Oxford University Hospitals NHS
NHS Foundation Trust

Technology and Exercise

Alistair Lumb

10.05.2017

Plan

- Cases for discussion
- Basic exercise physiology
- Benefits of insulin pumps for sport and exercise diabetes management
  - Insulin pumps
  - Continuous glucose monitoring
- Challenges for technology

Case 1

- 42 yr old man
  - Animas pump for 2 years
  - HbA1c currently 65 mmol/mol (down from 80 mmol/mol prior to pump therapy)
- Active – runs 5k 3 times per week
- Has obtained a charity place for next year's London marathon
- Comes to see you for advice
  - What do you want to discuss?
  - What adjustments might you recommend to his pump therapy?

Case 2

- 36 year old man

- Takes part in 24 hour mountain bike races
  - Relay team of 3
  - 2 laps each in turn through 24 hour period (approx 1.5 – 2 hours duration)
  - Will reduce basal by 80% - mantains glucose very well through 2 laps
  - Eats when finishes his 2 laps – finds glucose rises significantly through first 30 minutes following exercise
  - What do you recommend?

Case 3

- 26 yr old woman, powerlifter

- Starting wrestling training
  - Mat work
  - Falls/rolls
  - Conditioning
  - Character work

- Plan to eat normal b'fast then snack at 10.30am
- Training starting at 11

- What do you recommend?

Aerobic activity

- Lower intensity, longer duration e.g. long distance running or cycling
- CHO metabolism is predominantly aerobic, with NEFA also a significant energy source

Aerobic activity in diabetes

- Circulating insulin is often higher than is required
- This suppresses mobilisation of both CHO and NEFA fuel stores, and also promotes peripheral glucose uptake
- The main problem is therefore **hypoglycaemia**
- **It is important to note that fear of hypoglycaemia is the most important factor preventing people with T1DM undertaking a more active lifestyle**

Anaerobic activity

- Higher intensity, shorter duration
- CHO metabolism predominates
- Anaerobic metabolism so significant lactate production

Anaerobic activity - diabetes

- Circulating insulin is often not sufficient to counterbalance the significant rise in glucose production
- The result is often **hyperglycaemia**
- Glucose can subsequently fall as counter-regulatory hormones return to normal levels
- This can be very frustrating, especially when it is not what the person with diabetes expects.

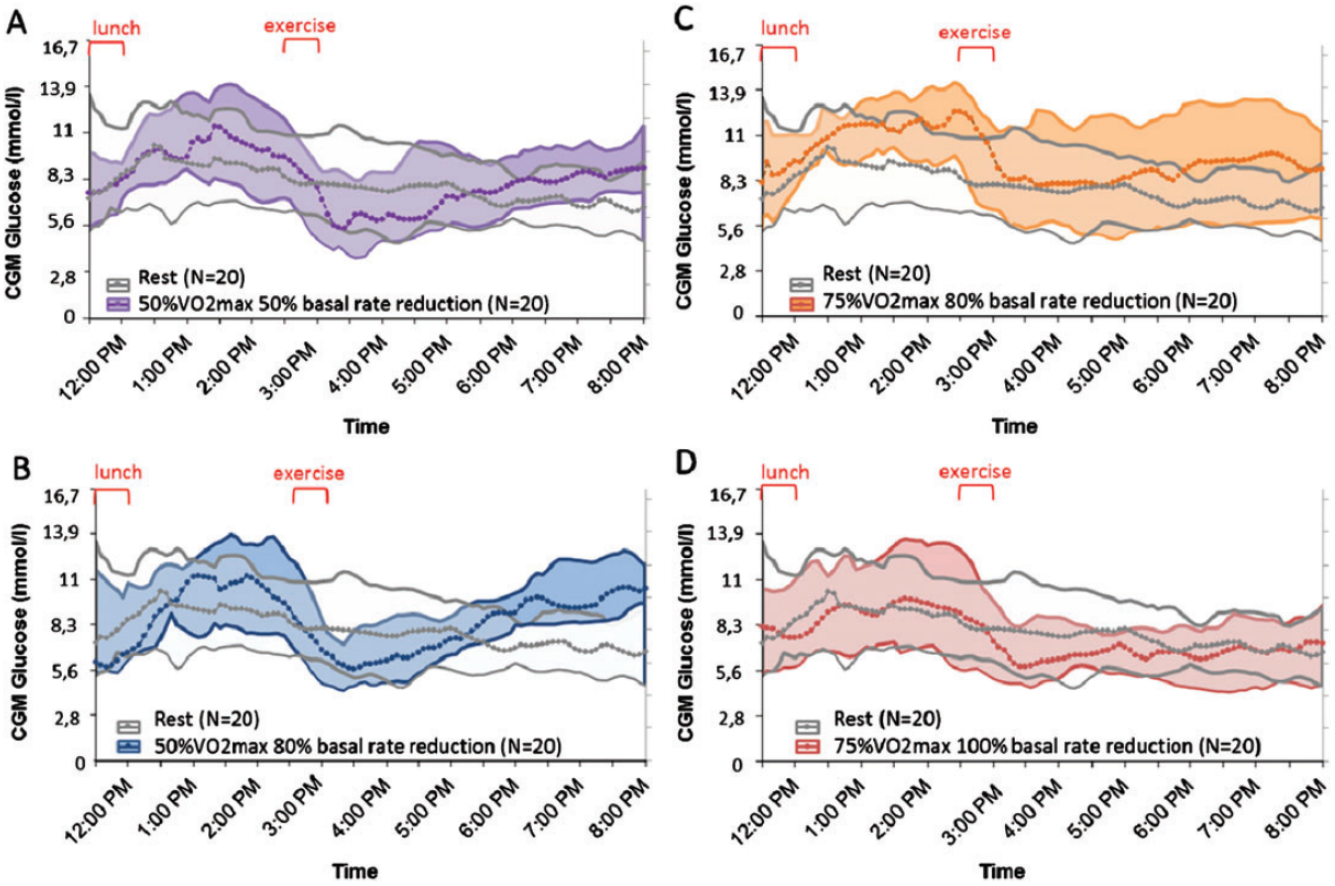
Intermittent High Intensity Activity

- A mixture of high and moderate intensity activity
- Bursts of high intensity interspersed with moderate intensity
- Characteristic of team sports, also children's play

