NHS
Birmingham Women's and Children's
NHS Foundation Trust

Exercise & Type 1 Diabetes

Birmingham Women's & Childrens Hospital

Dietitians: John Pemberton

What today is about!

NHS
Birmingham Women's and Children's
NHS Foundation Trust

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

DH (2011) recommendations? Sport England interpretation

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

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 (≥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

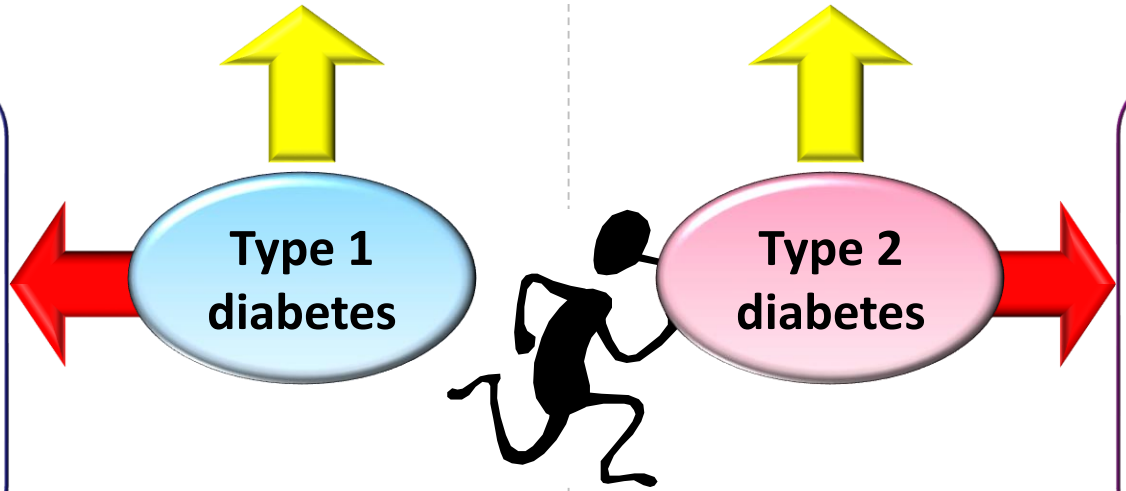
Kennedy A et al (2013) PLoS One 8:e58861

Beneficial

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

Uncertain / Limited data

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



Beneficial

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

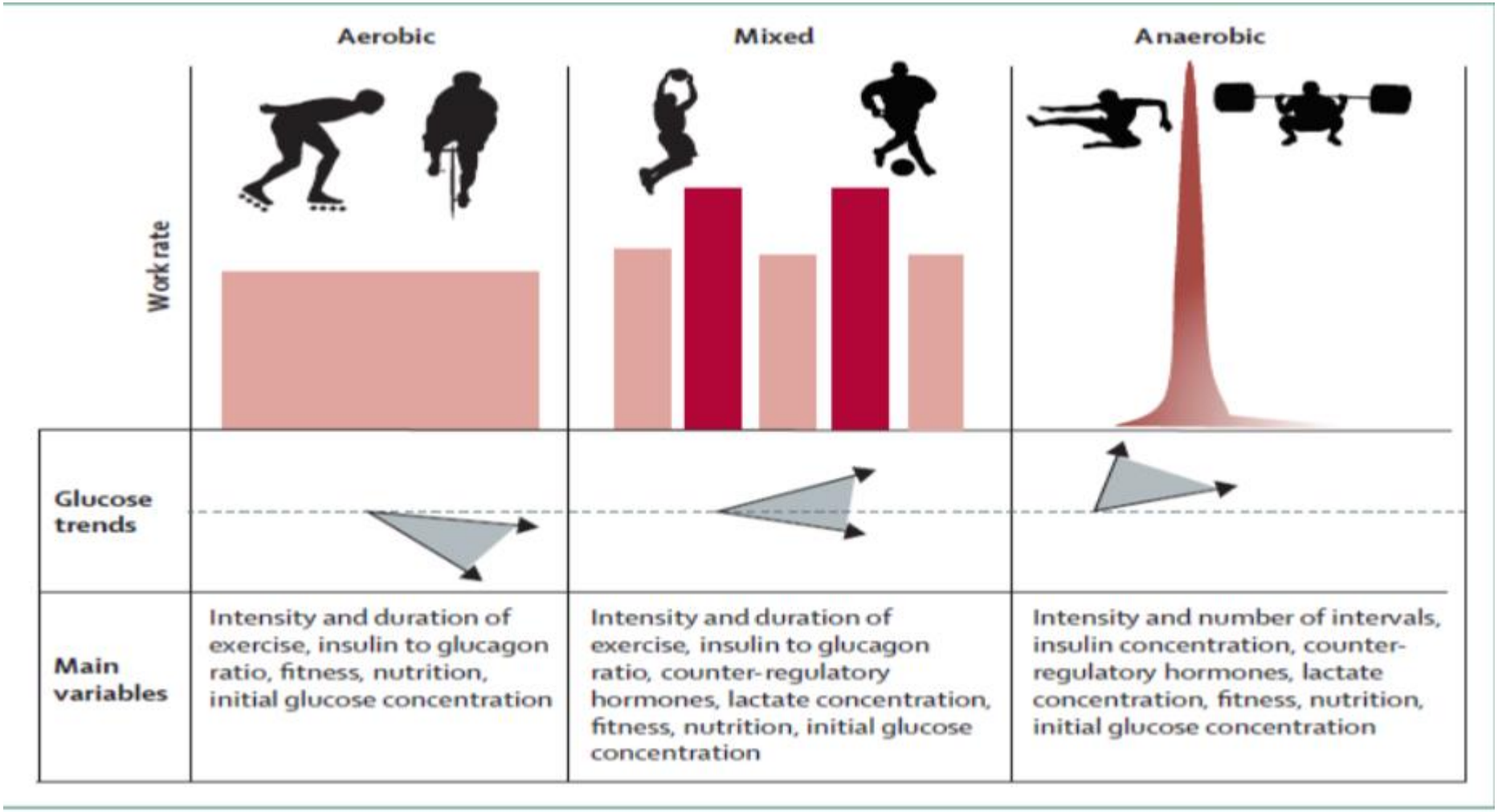
Uncertain / Limited data

- Microvascular complications
- Osteoporosis
- Cancer
- CVD
- Wellbeing

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

A fantastic infographic

NHS
Birmingham Women's and Children's
NHS Foundation Trust



Riddle et al. (2017) Exercise management in type 1 diabetes: a consensus statement.

