Strategies to control glucose before, during and after exercise

Parth Narendran – University of Birmingham

Rob Andrews – University of Exeter

ABCD
Association of British Clinical Diabetologists

JDRF PEAK
T1D Performance in Exercise and Knowledge

extod

Rob Andrews - conflict of interest

Investigator on

- Bariatric study -By-Band-sleeve study
- Lifestyle studies -Early ACTID, EXTOD, EXTOD education

Presentations

- Talk on education days sponsored by Novo-Nordisk, Lilly, MSD, Astra-Zeneca

Positions

- Chair of Clinical study group 3 – prevention + treatment T2DM
- Member of Royal College Obesity Forum

Parth Narendran - conflict of interest

Investigator on

- EXTOD, EXTOD education, EXTOD mechanisms

Presentations

- Talk on education days sponsored by Lilly, Astra-Zeneca

Positions

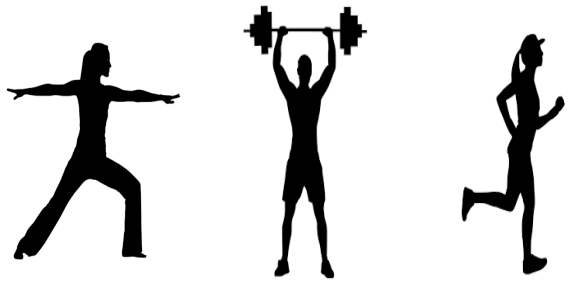
- Executive and Research Board Member – DAFNE
- Research Committee Member – Diabetes UK

What we will cover

- Preparing for exercise
- Controlling glucose during exercise
- Controlling glucose post exercise
- Role of diet in exercise

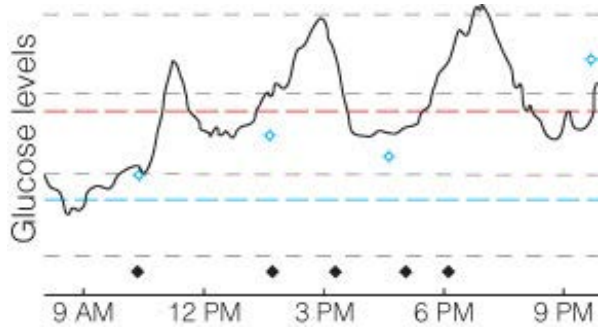
ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Considering exercise – three things to think about



The exercise

Time of day

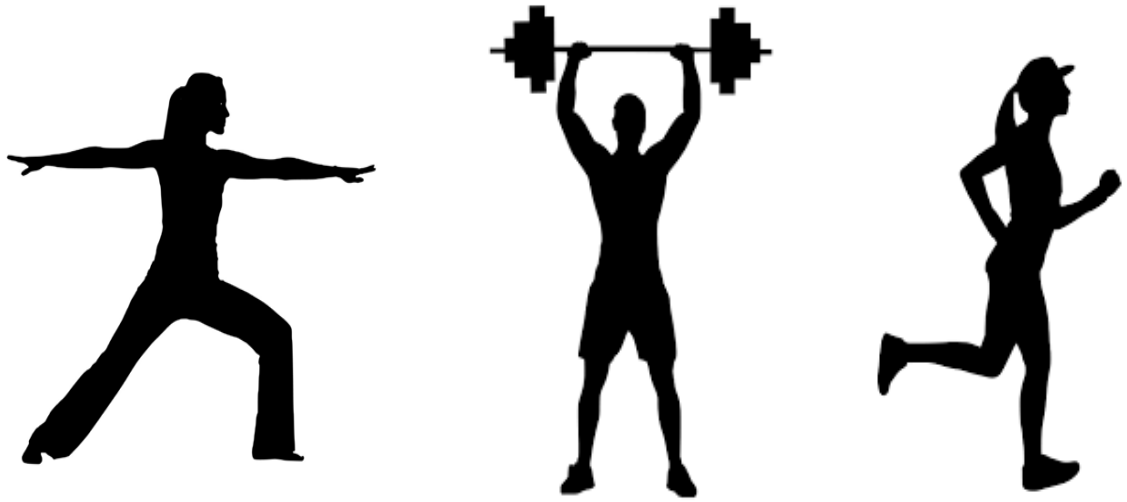


Glucose level

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

The exercise – three things need to know

- Type of exercise
- Intensity of exercise
- Length of exercise



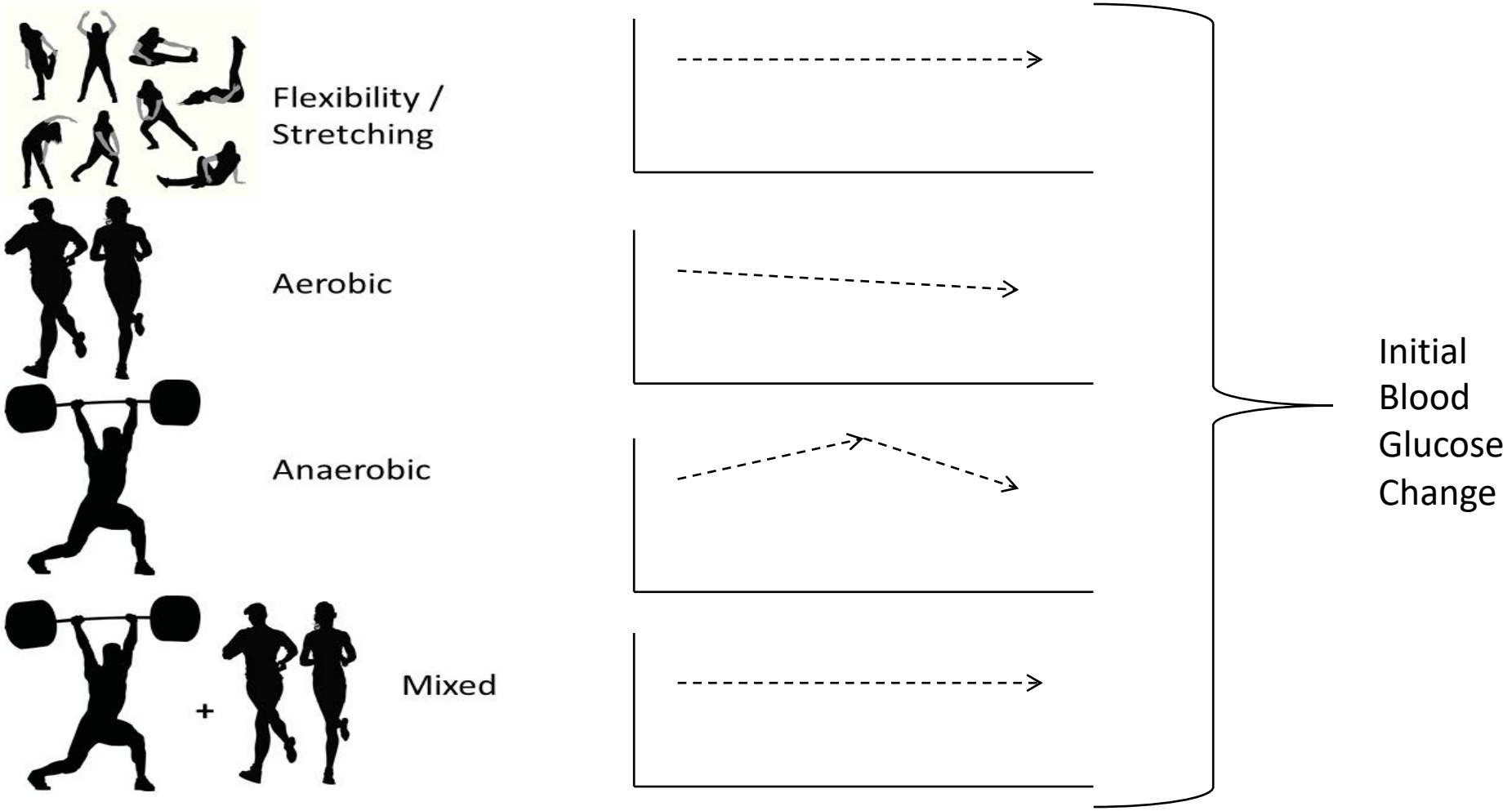
Three types of exercise

Flexibility

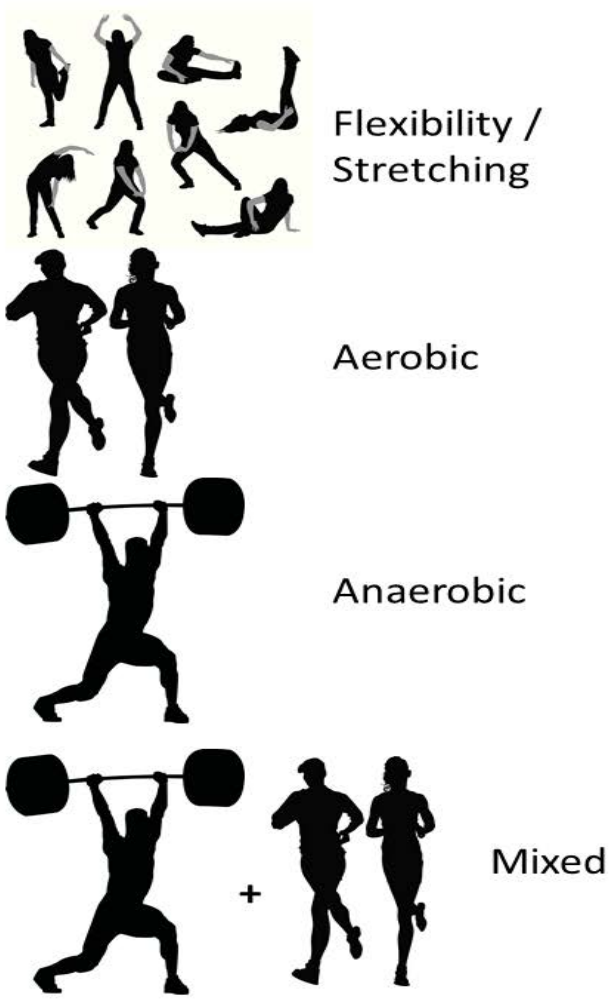
Anaerobic

Aerobic

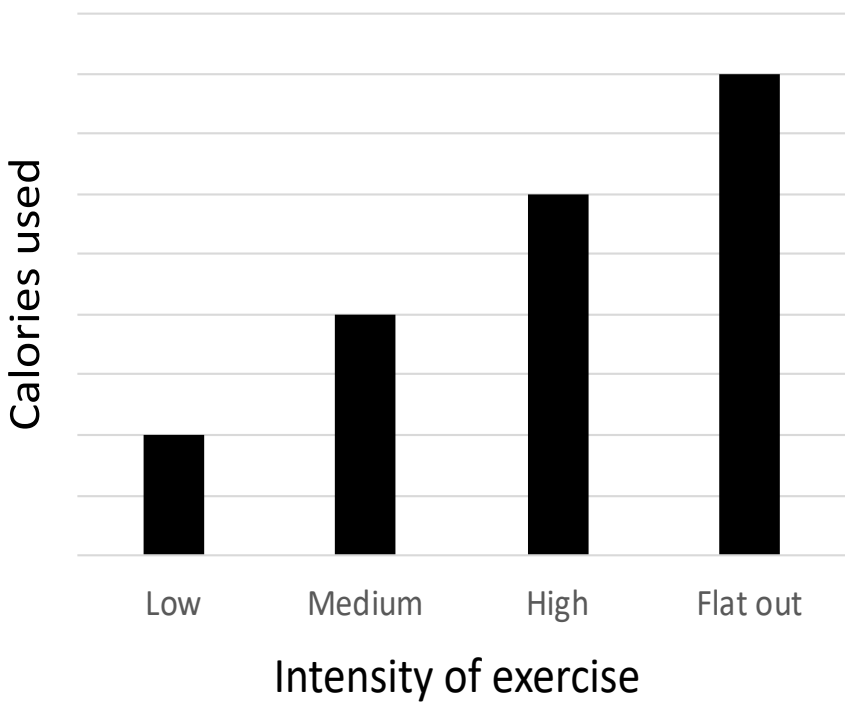
Normal glucose responses to different exercises