Case 1

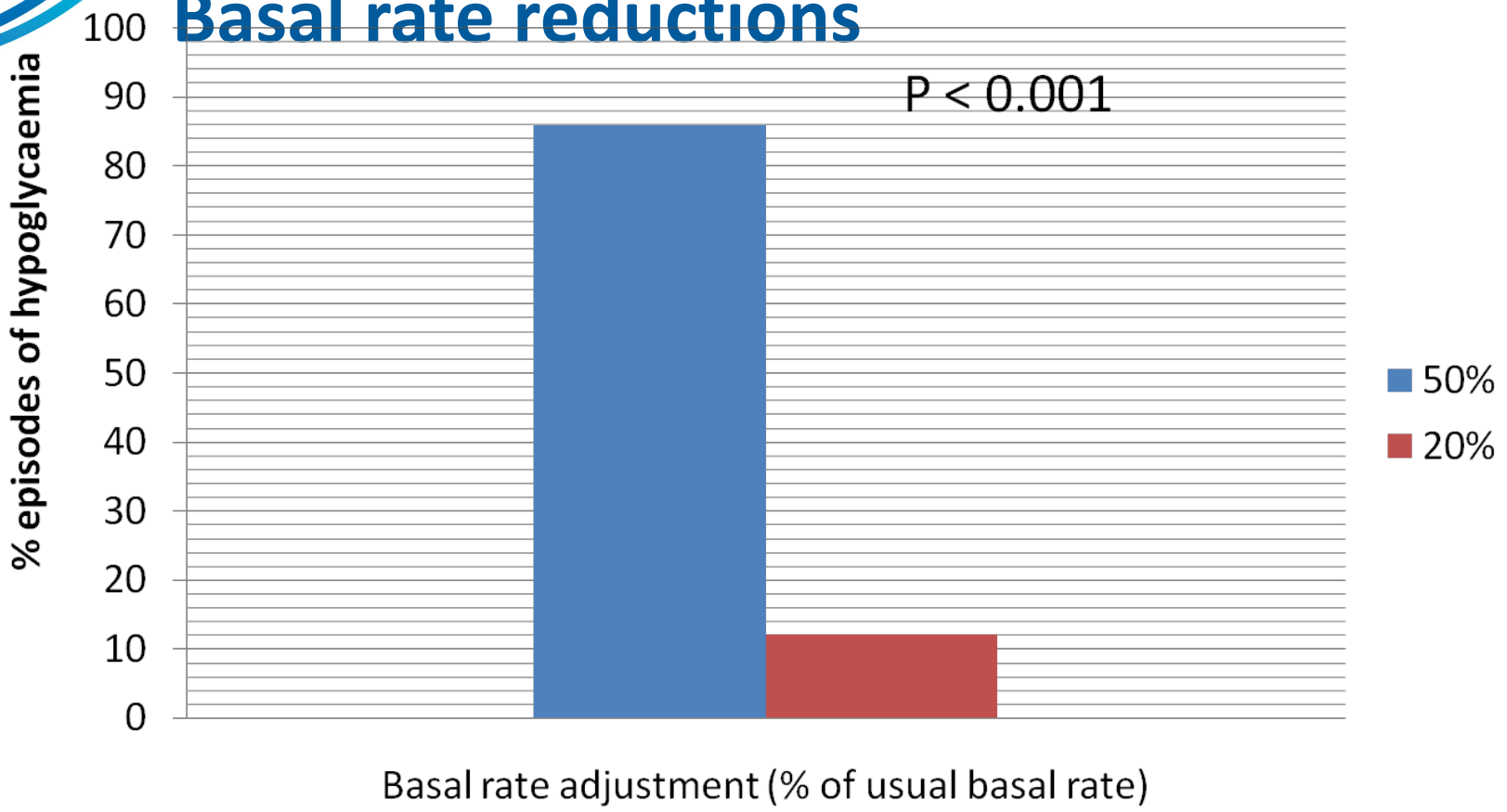
- 42 yr old man
  - Animas pump for 2 years
  - HbA1c currently 65 mmol/mol (down from 80 mmol/mol prior to pump therapy)
- Active – runs 5k 3 times per week
- Has obtained a charity place for next year's London marathon
- Comes to see you for advice
  - What do you want to discuss?
  - What adjustments might you recommend to his pump therapy?

Basal rate reductions



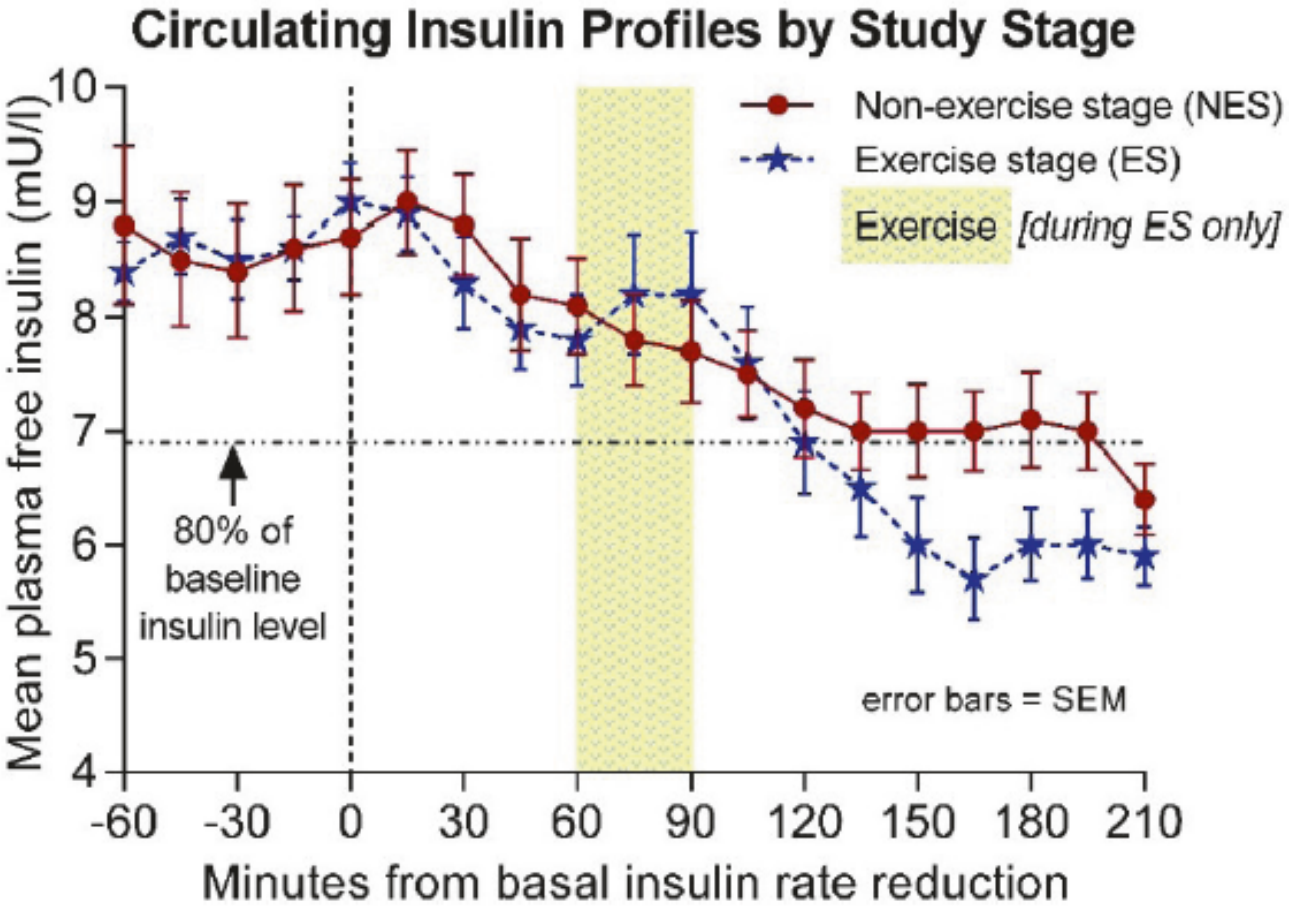
Franc et al (2015) *Diabetes Obesity and Metabolism* 17(12): 1150-1157

Basal rate reductions



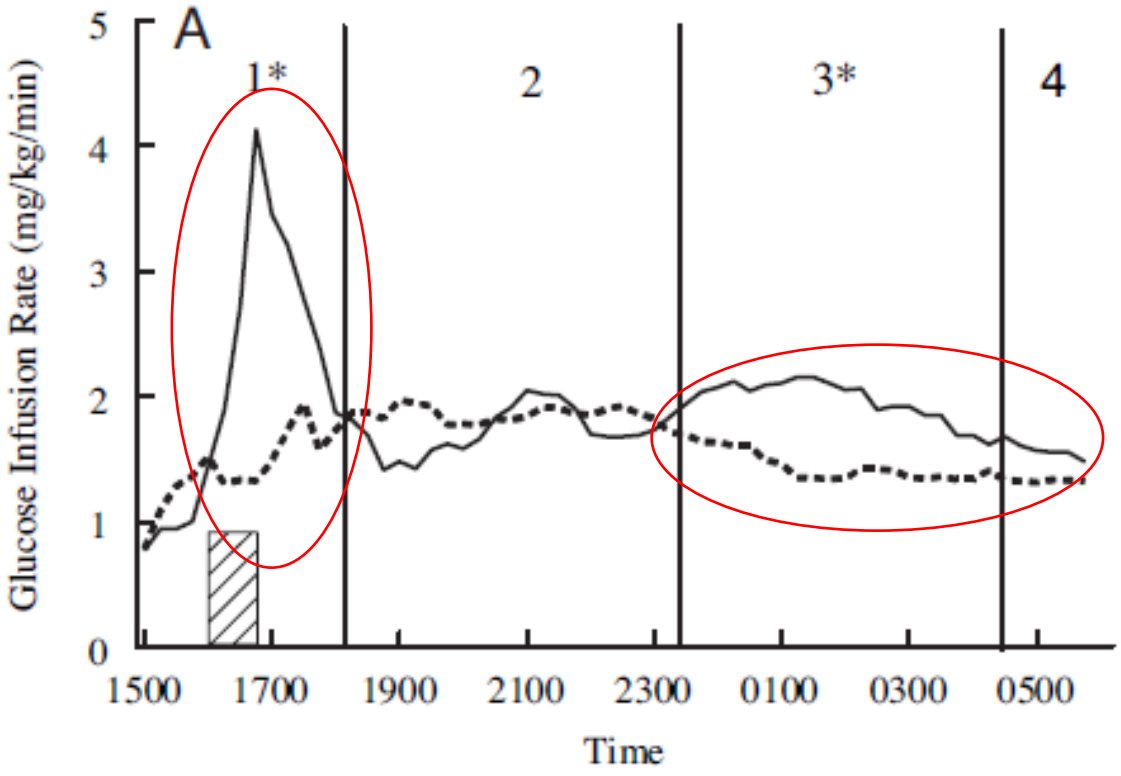
Lumb et al. (2012) presented at ADA Annual Scientific Sessions: 718-P

