blood glucose

- Blood glucose >15 mmol/L

- Ketone greater than 1.5 mmol/L
  - Take insulin wait until ketones have dropped before exercise

- Ketones less than or equal to 1.5 mmol/L
  - Eaten <2 hours: just monitor
  - Eaten >2 hours: take extra insulin
  - Can do low to moderate intensity exercise

If you cannot measure your blood ketones we suggest you take a 1/3 of your normal correction dose and then wait until your blood glucose is below 15 before exercising and ensure that you do not do anaerobic exercise on that day

University of Exeter

NHS Somerset NHS Foundation Trust

EXTOD guidelines for starting glucose for exercise

Flow diagram detailing basic carbohydrate replacement during exercise for people on multiple daily injections of insulin

KEY
< - Less than
≤ - Equal to or less than
> - Greater than

* If you have had a hypo in the last 24 hours but it was not severe, the risk of hypo will be higher so:
– Take extra precautions
– Do not do lone events on this day
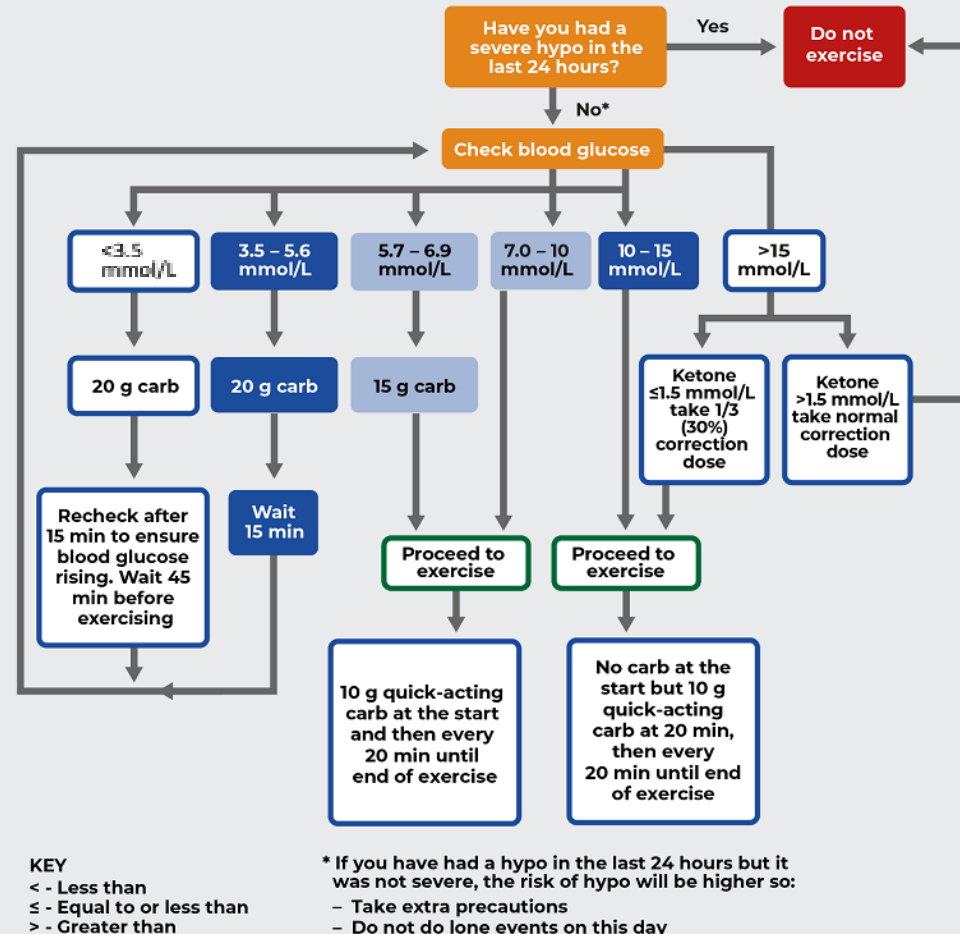
Additional information
Confirm with BG reading if
- Glucose <5.0
- Glucose >15

Libre	Dexcom	Medtronic	Description	% of suggested carbs
		↑↑↑	Rapidly rising	0%
↑		↑↑	Rising	50%
↗		↑	Slowly rising	75%
→			Stable	100%
↘		↓	Slowly falling	125%
↓		↓↓	Falling	150%
		↓↓↓	Rapidly falling	200%

ABCD Diabetes update meeting 2026

Glucose levels in 18 elite football players
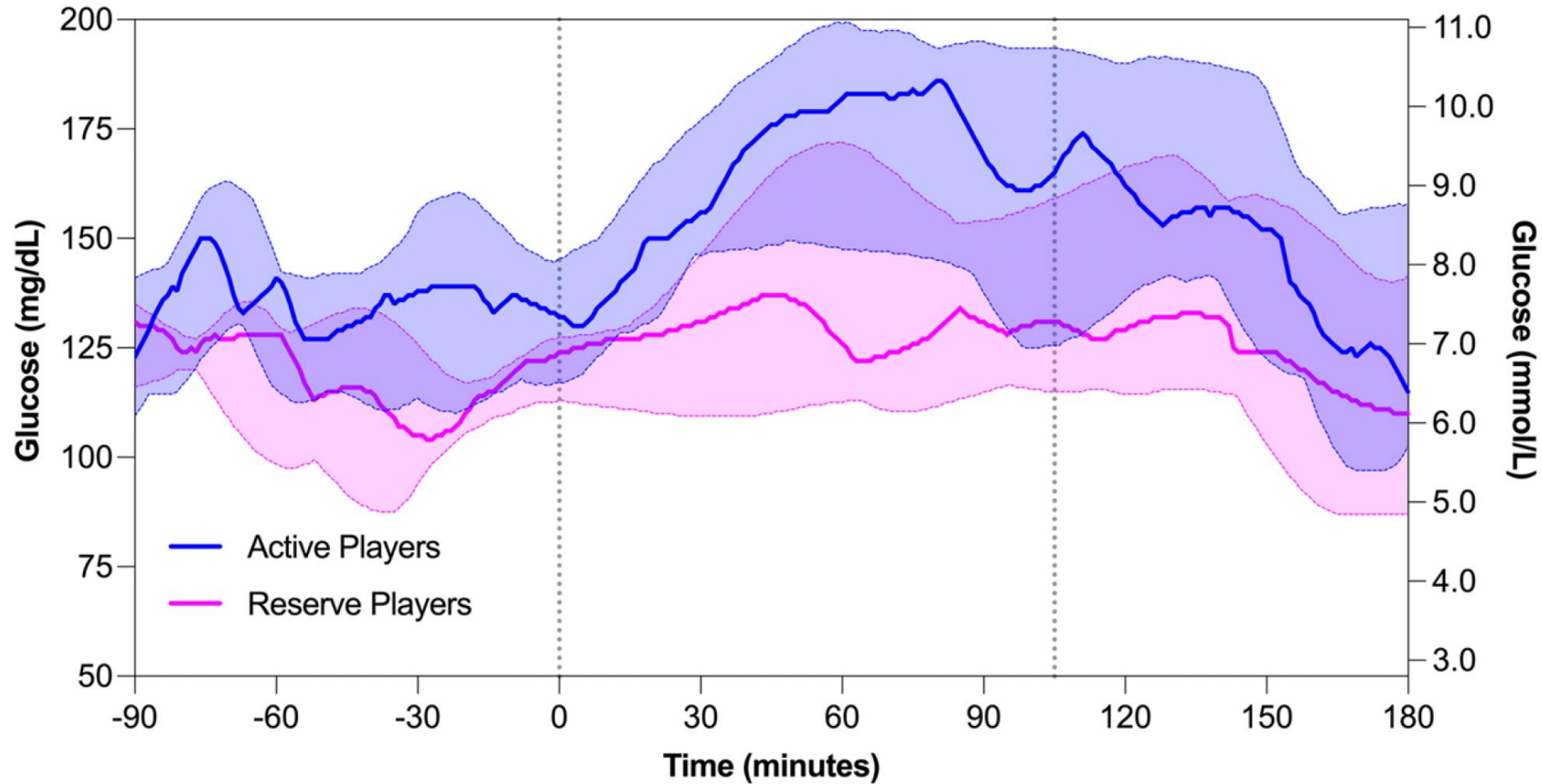
Skroce K et al. Conti. J Diabetes Sci Technol. 2025 Nov 14