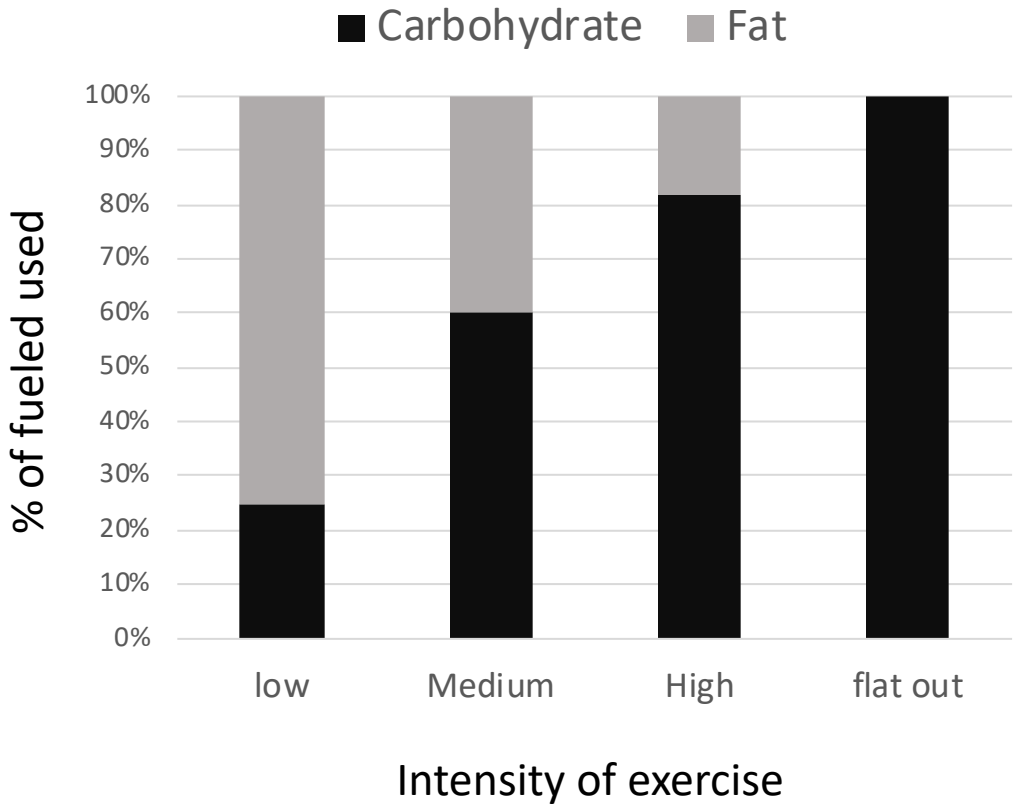


Glucose responses to different exercises in T1D

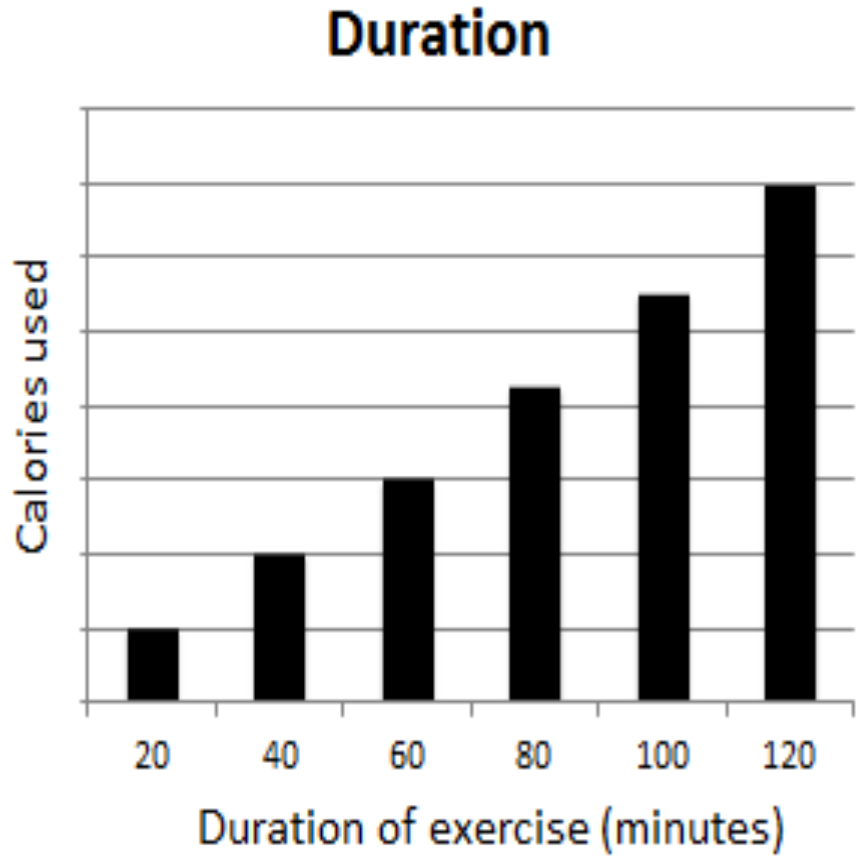


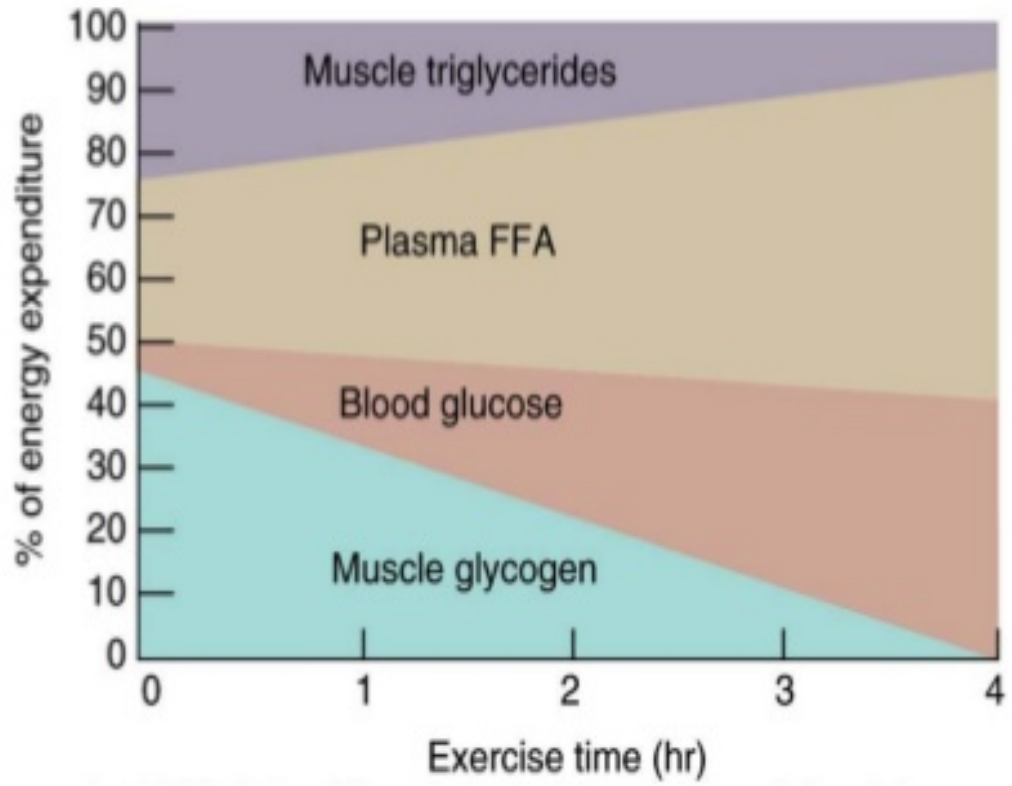
Intensity of exercise





Length of exercise





Summary 1

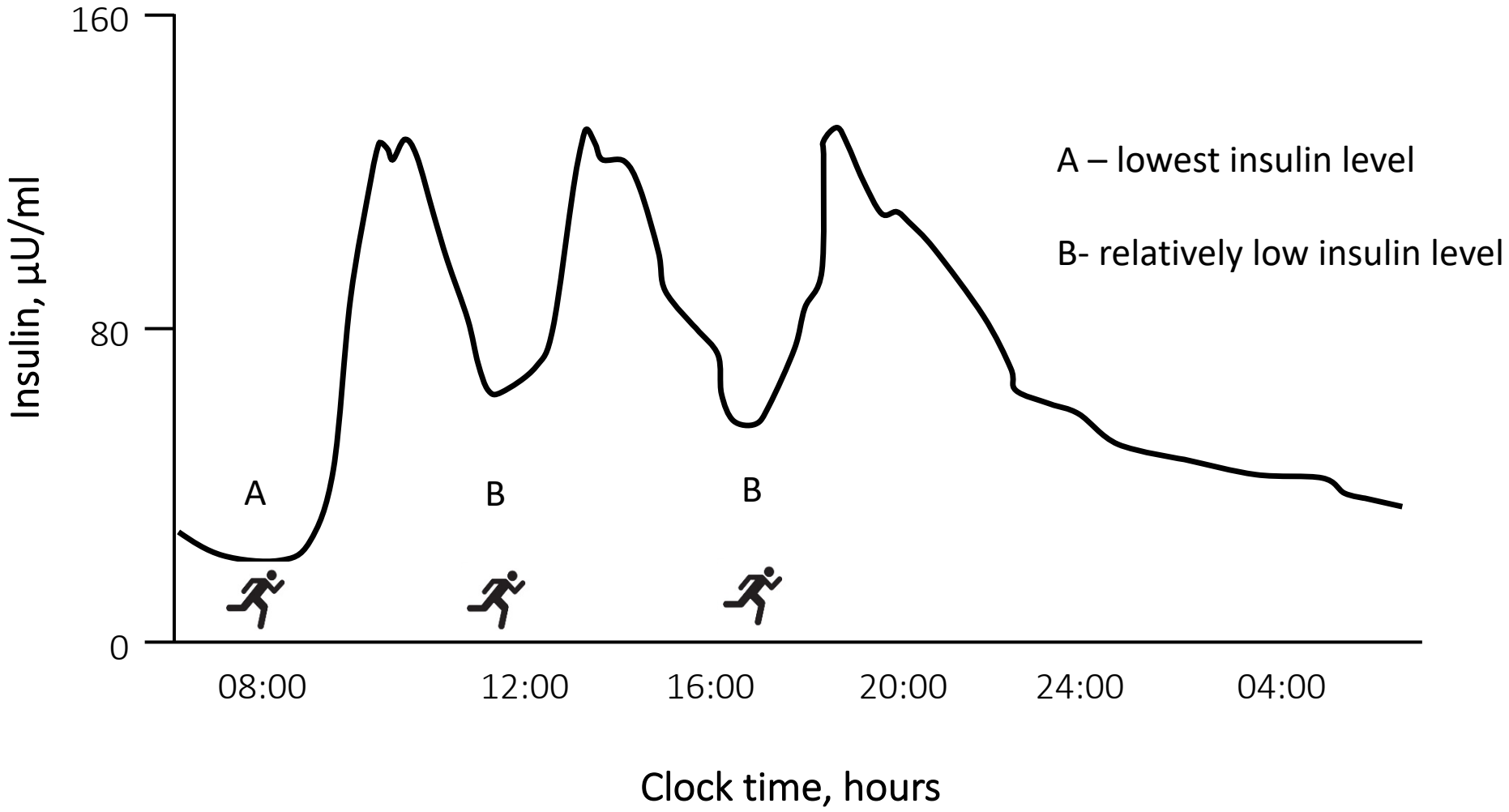
- Type of exercise will effect direction glucose goes in
- Intensity of exercise will determine amount of glucose used
- Length of exercise will determine amount of glucose used

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Time of day – three things to think about

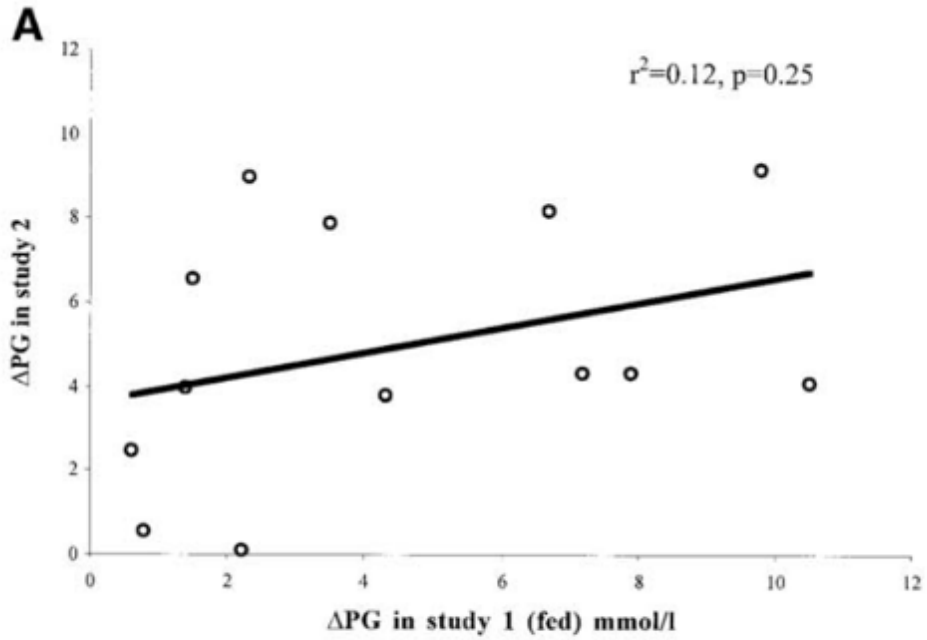
- Prevailing Insulin concentration
- When last ate
- Am or PM

Prevailing insulin levels



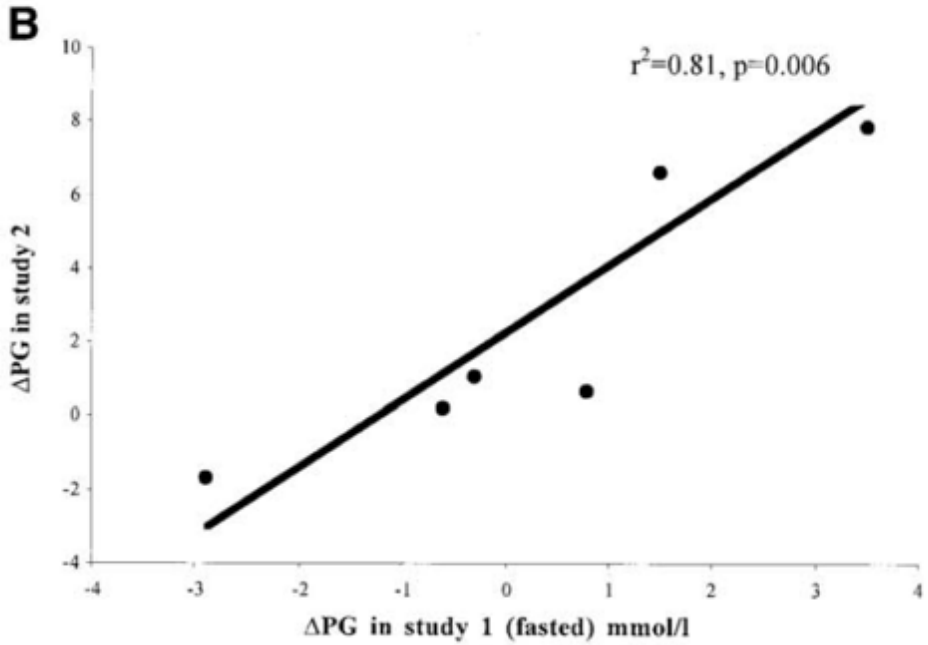
Glucose response to exercise Fed vs fasted

Fed



Poor reproducibility in the blood glucose response to aerobic exercise in individuals with T1D in the post meal state

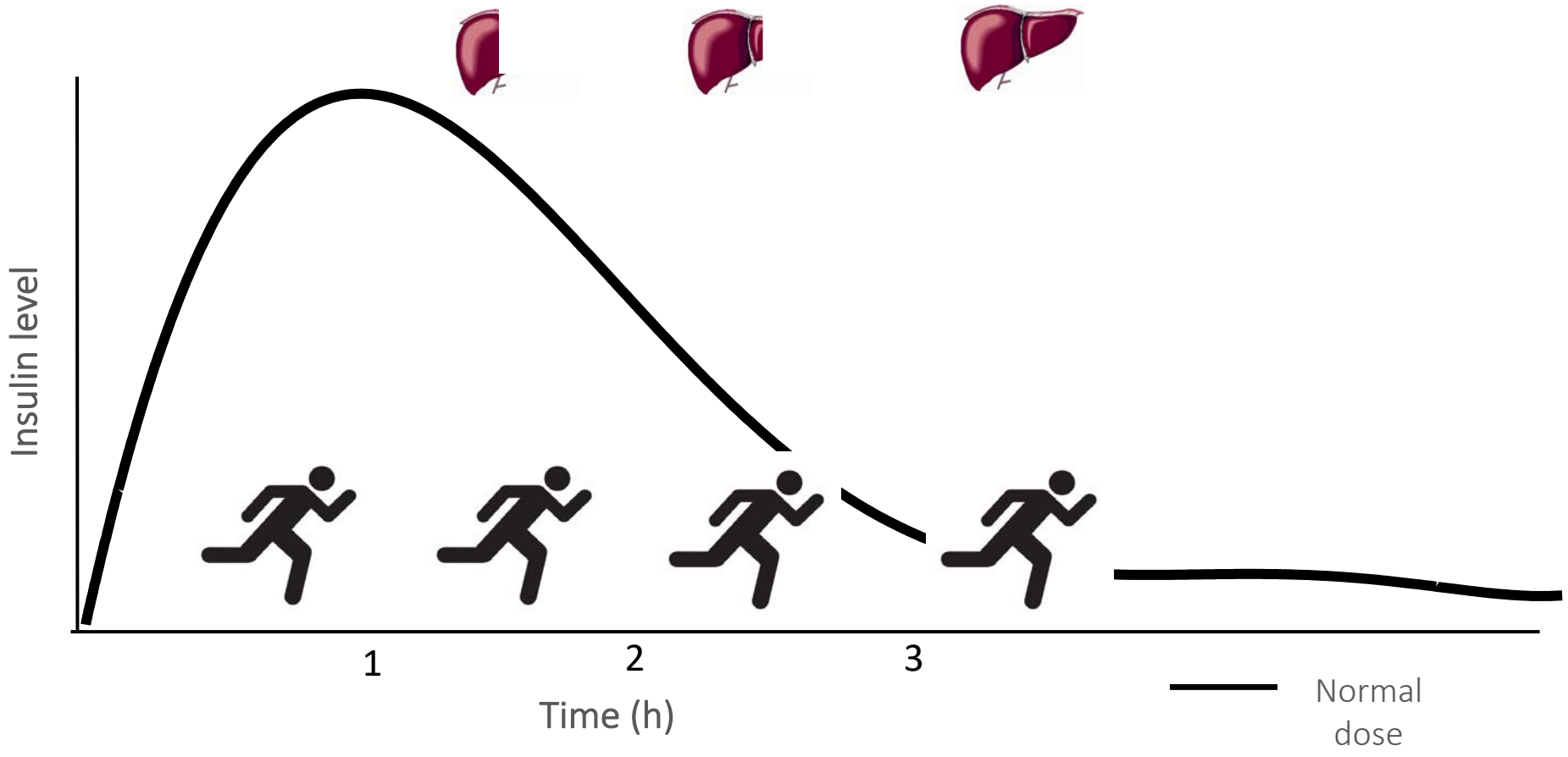
Fasted



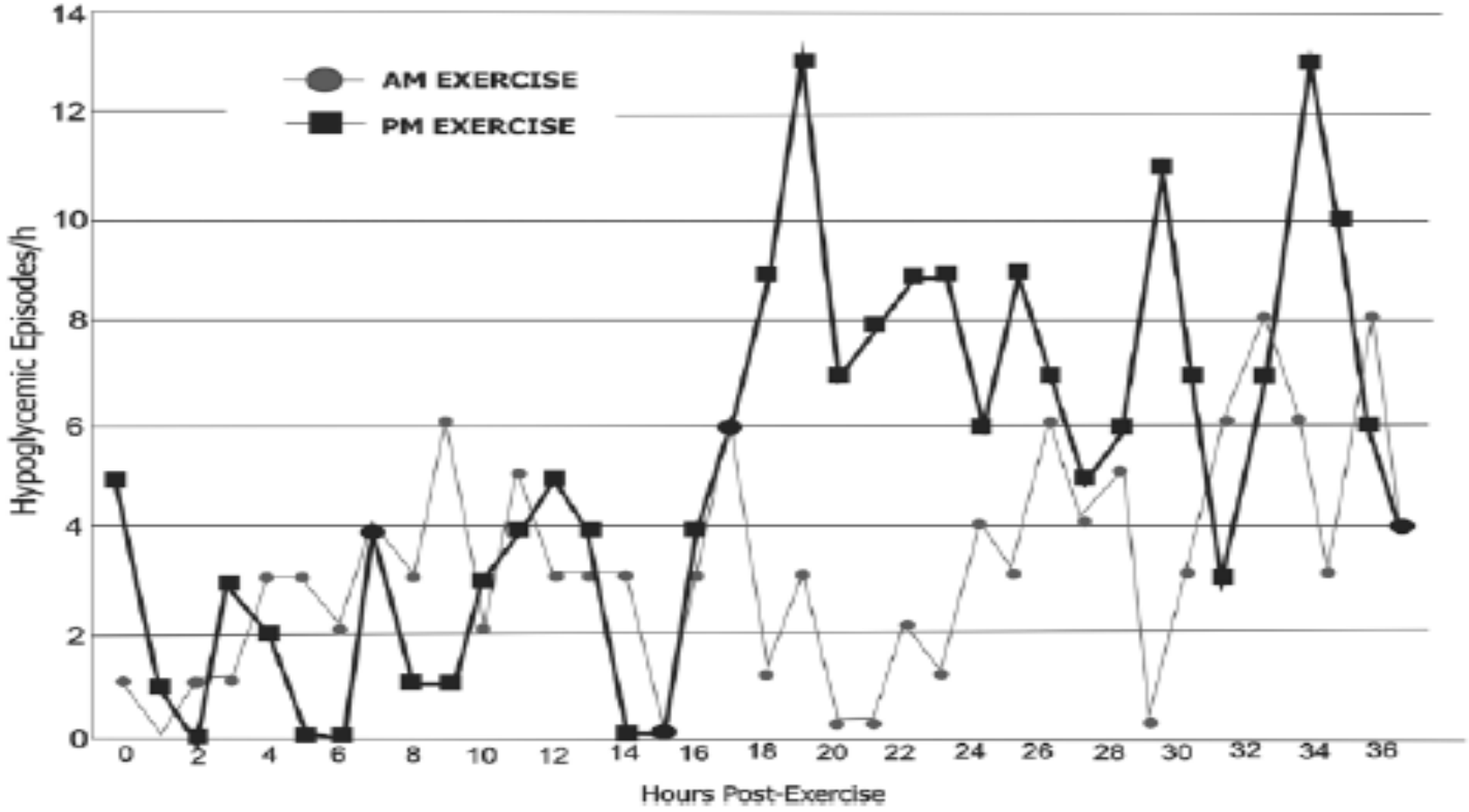
Good reproducibility in the blood glucose response to aerobic exercise in individuals with T1D in the fasted state