Reduce basal before exercise



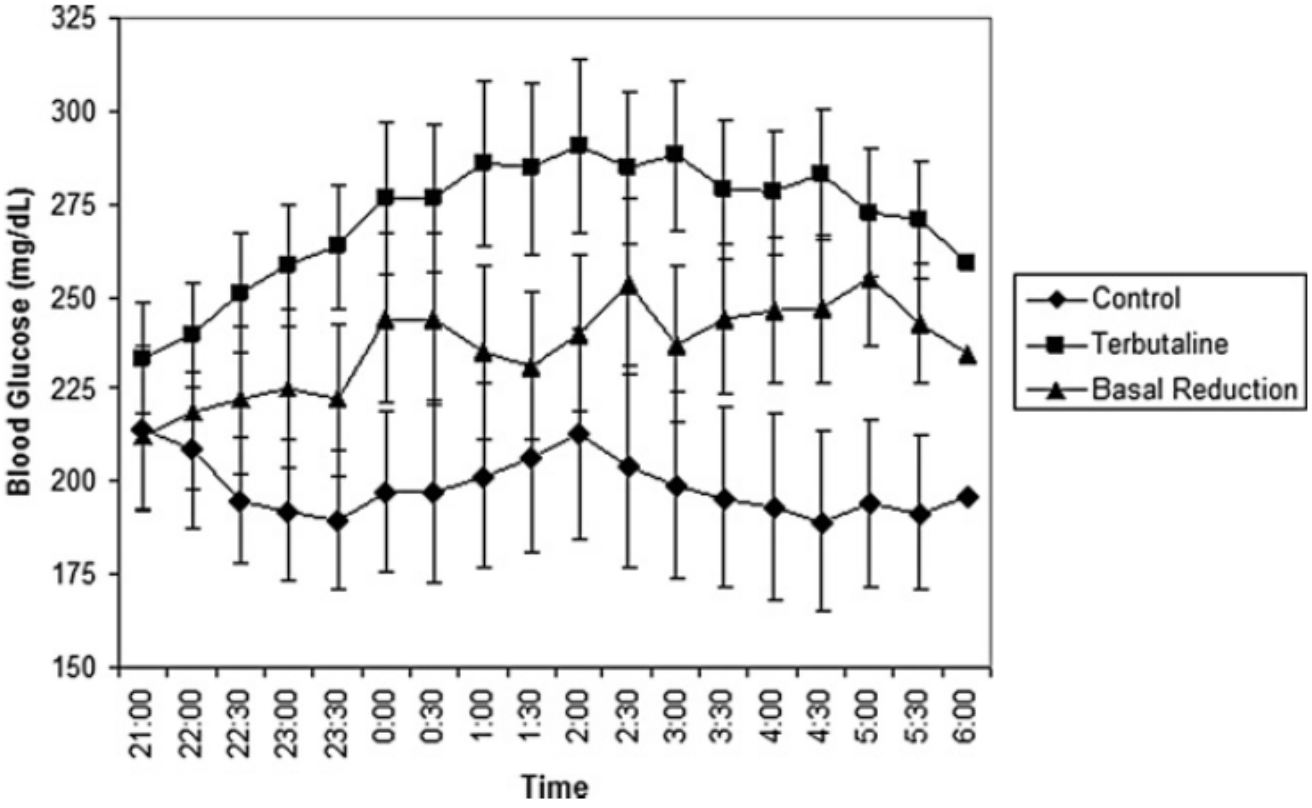
McAuley et al ePoster 1001 presented at EASD 2014

Nocturnal hypoglycaemia



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

Nocturnal hypoglycaemia



Taplin et al (2010) *Journal Pediatrics***157(5)**:784-788

Bolus dose adjustments

Exercise intensity (% VO_{2max})	% Dose reduction	
	30 min of exercise	60 min of exercise
25	25*	50
50	50	75
75	75	—

*Extrapolated.

Rabasa-Lhoret et al (2001) *Diabetes Care* **24:**625-30

Pump therapy for aerobic exercise

- Insulin at the start of exercise affects risk of hypoglycaemia, so likely worth reducing the basal rate up to 90 minutes before starting

- Optimal basal rate reduction for aerobic exercise is likely to be between 50% and 80%, although this is not yet clear and likely to vary from person to person and between different types of exercise. In some circumstances complete suspension might work best.

- Not clear when to bring basal rate back to usual after exercise. Reasonable starting point is to return to normal at the end of exercise, but earlier might be helpful/necessary

- Reducing nocturnal basal rate by 20% for a period of time overnight may help to prevent nocturnal hypoglycaemia

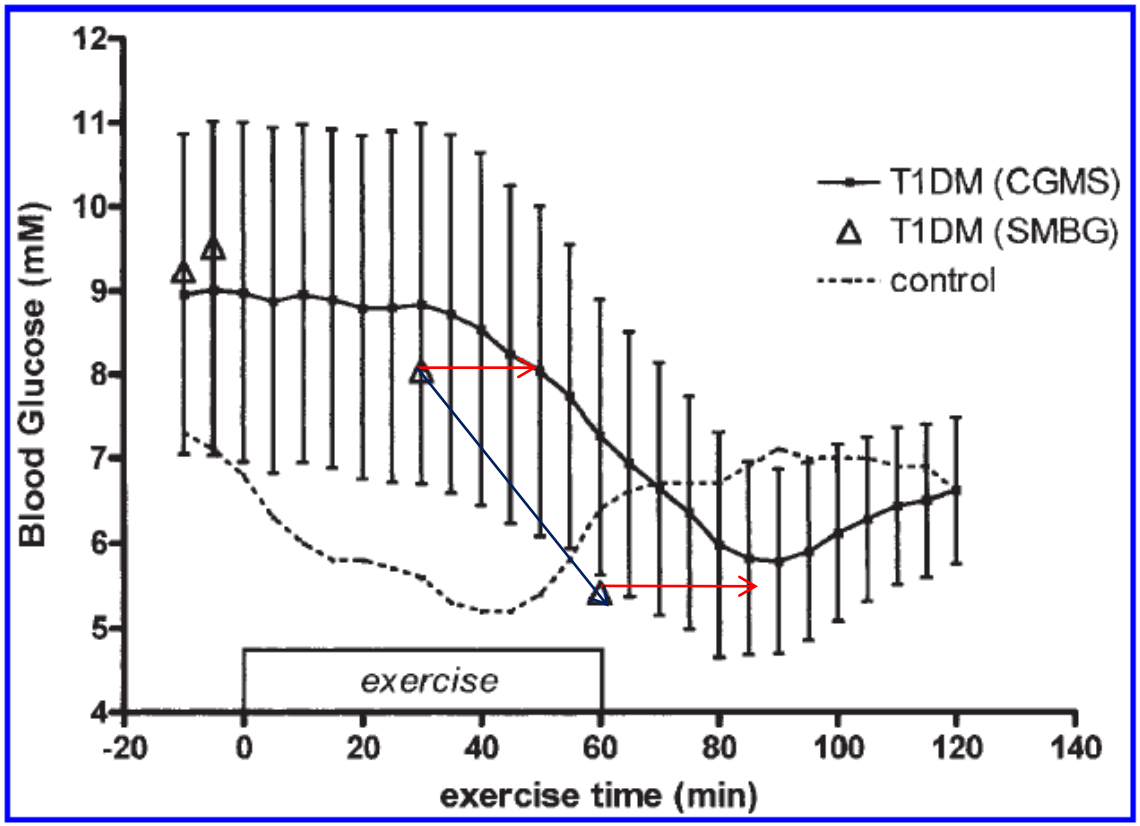
Oxford University Hospitals NHS
NHS Foundation Trust

CGM

What are the benefits/limitations of CGM?