ABCD Diabetes update meeting 2026

More complex adjustments

Moser et al (2020)
Diabetologia
63:2501-2520

ABCD Diabetes update meeting 2026

More complex adjustments

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[a]	Ex 0 and/or high hypo risk[b]	Direction	Increase in sensor glucose expected	Decrease in sensor glucose expected
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	
			↘↓	Can start all Ex	~15 g CHO, 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	~15 g CHO, Can start all Ex
			→	~10 g CHO, Can start all Ex	~20 g CHO, Can start all Ex
			↘	~15 g CHO, Delay all Ex[d]	~25 g CHO, Delay all Ex[d]
			↓	20 g CHO, Delay all Ex[d]	~30 g CHO, Delay all Ex[d]

Moser et al (2020)
Diabetologia
63:2501-2520

University of Exeter

NHS Somerset NHS Foundation Trust

GlucoseGo: A simple tool to predict hypoglycaemia during exercise

Fear of hypoglycaemia major barrier to exercise for people with type 1 diabetes

Machine Learning identified 3 key variables for prediction:

1. Starting glucose
2. Duration of exercise
3. Glucose trend arrows

GlucoseGo Heatmap

If rate of change trend arrow:
→ ↗ ↑ ↑↑

If rate of change trend arrow:
↘ ↓ ↓↓

- High (>20%)
- Medium (5-20%)
- Low (1-5%)
- Very Low (<1%)
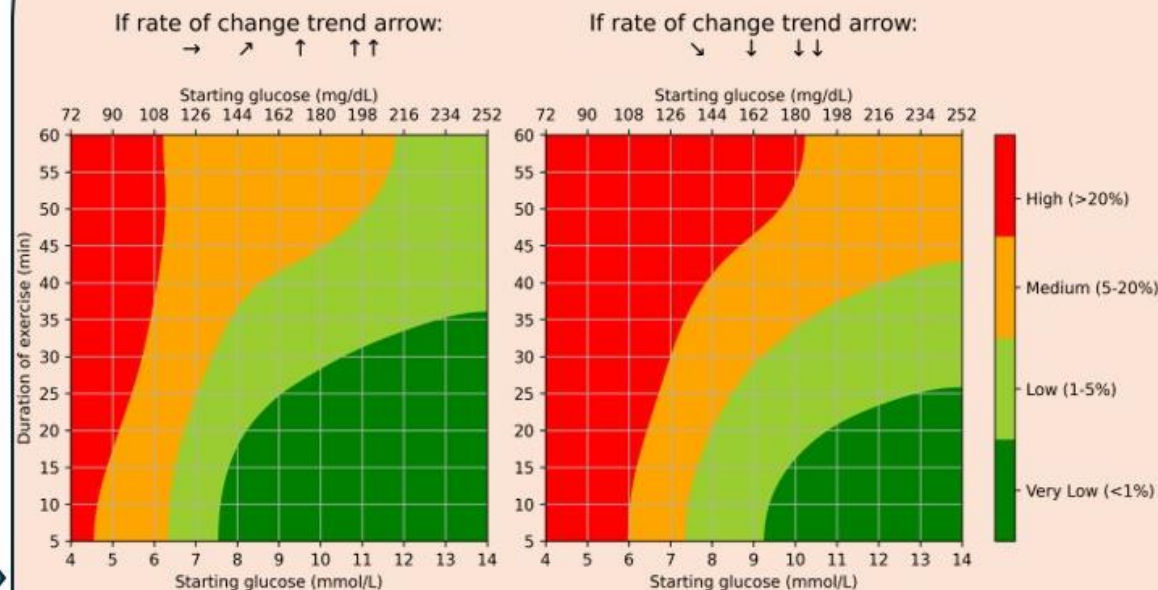
Accurate