Biankin et al., Diabetes Care 2003

Liver glucose release and timing of fast acting insulin



Likelyhood of further hypoglycaemia following morning or afternoon exercise



Journal of Diabetes Science and Technology
2015, Vol. 9(3) 619–624

Summary 2

- Less risk of hypo if exercise when fasted
- Glucose response to exercise is more reliant if exercise fasted
- Higher risk of post exercise hypoglycaemia if exercise later in day

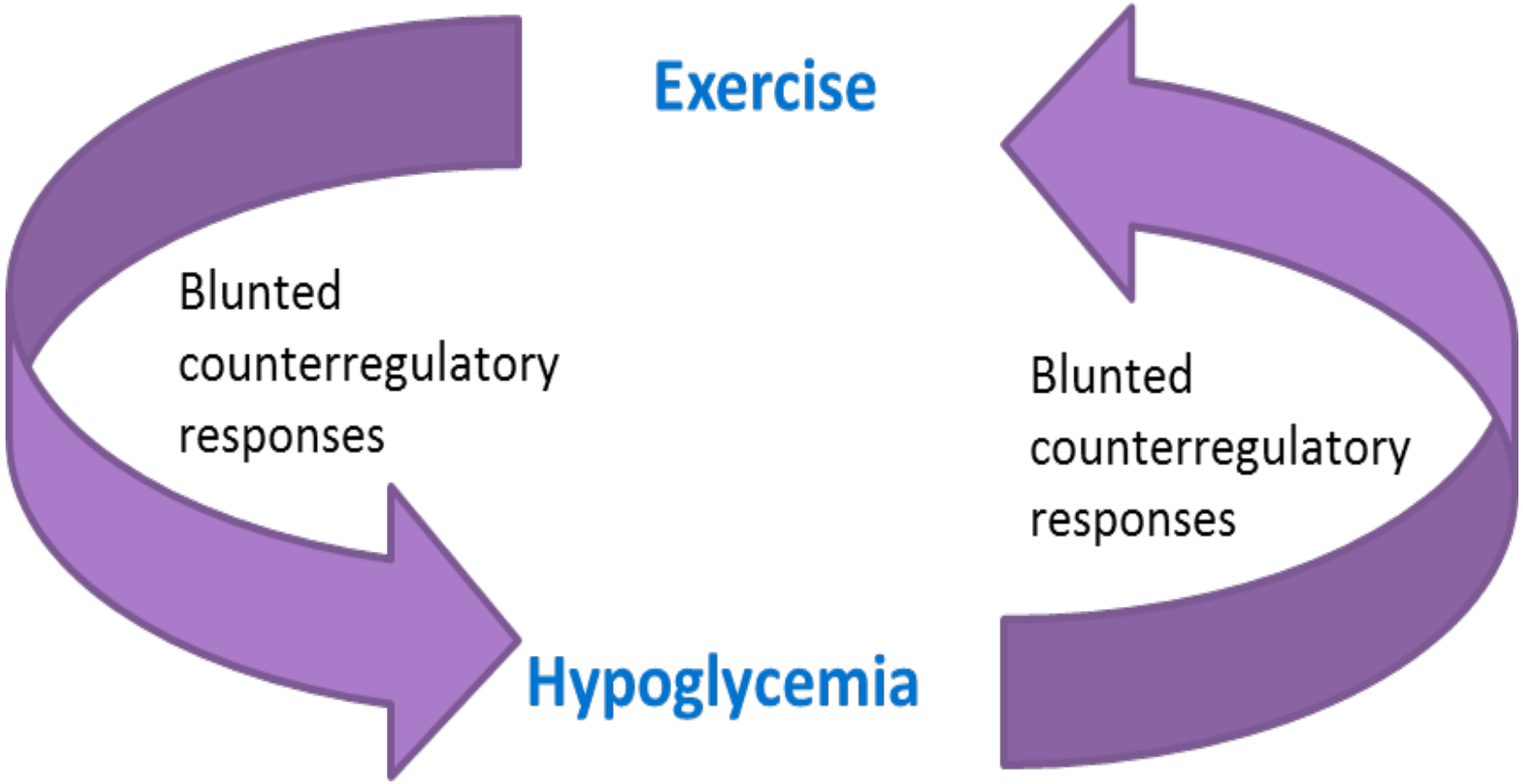
ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Glucose level– three things to think about

- Whether had any hypoglycaemic episodes
- Direction of travel of glucose
- Current blood glucose

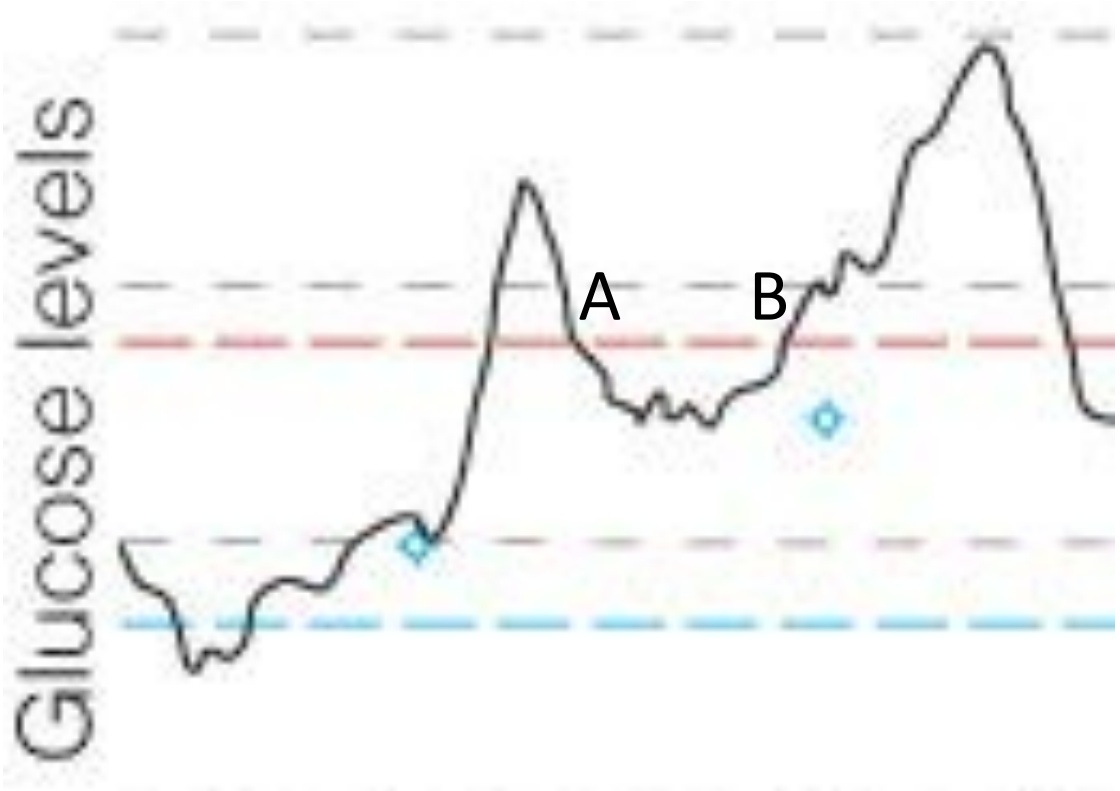
ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Vicious Cycle of Hypoglycemia and Exercise



Ertl & Davis, Diabetes Met Res Rev, 2004

Direction of glucose



Although A and B have similar glucoses. Exercising at these point is likely to see different glucose response to exercise

A few glucoses before exercise will enable you to see direction of travel

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Blood glucose that say's NO

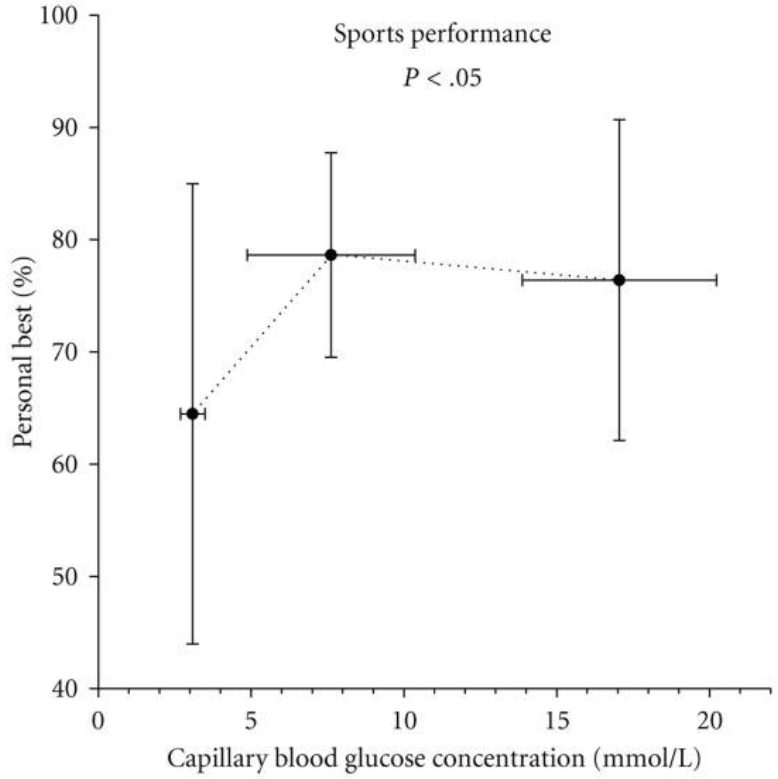
Low blood glucose Less than 3.5	High blood glucose More than 15
Severe hypoglycaemia (needed help) • Don't exercise for 24 hours	Ketones greater than 1.5 mmol/L • Take insulin and wait until have dropped to below 1.5 mmol/L before exercising
Self-treated hypoglycaemia • Be careful for 24 hours • If it 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	Ketones less than or equal to 1.5 mmol/L • Eaten less than 2 hours ago: just monitor • Eaten more than 2 hours ago: take extra insulin • Can do low-to-moderate intense exercise

© Rob Andrews 2017

Starting blood glucose

Blood glucose	Recommendations (rule of thumb)
Less than 5.6 mmol/L	Ingest 20g of glucose before exercise Delay exercise until blood glucose >5.6mmol/L
5.7 – 6.9 mmol/L	Ingest 15g of glucose Exercise can be started
7 – 15 mmol/L	Exercise can be started
More than 15 mmol/L	Check blood ketones • **If ketones greater than 1.5 mmol/L** take 1/3 (30%) of normal corrective dose of insulin and do not exercise until have dropped below 1.5 mmol/L • **If ketones less than or equal to 1.5 mmol/L** take 1/3 (30%) normal corrective dose of insulin if not eaten in last 2 hours and start to exercise, keeping an eye on your blood glucose

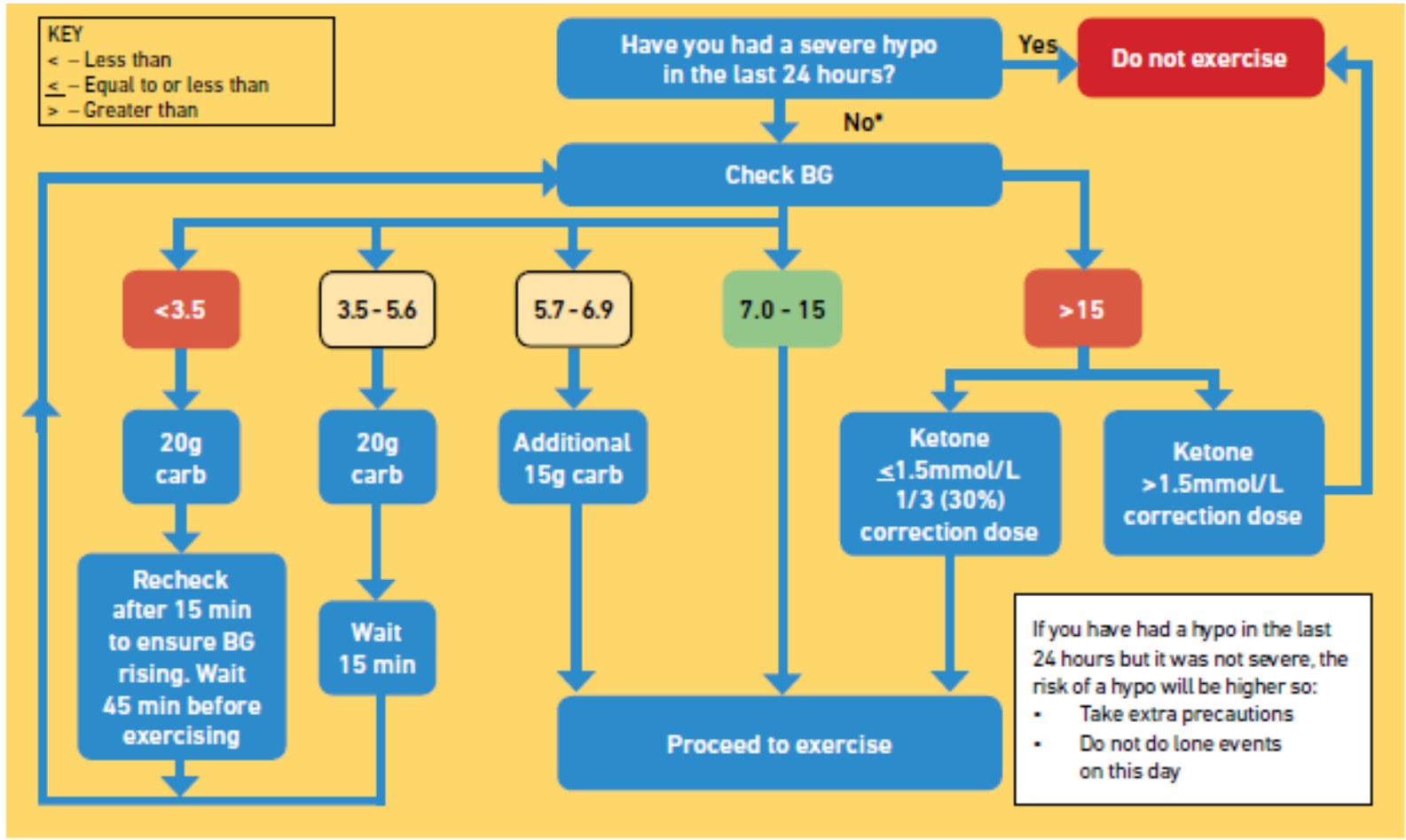
Glucose range for best performance



Kelly D et al Int J Pediatr 2010

- Clinically people seem to have ideal range for getting best performance – varies for different sports.
- Hypo before events effects performance.
- People who have recurrent hypo seem to not see as much improvement as expect – this could be due to nutritional issues rather than hypo.

Simple flowchart for glucose and exercise



© Rob Andrews 2017

If know direction of glucose from >two blood glucose readings, flash monitor, or continuous glucose monitor.

If ⬆ and glucose 5.7-6.9: no need for extra carbs, proceed to exercise. Stick to advice if in any other range.