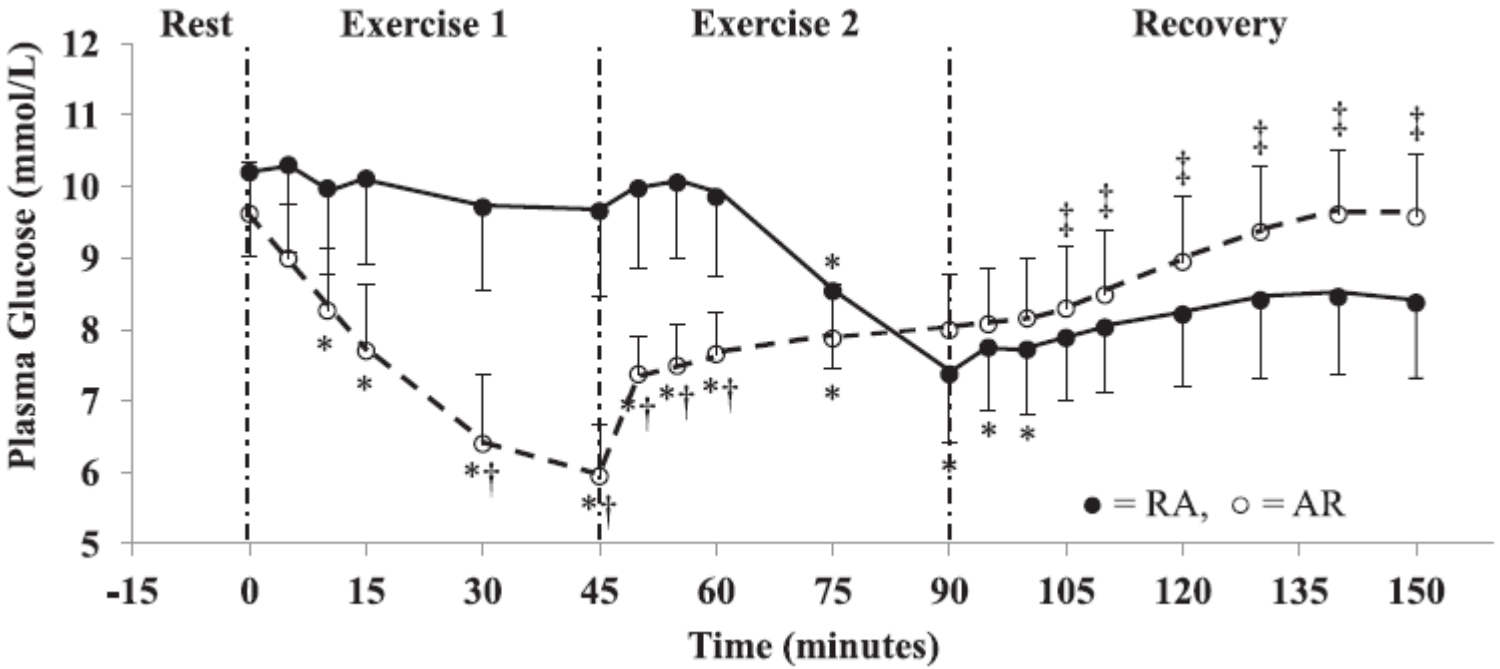
- Chance to review plans and make adjustments
- Chance to respond to changing situations in real time
- Need to be wary of the time lag between changes in blood glucose and changes in sensor glucose

CGM during spinning



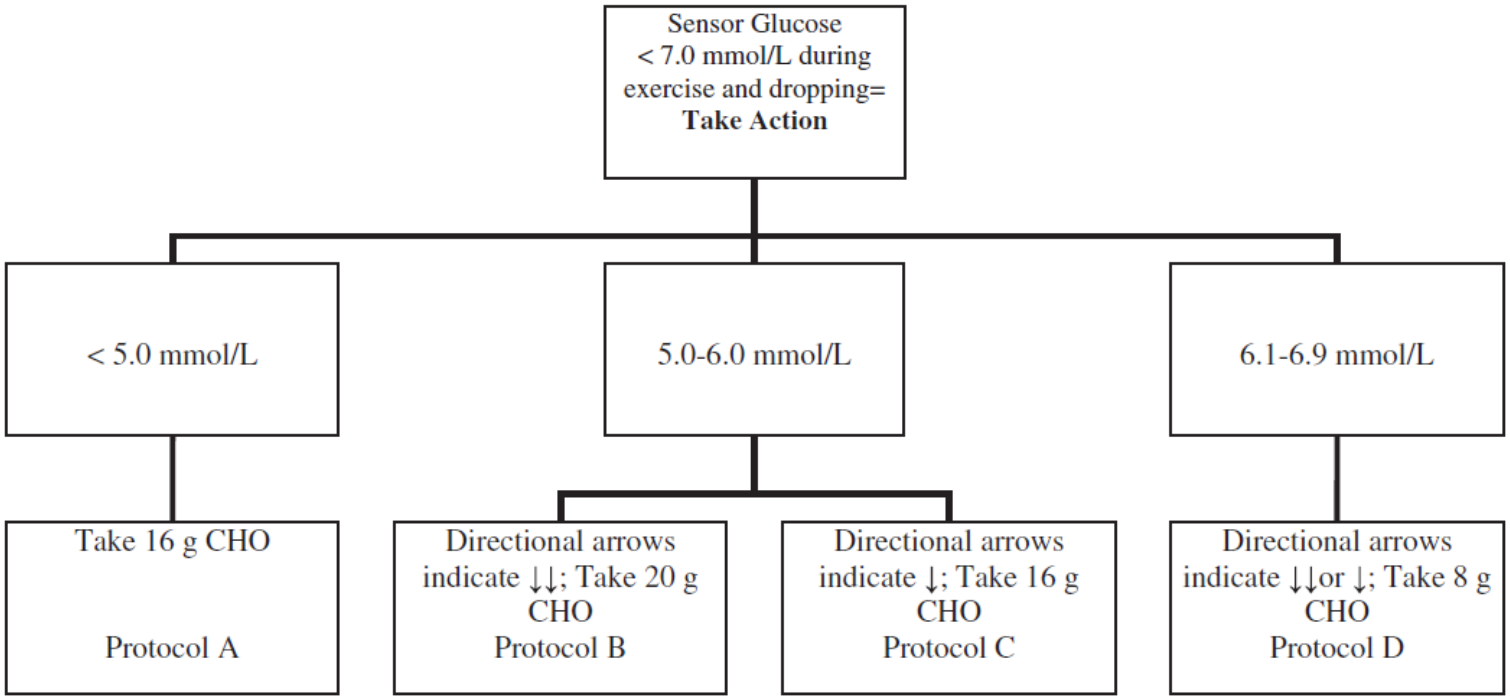
Iscoe et al (2006) *Diabetes Technology and Therapeutics* **8(6)**:627-635

Patterns can be very useful



Yardley et al (2012) *Diabetes Care* **35**: 669-675

How could we use real-time info?