Riddle and Pankowska Talk ISPAD 2012

Weightlifting, Track cycling

Track (sprinting & field events), Diving (Platform & springboard)

American football, Swimming (sprints), Gymnastics, Fencing

Wrestling, Volleyball, Ice hockey, Tree/rock climbing,

Basketball, Soccer, Racquet sports, Lacrosse

Speed skating (500-1000m)

Skiing (slalom & downhill), Field hockey

Jumping rope, Rowing (middle distance)

Gymnastics, Martial arts, Horseback ridding

Running (middle distance), Games like tag

Skateboarding

Road cycling

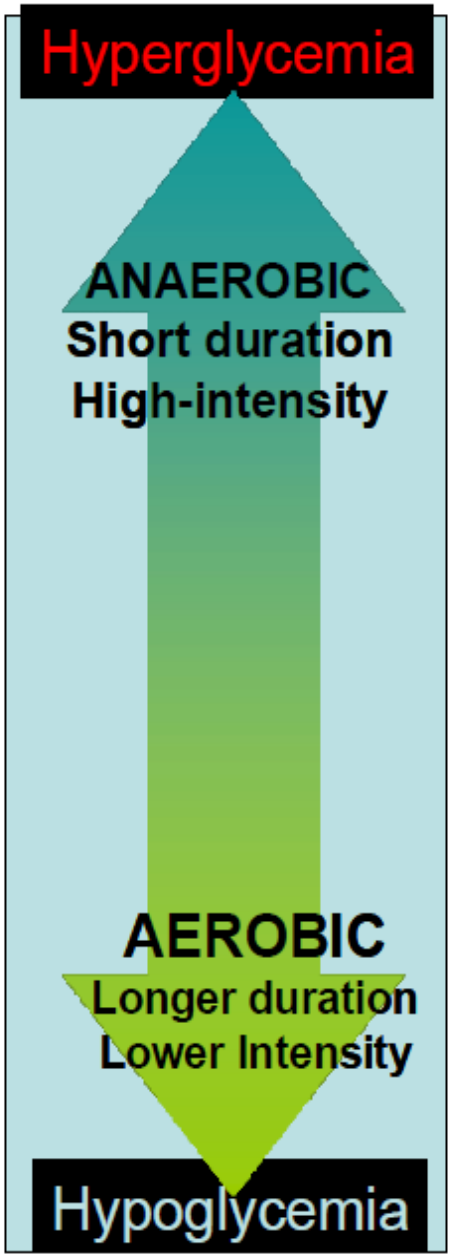
In-line skating

Cross country skiing

Brisk walking

Marathon running

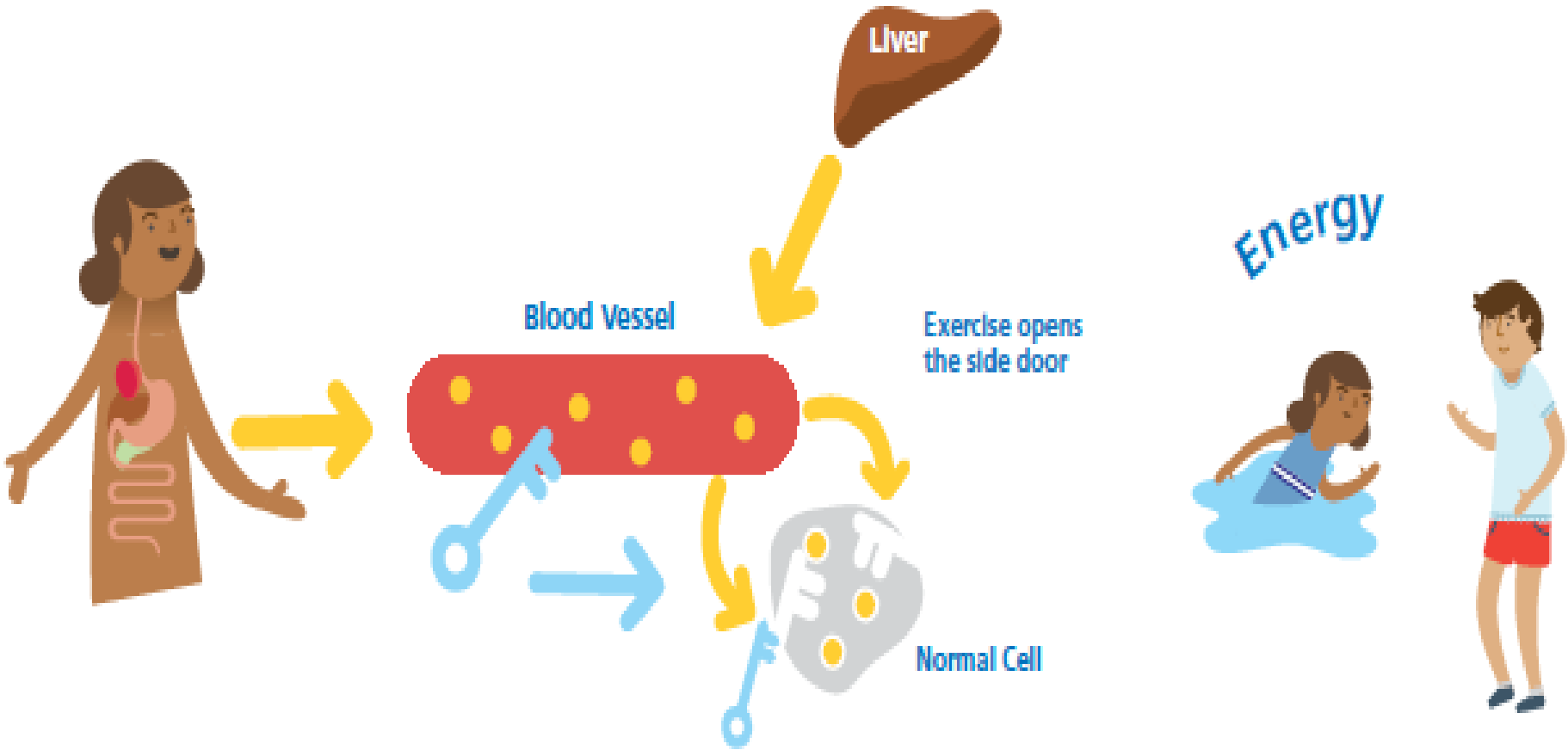
Triathlon



Aerobic / Continuous Exercise

NHS
Birmingham Women's and Children's
NHS Foundation Trust

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



What are your options for aerobic / continuous exercise?

NHS
Birmingham Women's and Children's
NHS Foundation Trust

12 year old boy – 50kg

Brisk walking to school 30 minutes morning after breakfast.