If ⬇ and glucose 5.7-6.9: take twice as much carbs at 20 and 40 minutes into exercise

If ⬇ and glucose 7.0-9.0: take 15 grams of carbs at start of exercise

⬇ = ↓ or ↘

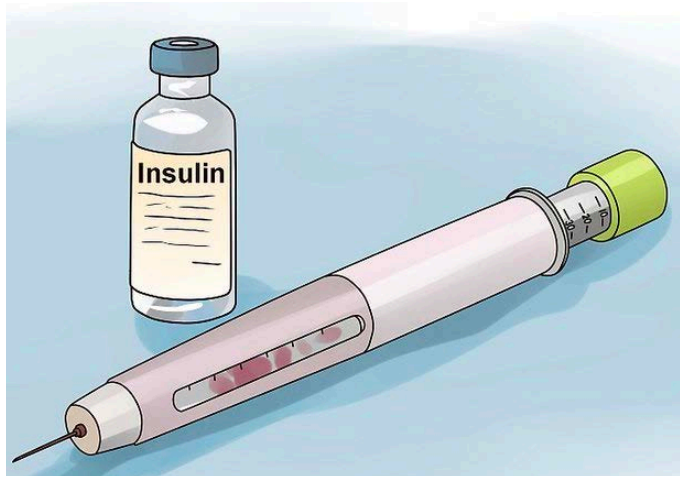
⬆ = ↑ or ↗

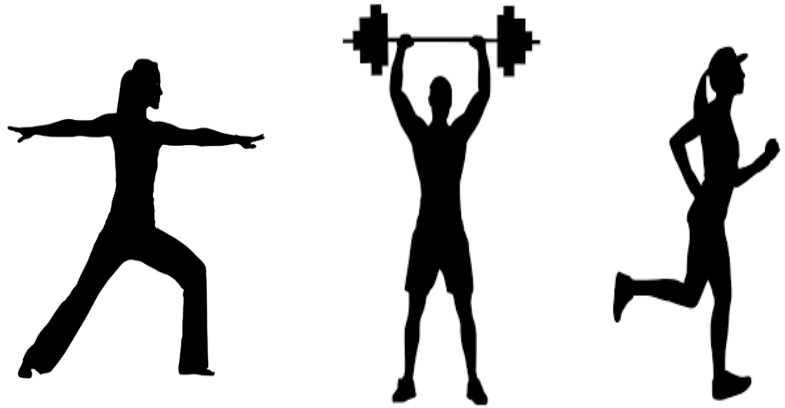
Summary 3

- Glucoses in the last 24 hours are important in determining if someone can exercise and how they should exercise

- Blood glucose just before starting to exercise can determine whether safe to exercise and whether action needs to be taken before exercise

Three ways to manage glucose during exercise - ICE





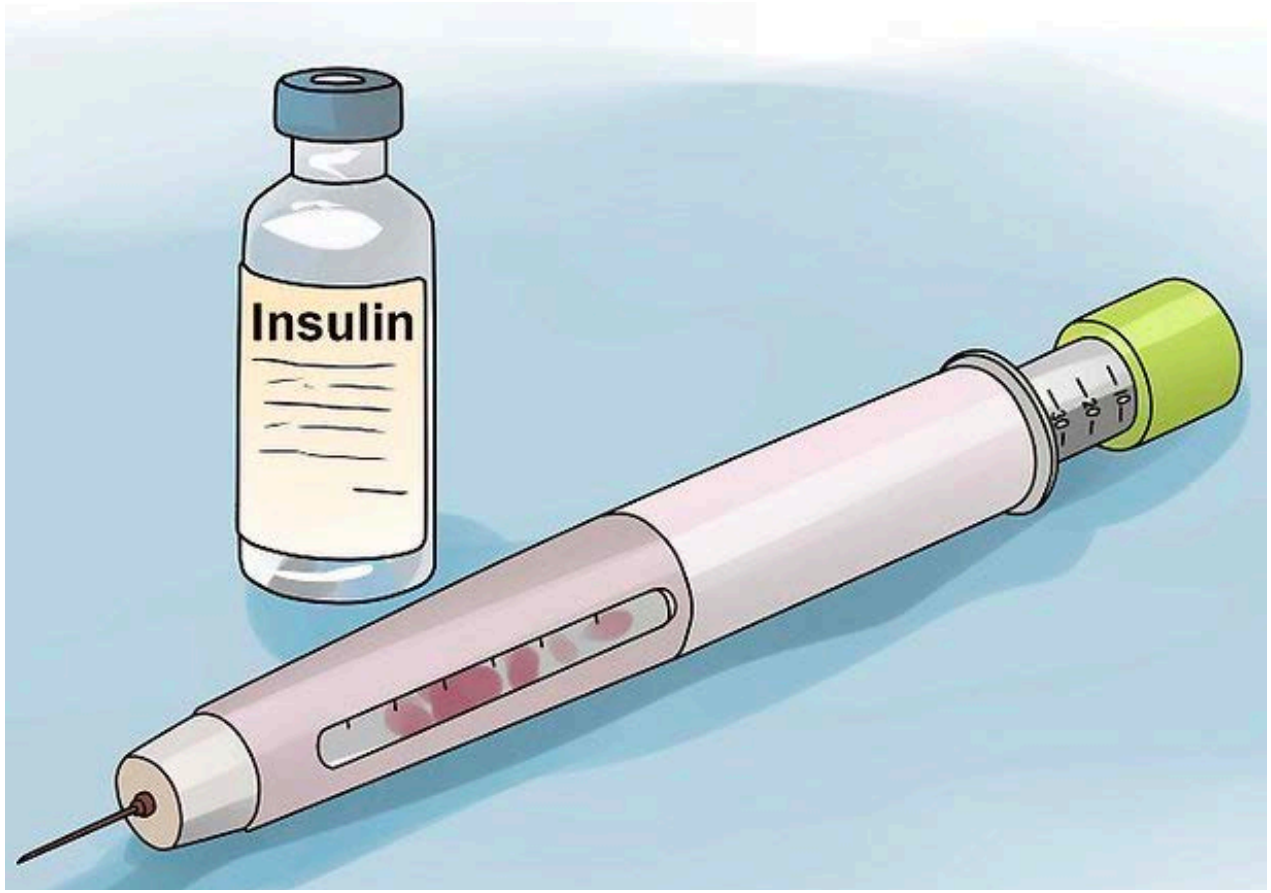
Insulin

Carbohydrate

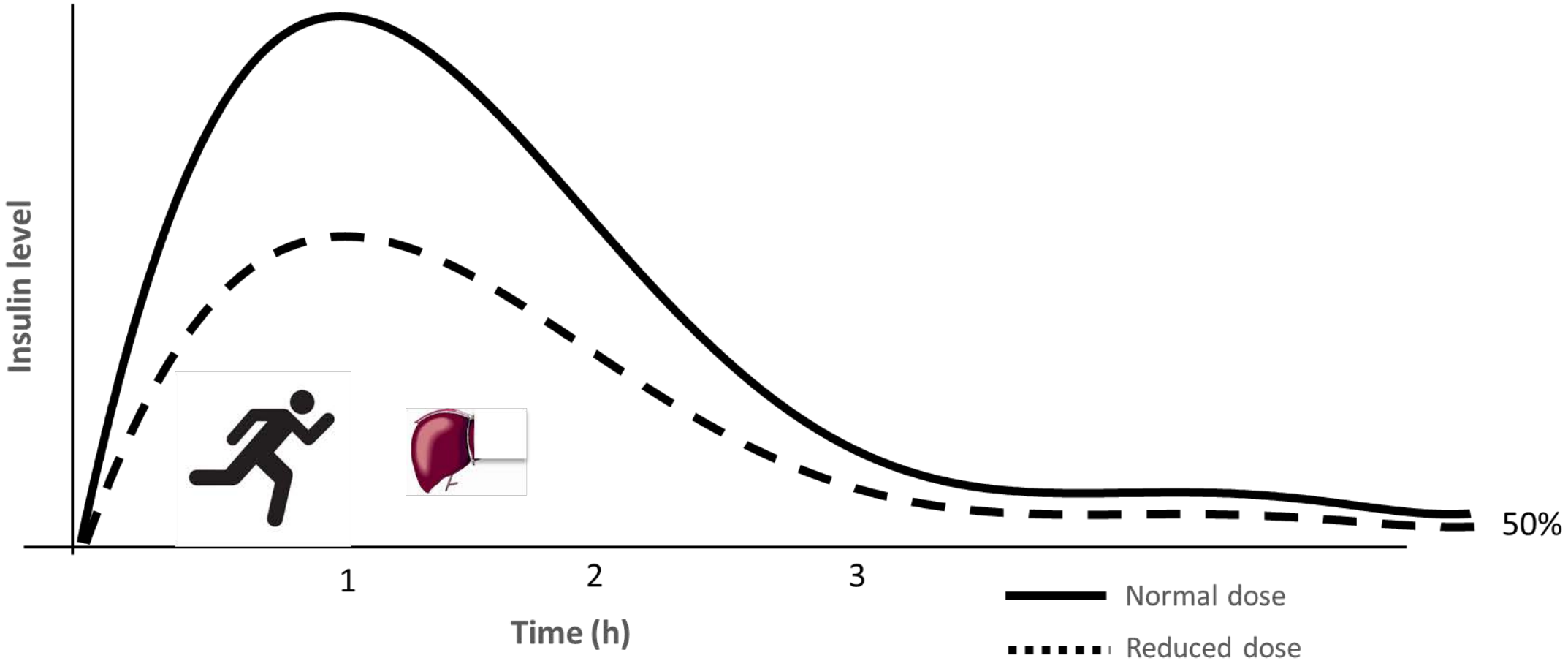
Exercise

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Using insulin to manage glucose during exercise



Affect of lowering fasting acting insulin by 50%



Simple strategy for insulin

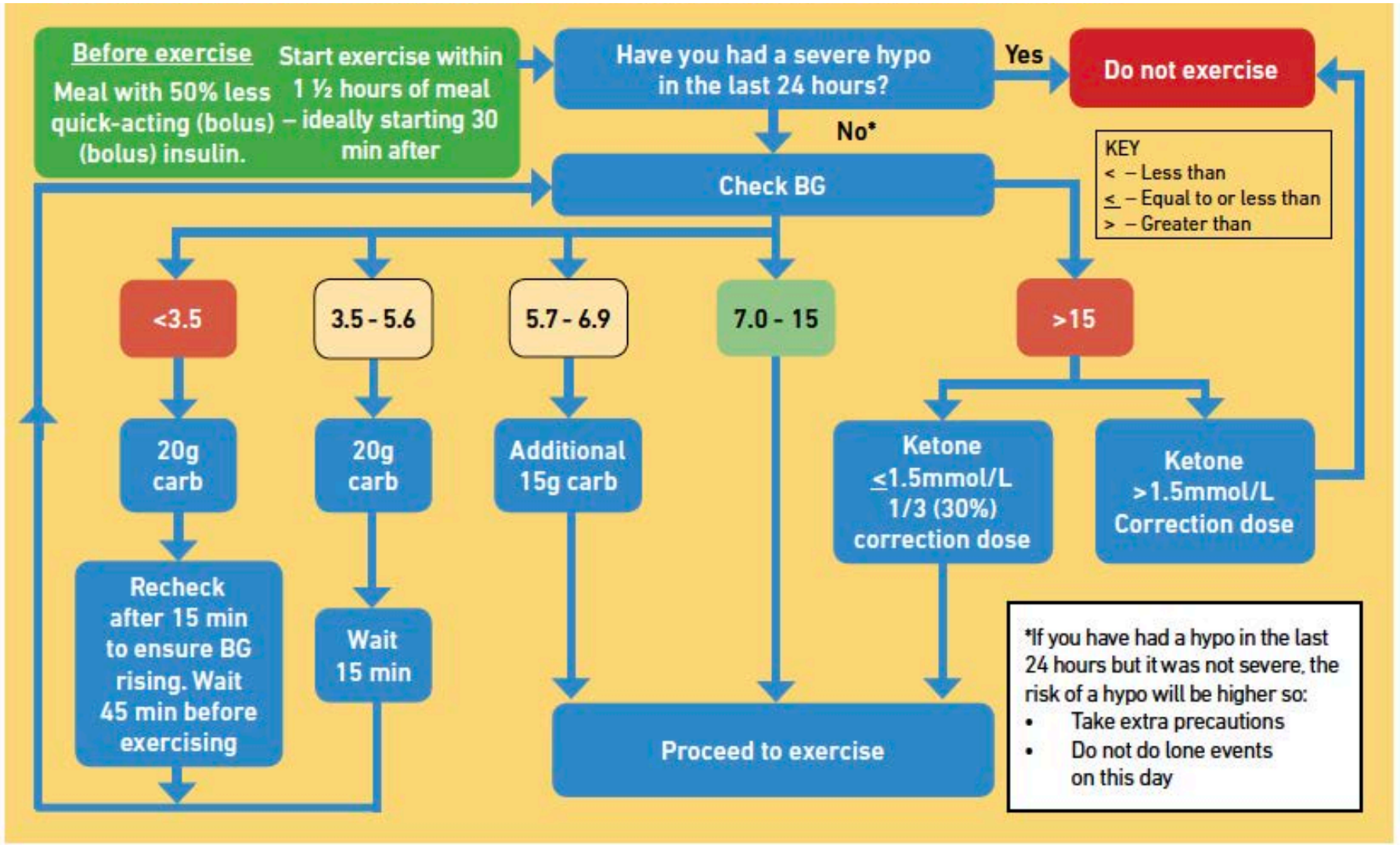
If exercising within 2 hours of quick acting (bolus) insulin

- Reduce pre-exercise fast acting (bolus) insulin by 50%

This works for pumps as well.

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Flowchart for simple Insulin Strategy pre exercise



Semi-quantitative method for fast acting insulin

- Insulin reduction is made dependent on the intensity and type of the exercise that is going to be preformed. To gain the best advantages from this reduction, exercise is best-performed 30 minutes after eating. This works for people on pumps

	% Dose reduction	
Exercise	**30 min of exercise**	**60 min of exercise**
Low intensity continuous	25	50
Medium intensity continuous	50	75
High intensity continuous	75	Not applicable
Resistance; weight lifting	0	25-50%
High intensity interval training	0	
Mixed : intermittent aerobic and anaerbic	25%	50%

Riddell MC 2017

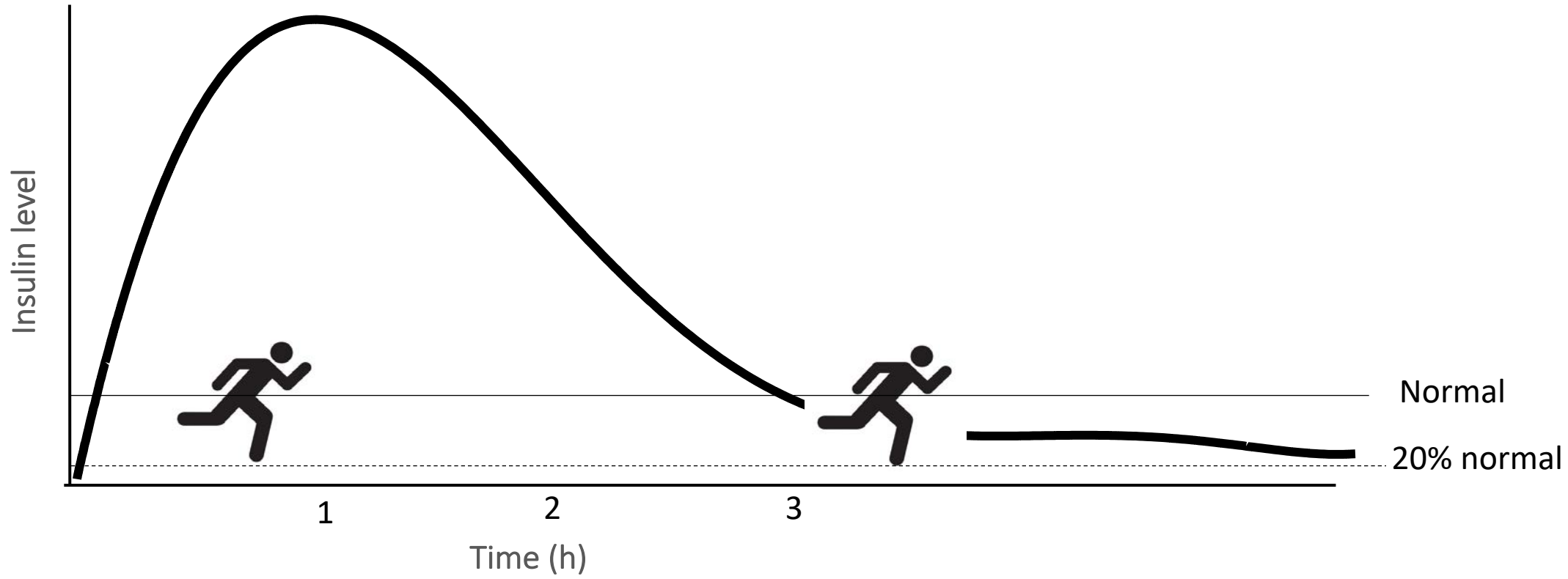
Quantitative method for fast acting insulin

- For this you will need to know; how much energy will be burnt during exercise, and your insulin carbohydrate ratio. The energy burnt can be based on previous glucose need for that exercise or from one of the carbohydrate tables.

Example 1

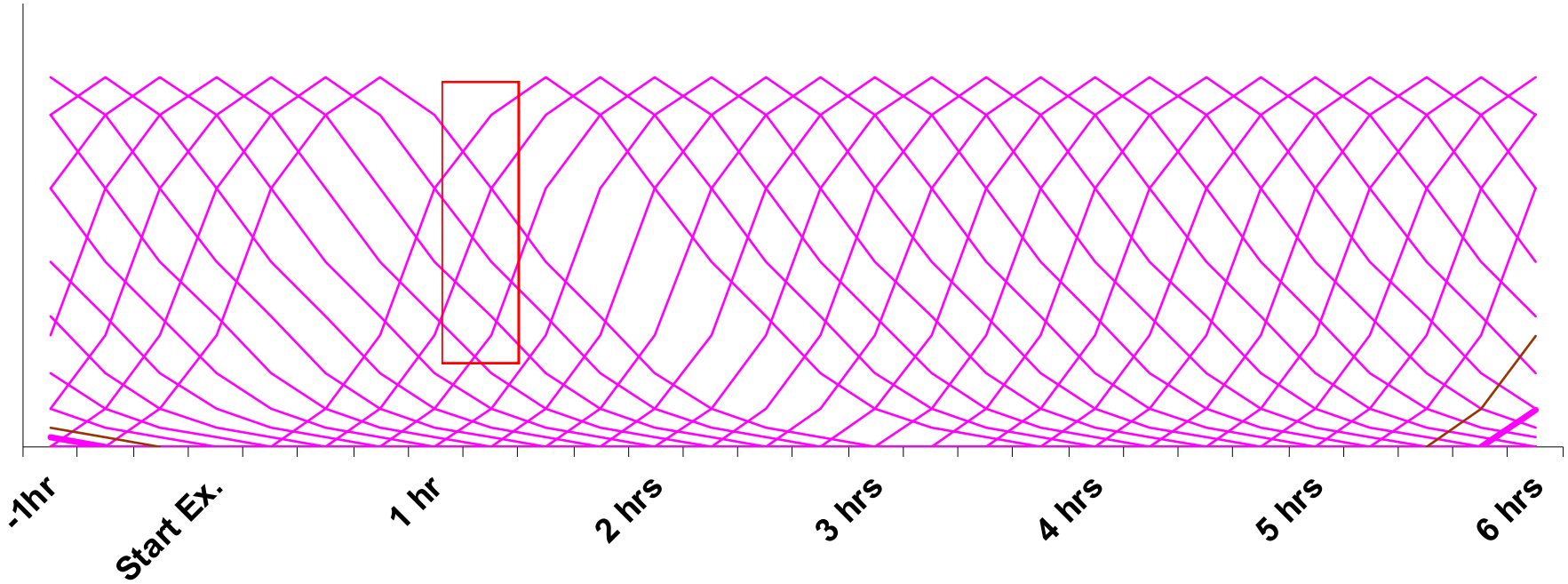
- Diane wants to cycle for one hour after breakfast at 14 miles/hr. she normally takes insulin in ratio 1 unit for 10 grams. For breakfast he has 95 grams of carbohydrate. On her ride he will burn 75 grams of carbohydrate (see table) above. So the Difference is 95-75 = 20 grams. So she needs to take insulin to cover 20 grams – 2 units, as opposed to his normal 9.5 units.