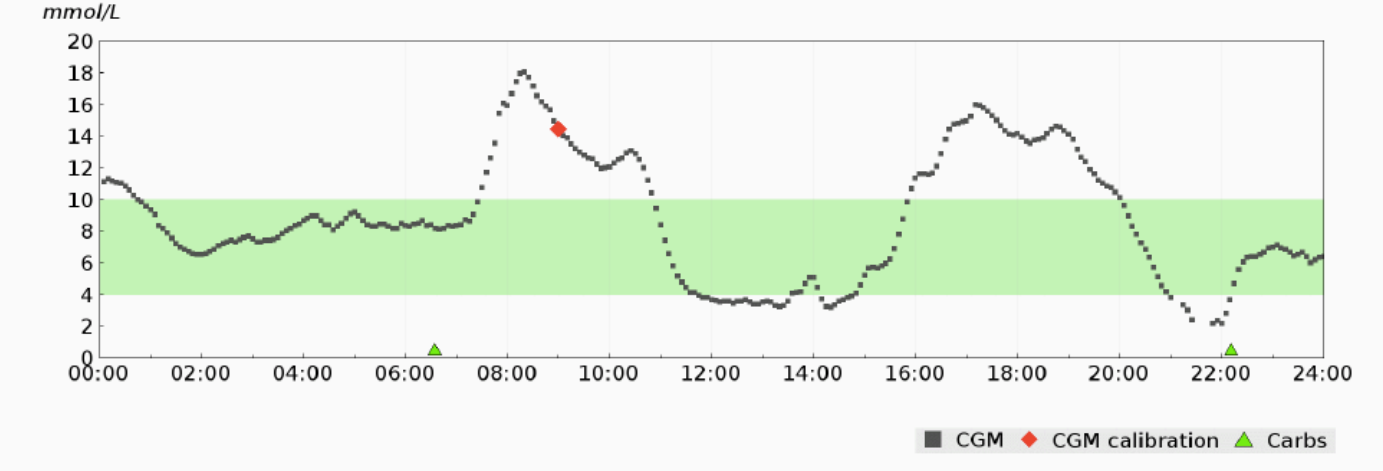


Riddell & Milliken (2011) *Diabetes Technology and Therapeutics* **13(8)**:813-825

Review of data from Marathon Day

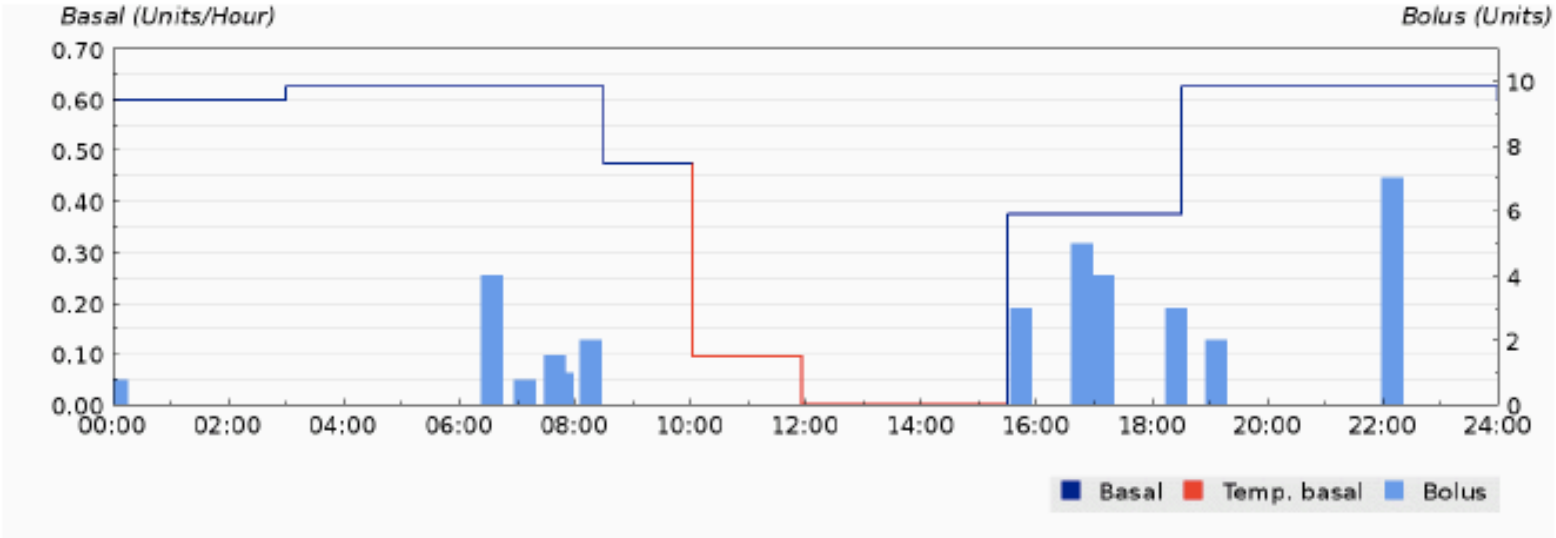
Patient:		**Date interval:**	15/04/2015 to 28/04/2015	diasend.
Patient ID:		**Number of days:**	14	
Print date:	19/05/2016			
Glucose meters:	-	**Insulin pump:**		**Combination device:** -

Sunday 26/4

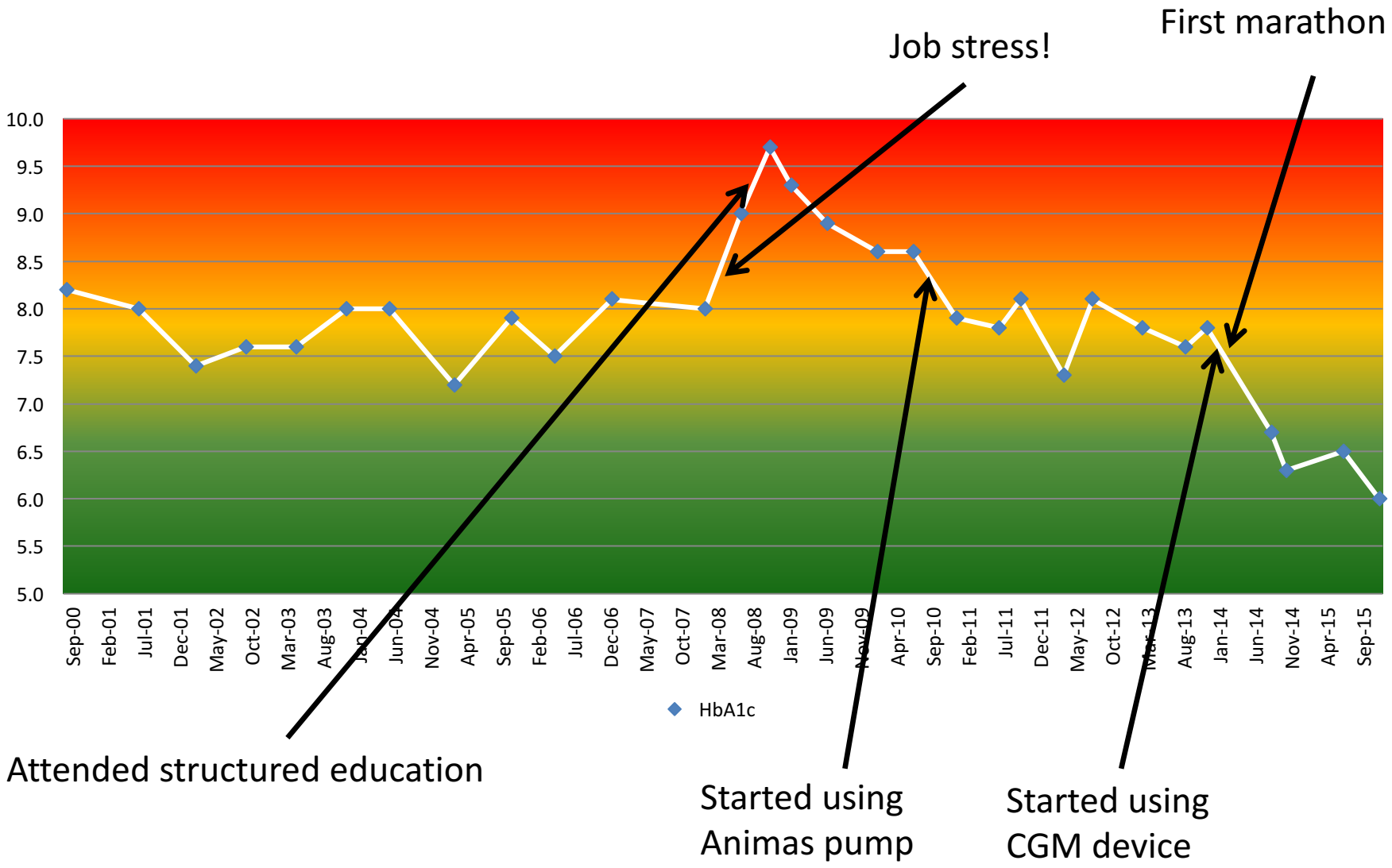


Review of pump activity

Sunday 26/4



HbA1c results, 2000-2016



Case 2

- 36 year old man

- Takes part in 24 hour mountain bike races
  - Relay team of 3
  - 2 laps each in turn through 24 hour period (approx 1.5 – 2 hours duration)
  - Will reduce basal by 80% - maintains glucose very well through 2 laps
  - Eats when finishes his 2 laps – finds glucose rises significantly through first 30 minutes following exercise
  - What do you recommend?