Brisk walking home after school 30 minutes

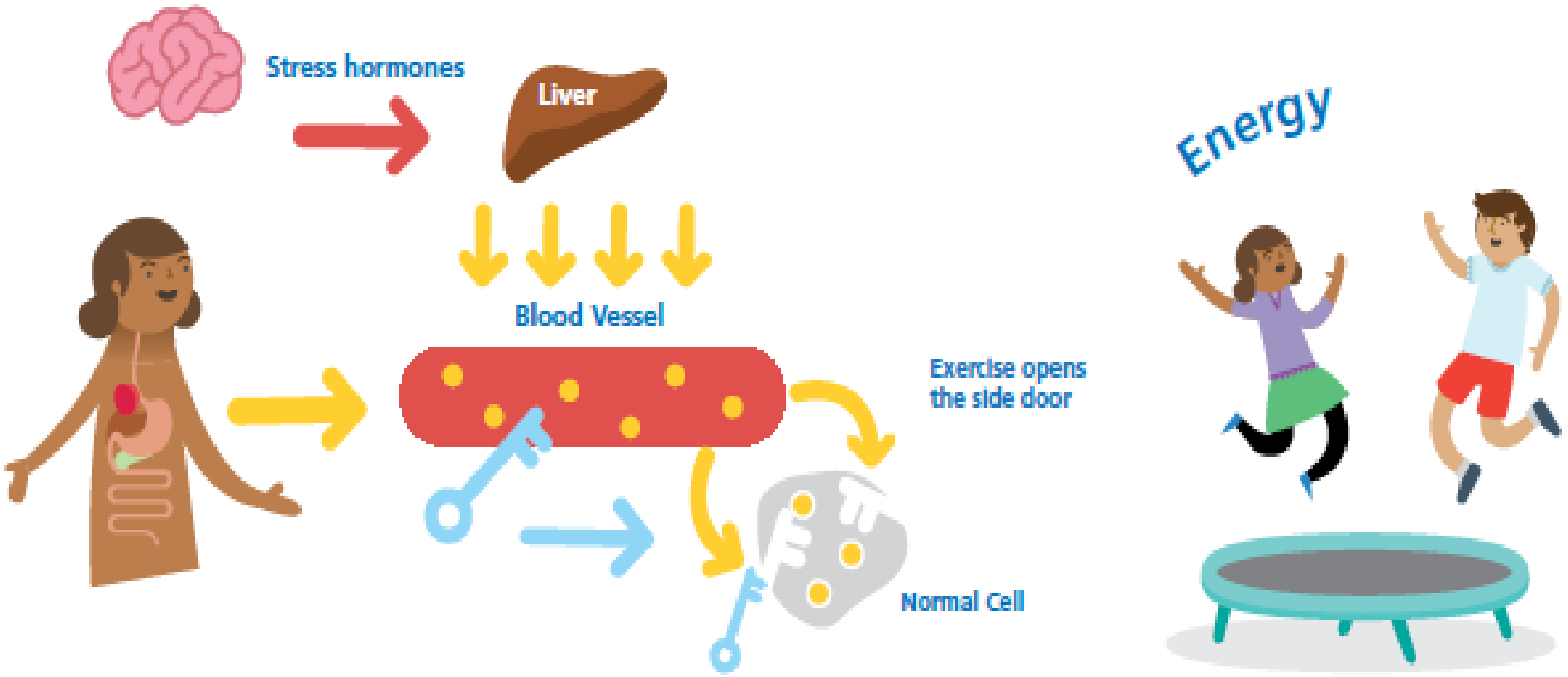
14 year old girl – 50kg

60 minutes swimming before breakfast

Anaerobic / Short Sharp Exercise

NHS
Birmingham Women's and Children's
NHS Foundation Trust

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



What are your options for Supra-maximal exercise during activity?

Birmingham Women's and Children's NHS Foundation Trust

17 year old boy – 60kg

Weights session after school 16:30, no meal before

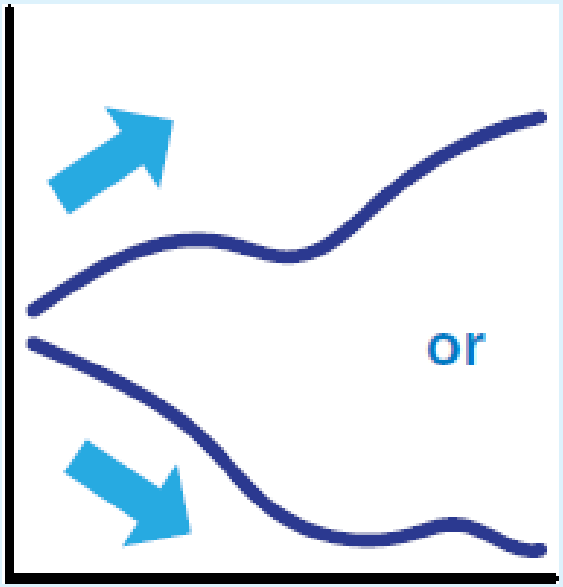
14 year old girl – 50kg

60 minute sprint training session 18:00 after evening meal 17:00

Mixed / Intermittent Exercise

NHS
Birmingham Women's and Children's
NHS Foundation Trust

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.

What are your options for intermittent exercise?

Birmingham Women's and Children's NHS Foundation Trust

13 year old boy – 40kg

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

13 year old girl – 40kg

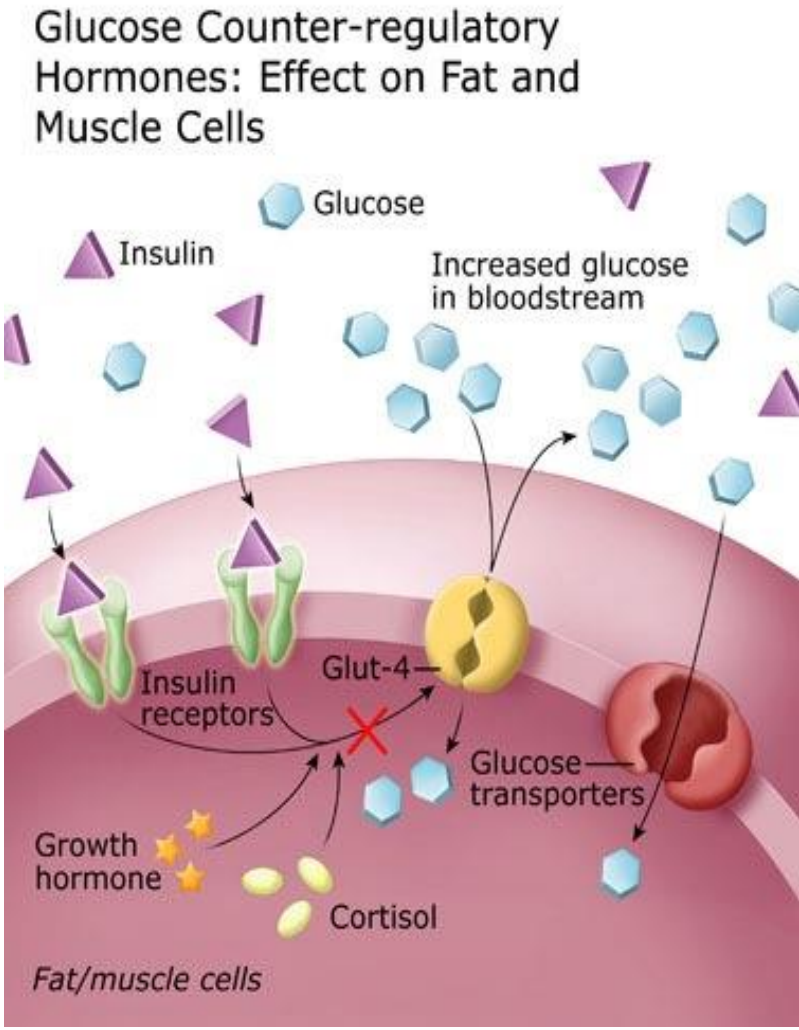
Netball after school practice 15:30 "easy practice" after school 60 minutes, last meal 12:30 - Lunch