Lowering background insulin



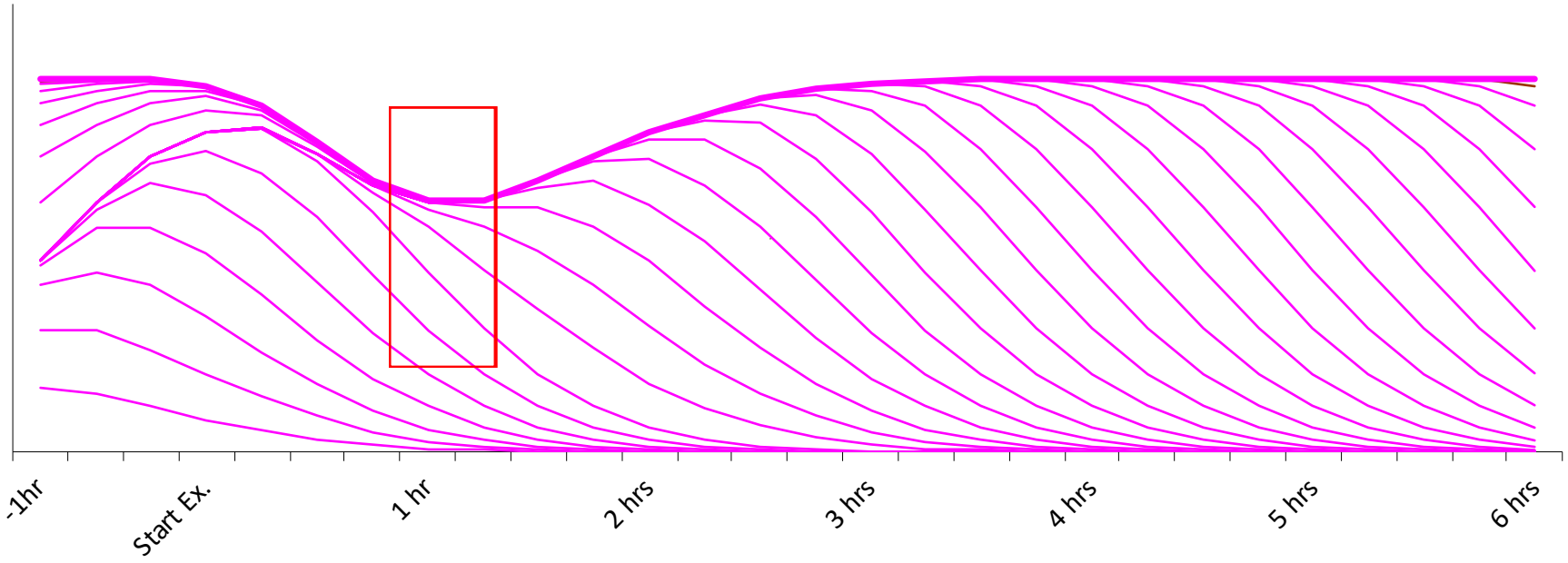
Effect of pump disconnection on basal insulin levels

Disconnection/suspension during 30 minutes of exercise
eliminates basal pulses for 30 minutes



Effect of pump disconnection on basal insulin levels

Level of active basal insulin resulting from
disconnection/suspension during 30 minutes of exercise

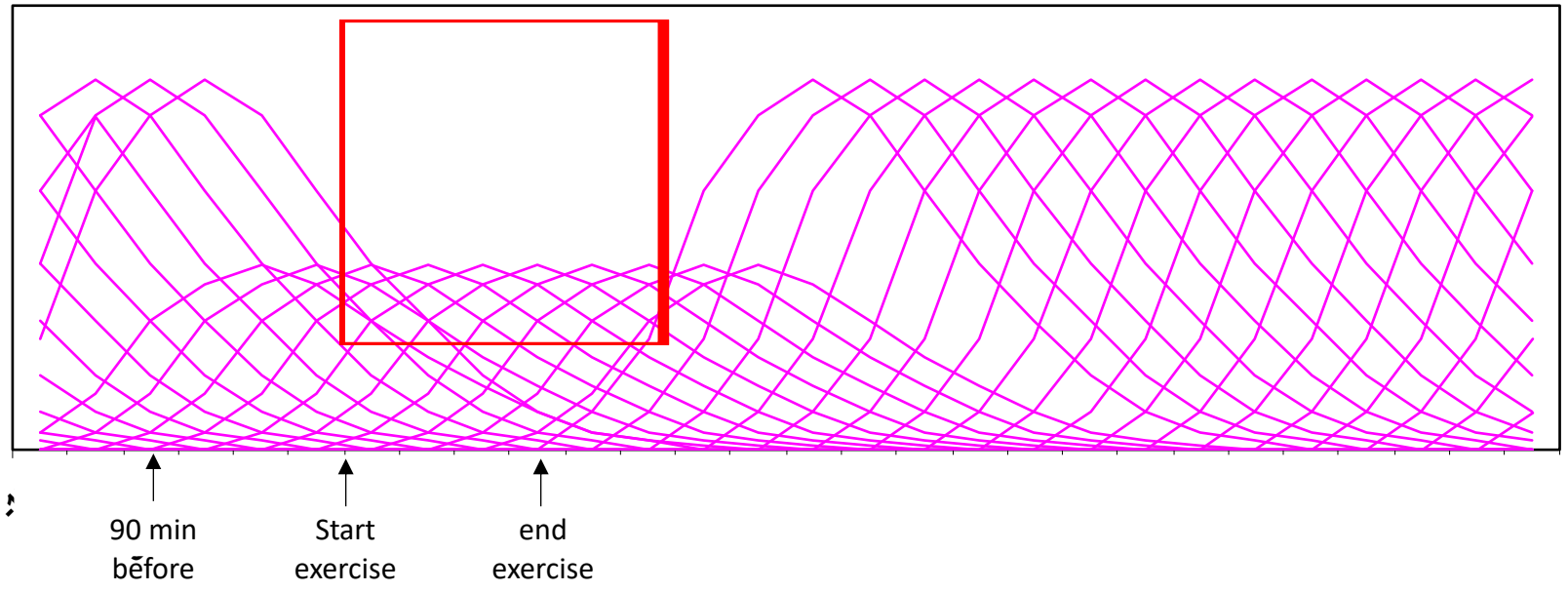


Disconnection during a short exercise session has minimal effect on insulin levels

Effect of pump temp rate on basal insulin levels

Reduced bolus by 50% with no change to background if exercising with 2 hours of meal.

Reduce background by 50% from 60 minutes before until end of exercise if exercising 2 hours after eating



Semi-quantitative method basal insulin pump

Insulin reduction is made dependent on the intensity and type of the exercise that has been preformed. Reduction with exercise only if exercising 3 hours after meal.

	Exercise ~ 30 minutes	Exercise ~ 60 minutes
Aerobic	50% basal reduction, performed 90 min before exercise or 100% reduction at exercise onset	50%-80% basal reduction, performed 90 min before exercise or 100% reduction at exercise onset
Resistance (anaerobic)	No reduction	50% basal reduction, performed 90 min before exercise
High intensity interval training	No reduction	No reduction
Mixed (aerobic and anaerobic)	100% reduction at exercise onset	50% basal reduction, performed 90 min before exercise or 100% reduction at exercise onset 20-30% reduction

Riddell MC 2017

Using carbohydrate to manage glucose during exercise

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Simple carbohydrate regime

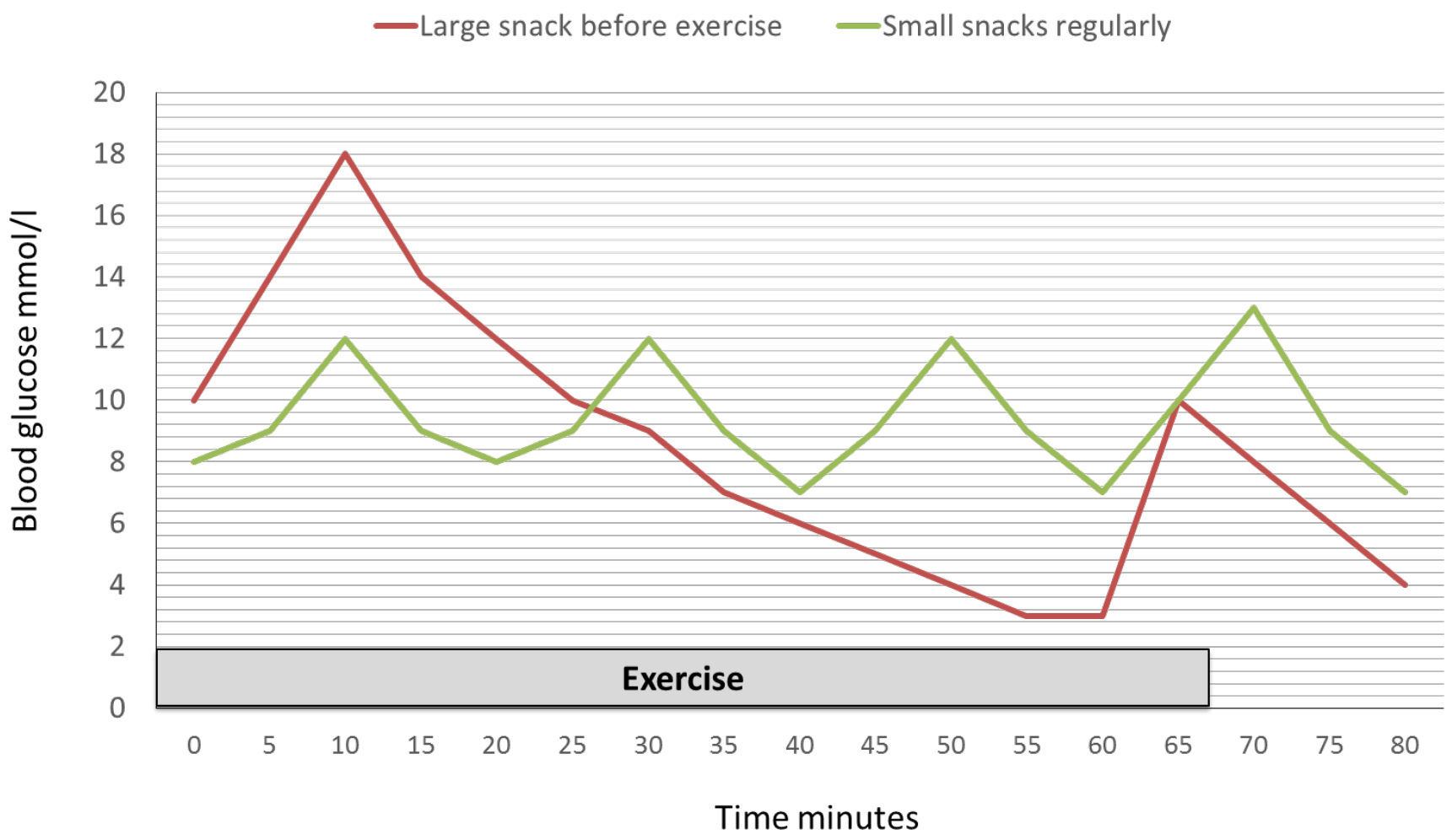
- 30 grams/ hr

Examples of carbohydrates you could try

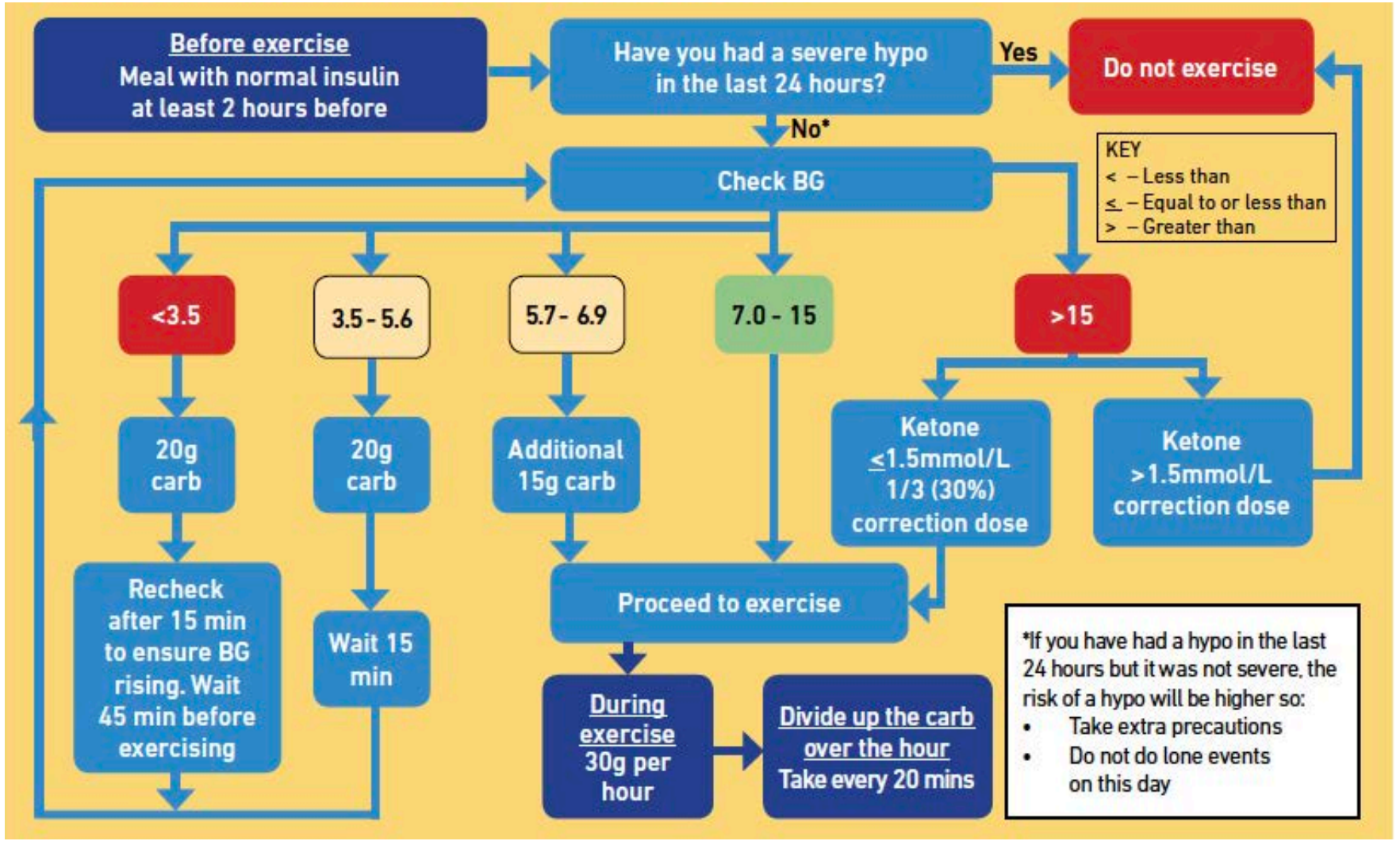
Carbohydrate source	10 grams	15 grams	30 grams
Jelly Babies (large)	2	3	6
Jelly Beans	6	9	18
Cola	100 ml	150ml (mini can)	300ml
Lucozade Body Fuel Energy Gel	1/3 X 45g tube	½ X 45g tube	1 X 45g tube
Apple Juice	80 ml	120ml	240ml
Lucozade Sport Body Fuel	167 ml	250ml	500ml
Powerade Isotonic	133 ml	200ml	400ml
Gatorade	167 ml	250ml	500ml

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Take Carbohydrate every 20 minute



Simple Flowchart for Carbohydrate replacement during exercise



Semi-quantitative method

- In this an estimate of carbohydrate requirements based on body weight. For moderate activity 0.5g/kg/hr is used and for intense activity 1g/kg/hr is used.

- For example: Diane wishes to exercise at intense activity for 60 minutes. She weighs 56 kg so will take 20 grams at the start, 20 grams at 20 minutes and 16 grams at 40 minutes.

Quantitative method

- To account for the variable fuel requirements of different types of exercise, standardised tables have been devised to help athletes estimate ExCarbs for many different activities with varying intensities according to body weight.

- This activity-specific approach to estimating ExCarbs, although not tested in a clinical trial setting, is a popular resource among active patients with Type 1 Diabetes

Using EX carb table

- For example: Diane wishes to cycle for 1 hour at ~ 14 miles per hour. Using table below this requires 75 g, so will take 25 grams at the start, 25 grams at 20 minutes and 25 grams at 40 minutes.