Potential strategies

- Check he is taking insulin with his post-ride food
  - 30-50% of calculated insulin bolus (or modify Insulin:CHO ratio)
- Consider “super bolus”
- Return to usual basal rate earlier
- Use increased temporary basal rate

Case 3

- 26 yr old woman, powerlifter

- Starting wrestling training
  - Mat work
  - Falls/rolls
  - Conditioning
  - Character work

- Plan to eat normal b'fast then snack at 10.30am
- Training starting at 11

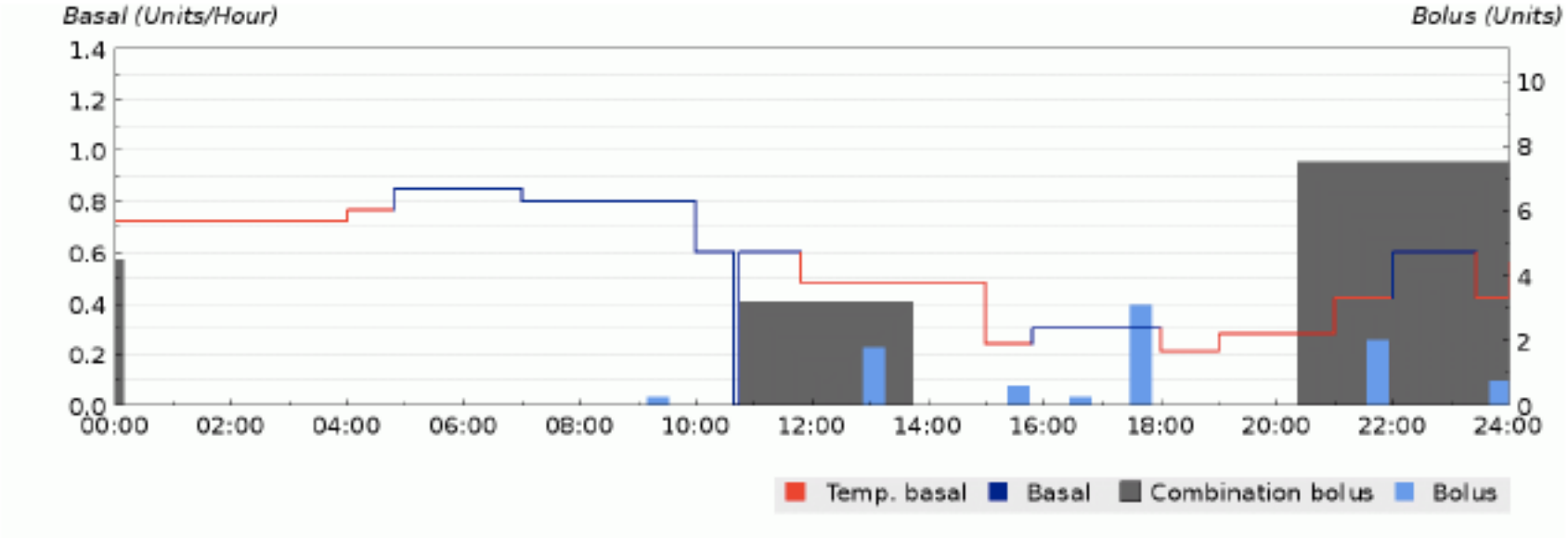
- What do you recommend?

Some considerations

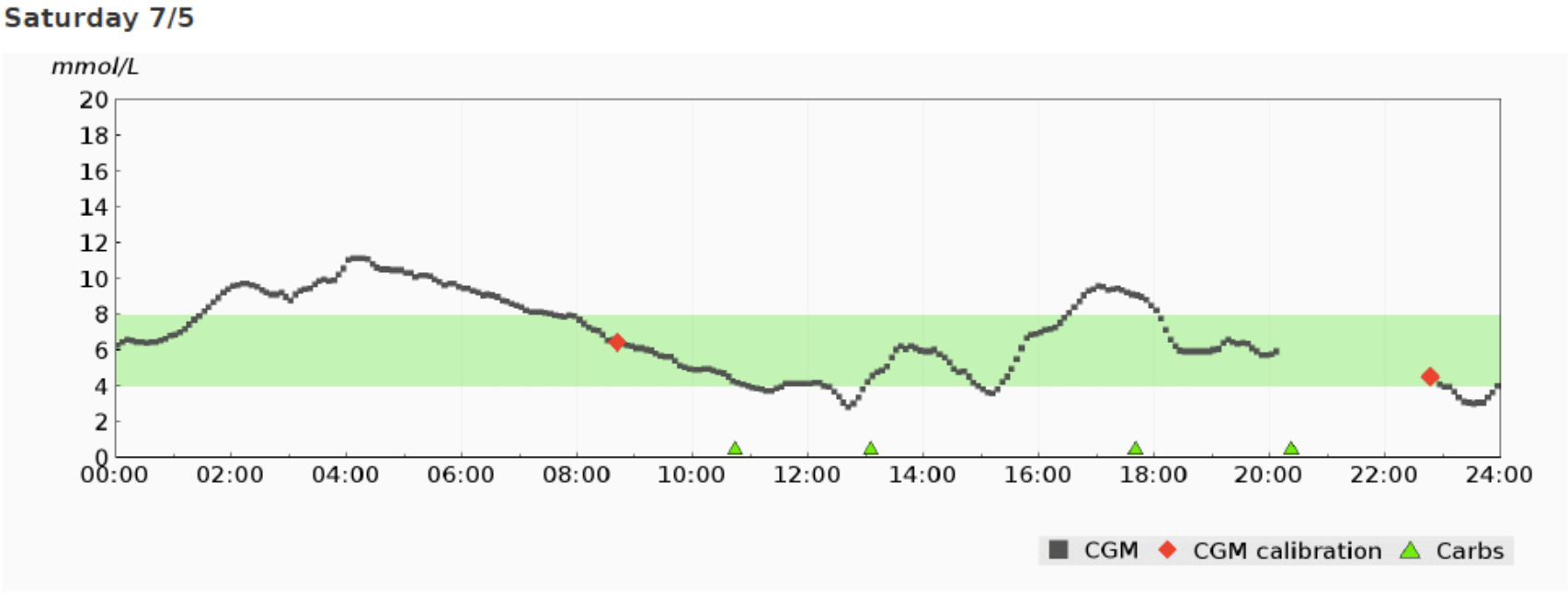
- Reduced bolus with snack before training (perhaps using modified Insulin:CHO ratio)
- May need to remove pump for some elements of training
  - Consider bolus for percentage/all of missed basal
  - Could be before removal/after putting back on
    - May be a different strategy for different types of exercise
- Temporary basal rates when able to keep pump on
- Could she wear CGM?