Simple, usable tool

C Russon et al
In press with
Diabetologia

University of Exeter

NHS Somerset NHS Foundation Trust

ABCD Diabetes update meeting 2026

Step 2 – explain about lag of CGMs

ABCD Diabetes update meeting 2026

Continuous glucose monitors – effect of exercise

8.1

Large difference

Blood glucose level

6.1
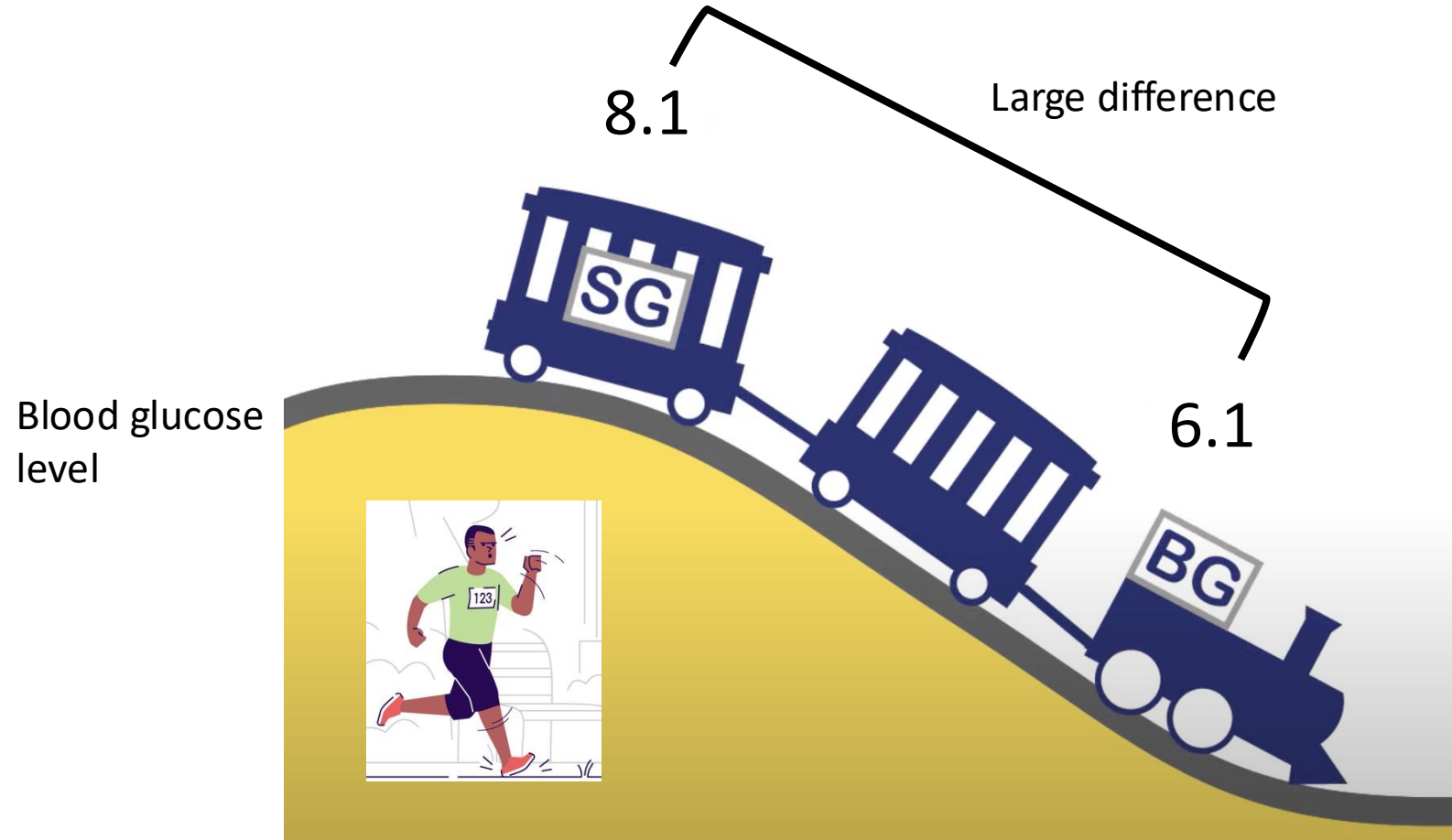
BG = blood glucose

SG = sensor glucose

University of Exeter

NHS Somerset NHS Foundation Trust

CGMs and exercise

Sensors and meters measure glucose in different places
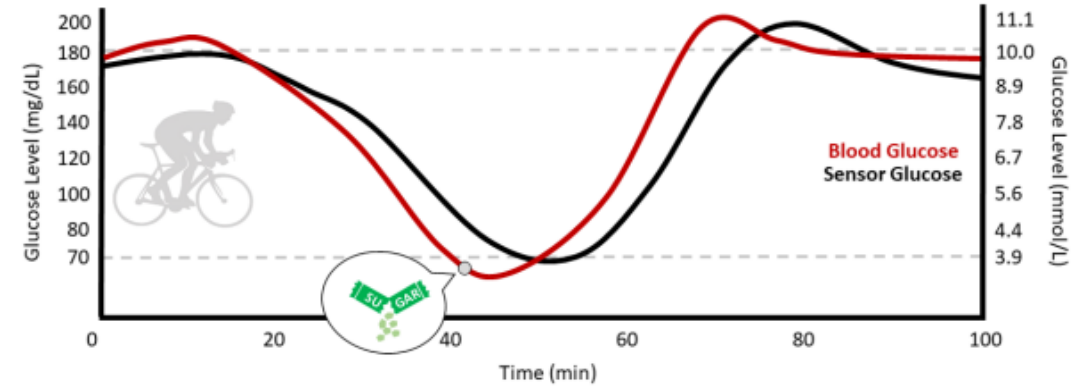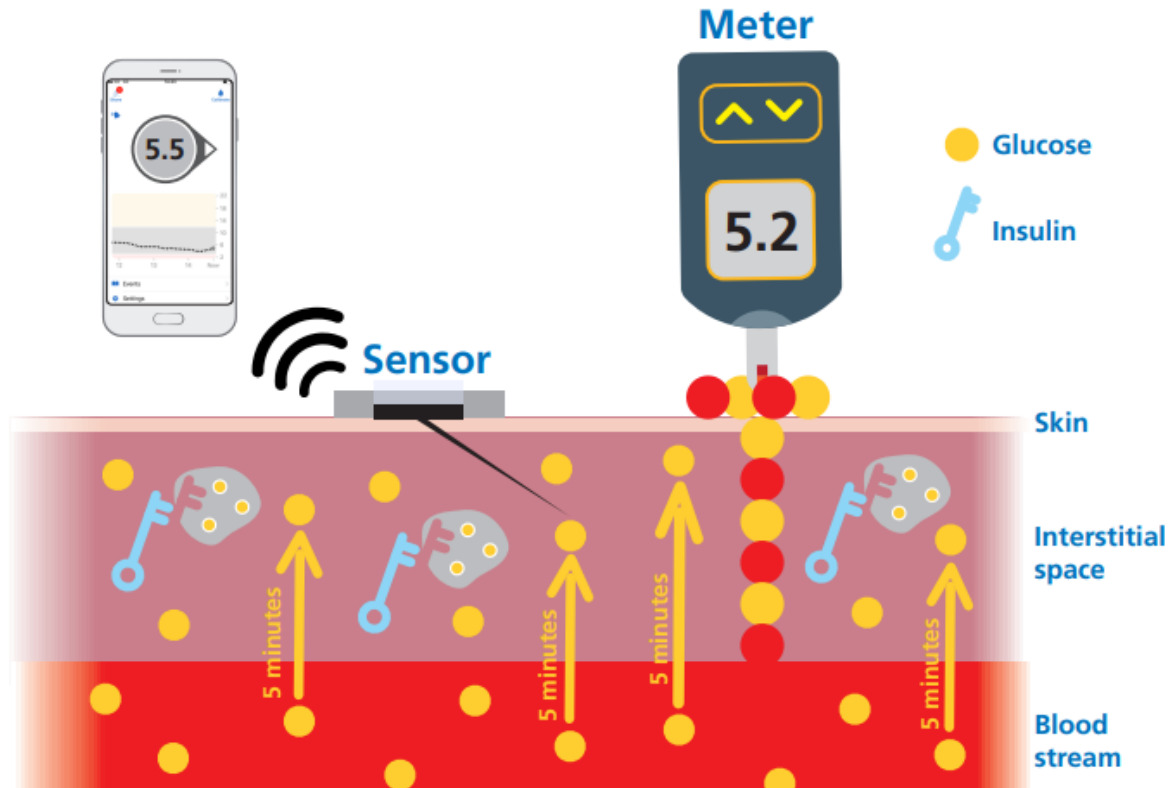
To optimise around exercise: Consider

- Set low glucose alert higher at 5.5mmol/L

- Setting fall alert

- Test blood glucose if falling rapidly and close to hypo

- *EASD/ISPAD – Diabetologia* **63**, 2501−2520 (2020)

ABCD Diabetes update meeting 2026

Step 3 – Exercise at point with lowest insulin concentration

ABCD Diabetes update meeting 2026

Prevailing insulin concentration

A = Lowest chance of glucose falling with exercise
B = Second lowest change of glucose falling with exercise
C =Highest chance of glucose falling with exercise

ABCD Diabetes update meeting 2026
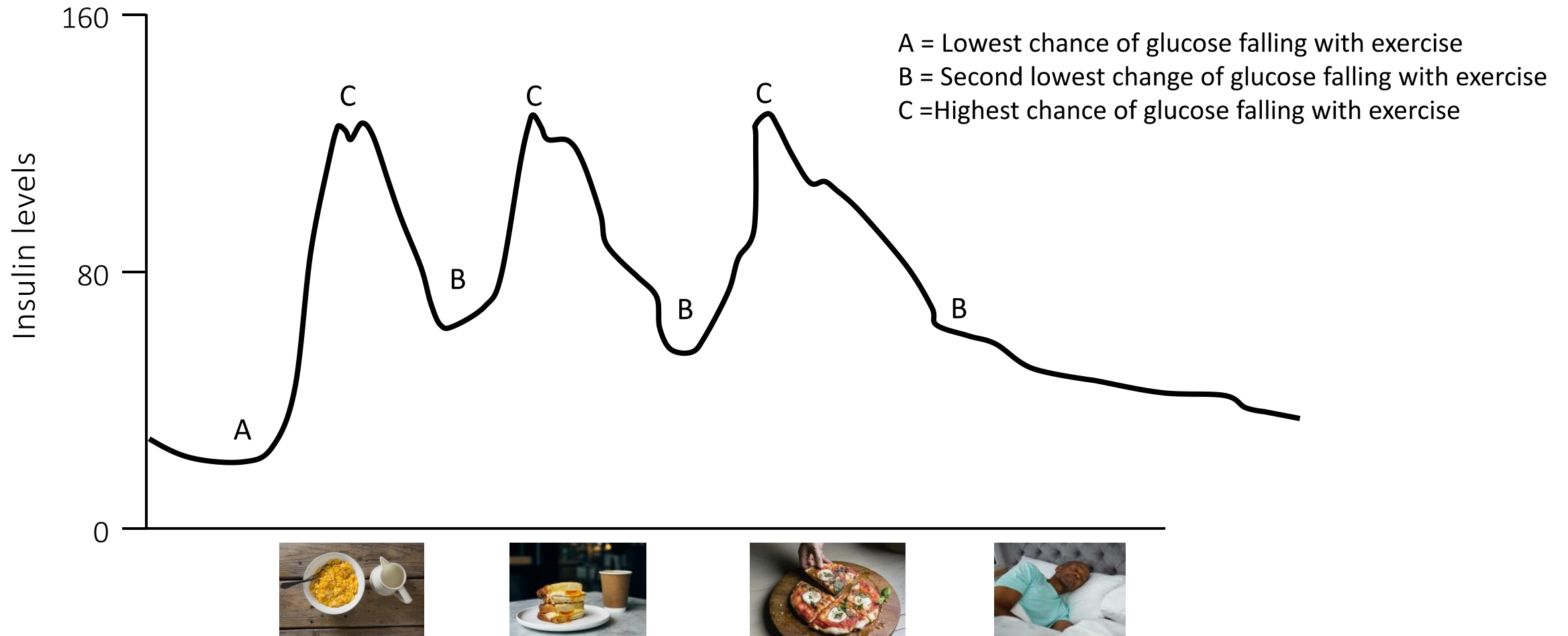
Exercising fasted gives more reproducible glucose changes

