

Technology and Exercise

Anne Marie Frohock RD, Specialist Paediatric Diabetes Dietitian, Oxford, UK

John Pemberton RD, Specialist Paediatric Diabetes Dietitian, Birmingham, UK

Rob Andrews, Associate Professor of Diabetes/Honorary Consultant in Diabetes, Exeter, UK

Disclosures

Anne-Marie Frohock

Speaker Fees:

- Dexcom
- EXTOD
- NNF

John Pemberton

Speaker Fees:

- Dexcom
- Insulet
- EXTOD

Advisory Board:

- ROCHE
- Abbott

Rob Andrews

Speaker Fees:

ABCD
Novonordisk
Lilly
Astra zenica

Three Things to Take Home

- Using glucose values and trend arrows to determine carbohydrates for exercise
- 50/50/20 for MDI and Pump Therapy
- T25/T25 for Hybrid Closed-Loop Therapy



Challenge of exercise in T1D



Fear of **hypoglycaemia**

Keeping BG in control



Unsure what to do with diabetes and no-one to give advice to me.

Planning prevents spontaneous fun!



Lack of time, accessing facilities, lack of motivation, body image issues



Peer pressure



Should exercise ever be delayed?

Hypoglycaemia

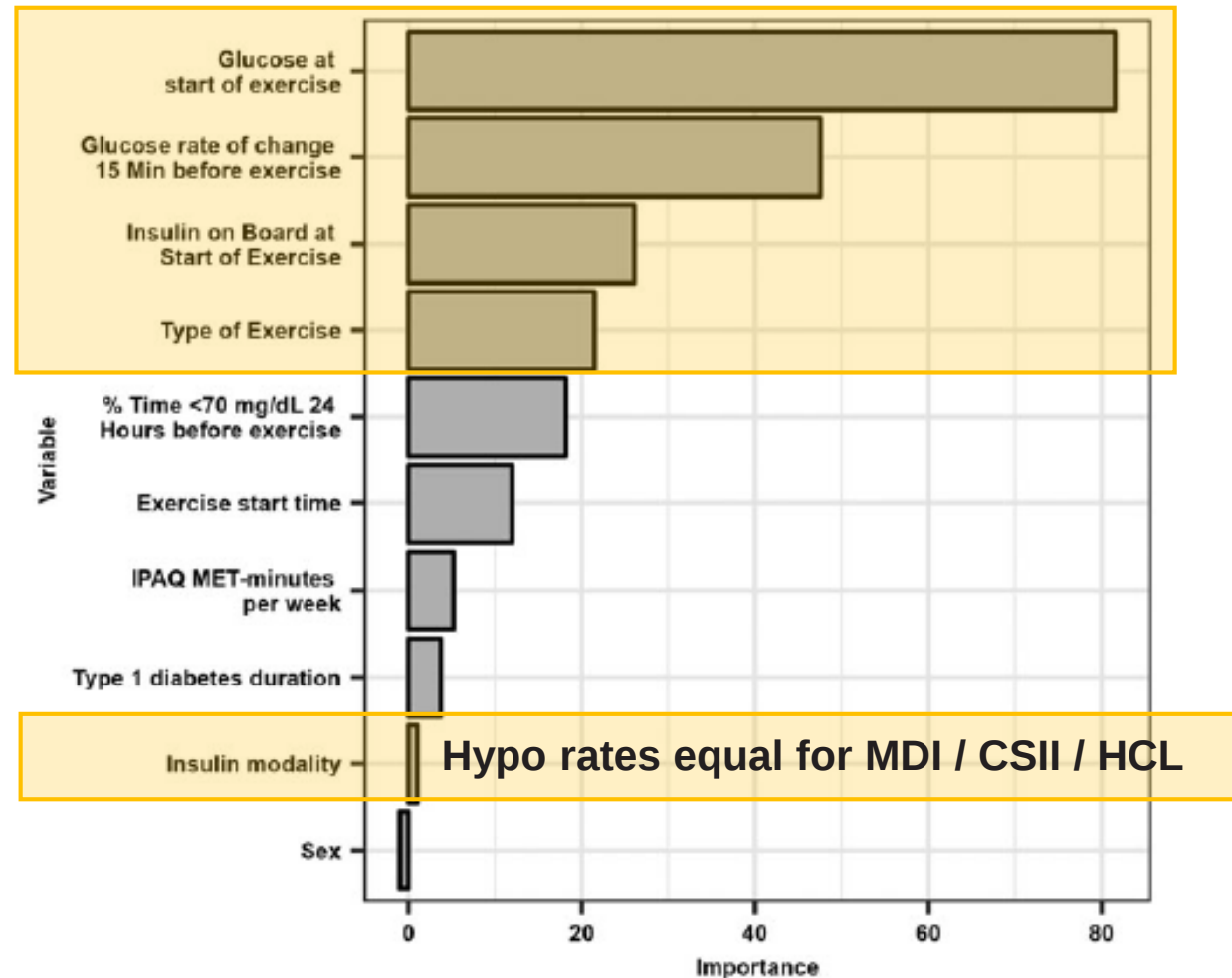
- Severe hypo in past 24 hours **do not exercise**
- For self-treated hypos: caution for 24 hours due to depleted glycogen stores in the liver; no lone events; if hypo is just before exercise aim for stable glucose for 60 mins before commencing
- If hypo during – stop, treat, wait 45 mins before recommencing

Ketones

- Ketones >1.5 mmol/L: follow usual ketone advice and **avoid exercise**
- Ketones 1.1–1.4 mmol/L: Give ½ correction dose by pen, HCL to manual mode, wait 60 min to reassess
- Ketones 0.6–1.0 mmol/L: Give ½ correction dose by pen, HCL to manual mode, wait 15 min to exercise