Data from training day

Saturday 7/5



Data from training day



International Consensus Guidance

Review

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

Type 1 diabetes is a challenging condition to manage for various physiological and behavioural reasons. Regular exercise is important, but management of different forms of physical activity is particularly difficult for both the individual with type 1 diabetes and the health-care provider. People with type 1 diabetes tend to be at least as inactive as the general population, with a large percentage of individuals not maintaining a healthy body mass nor achieving the minimum amount of moderate to vigorous aerobic activity per week. Regular exercise can improve health and wellbeing, and can help individuals to achieve their target lipid profile, body composition, and fitness and glycaemic goals. However, several additional barriers to exercise can exist for a person with diabetes, including fear of hypoglycaemia, loss of glycaemic control, and inadequate knowledge around exercise management. This Review provides an up-to-date consensus on exercise management for individuals with type 1 diabetes who exercise regularly, including glucose targets for safe and effective exercise, and nutritional and insulin dose adjustments to protect against exercise-related glucose excursions.

Lancet Diabetes Endocrinol 2017

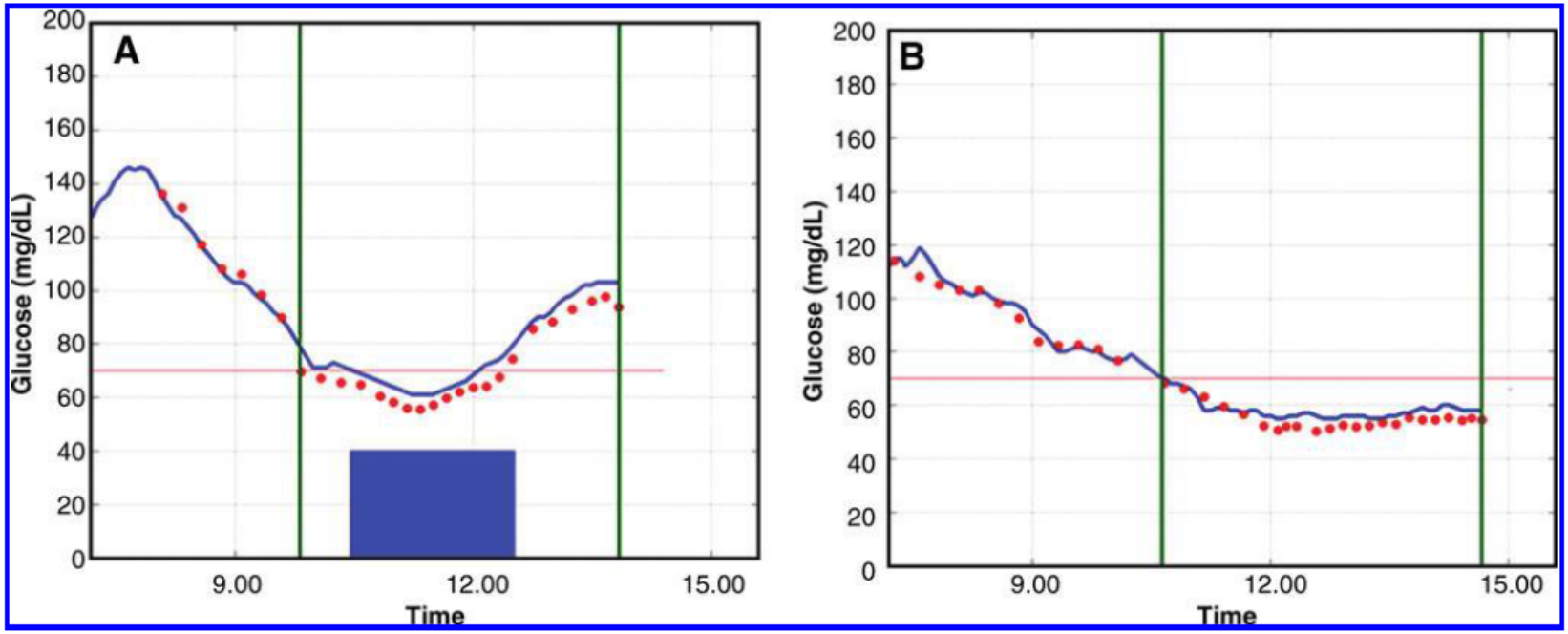
Published Online
January 23, 2017
http://dx.doi.org/10.1016/S2213-8587(17)30014-1

Muscle Health Research Centre, York University, Toronto, ON, Canada (Prof M C Riddell PhD); **Royal Berkshire NHS Foundation Trust Centre for Diabetes and Endocrinology, Royal Berkshire Hospital, Reading, UK** (IW Gallen FRCP); **Hunter Medical Research**