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

Birmingham Women’s and Children’s NHS Foundation Trust

With thanks to Francesca Annan RD

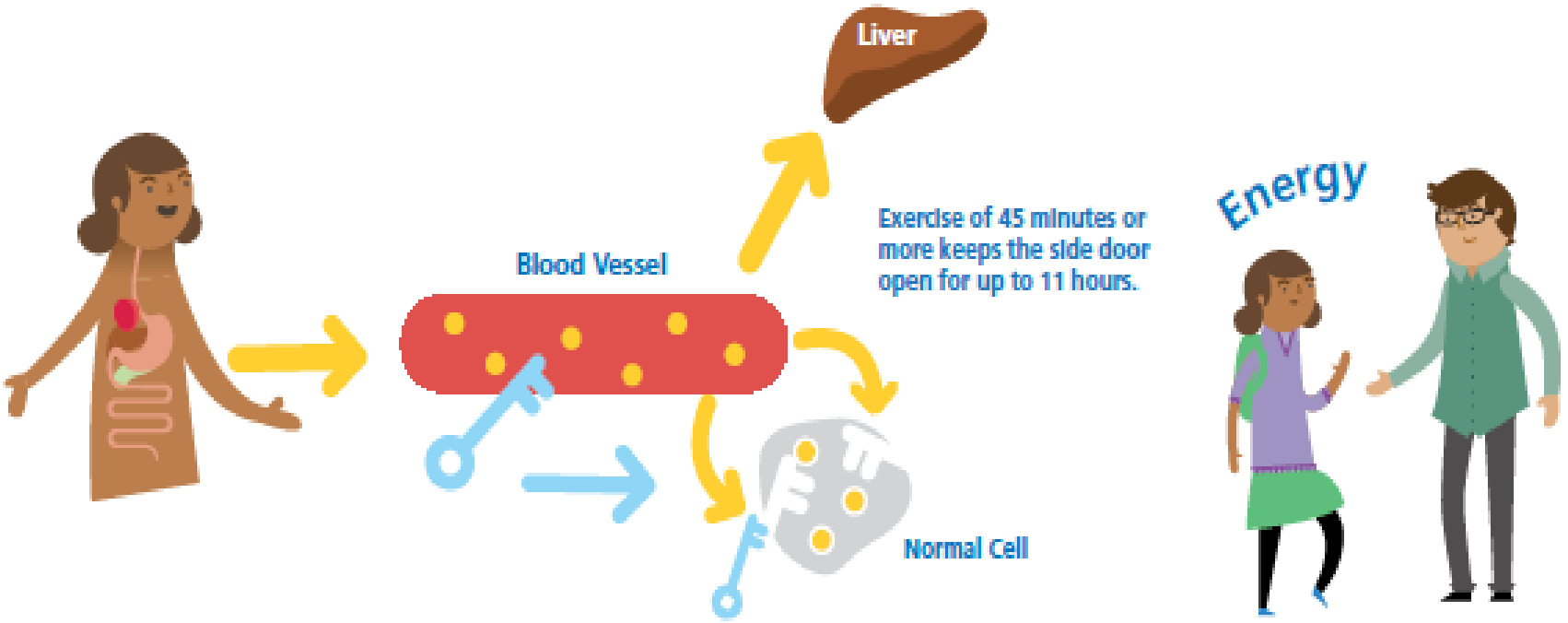
- Adrenaline, Cortisol, Glucagon = “Glucose release & insulin resistance”
- Anaerobic or hard intermittent
- Disconnected pump
- Cool Down



After Exercise

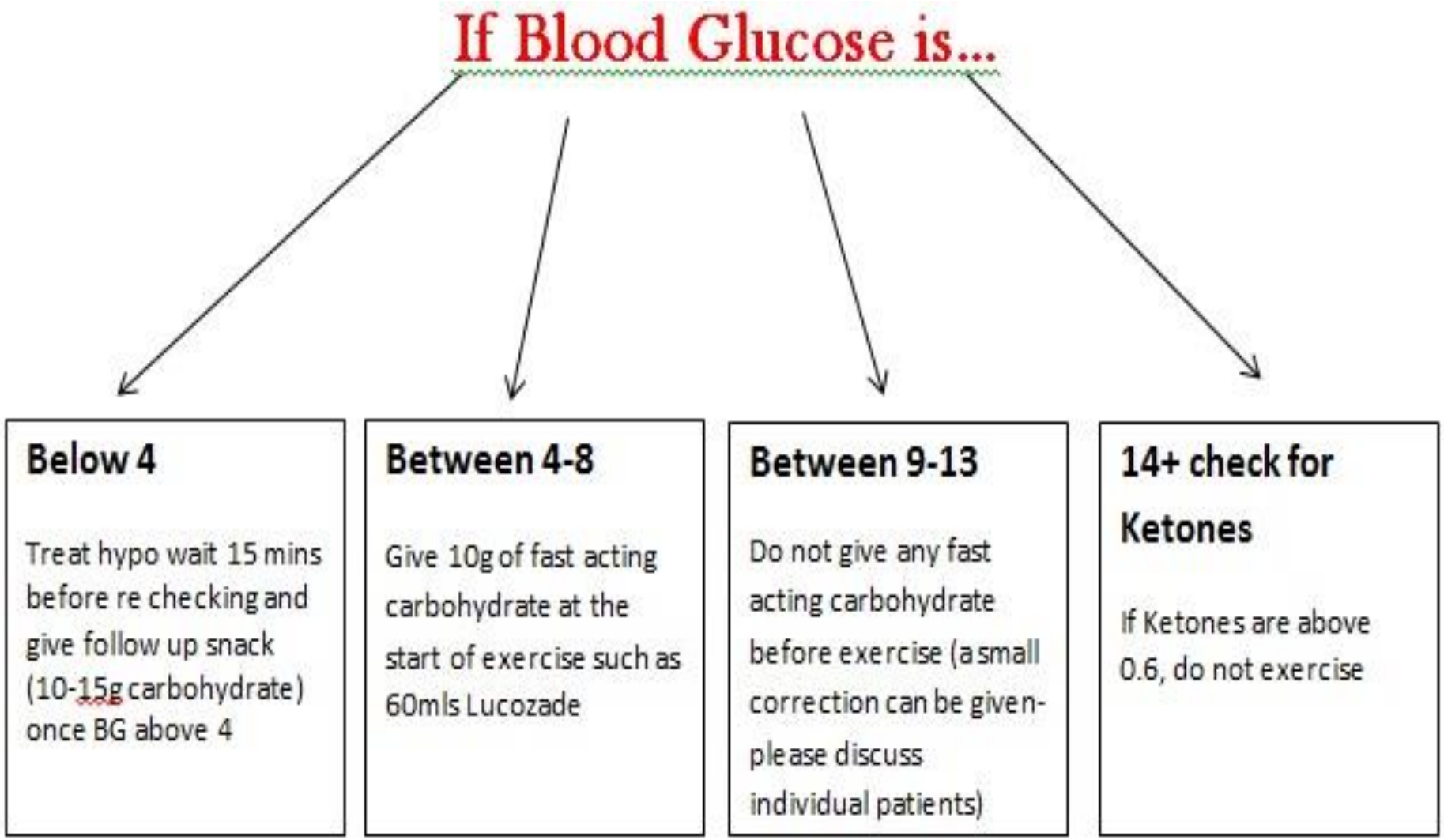
NHS
Birmingham Women's and Children's
NHS Foundation Trust