Biankin et al., Diabetes Care 2003

Fed

$r^2=0.12, p=0.25$
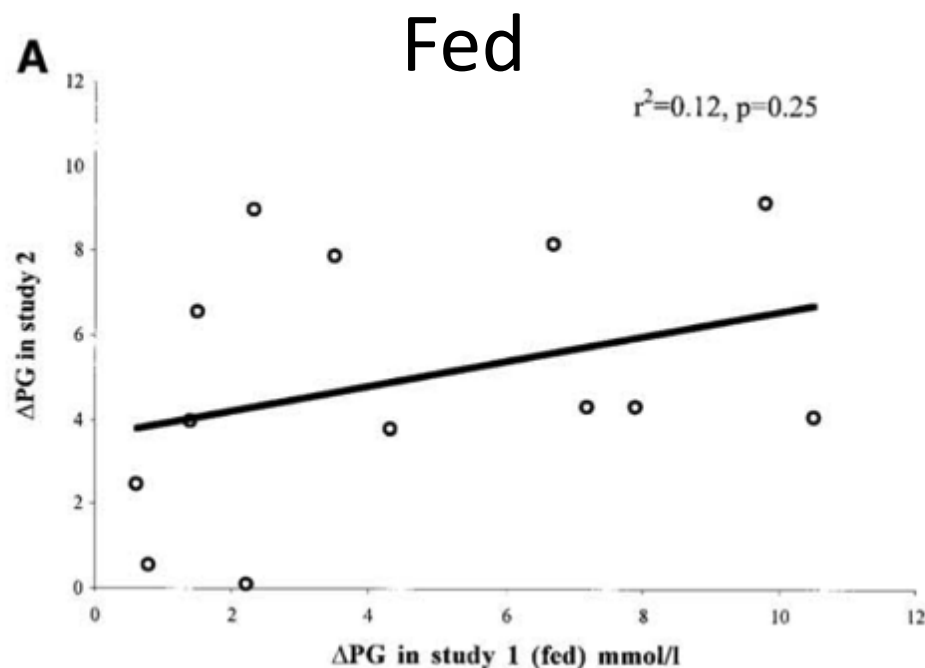
Poor reproducibility in the blood glucose response to aerobic exercise in individuals with T1D in the post meal state

Fasted

$r^2=0.81, p=0.006$
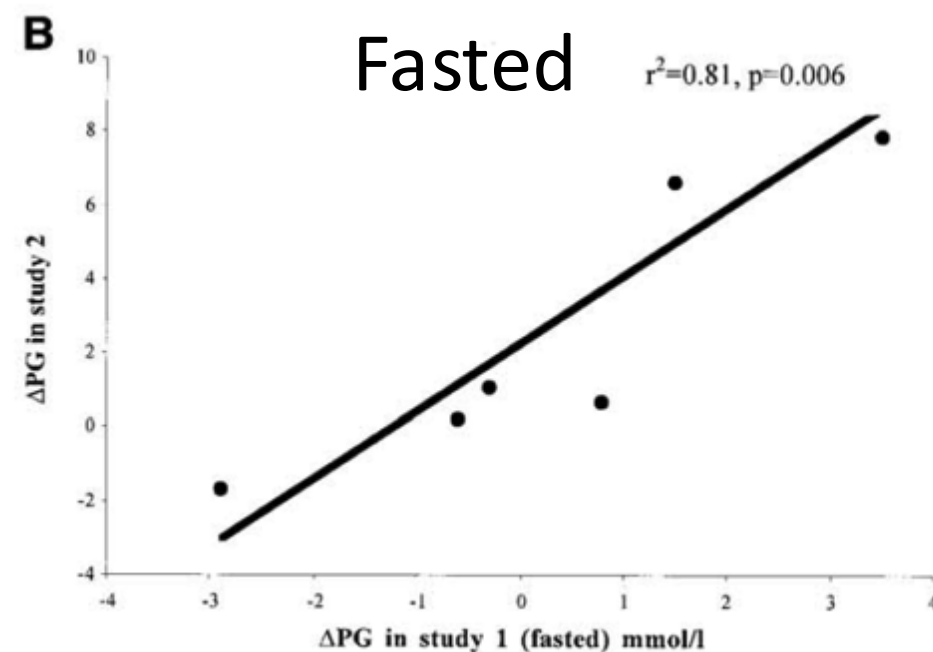
Good reproducibility in the blood glucose response to aerobic exercise in individuals with T1D in the fasted state

ABCD Diabetes update meeting 2026

Exercising in the morning has less risk of hypoglycaemia

Greater risk of hypo if
exercise undertaken
after 4pm

Insulin resistance

Wakefulness
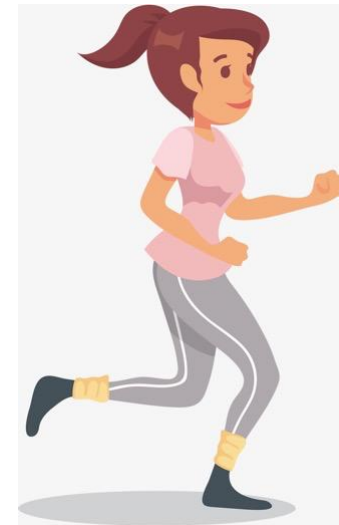
ABCD Diabetes update meeting 2026

Step 4 – three options

Three ways to manage glucose during exercise - ICE

Insulin

Carbohydrate

Exercise

ABCD Diabetes update meeting 2026

Step 4a – changing insulin level – best if trying to lose weight
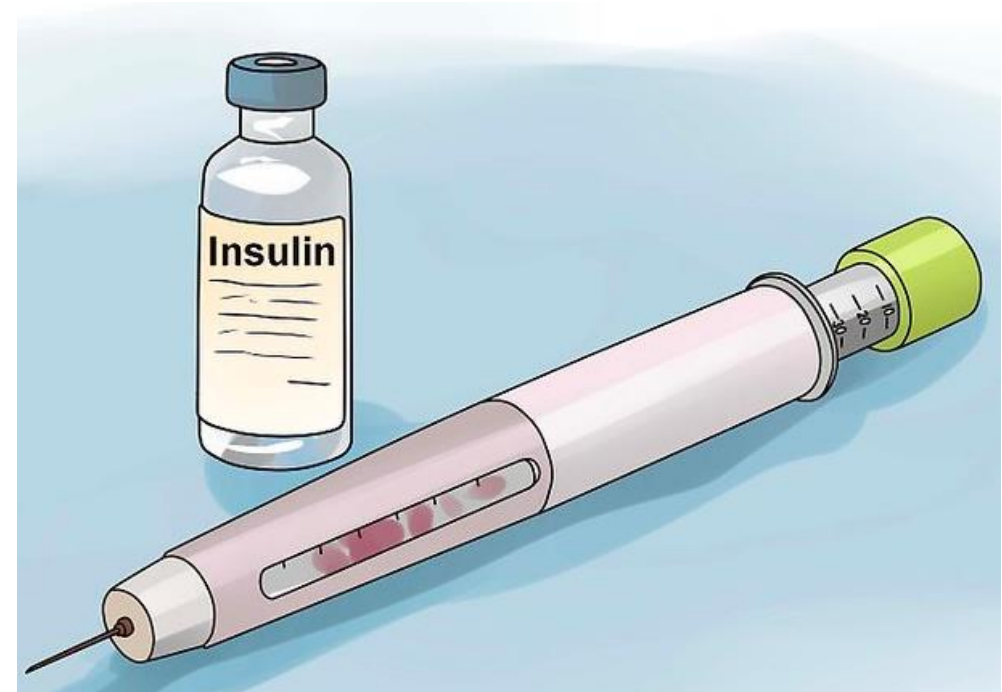
Simple strategy if exercising within 2 hrs of meal
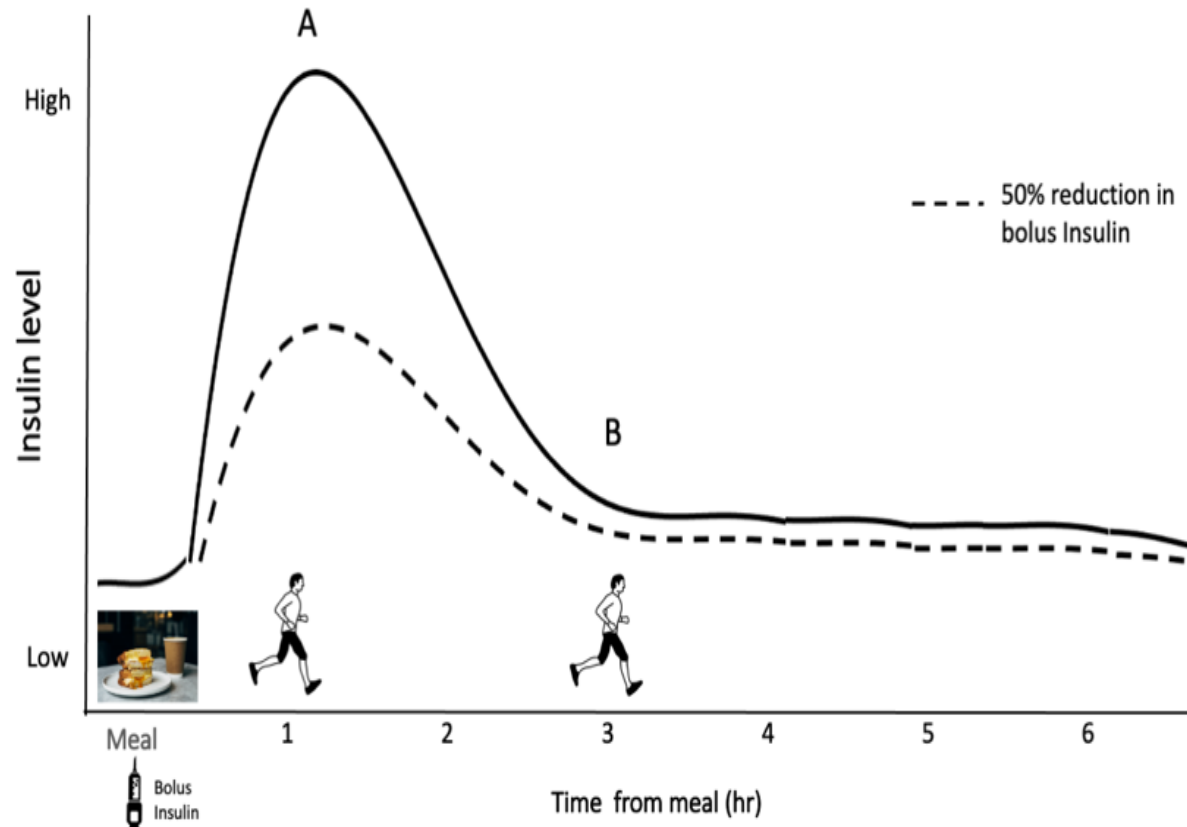
If exercising within 2 hours of quick acting (bolus) insulin