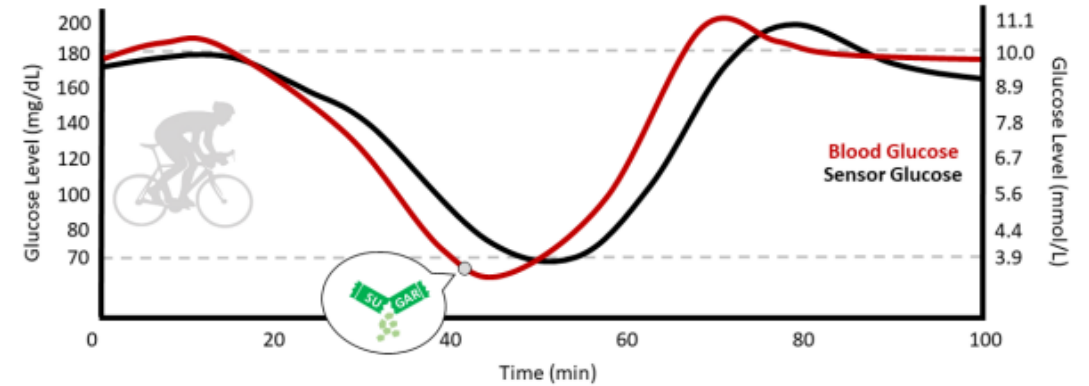
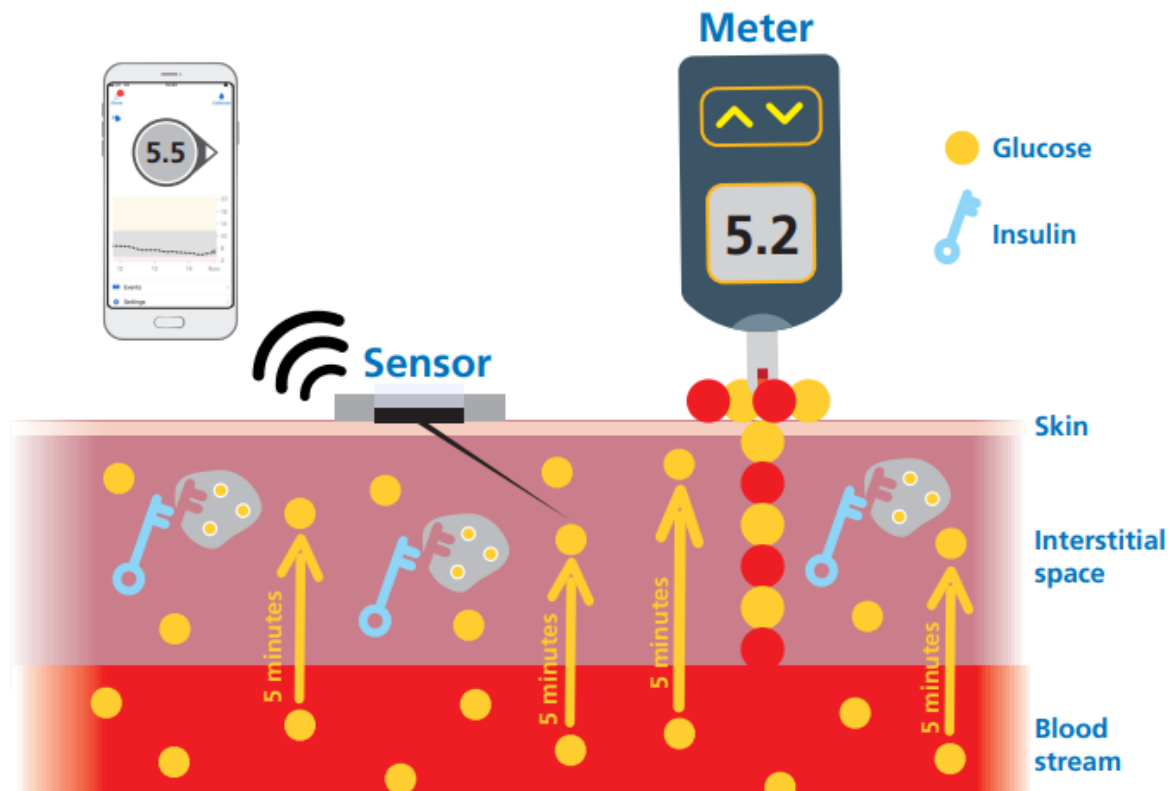
**Write down the top four risk factors
for hypos during exercise**

Risk factors for hypoglycemia during exercise



CGM and lag time

Sensors and meters measure glucose in different places



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)

Trend arrows

Where will these two glucose values be in 5-10mins



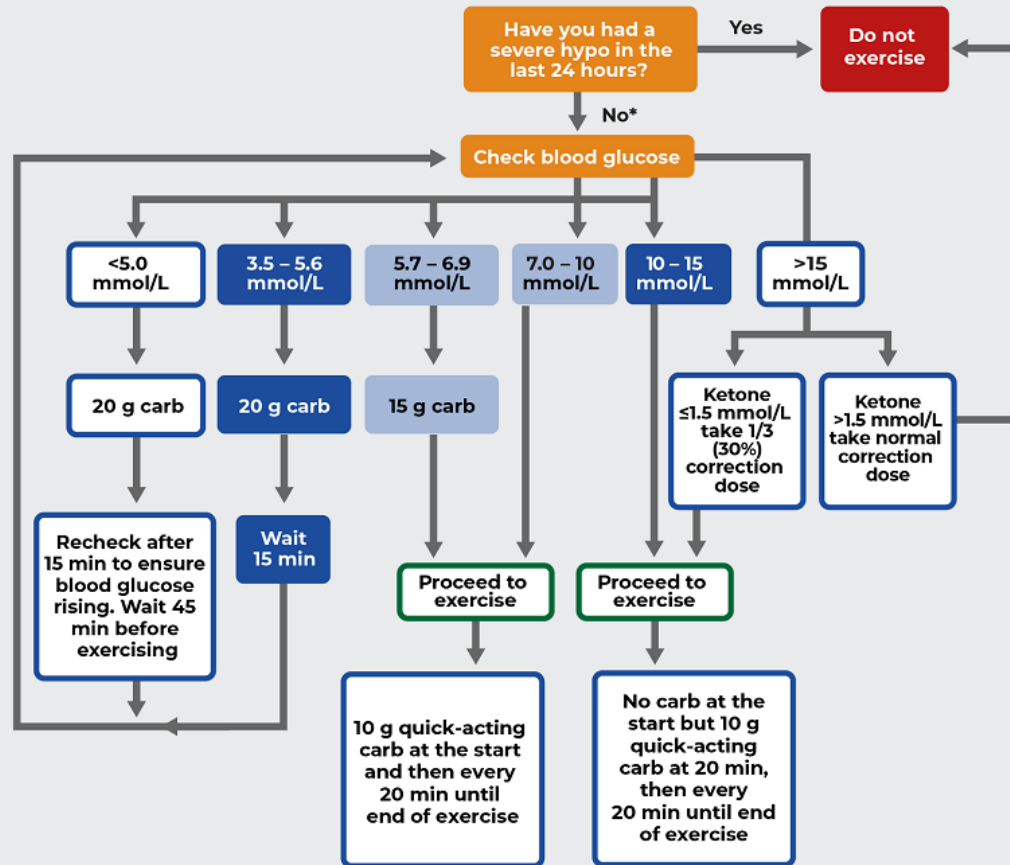
.....



Libre	Dexcom	Medtronic	Description	Where the glucose will be in 10 minutes
		↑ ↑ ↑	Rapidly rising	more than 2.0mmol/l higher
↑		↑ ↑	Rising	1.5mmol/l higher
↗		↑	Slowly rising	1mmol/l higher
→			Stable	Same
↘		↓	Slowly falling	1 mmol/l lower
↓		↓ ↓	Falling	1.5 mmol/l lower
		↓ ↓ ↓	Rapidly falling	more than 2.0mmol/l lower