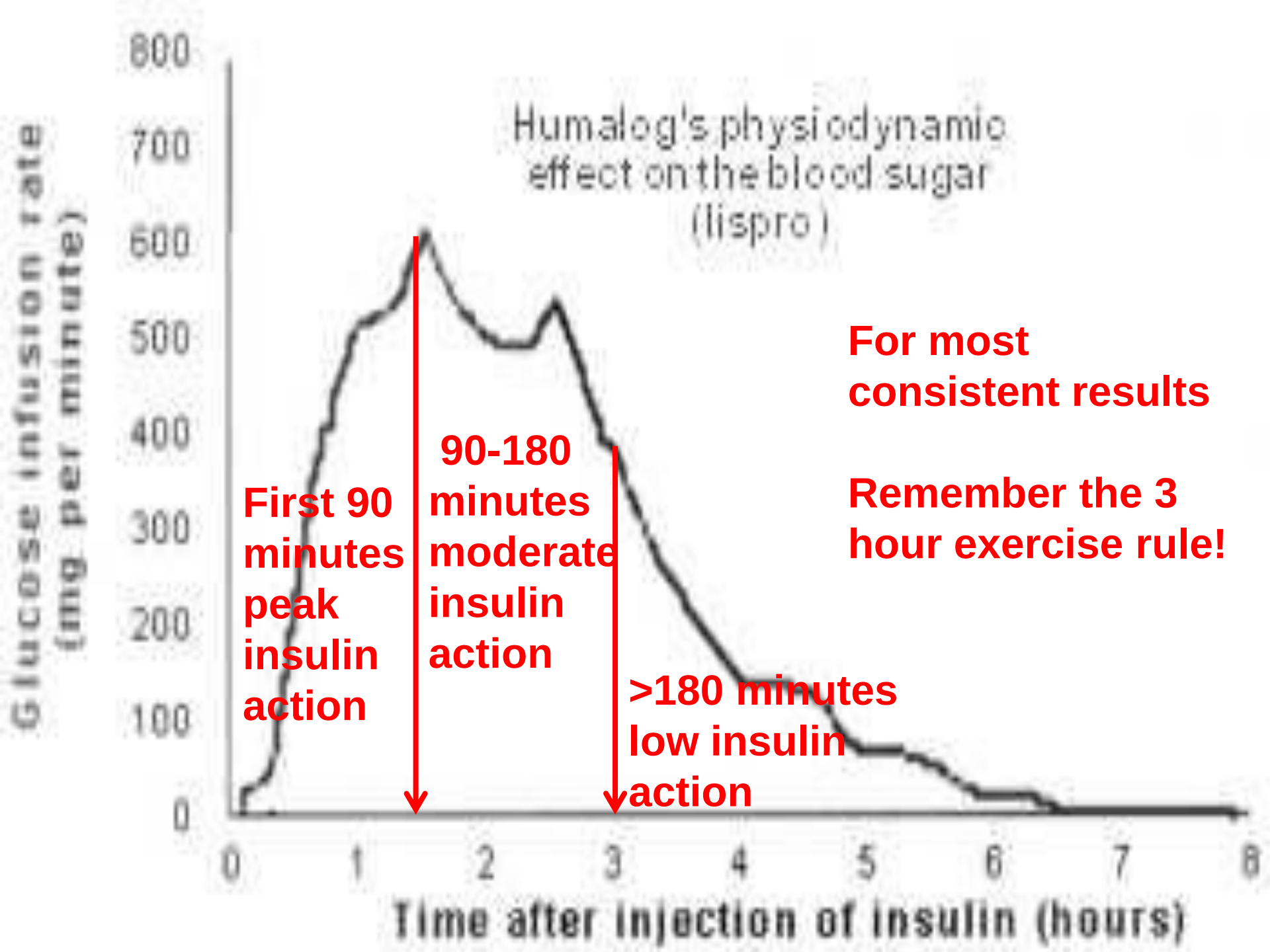
Effect of exercise on blood glucose after activity



The Standard

Birmingham Women's and Children's NHS Foundation Trust




Humalog's physiodynamic effect on the blood sugar (lispro)
Glucose infusion rate (mg per minute)
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
Time after injection of insulin (hours)
First 90 minutes peak insulin action
90-180 minutes moderate insulin action
>180 minutes low insulin action
For most consistent results
Remember the 3 hour exercise rule!

ADA position statement

Diabetes Care 2016;39:2065–2079 | DOI: 10.2337/dc16-1728

NHS
Birmingham Women's and Children's
NHS Foundation Trust

Table 2—Suggested initial pre-exercise meal insulin bolus reduction for activity started within 90 min after insulin administration

	Exercise duration	
Exercise intensity	30 min	60 min
Mild aerobic (~25% VO_{2max})	−25%*	−50%
Moderate aerobic (~50% VO_{2max})	−50%	−75%
Heavy aerobic (70%−75% VO_{2max})	−75%	N-A
Intense aerobic/anaerobic (>80% VO_{2max})	No reduction recommended	N-A

Recommendations compiled based on four studies (94–97). N-A, not assessed as exercise intensity is too high to sustain for 60 min. *Estimated from study (95).