MDI
Reduce pre-exercise quick acting (bolus) insulin by 50%
No change to background unless exercising longer than 90 minutes

Pumps
Reduce pre-exercise quick acting (bolus) insulin by 50%
No change to background unless exercising longer than 90 minutes

Closed loop systems
1. Exercise(or other) target 90 minutes before.
2. If did not work then add reduction of 30% bolus.

ABCD Diabetes update meeting 2026

Simple strategy if exercising >2hs after meal
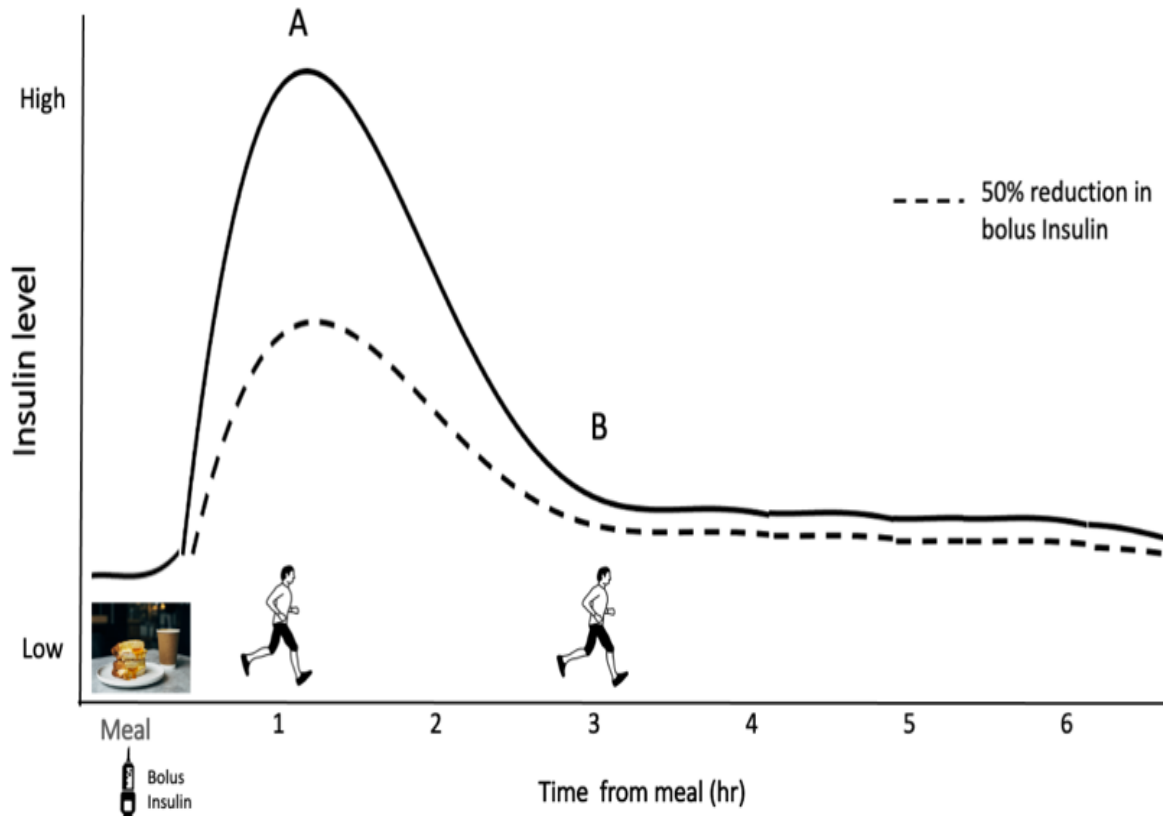
If exercising greater than 2 hours after meal

MDI
No change bolus- only change background if very prolonged exercise.

Pumps
No change bolus- 50% reduction background from 90 minutes before exercise until the end.

Closed loop systems
No change bolus – exercise (or other) target 90 minutes before exercise until the end