EXTOD staring guide for before and every 20 minutes

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

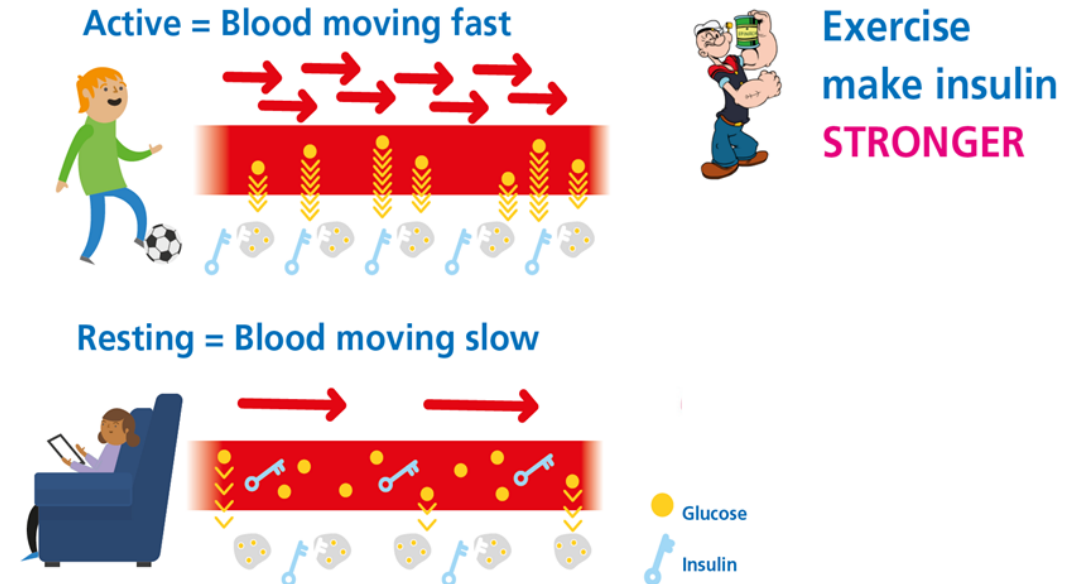
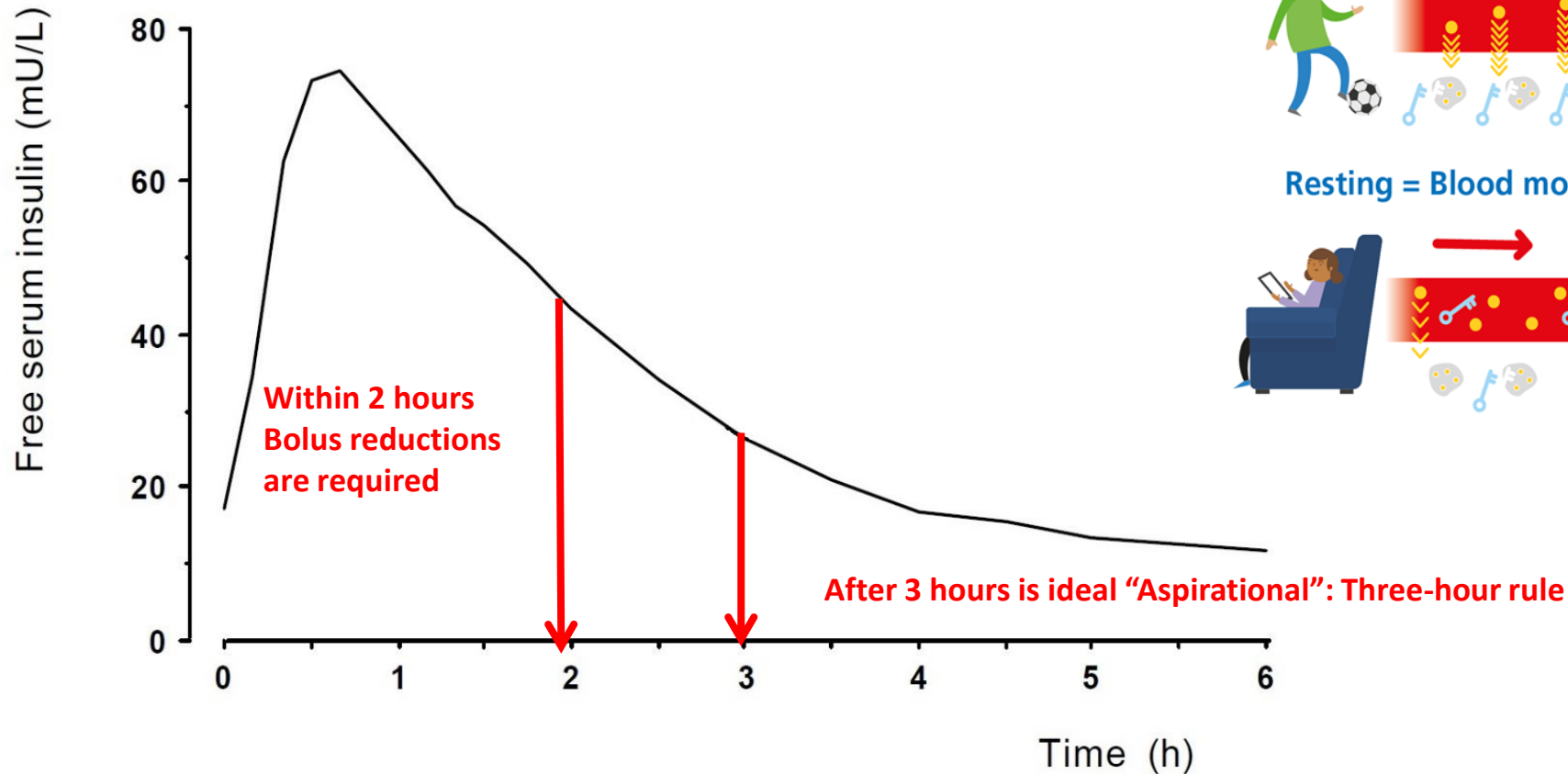
- Glucose <5.0
- Glucose >15