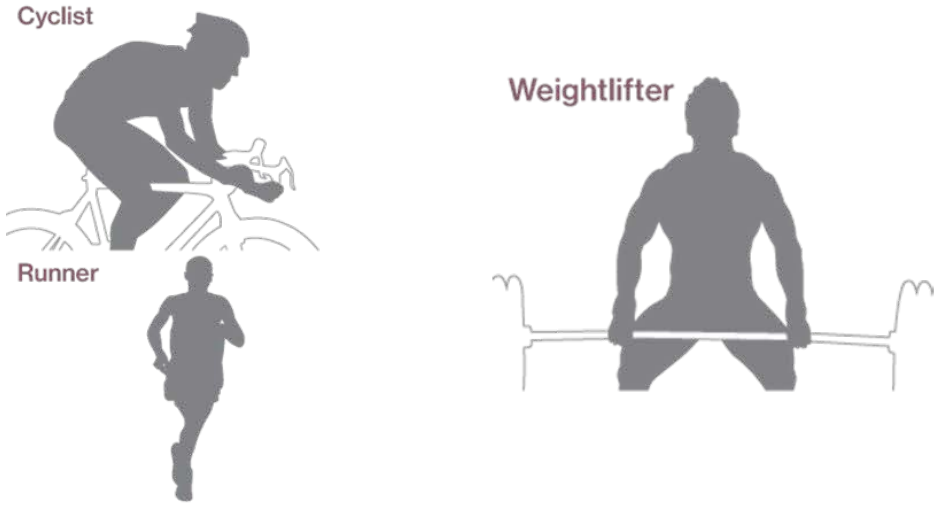
Type of Activity	Speed/ intensity	Carb (grams) per kg per hour	Carbs (grams)for 75kg person per hour	Carbs for me WT=
Walking	3 miles/hr	0.33	25	
	5 miles/hr	0.67	50	
Running	5 miles/hr	1.0	75	
	8 miles/hr	2.1	158	
	10 miles/hr	2.8	210	
Cycling	6 miles/hr	0.45	34	
	10 miles/hr	0.78	59	
	14 miles/hr	1.34	101	75
	18 miles/hr	2.0	150	
	20 miles/hr	2.7	203	

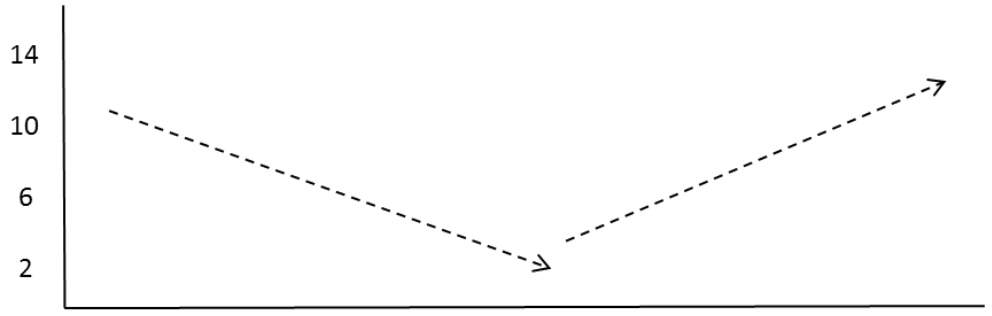
Using exercise to manage glucose during exercise

Order of gym events

Order 1

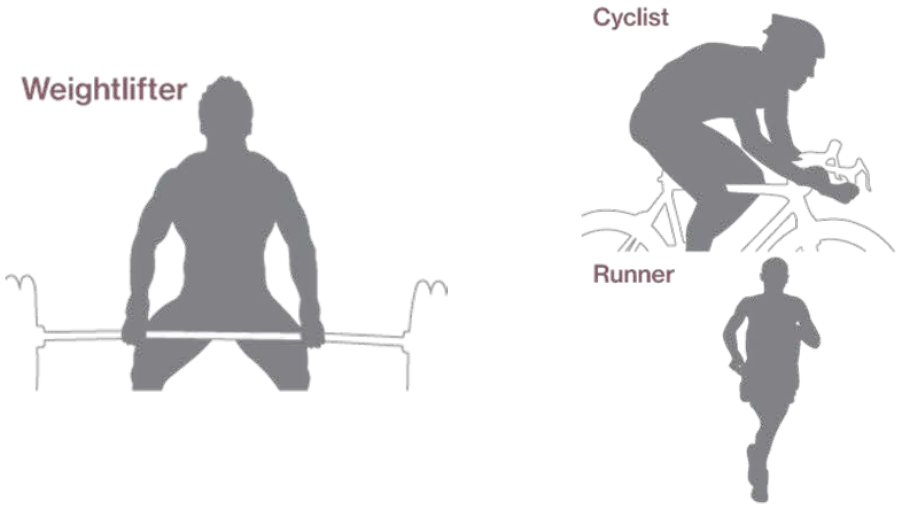
Aerobic then Anaerobic

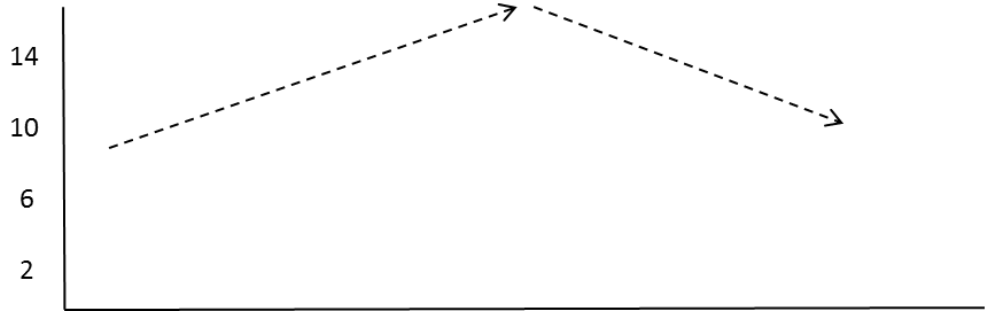




Order 2

Anaerobic then Aerobic



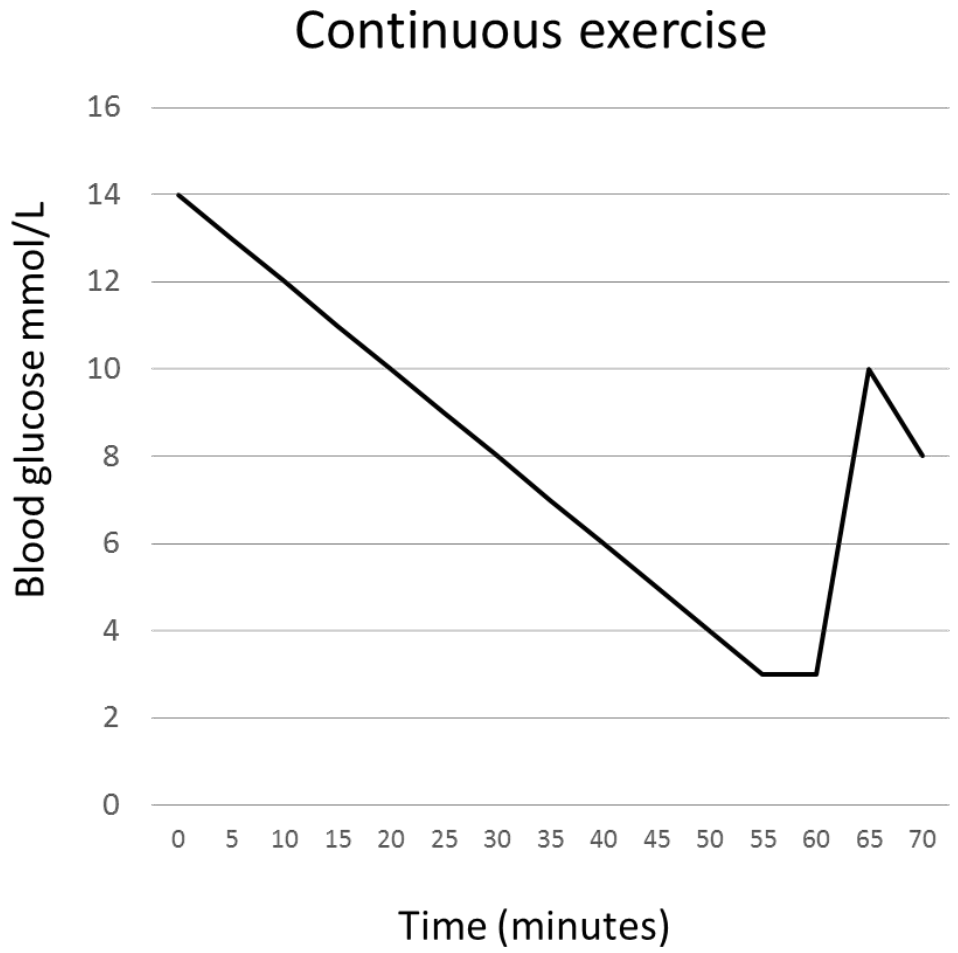


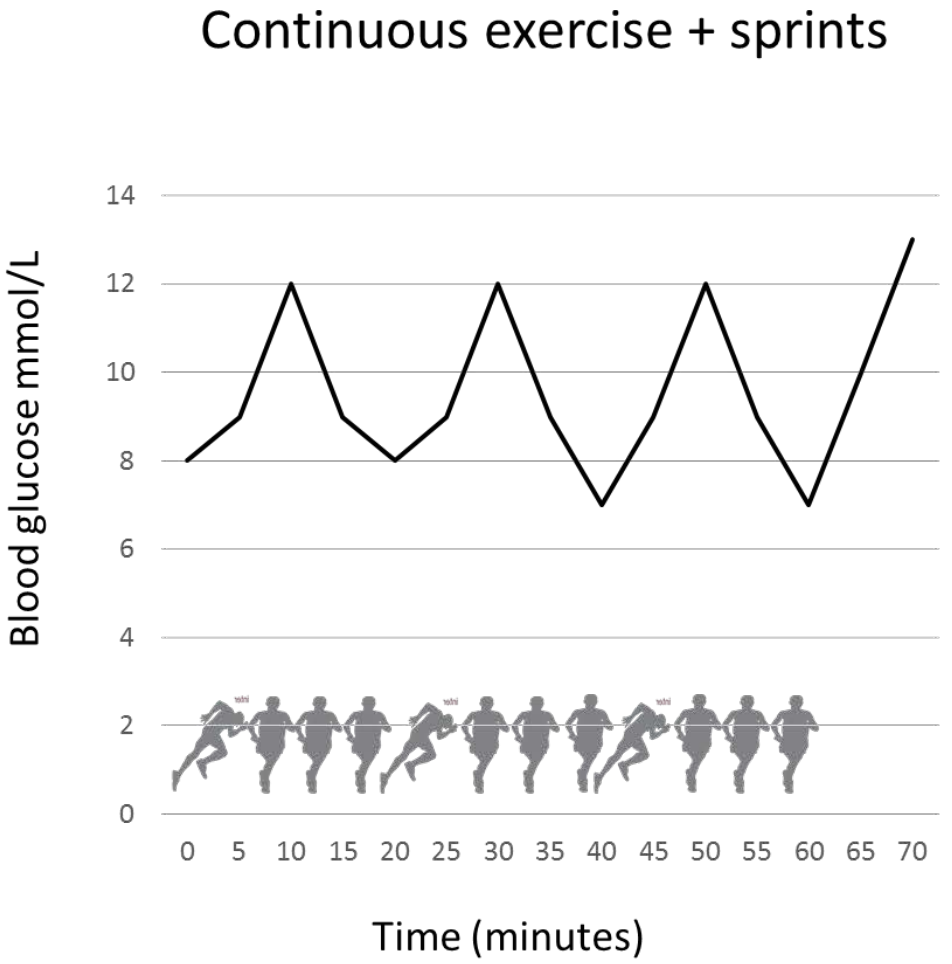
ABCD Association of British Clinical Diabetologists

JDRF PEAK T1D Performance in Exercise and Knowledge

extod

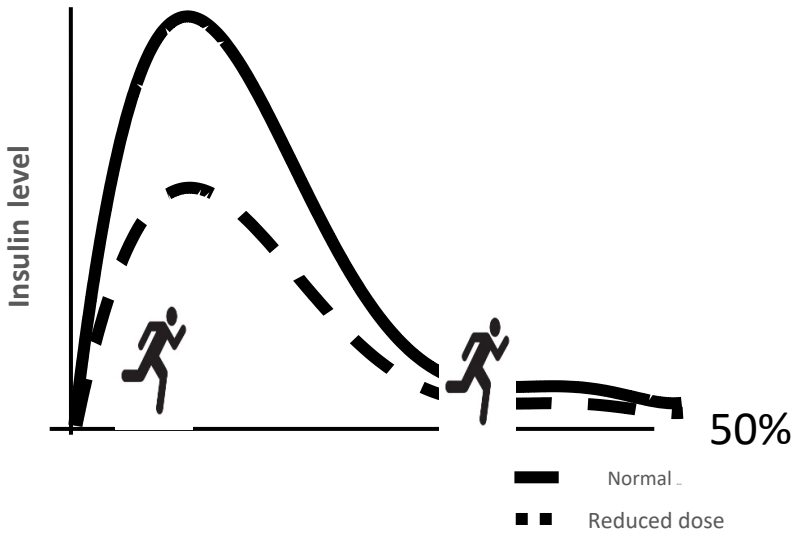
Using intensity of exercise to control glucose





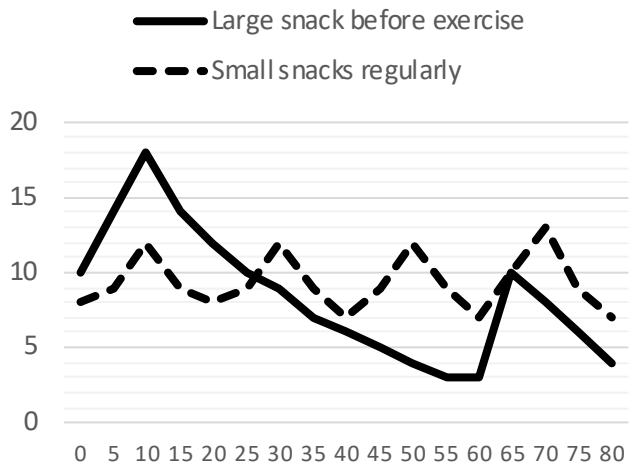
Three options for managing glucose during exercise - ICE

Insulin – how much on board / how do you alter it



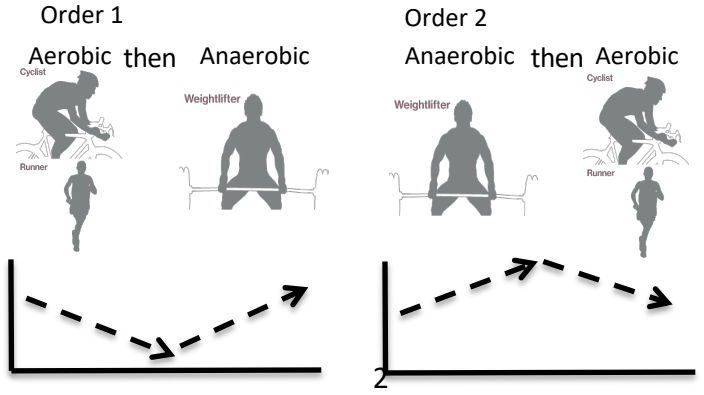
Reduce quick acting by 50% if exercising
Within 2 hrs of meal
Or
Exercise 2 hours after meal

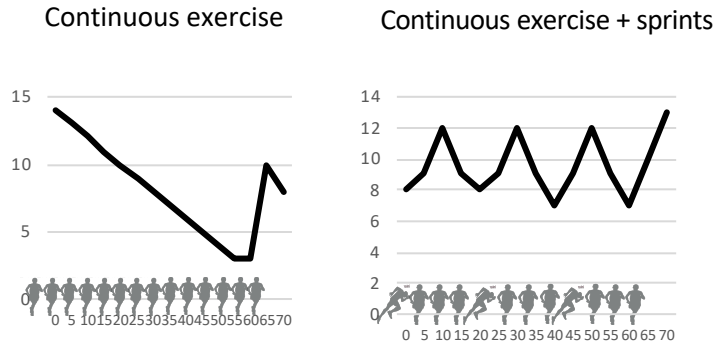
Carbohydrate for exercise



30 gram per hour
Divide carbohydrate over hour
Take some every 20 minutes

Exercise type and intensity





© extod 2017

ABCD Association of British Clinical Diabetologists

JDRF PEAK T1D Performance in Exercise and Knowledge

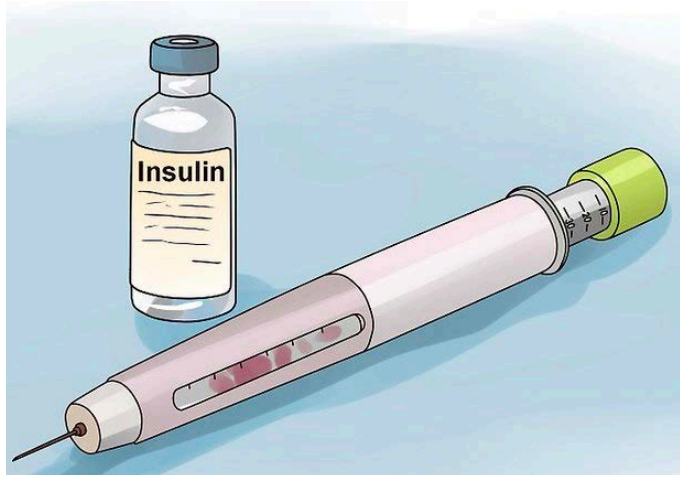
extod

Summary of the three options

Strategy	Pros	Cons
Reducing pre-exercise fast acting insulin	Reduces hypoglycaemia during and following exercise, reduces carbohydrate requirement	Needs planning Not helpful for spontaneous exercise, or for exercise more than 2 hours after taking fast acting insulin
Exercise carbohydrate	Useful for unplanned exercise	May not be possible with some exercises Not helpful where weight control important May over-replace so blood glucose goes too high
Altering order or make of exercise	Useful for unplanned exercise	May not be possible with some exercises May not always have desired effect, lowering glucose or raising glucose more than wish