Step 4b – carbohydrate – good for spontaneous exercise

ABCD Diabetes update meeting 2026

Simple carbohydrate replacement

—— Large snack before exercise

······ Small snacks regularly
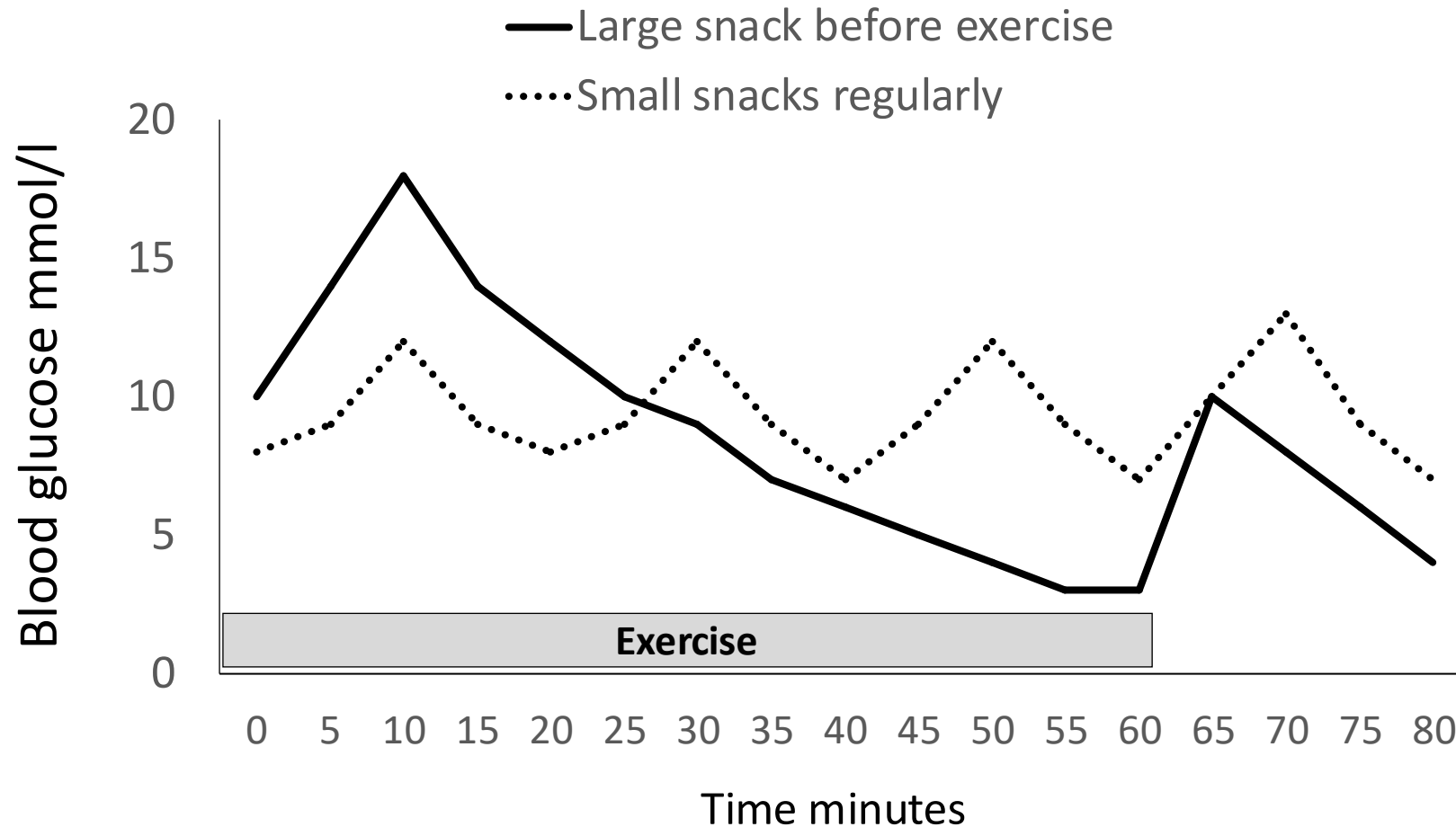
MDI/ Pump
Start with 0.5
grams/ kg / hr

Closed loop
Start with 0.25
grams/ kg / hr

Take carbs every 20
mins or every 10 if
on Hybrid close loop

Blood glucose mmol/l — Exercise — Time minutes

University of Exeter

NHS Somerset NHS Foundation Trust

Carb replacement based on CGM readings

Based on guidelines John Pemberton has made a PDF that people can work out how much carbohydrate to take dependent on flash or continuous glucose readings

Carb replacement based on CGM readings

What looks like if on pump or MDI and Libre

Sensor Gucose Level	Trend arrow & action to take		Carbohydrate grams needed for 20 mins		Dextrose (3g) ▼	Glucotab (4g) ▼
<4.0mmol/L Check BG	<3.0mmol/L: NO exercise		18	Treat & re-check in 20 minutes	6	5
4.0-4.9 mmol/L	↓		30	& delay exercise for 20 minutes	10	8
	↘		24	& delay exercise for 20 minutes	8	6
	→		18	& delay exercise for 20 minutes	6	5
	↗		12	& delay exercise for 20 minutes	4	3
	↑		6	& delay exercise for 20 minutes	2	2
5.0-6.9 mmol/L	↓		30	& start exercise check in 20 mins	10	8
	↘		24	& start exercise check in 20 mins	8	6
	→		18	& start exercise check in 20 mins	6	5
	↗ ↑		12	& start exercise check in 20 mins	4	3
7.0-10.0 mmol/L	↘ ↓		18	& start exercise check in 20 mins	6	5
	→		0	& start exercise check in 20 mins		
	↗ ↑		0	& start exercise check in 20 mins		
10.1-14.9 mmol/L	All Arrows		0	& start exercise check in 20 mins		
≥15.0mmol/L (Check BG) & ketones <1.5mmol/L	→ ↘ ↓		OK to exercise: No carbohydrate for 20 minutes			
	↗ ↑		OK to exercise: Consider 50% of correction dose before starting			
≥15.0mmol/L & ketones ≥1.5mmol/L	All Arrows		No exercise: Correction dose & ketones <1.5mmol/L before starting exercise			

Rob Andrews — running

University of Exeter

NHS Somerset NHS Foundation Trust

Step 4c – using exercise – the eye opener

Changing the order of exercise

Left panel — Aerobic then Anaerobic: Blood glucose (mmol/L) on y-axis (2 to 14), Time on x-axis (5 to 30). Aerobic exercise (cycling/running) first causes blood glucose to fall to ~3 mmol/L around time 18, then Anaerobic exercise (weightlifting) raises it back up toward time 30.

Right panel — Aerobic then Anaerobic (reversed order): Blood glucose (mmol/L) on y-axis (2 to 14), Time on x-axis (5 to 30). Anaerobic exercise (weightlifting) first raises blood glucose from ~6 to ~9 mmol/L around time 18, then Aerobic exercise (cycling/running) lowers it toward time 30.

ABCD Diabetes update meeting 2026

University of Exeter

NHS Somerset NHS Foundation Trust

Sprints can help to control glucose during exercise
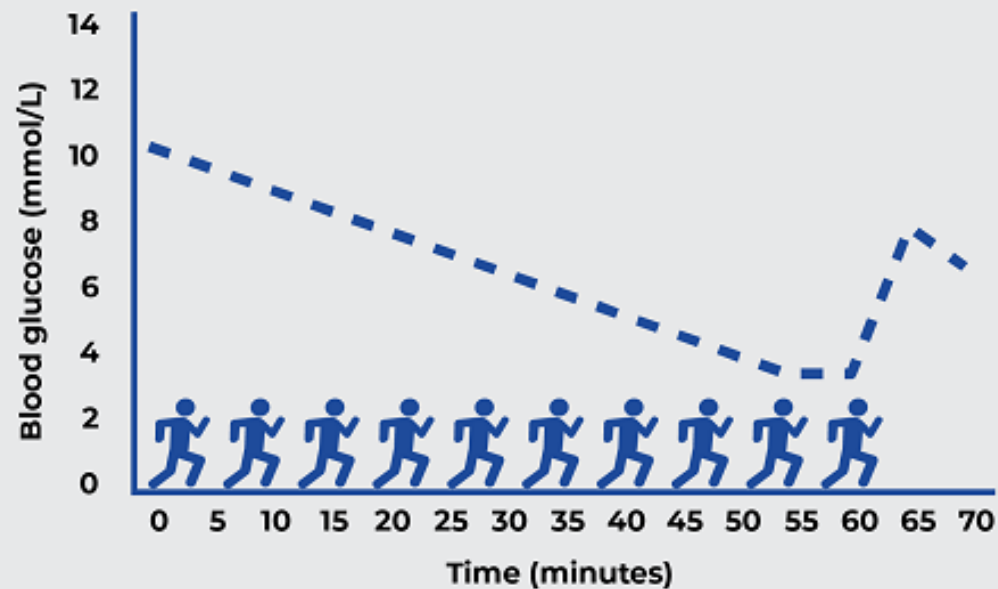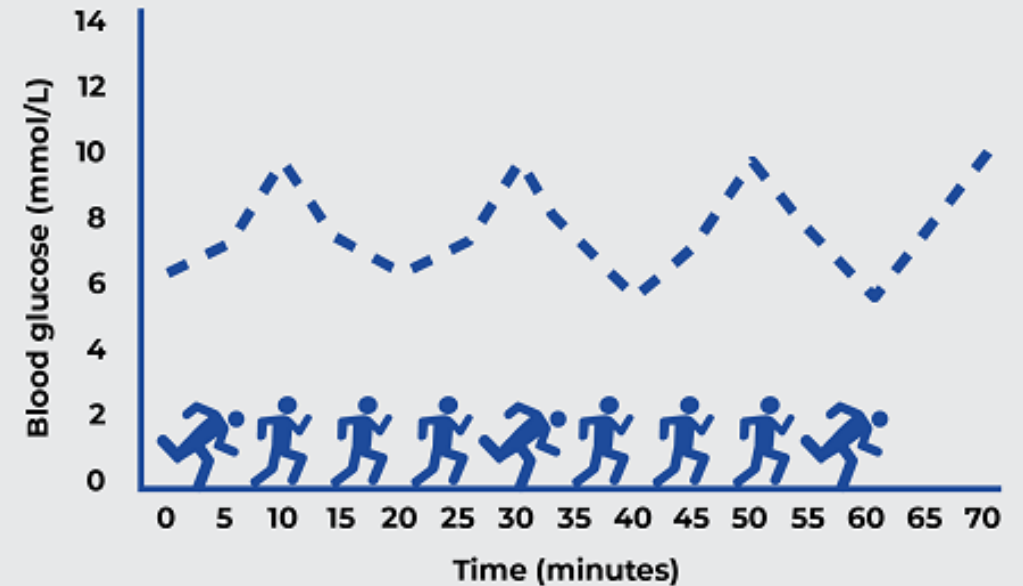
Three ways to manage glucose post exercise ICE