Studies on aerobic moderate intensity exercise and the reductions are likely to be less for intermittent and high intensity activities

BWCH: Insulin reductions within 90 minutes of exercise

NHS
Birmingham Women's and Children's
NHS Foundation Trust

	Anaerobic Short-Sharp		Intermittent Mixed		Aerobic Continuous	
	<30 mins	>30mins	<30 mins	>30mins	<30 mins	>30mins
RPE 3-5	N/A	N/A	-35%	-45%	-25%	-50%
RPE 5-7	N/A	N/A	-25%	-35%	-35%	-65%
RPE 7-10	N/A	N/A	-15%	-25%	-50%	-75%

Recommendations: Carbohydrate during activity

Birmingham Women's and Children's NHS Foundation Trust

- Aerobic exercise extra carbohydrate:
  - If no adjustment to pre-meal insulin delivery has occurred:
    - 1.0g/kg of carbohydrate per kg per hour
  - Where pre-exercise insulin has been reduced
    - 0.5 g/kg of carbohydrate per hour
- Mixed / intermittent the carbohydrate requirement will be less.
  - If no adjustment to pre-meal insulin delivery has occurred:
    - 0.5 g of CHO per kg per hour
  - Where pre-exercise insulin has been reduced:
    - 0.25 g/kg per hour

BWCH: Carbohydrate during activity
If glucose in target

Birmingham Women's and Children's NHS Foundation Trust

Carbohydrate Requirement g/kg/hr (grams per kilogram per hour)

	Anaerobic Short-Sharp		Intermittent Mixed		Aerobic Continuous	
	Insulin reduction	No insulin reduction	Insulin reduction	No insulin reduction	Insulin reduction	No insulin reduction
RPE 3-5	0.075	0.01	0.15	0.25	0.3	0.5
RPE 5-7	0.125	0.15	0.225	0.375	0.45	0.75
RPE 7-10	0.15	0.2	0.3	0.5	0.6	1.0

Recommendations: After exercise

Birmingham Women's and Children's NHS Foundation Trust

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

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

Six Key questions

NHS
Birmingham Women's and Children's
NHS Foundation Trust

- **Therapy: Pump or MDI?**
- **What type of activity will they be doing?**
  - Aerobic/ Anaerobic/ Intermittent
- **When eating and bolusing prior to activity?**
  - Within 90 mins/ >90 minutes
- **How long?**
  - Minutes
- **How intense will they be working out of 10?**
  - Light: 3 – 5
  - Medium: 5 – 7
  - High: 7 – 10
- **Are they eating after the activity?**