Oxford University Hospitals NHS
NHS Foundation Trust

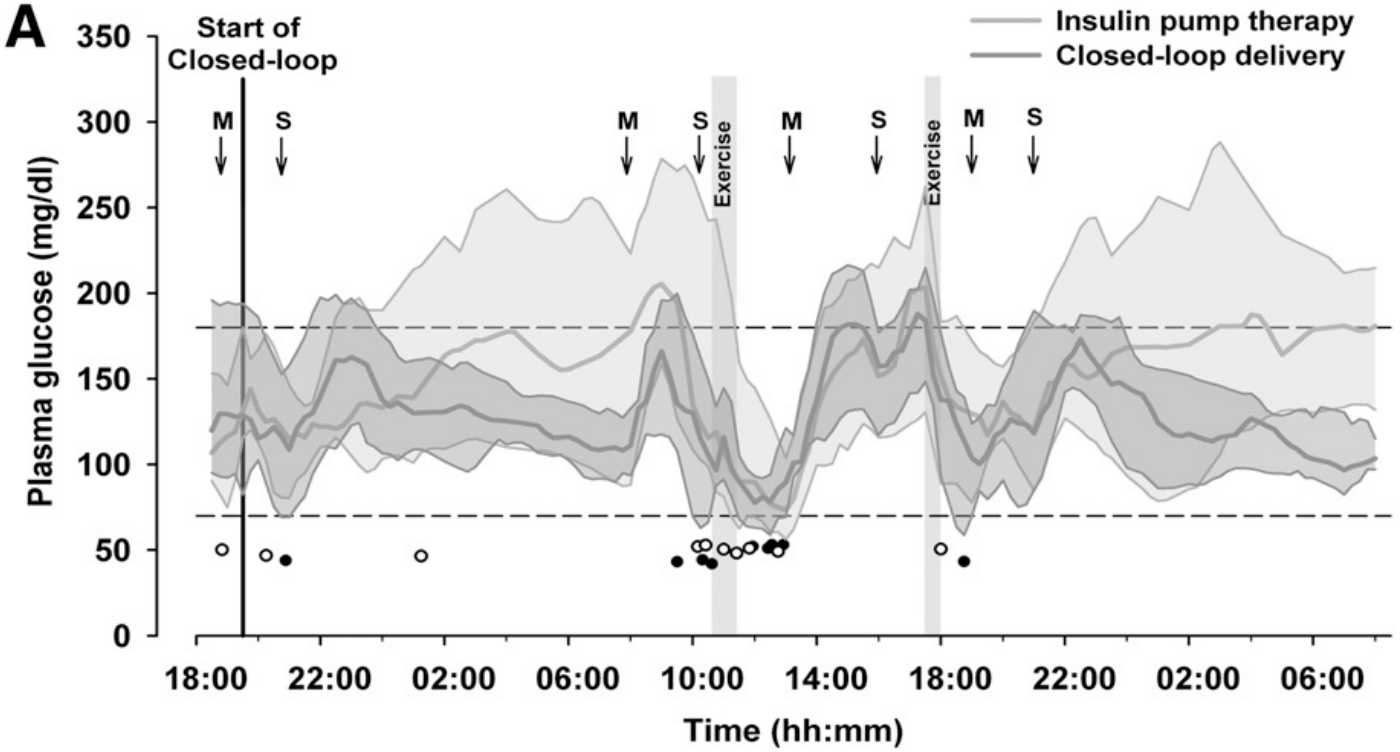
Closed loop systems

Closed loop systems - LGS



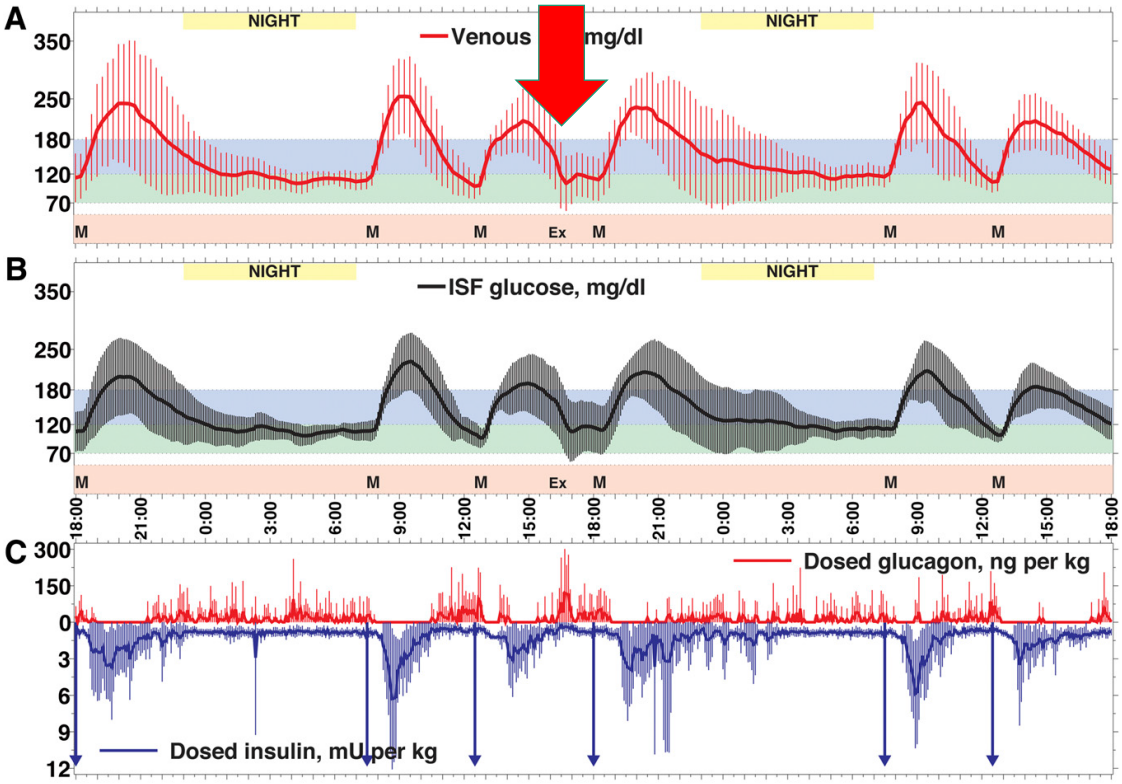
Garg et al (2012) *Diabetes Technology & Therapeutics* **14(3)**:205-209

Closed loop systems: insulin only



Elleri et al (2013) *Diabetes Care* 36:838-844

Closed loop systems: bi-hormonal



Russell et al (2012) *Diabetes Care* **35(11): 2148-2155**

Closed loop systems: overnight

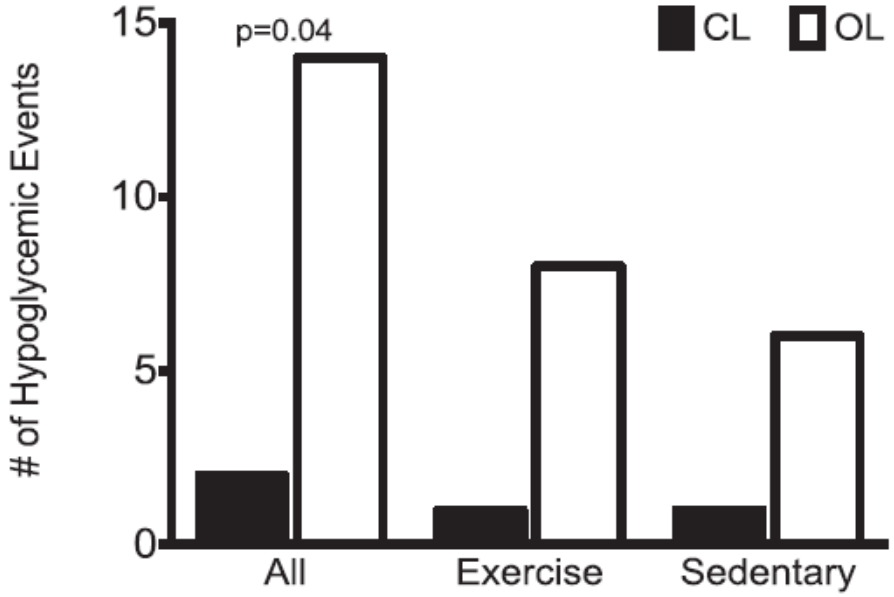
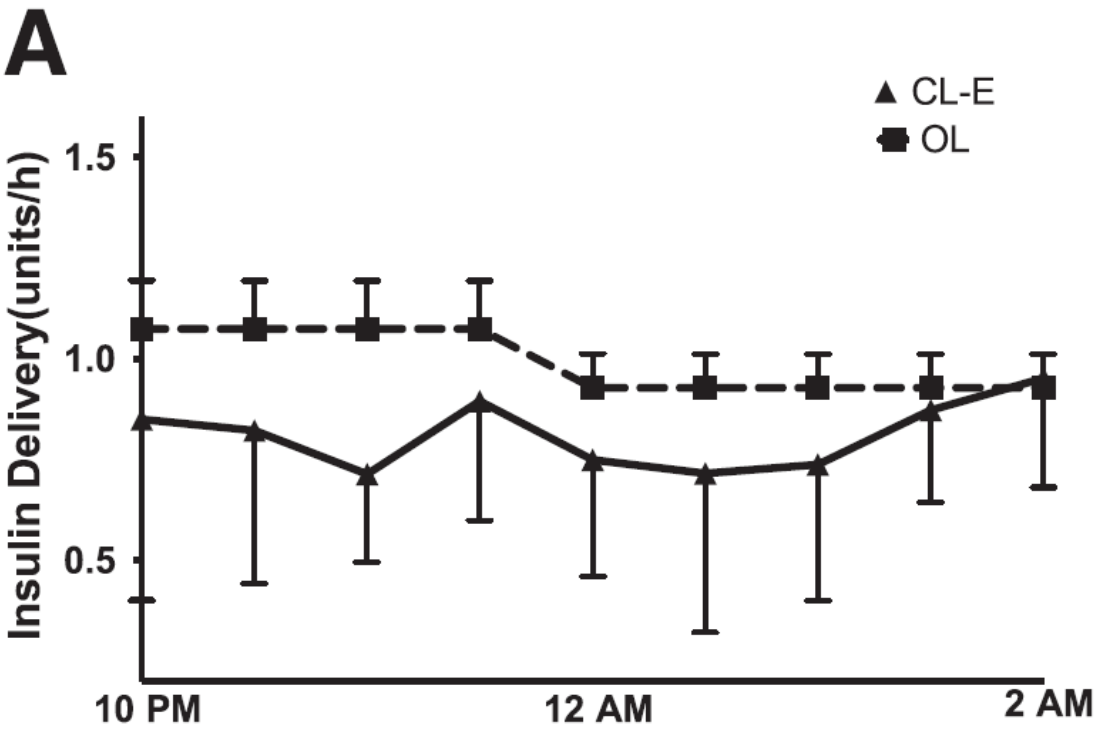


Figure 2—*Episodes of overnight treatable hypoglycemia (reference blood glucose <60 mg/dL) during OL and CL.*

Sherr et al (2013) *Diabetes Care* **36**:2909-2914

Closed loop systems: overnight



Sherr et al (2013) *Diabetes Care* **36**:2909-2914

The future?

- Can we use other ways to modify what the pump is doing?
- What about the pump algorithms learning from the pump user's experience?
- What about using technology we already own?

Oxford University Hospitals NHS
NHS Foundation Trust

EXTOD/JDRF PEAK programme

Conference 13 October 2017 in Birmingham

Discounts available for early bird registration and multiple bookings from the same centre

Details at

www.peak-extod.events

Oxford University Hospitals NHS
NHS Foundation Trust