Insulin

Carbohydrate

Exercise

University of Exeter

NHS Somerset NHS Foundation Trust
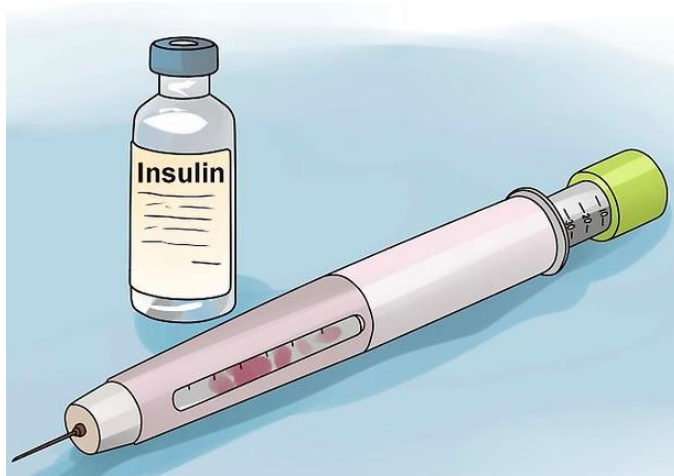
Option 1 – Insulin changes
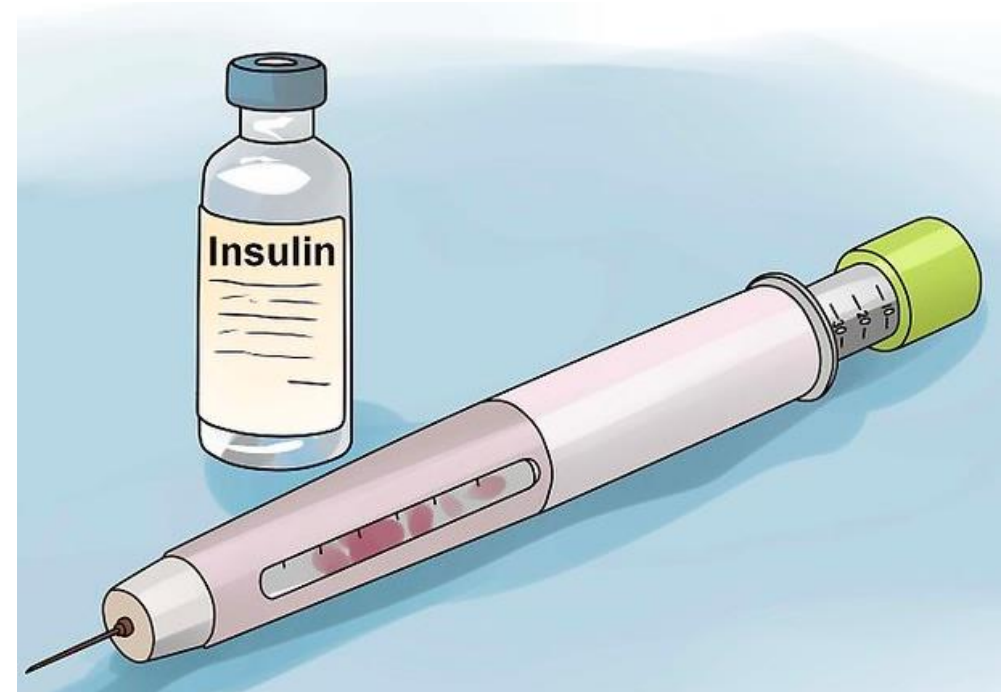
Effect of exercise on Insulin sensitivity
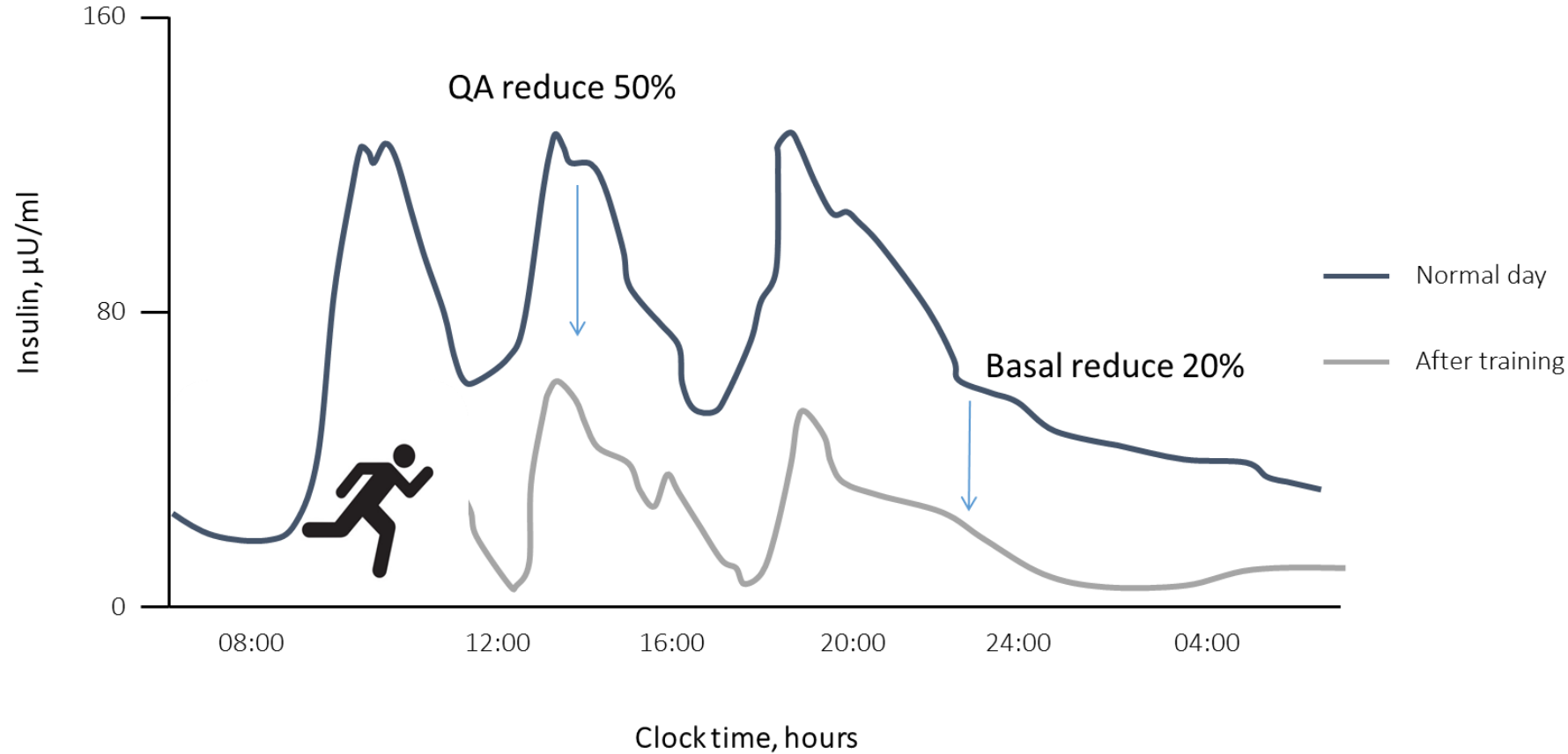
The 50-50-20 rule

- 50% reduction of normal bolus for next 2 meals

- 50% reduction of normal correction for the next 12 hours

- 20% reduction of normal evening background if:
  - after 4pm
  - over 2 hours of exercise
  - HIT at any time of the day

  - MDI - only applies to glargine / determir / intermediate acting insulin
  - Pump - 20% reduction background for 6 hours from when gone to bed

ABCD Diabetes update meeting 2026

Hybrid close loops - after exercise

- 25% less bolus for first meal

- Keep at exercise target for first few hours if prolonged exercise

- Return to normal set points overnight

When to change bolus after exercise

Did you do more than 120 minutes moderate intensity exercise or more than 60 minutes of high intensity exercise?