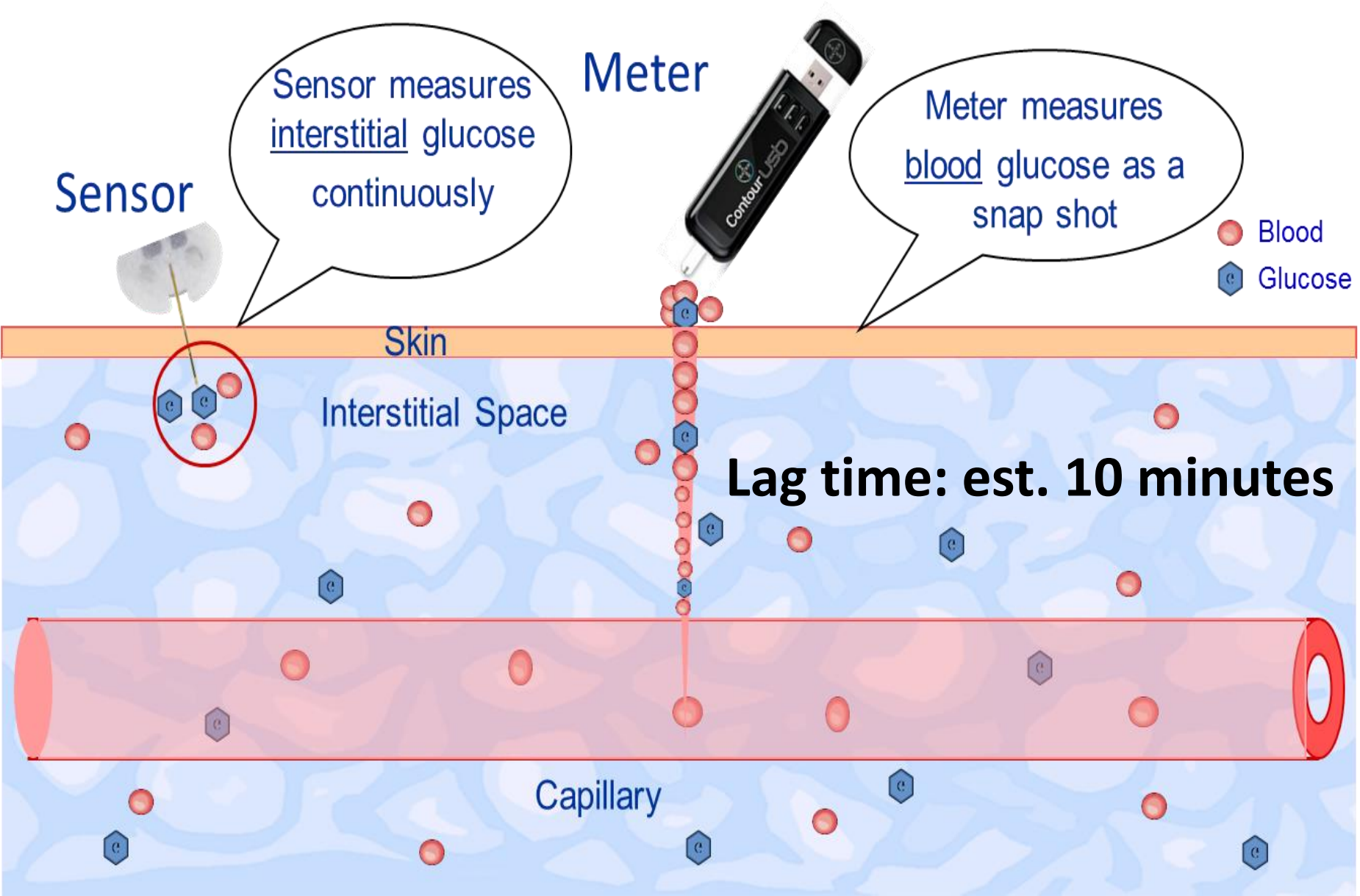
Basic Calculator

NHS
Birmingham Women's and Children's
NHS Foundation Trust

- **Live Example**

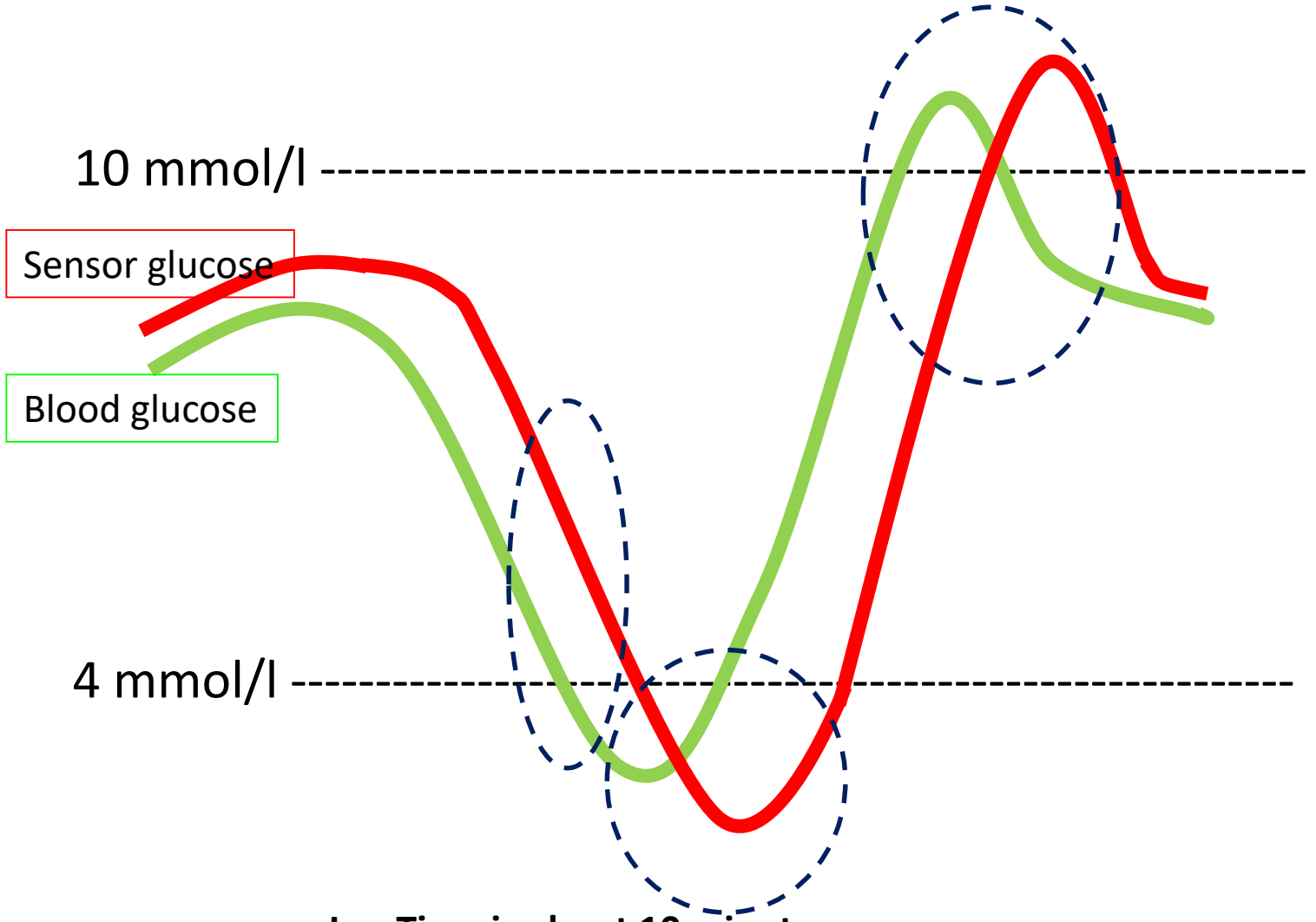

CGM – it's the future!

Where Sensors and Meters Measure



Differences – blood glucose vs sensor glucose

NHS
Birmingham Women's and Children's
NHS Foundation Trust



Lag Time is about 10 minutes

Libre:
What do the arrows mean?

NHS
Birmingham Women's and Children's
NHS Foundation Trust

Trend Arrow	Description	Where the blood glucose is now (10 minutes ahead)
	Rising quickly	2mmol/l higher
	Rising	1mmol/l higher
	Stable	Same
	Falling	1 mmol/l lower
	Falling quickly	2mmol/l lower

What's on offer?

Birmingham Women's and Children's NHS Foundation Trust

	Medtronic 640G with smart guard and VEO with Low Glucose Suspend	Dexcom CGM G4	Dexcom CGM G5	Freestyle Libre
				
	This is an integrated system where insulin pump acts as a receiver of CGM data. The auto suspend feature helps in suspending the pump if glucose level hits a threshold (VEO) or is predicted to hit a threshold in the next 30 minutes (640G)	Continuous Glucose monitoring system which can be used alone or integrated with animas pump where CGM data can be viewed on the pump. A Newer version G5 is available in the market which is the first and only remote glucose monitoring system.	Continuous Glucose monitoring system which can be used alone. It can send data wirelessly to a compatible smart phone. It is FDA approved to make treatment decisions upon it's results.	Flash glucose monitoring system. Monitor when scanned over transmitter gives the current sugar reading. It provides the glucose history for previous 8 hours **13.6% Paeds**
	13.6%	13.0%	10% - Paediatrics	11.4%
ment	Every 5 mins	Every 5 mins	Every 5 mins	Every second (when flashed)
	Age 2 and above	Age 2 and above	Age 2 and above	Age 4 and above
				
	6 days	7 days	7 days	14 days

CGM Accuracy during exercise
Bracken et al (2018) Review

Birmingham Women's and Children's NHS Foundation Trust

- Solutions to make CGM more reliable during exercise:
  - Last meal insulin 3hrs before exercise – Check IOB???
  - Set low alarm at 6.0mmol/l
  - Hydrate effectively
  - Set rate of change alarms: if goes off use BG not SG
    - 0.17mmol/l per min
    - 1.7mmol/l in 10 mins
    - One arrow down (Libre & Dexcom)
    - Two Arrows down (Medtronic)
  - Sensor placed away from exercising muscle

Medtronic Minimed 640G & VEO	Dexcom G4 & G5	Abbott Libre & Navigator	Change in glucose mmol/l in 15 minutes	Real life speak	SG 6.0 mmol/l expected SG range mmol/l in 15 minutes	SG 12mmol/l expected SG range mmol/l in 15 minutes
	→	→	0.0 - 0.8	Stable	5.2 - 6.8	11.2 - 12.8
↓	↘	↘	0.8 - 1.7	Falling slowly	4.3 - 5.2	10.3- 11.2
↓↓	↓	↓	>1.7	Falling qucikly	<4.3	<10.3
↓↓↓ Minimed 640G	↓↓ G5		>2.5	Falling rapidly	<3.5	<9.5
↑	↗	↗	0.8 - 1.7	Rising slowly	6.8 - 7.7	12.8 - 13.7
↑↑	↑	↑	1.7- 2.5	Rising quickly	>7.7	>13.7
↑↑↑ Minimed 640G	↑↑ G5		>2.5	Rising rapidly	>8.5	>14.5

How much carbohydrate for 45 minutes of football?