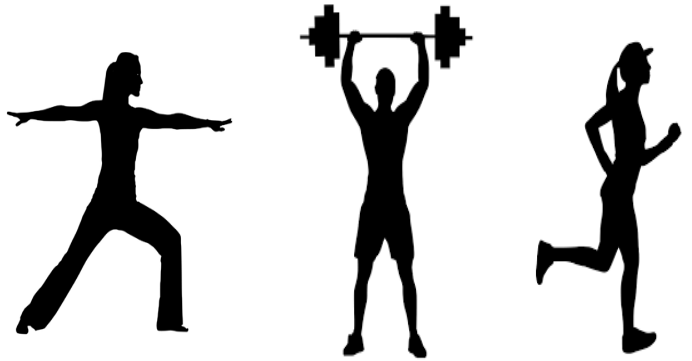
ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Three ways to manage glucose post exercise - ICE



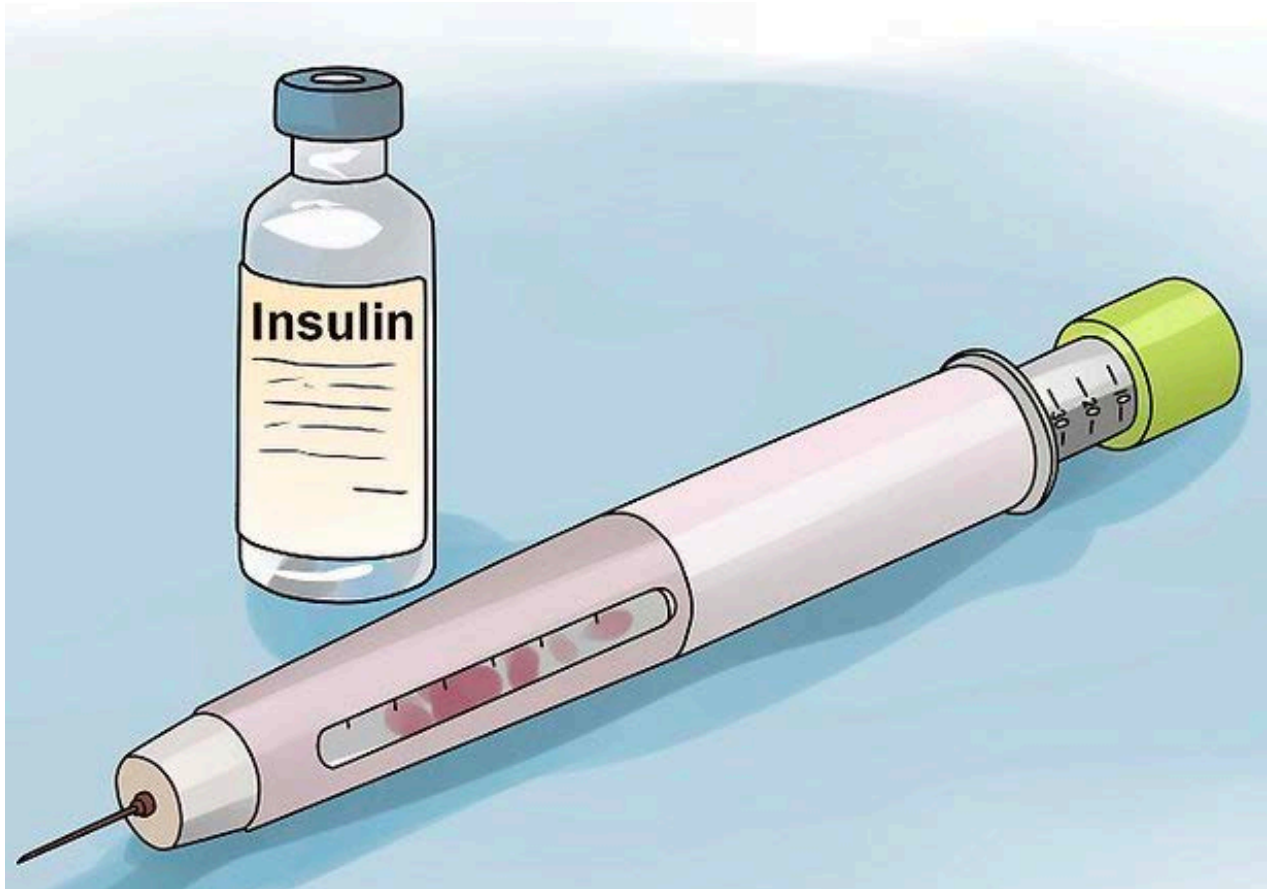
Insulin

Carbohydrate

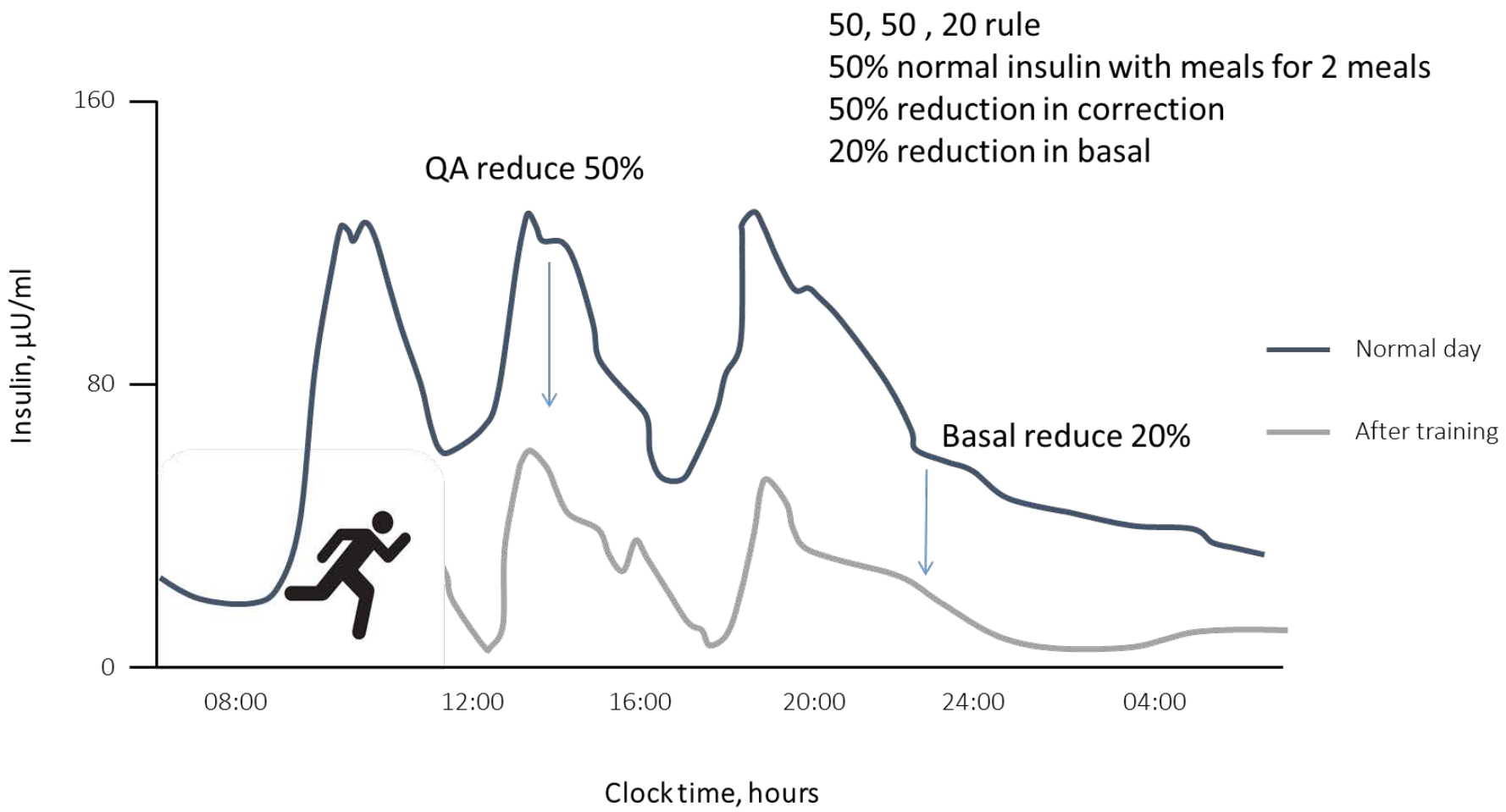


Exercise

Using insulin to manage glucose post exercise



Effect of exercise on Insulin sensitivity



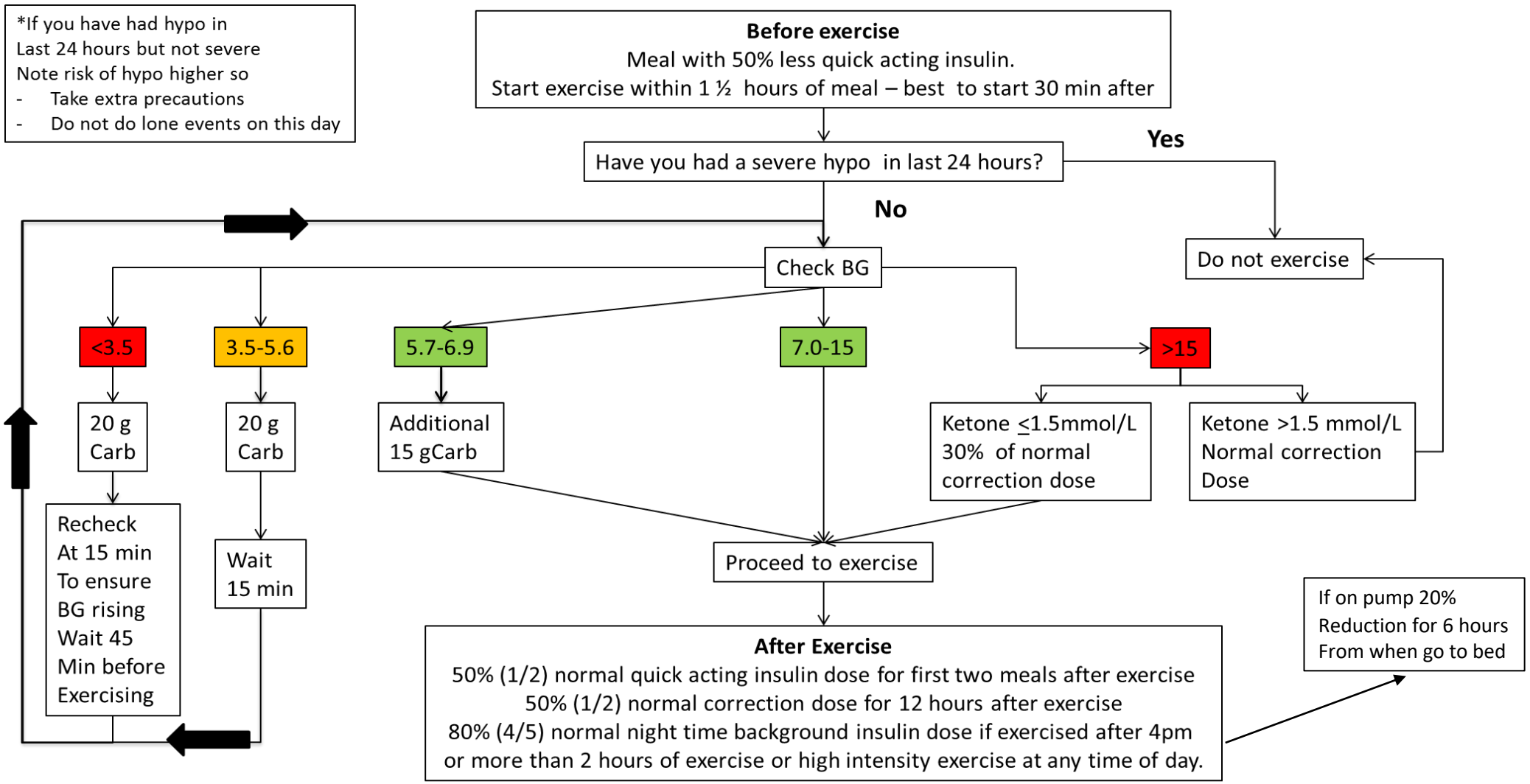
Simple strategy for insulin post exercise

50 50 20 rule

- 50% reduction of normal bolus that would give with snack/meal – for first 2 meals/snacks post exercise
- 50% reduction of normal correction would give for 12 hrs
- 20% reduction of normal evening background or 20% reduction basal rate for 6 hrs from when go to bed if exercise >2hrs, new exercise or exercise after 4pm.

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Simple flow sheet for changing insulin post exercise



Semi-quantitative method basal insulin MDI

- Insulin reduction is made dependent on the intensity and type of the exercise that has been preformed.

	Single exercise bout (up to 60 minutes)	Unusually active day (>90 minutes accumulated) or new exercise
Aerobic	No reduction	20-30% reduction
Resistance (anaerobic)	No reduction	10-20% reduction
High intensity interval training	No reduction	No reduction
Mixed (aerobic and anaerobic)	No reduction	20-30% reduction

This only applies to Long acting (glargine and determir) and intermediate acting insulin

Riddell MC 2017

Semi-quantitative method basal insulin pump

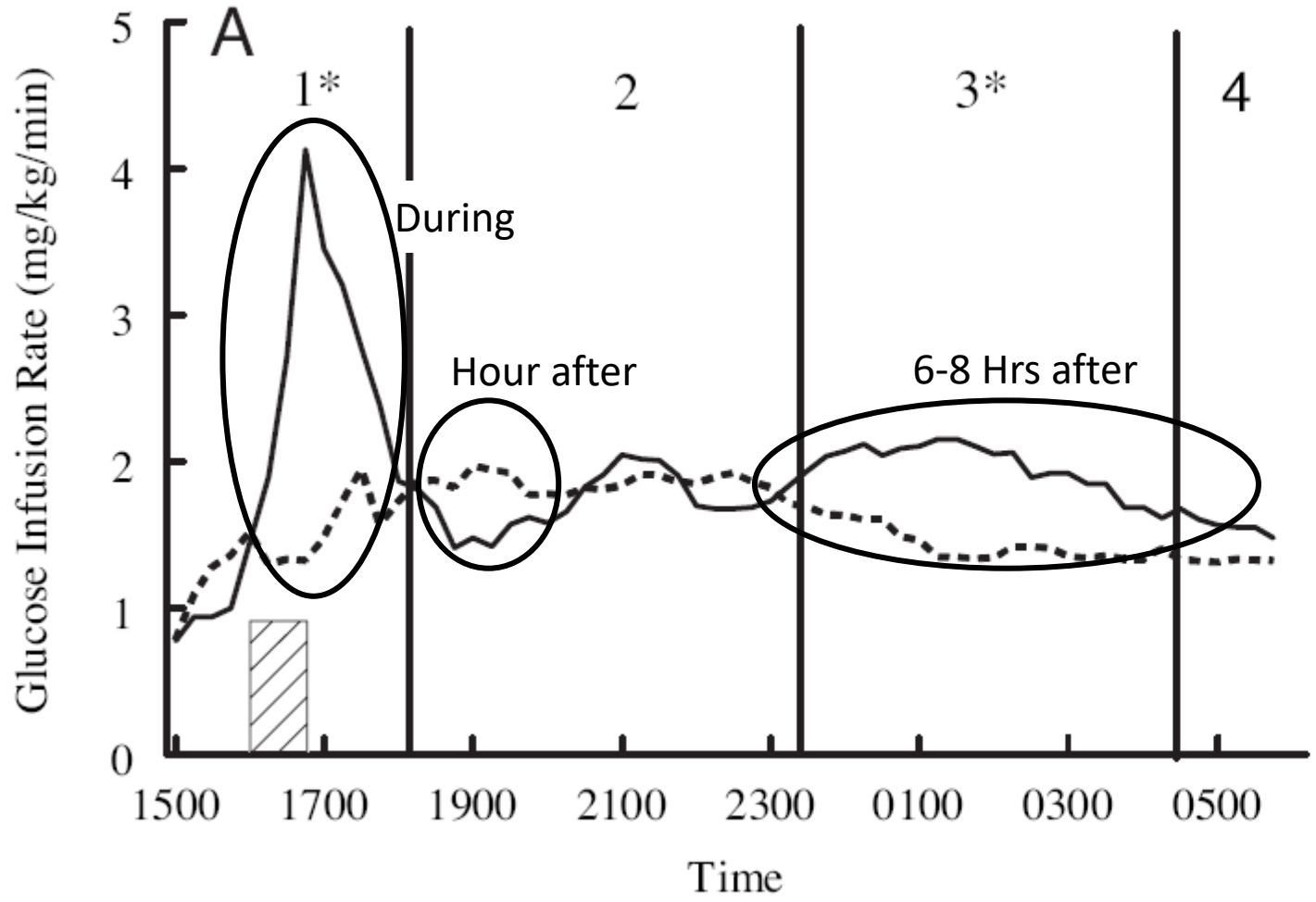
- Insulin reduction is made dependent on the intensity and type of the exercise that has been preformed. Reduction with exercise only if exercising 3 hours after meal.