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%

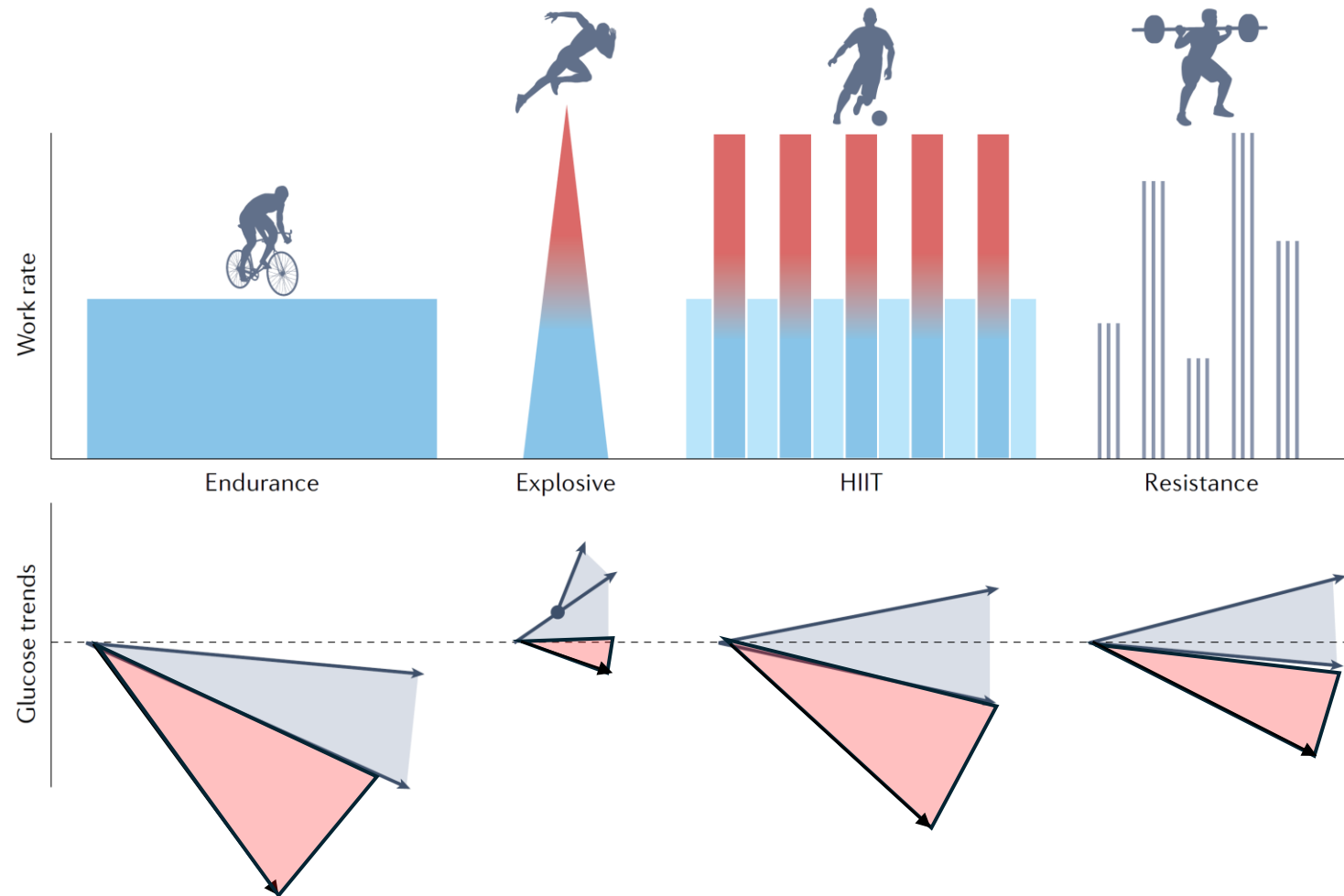
How many carbs

- 50kg lady playing netball for 1 hour on Dexcom
 - Glucose level 8.0 double arrows down at start
 - Glucose level 8.0 arrow up at 30 minutes
- 90kg man playing rugby for 80 minutes on Libre
 - 5.5 with one arrow down at the start
 - 6.2 with steady arrow at half time (40 minutes)

Insulin on board



Type of exercise



Exercise when meal
insulin was delivered
within 2-3 hrs
(Not on the original graphic,
added by J Pemberton
October 2023)

After exercise... 'Whip, Double dip'

Immediate high BGs

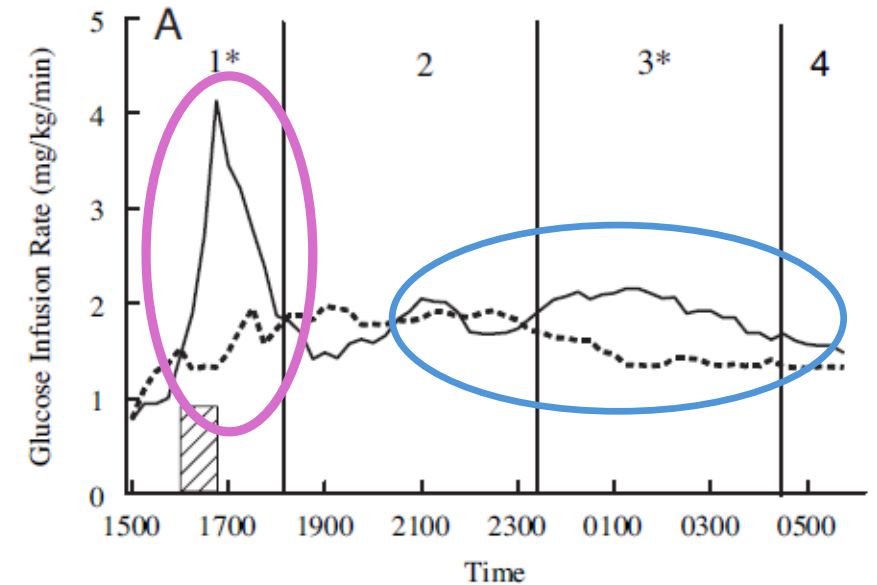
- Over fuelling with carbs
- Ongoing gluconeogenesis as muscles stop needing fuel
- Pump removal

Then **hypos** within 2hrs

- Insulin sensitivity
- Blunted glucagon response

And **hypos** again 6hr or on sleeping

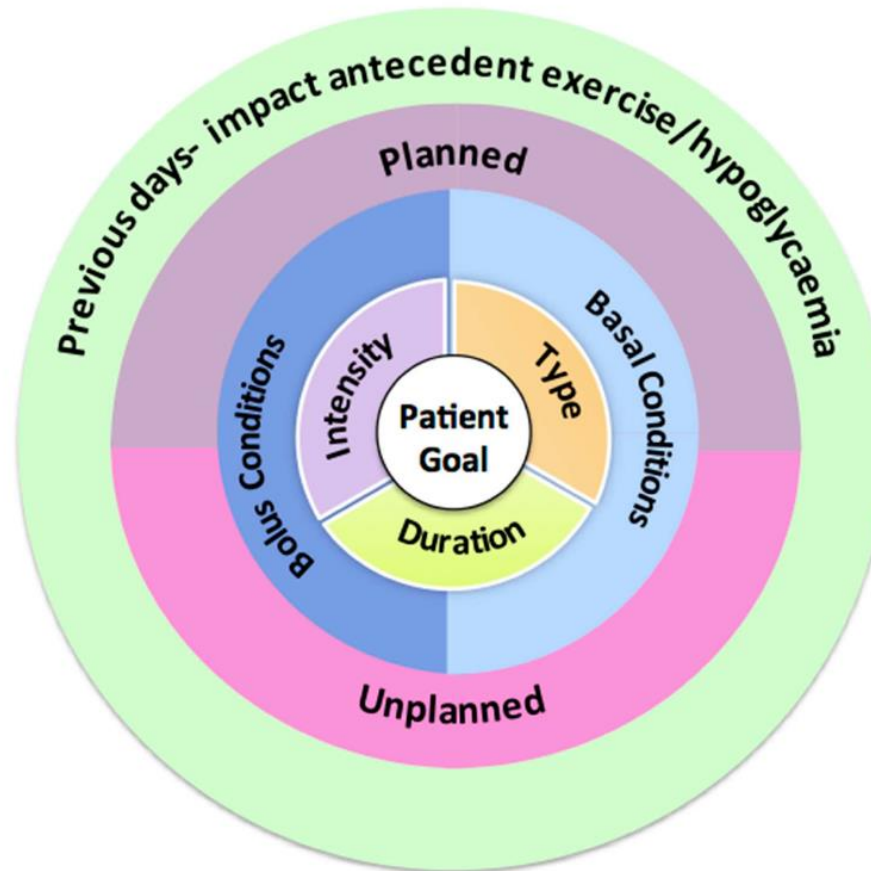
- Insulin sensitivity
- Blunted glucagon response
- Increased muscle and liver uptake of glucose



McMahon et al (2007) *JCEM* **92**(3):963-968

**Write down your top four questions to help
determine an exercise plan for a person with T1D**

Structuring a consultation



Strategies for managing exercise with T1D

We are balancing 3 things...