No → No need to change bolus insulin after exercise

Yes → Reduce bolus insulin by 25% for the first meal after exercise

Option 2– carbohydrate

ABCD Diabetes update meeting 2026

Recovery food

Did you do more than 60 minutes moderate intensity exercise or more than 30 high intensity exercise?

No → No recovery food needed

Yes → Have food with carbohydrate and protein in Ratio 4:1. For example

Ham sandwich

Milkshake

Cereal and milk

University of Exeter

NHS Somerset NHS Foundation Trust

Option 3 - exercise

Using exercise to manage glucose post exercise

Glucose >10 →

warm down
10 minutes warm
Down lowers by 1-2 mmol
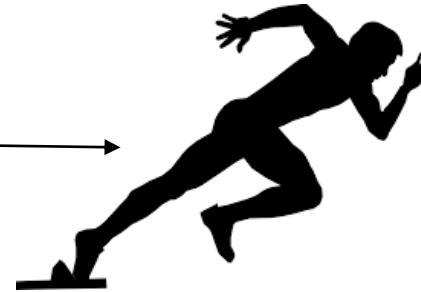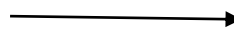
Glucose <4 →

10 sec sprint
Raises by 2-4 mmol
Protects from hypo for
30-40 minutes

University of Exeter

NHS Somerset NHS Foundation Trust

Summary 7- options for managing glucose after exercise

Insulin - how do you alter it

MDI and Pump
- 50% of normal quick acting with meal prior to exercise if exercising within 2 hours of meal

- 50% of normal quick acting insulin for first 2 meals/snacks after

- 20% reduction night time background insulin or 20% reduction background for 6 hours when go to bed , If exercise after 4 pm or longer than 2 hours

Closed Loop
- 25% less bolus for first meal

- Keep at exercise target for first few hours if prolonged exercise

- Return to normal set points overnight

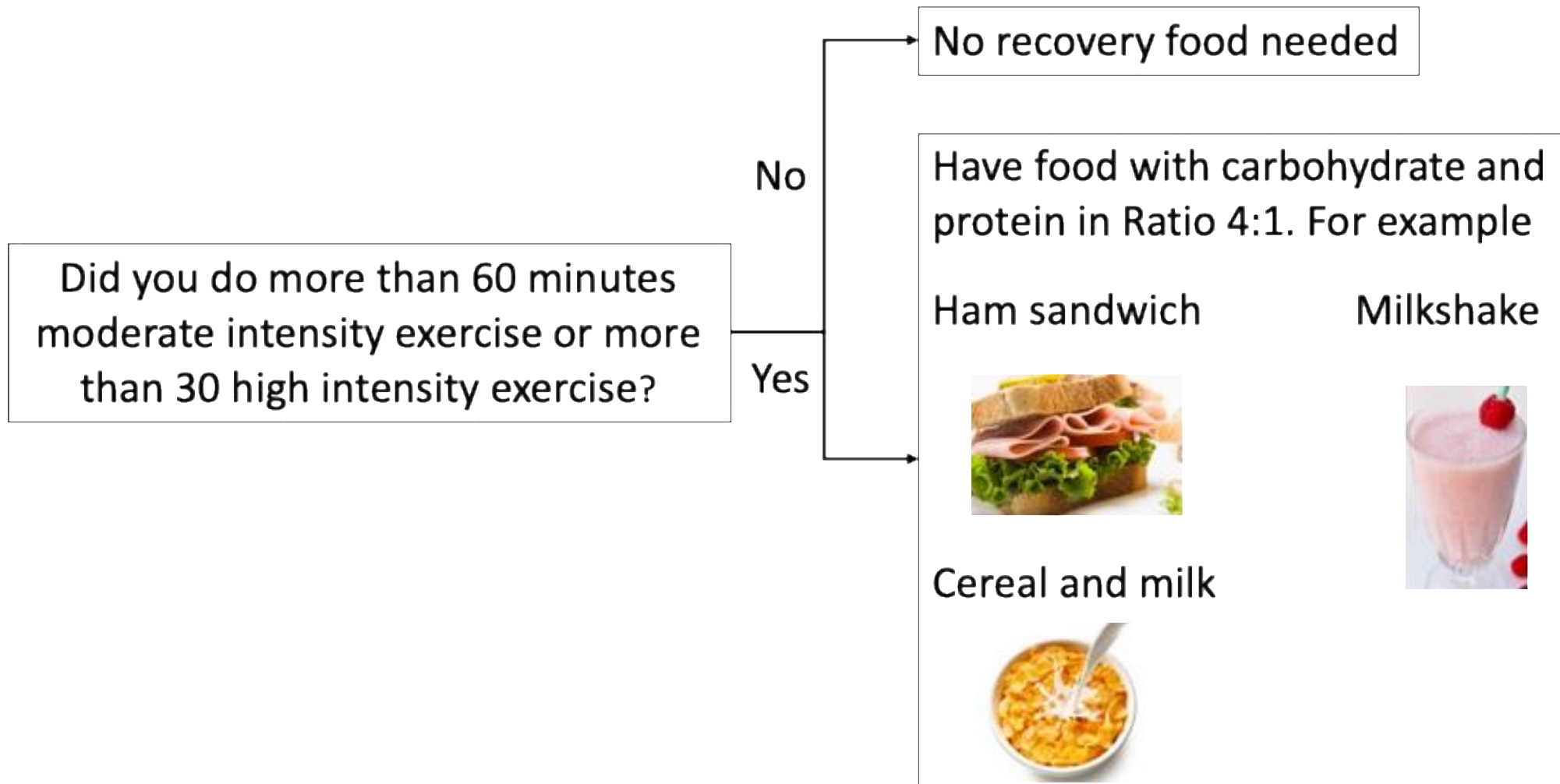## Carbohydrate for exercise

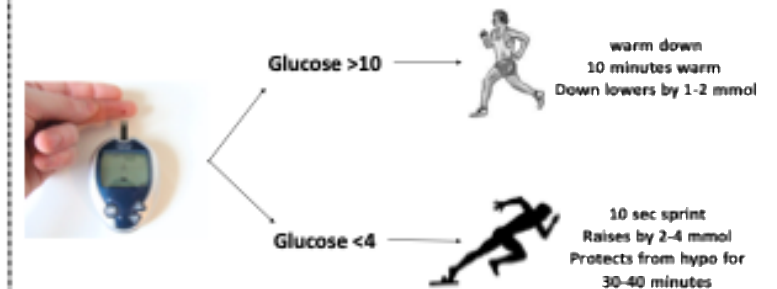|	
Recovery	1 -1.2g/kg during the first hour
Before bed	Slow release carbohydrate

Exercise type and intensity

Glucose >10 → warm down 10 minutes warm Down lowers by 1-2 mmol

Glucose <4 → 10 sec sprint Raises by 2-4 mmol Protects from hypo for 30-40 minutes

ABCD Diabetes update meeting 2026

University of Exeter

NHS Somerset NHS Foundation Trust

Further information HCPs

Websites	Face to face training

EXTOD website
www.extod.org

Other sites
https:// Runsweet.com
https://theglucoseneverlies.com
https://www.digibete.org

National 2-day conference
Birmingham 17^h and 18th
November 2026

1-day conference
Cheltenham
15th May 2026

ABCD Diabetes update meeting 2026

Type 1 diabetes sports clinics

ABCD Diabetes update meeting 2026

Email:- R.C.Andrews@Exeter.ac.uk

ABCD Diabetes update meeting 2026