Birmingham Women's and Children's NHS Foundation Trust

- Blood Glucose 6.0 mmol/l

The BCH CGM Calculator

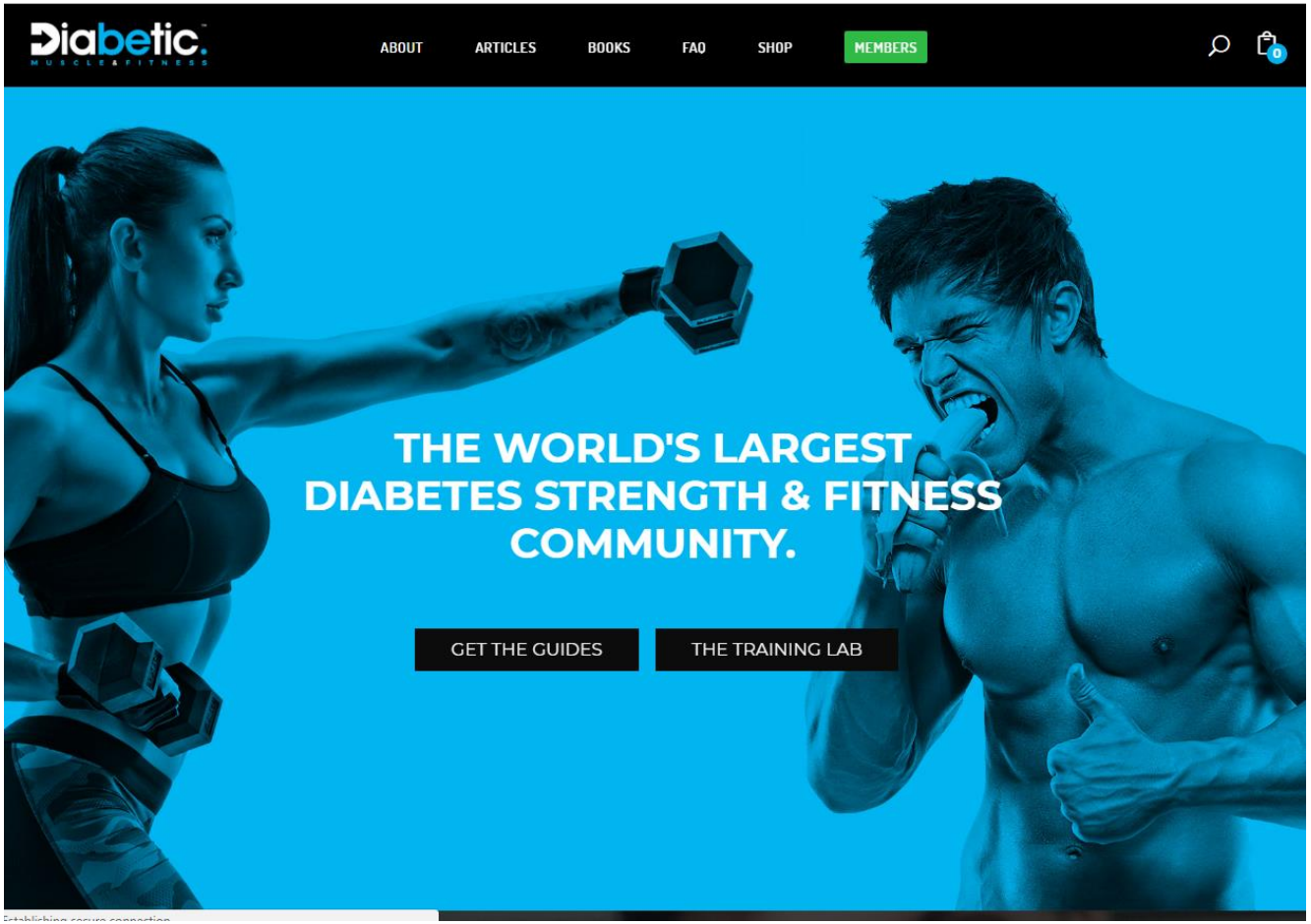
Example

Monitoring

NHS
Birmingham Women's and Children's
NHS Foundation Trust

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

www.diabeticmuscleandfitness.com



What I was hoping?

Birmingham Women's and Children's NHS Foundation Trust

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

References Exercise

NHS
Birmingham Women's and Children's
NHS Foundation Trust

- Galassetti & Riddle (2013) Exercise and Type 1 Diabetes**. *Compr Physiol* 3:1309-1336, 2013**

- Riddell, M.C., Gallen, I.W., Smart, C.E., Taplin, C.E., Adolfsson, P., Lumb, A.N., Kowalski, A., Rabasa-Lohert, R., McCrimmon, R.J., Hume, C., Annan, F., Fournier, P.A., Graham, C., Bode, B., Galassetti, P., Jones, T.W., Millan, I.S., Heise, T., Paters, A.L., Peta, A., Laff, L.M. (2017) Exercise management in type 1 diabetes: a consensus statement. ***Lancet Diabetes Endocrinology* 2017: January 23, 2017 http://dx.doi.org/10.1016/ S2213-8587(17) 30014-1**

- Robertson, k. et al (2014) Exercise in children and adolescents with diabetes. ISPAD Clinical Practice Consensus Guidelines Compendium 2014 Chapter 14. ***Pediatric Diabetes* 10 (Suppl, 12): 154 – 168.**

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

References CGM

Birmingham Women's and Children's NHS Foundation Trust

- Braken et al (2018) CGM and Exercise Review - **Nutrients 2018, 10, 93; doi:10.3390/nu10010093**

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

- Moser, O., Mader, J.K., Tschakert, G., Muller, A., Groschel, W., Pieber, T.R., Koehler, G., Messerschmidt, J., Hoffman, P. (2016) Accuracy of Continuous Glucose Monitoring (CGM) during Continuous and High-Intensity Interval Exercise in Patients with Type 1 Diabetes Mellitus**. *Nutrients* 2016, 8, 489;**

- Taleb N, Emami A, Suppere C, et al. (2016) Comparison of two continuous glucose monitoring systems, Dexcom G4 Platinum and Medtronic Paradigm Veo Enlite System, at rest and during exercise**. *Diabetes Technol Ther*; 18: 561–77.**

- Yardley JE, Sigal RJ, Kenny GP, Riddell MC, Lovblom LE, Perkins BA. Point accuracy of interstitial continuous glucose monitoring during exercise in type 1 diabetes. ***Diabetes Technol Ther* 2013; 15: 46–49.**