Insulin



Carbs



Exercise

Before, during and after

And tech
can help

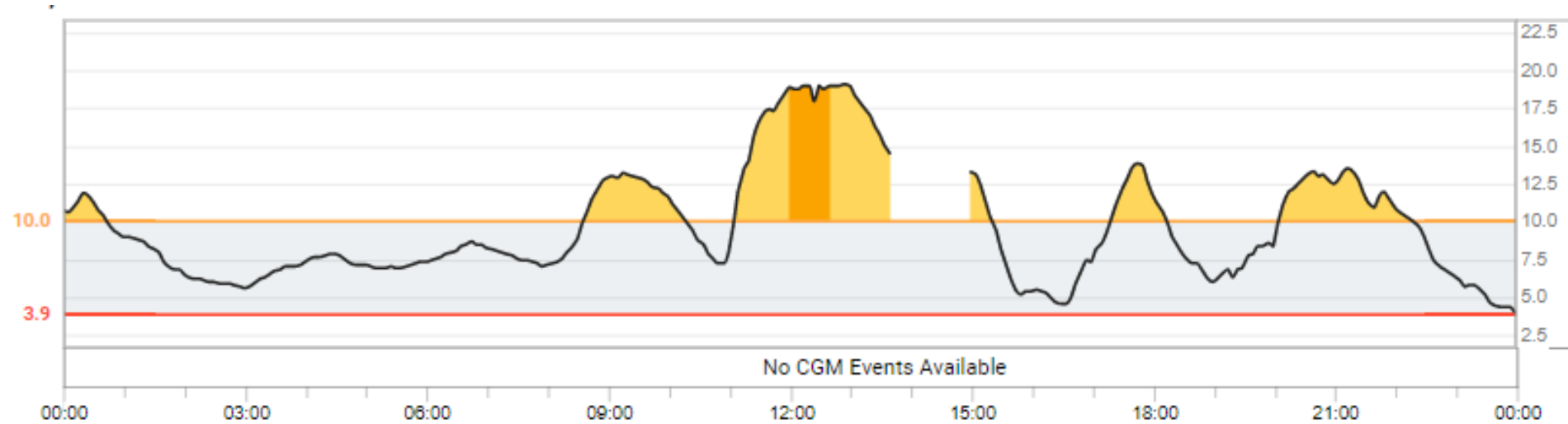
50/50/20 – A Safe starting place

- 50% reduction in bolus insulin if taken within 2 hours of exercise
- 50% reduction of bolus insulin for meal after
- 20 – if activity after 4 pm – one options before bed if less than 7-10 mmol/L
 - 20% reduction of background (Basal rate, Levemir or Lantus, Not Deguldec)
 - 20g carbs without insulin
 - 20g protein without insulin

50/50/20 – Case Study

- Chris is running at 18:00 for 60 minutes
 - 1u:10g Carb ratio all day
 - 1u:2.0mmol/L ISF
 - Levemir 22 units at 20:00
 - Weighs 77kg
- Small meal at 16:30: 50g
- Glucose 13.5 mmol/L with one arrow up at the start
- Glucose 6.5 mmol/L with one arrow down after 30 minutes
- Dinner 19:30: 100g and glucose 6.8 mmol/L – steady arrow

50/50/20 – Case Study



Next time?

Hybrid Closed Loop Systems

How do they cope with exercise?



Medtronic 780 G



Cam APS

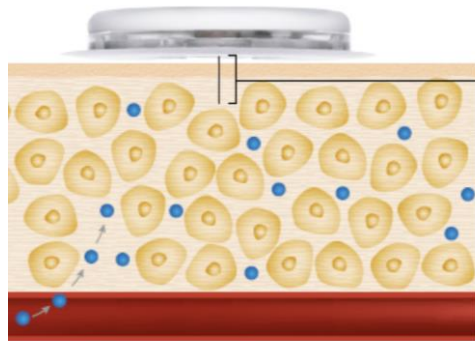


Tandem Control
iQ

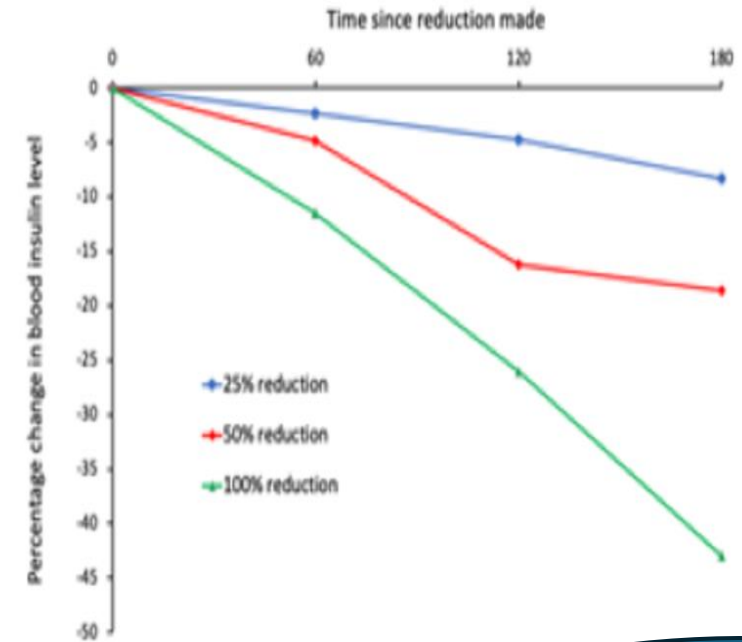


Omnipod 5

The 'problem'



Filament sensor
5mm insertion



All HCL systems are
challenged by exercise

But overnight – they
come into their own

The principles of managing T1D for exercise remain the same

Effect of bolus insulin

Drip feeding carbs

Exercise types

Post exercise insulin sensitivity



Exercise mode on HCL systems

Variable	780G	T-Slim Control IQ	CAMAPS FX	Omnipod 5
Usual Target	5.5mmol/l Default 6.1mmol/l 6.7mmol/l	6.3-8.9mmol/L	Set at 5.8mmol/L 4.4 – 11.0mmol/L	User defined 6.1-7.2mmol/L
Activity targets	<u>Temp Target:</u> 8.3mmol/l & no auto correction	<u>Exercise Target:</u> 7.8-8.9mmol/l Autocorrections still happen & target 6.1	<u>Ease Off:</u> Increases set target by 2.5mmol/l	<u>Activity mode:</u> Increases set target to 8.3mmol/L
Adjustable parameters	ICR AIT PGT	ICR ISF Basal	ICR PGT	ICR (ISF) PGT AIT

Effectively reduces insulin delivery by ~30%

Effectively reduces insulin delivery by ~50%

**Do you still need bolus reductions
with HCL Systems?**

If so by how much to start with?

Exercise 90 minutes after breakfast

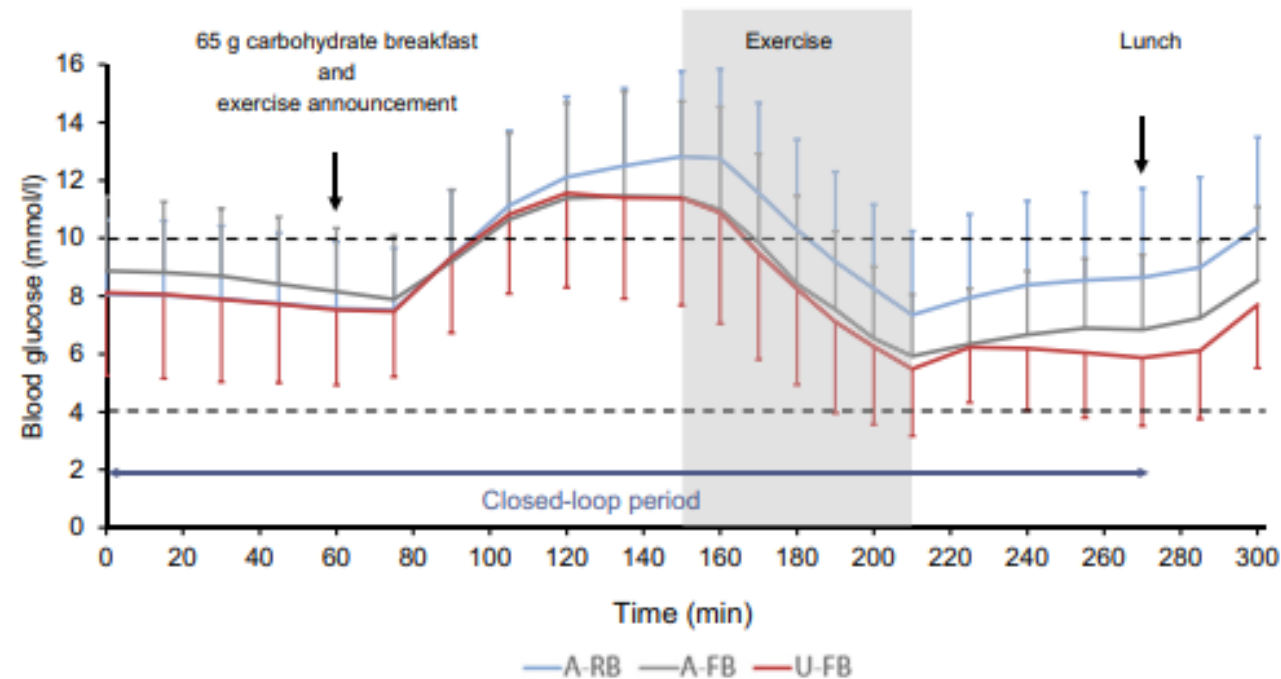
39 adults under three conditions

A-RB = Activity mode and reduced bolus (33%)

A-FB = Activity mode and Full bolus

U-FB = Usual target and Full bolus

Model Predictive Control Algorithm



Exercise 90 minutes after breakfast

39 adults under three conditions

A-RB = Activity mode and reduced bolus (33%)

A-FB = Activity mode and Full bolus

U-FB = Usual target and Full bolus

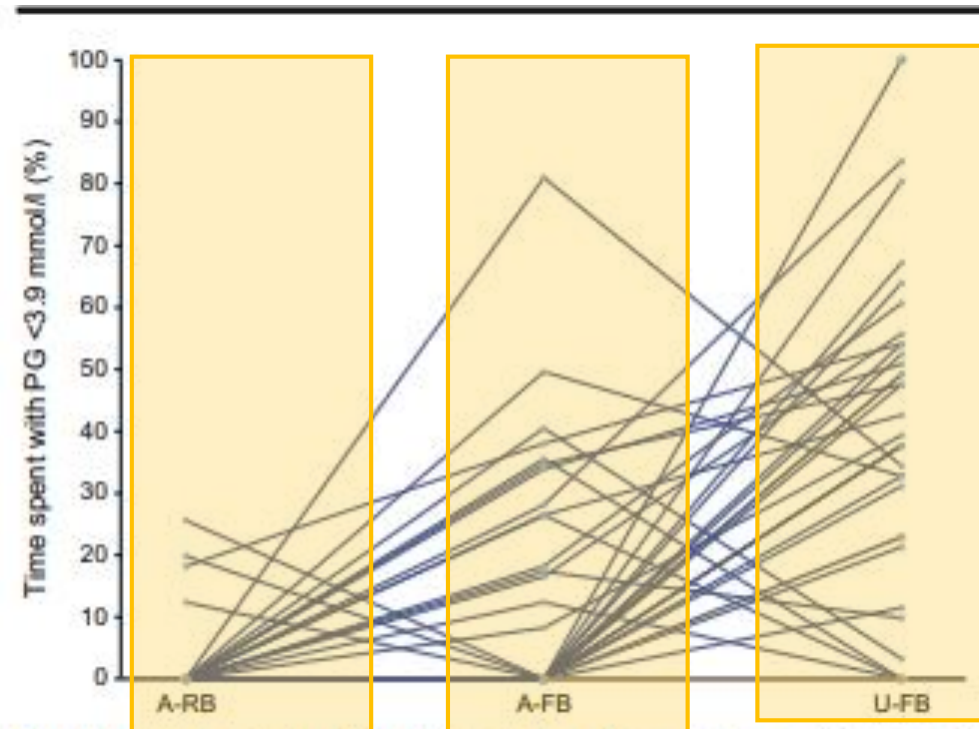
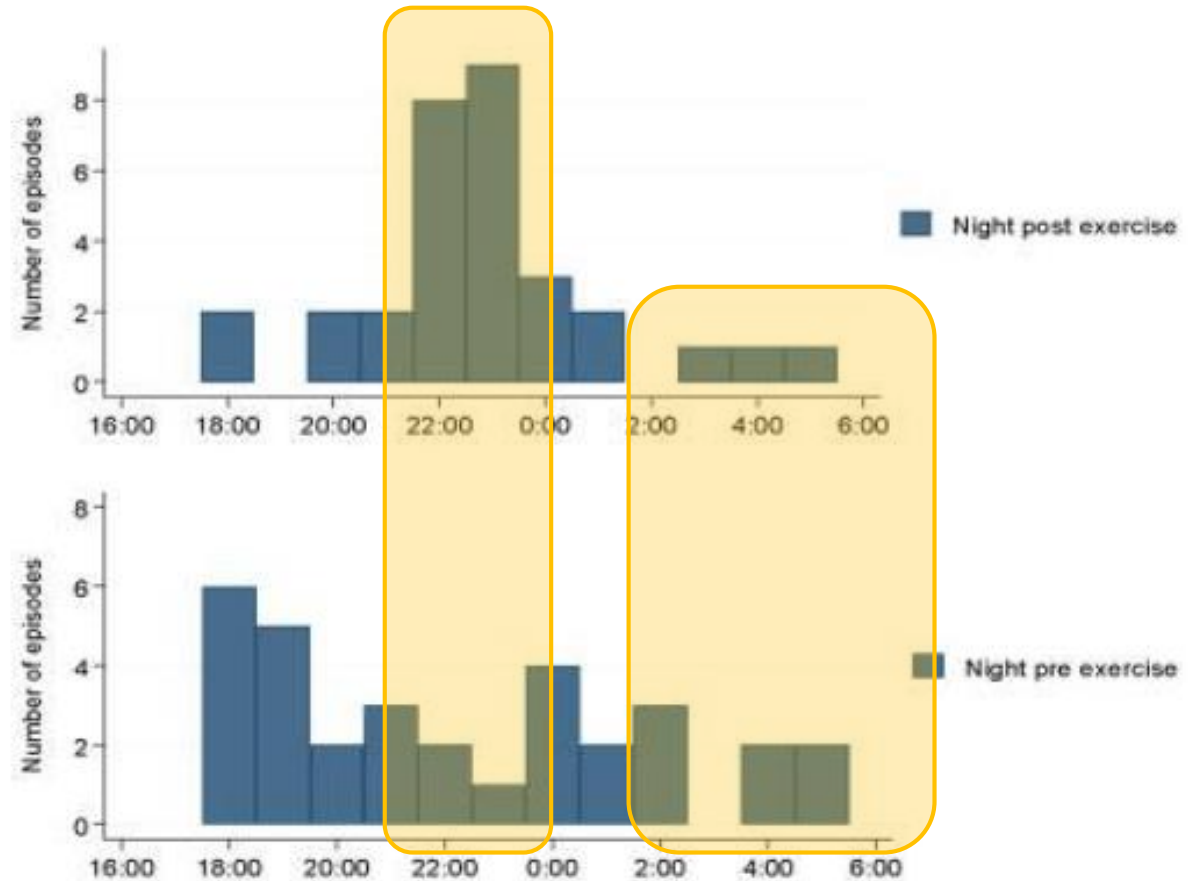


Fig. 1 Individual data points for the study primary outcome of time spent in hypoglycaemia (plasma glucose [PG] <3.9 mmol/l)

Slight bolus reduction after but activity mode is generally not needed overnight

- 33 adults with T1D
- Last meal and food insulin 13:00
 - (45g CHO, 25g PRO, 10g FAT)
- Exercise target stated 14:00
- Exercise at 16:00 for 40 mins
 - HITT (4x4 of 80% max ergometer)
 - Resistance (4 sets whole body)
 - Moderate (25% max ergometer)
- Exercise target off immediately after
- No food for 4 hours
- Usual insulin with meal 20:40
 - 60g (45g) CHO, 25g PRO, 20g FAT)
- Overnight 00:00-06:00



T25/T25

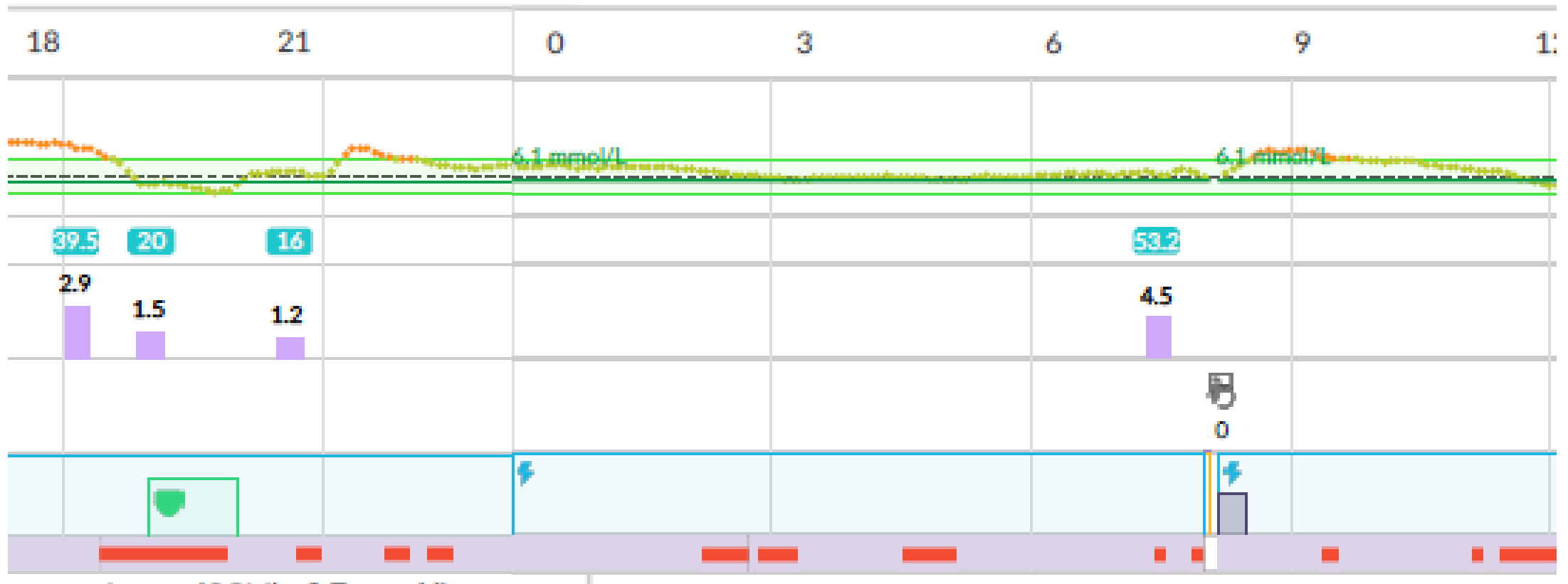
	Before exercise		During Exercise	After exercise	
	Activity target	Meal insulin	Carbohydrate	Activity target	Post exercise meal insulin
Plan execution	Start 1-2 hours before	Meal within 2 hours of exercise	Before and every 20-30 min		
>15.0mmol/L using starting plan	Off	No reduction	<7.0 mmol/L carbohydrate 3-20g per 30 min	Off	No reduction
Starting plan	On	-25%		Off	-25%
<5.0mmol/L using starting plan	On	-50%		On for 6 hours	-50%

T25/T25 – Case Study

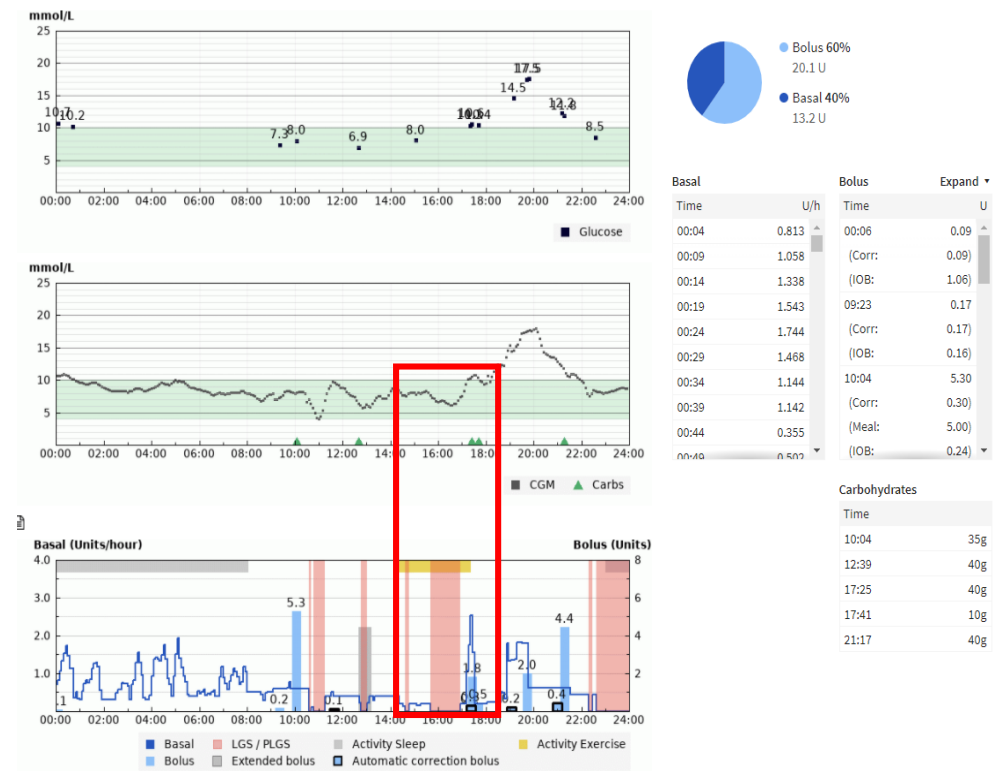
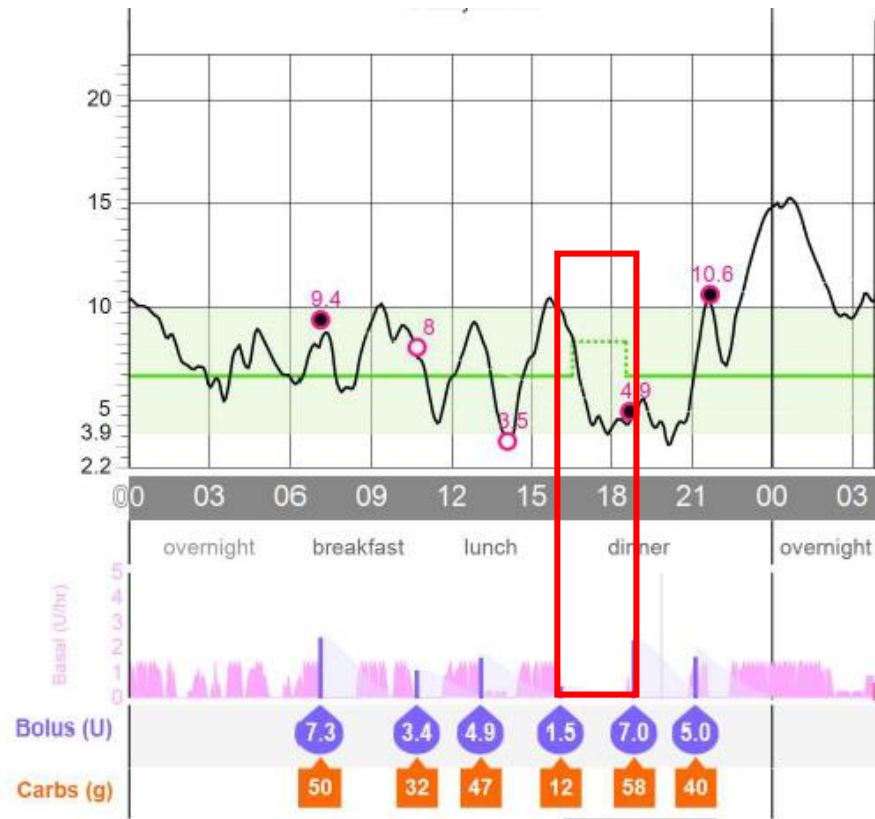
65kg lady playing Netball at 19:00 – 20:00

- One meal of 60g carbs at 18:00
- Dessert 30g at 18:30
- Glucose 19:00 5.0 mmol/L with steady arrow
- Glucose 19:30 5.5 mmol/L with a steady arrow
- Supper of 25g at 20:30

T25/T25 – Case Study



Beware of long suspensions and negative insulin on board



Solutions?

Solutions

There is a risk of prolonged insulin suspension >120 min:

- Ketones is generally not an issue (? Low carb ultra-athletes)
- Post-exercise rise can be significant

If causing problems:

- Stop activity mode half way through
- Bolus 50% of usual basal every hour
- CamAPS can use Boost after exercise
- Other systems: 50% missed basal as a bolus on reconnection after exercise
- Golden hour snack with a reduced bolus will help compensate

Open loop for exercise?

- Challenges with exercise is a main reason why people stop using AID Systems
- AID systems = inconsistent insulin conditions = variable glucose response to exercise
- Consider:
 - Open loop 90-120 minutes before exercise and switch loop on after exercise has finished
- BUT
 - Must have manual basal rates set correctly
 - Try to have last meal and bolus insulin 3 hours prior to exercise
 - Trial and error required

What if exercise mode is not enough alone to prevent hypos

Control IQ

- Additional profile with 25-50% lower basal rates and weaker ICR & ISF
- If caused by autocorrections during exercise – 0.05u micro correction at onset to stop autocorrections for an hour

CamAPS

- Consider raising PGT

Medtronic 780g & OP5

- Off loop and temp basal rate (relies on sensible basal programme)

Activity camps, expeditions, ski holidays

Periods of repeated and prolonged exercise can have a dramatic and rapid impact on insulin sensitivity which HCL systems cannot adjust to quickly

How to help them:

- Control IQ – Additional profile with lower basal, weaker ICR & ISF
- CamAPS – raise PGT (at least by 1mmol/l to have clinical impact) and weaken ICR
- Medtronic/OP5 – raise PGT if possible – if not consider manual mode with temp basals. Weaken ICR (and ISF OP5)
- ALL OF THEM – use exercise mode function



Frequent pump removal

- Consider an injected basal insulin in the morning of tournament days prior to pump removal (e.g. Humulin S)
- Reconnect HCL in the evening to benefit from overnight automated insulin delivery



Practical considerations



Practicalities of CGM with exercise

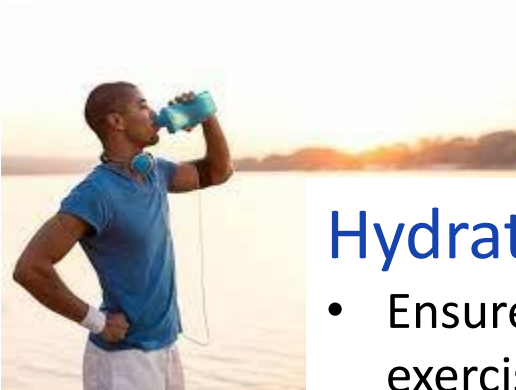


Sensor sites

- Site away from heavily used muscles
- Avoid impact areas for contact sports

Keep the sensor stuck on

- Additional adhesive tape
- Neoprene bands – be aware of compression lows



Hydrate

- Ensure good hydration around exercise and habitually



Receiver range

- Keep on touchline or edge of pool to maintain signal

Cannula sites

- Consider where cannula is placed
- Working muscles see increased blood flow – this will impact insulin circulation
- How to keep cannula in on sweaty bodies?



Summary

- Using glucose values and trend arrows to determine carbohydrates for exercise
- 50/50/20 for MDI and Pump Therapy
- T25/T25 for Hybrid Closed-Loop Therapy



Educating HCPs and patients - EXTOD



EXTOD Healthcare Professionals National Conference

Tuesday 26th and Wednesday 27th November 2024,
Radisson Blu Hotel, Edinburgh

Booking : [Diabetes NNF website](#), call [01732 897788](tel:01732 897788)
or email bookings@sbk-healthcare.co.uk

<https://www.extod.org/>



Practical aspects

DiabetesSpectrum®

Current ▾

Browse ▾

Info & About ▾

Podcasts ▾

Volume 36, Issue 2

Spring 2023



FROM RESEARCH TO PRACTICE | MAY 15 2023

Practical Aspects and Exercise Safety Benefits of Automated Insulin Delivery Systems in Type 1 Diabetes **FREE**

Dessi P. Zaharieva ; Dale Morrison ; Barbora Paldus ; Rayhan A. Lal ; Bruce A. Buckingham; David N. O'Neal

Check for updates

Corresponding author: Dessi P. Zaharieva, dessi@stanford.edu

Diabetes Spectr 2023;36(2):127–136

<https://doi.org/10.2337/dsi22-0018>

PubMed:37193203

Split-Screen Views ▾ PDF Share ▾ Cite Get Permissions

Regular exercise is essential to overall cardiovascular health and well-being in people with type 1



Thank you

Any questions...?