	Exercise ~ 30 minutes	Exercise ~ 60 minutes	After exercise
Aerobic	50% basal reduction, performed 90 min before exercise or 100% reduction at exercise onset	50%-80% basal reduction, performed 90 min before exercise or 100% reduction at exercise onset	20% basal reduction overnight from bedtime for 6 hours
Resistance (anaerobic)	No reduction	50% basal reduction, performed 90 min before exercise	20% basal reduction overnight from bedtime for 6 hours
High intensity interval training	No reduction	No reduction	No reduction
Mixed (aerobic and anaerobic)	100% reduction at exercise onset	50% basal reduction, performed 90 min before exercise or 100% reduction at exercise onset 20-30% reduction	20% basal reduction overnight from bedtime for 6 hours

Riddell MC 2017

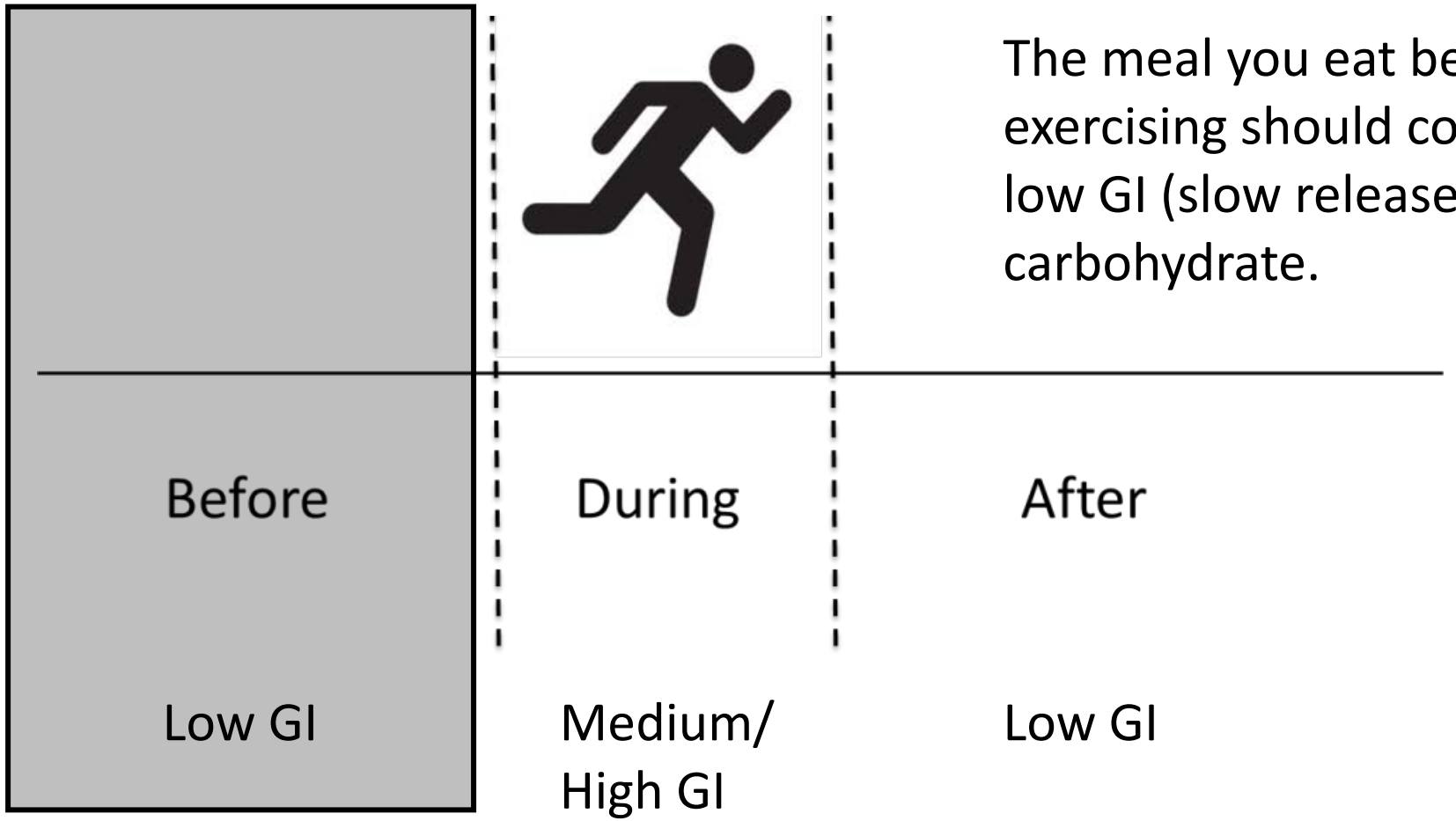
Using carbohydrate to manage glucose post exercise

Three times need to give glucose



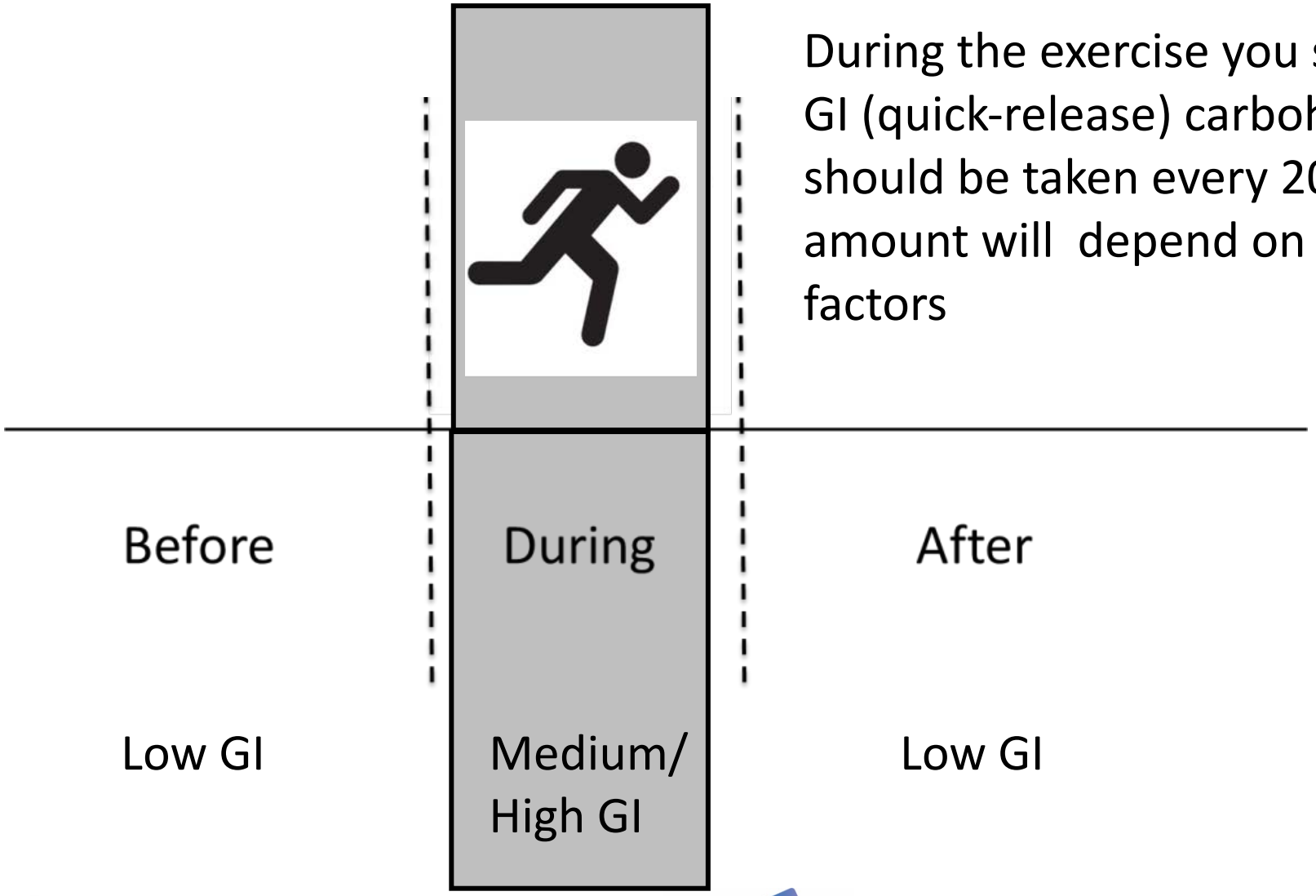
McMahon, S. K. et al. J Clin Endocrinol Metab 2007;92:963-968

Type & Timing of carbohydrate



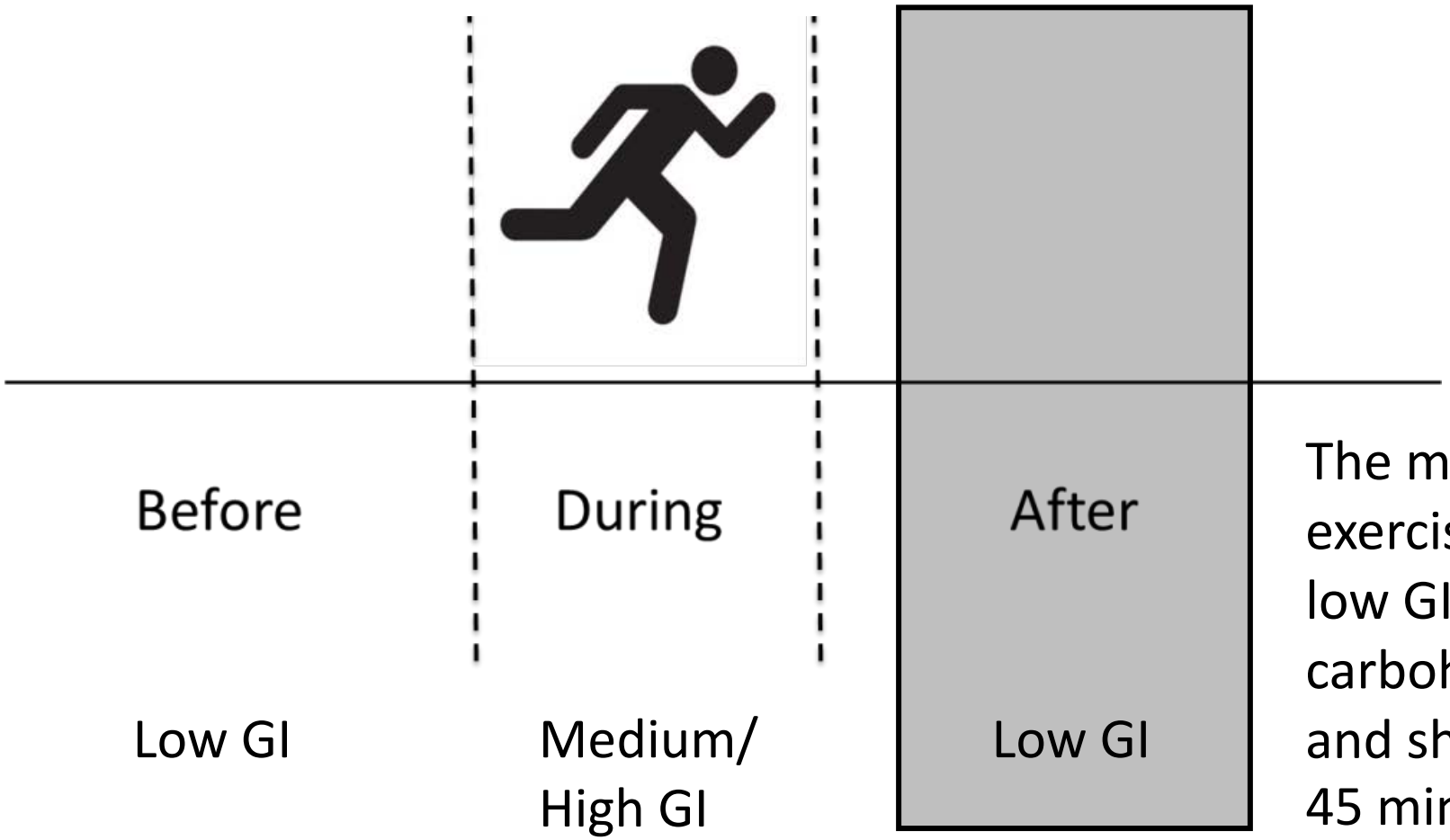
The meal you eat before exercising should contain low GI (slow release) carbohydrate.

Type & Timing of carbohydrate



During the exercise you should take high GI (quick-release) carbohydrate which should be taken every 20 minutes. The amount will depend on number of factors

Type & Timing of carbohydrate



The meal/snack you eat after exercising should contain low GI (slow release) carbohydrate and protein and should be eaten within 45 min of finishing exercise

Daily carbohydrate requirements

Training Load	CHO Recommendations
Very light training (low intensity exercise or skill-based exercise)	3-5 g.kg-1.day-1
Moderate intensity exercise for 1 hr/day	5-7 g.kg-1.day-1
Moderate to high intensity exercise for 1-3 hrs/day	6-10 g.kg-1.day-1
Moderate to high intensity exercise for 4-5 hrs/day	8-12 g.kg-1.day-1

Burke, L.M., (2010)

Daily protein requirements

Training type and load	Protein recommendations	Training type and load
Sedentary men & women	0.8 – 1.0g/kg/day	Sedentary men & women
Endurance athletes	0.8 – 1.2g/kg/day	Endurance athletes
Resistance (strength) athletes	1.0 – 1.7g/kg/day	Resistance (strength) athletes

Burke, L.M., (2010)

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

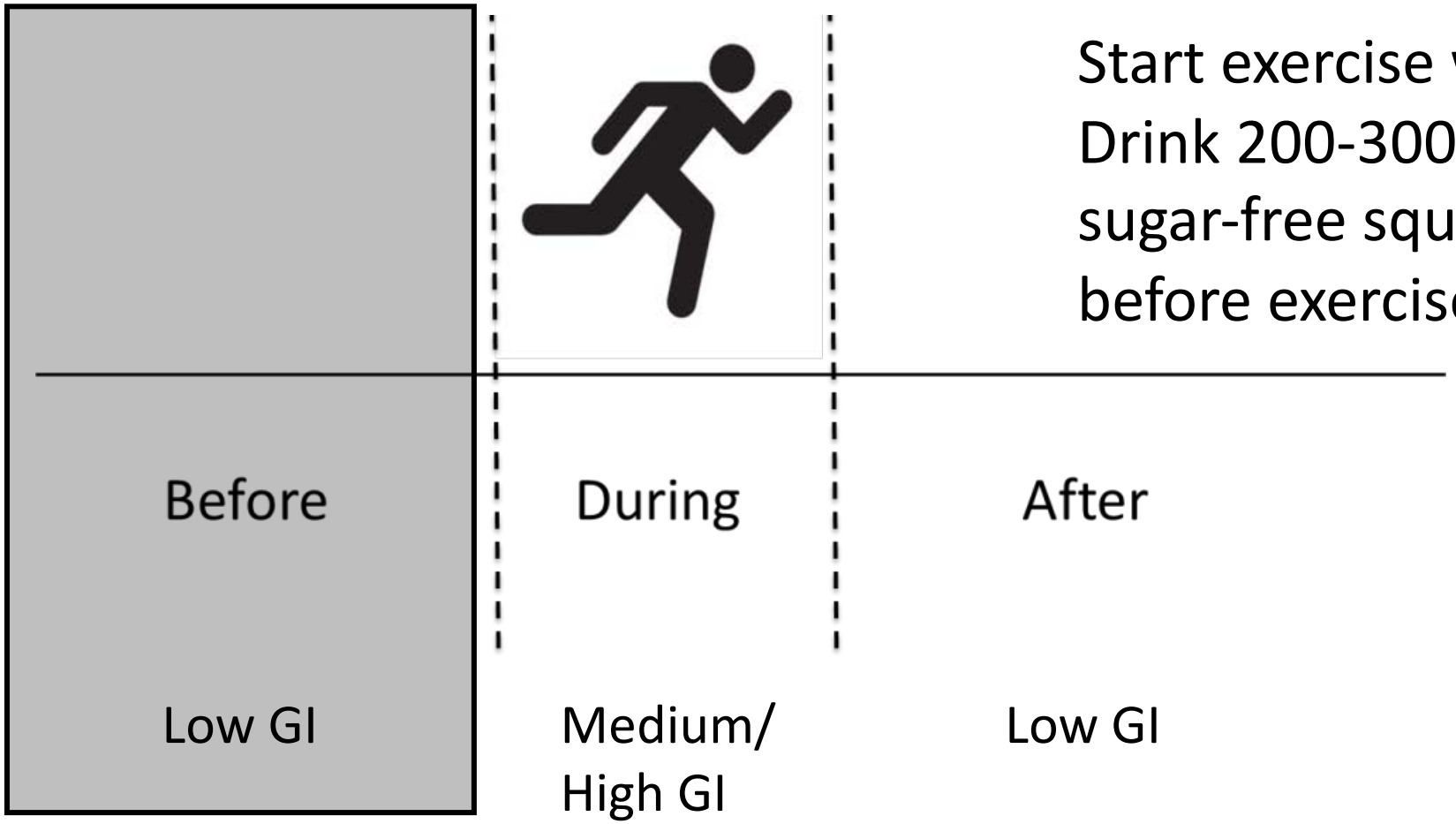
ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod

Recovery food

- Protein and Carbohydrate together improve glycogen storage 2 hours post exercise
- 4 carb : 1 protein
- 1g/kg/hr Carb (greater than 90 minutes 1.2 g/kg/hr)
- 0.2g/kg/hr Protein (up to 20 grams)

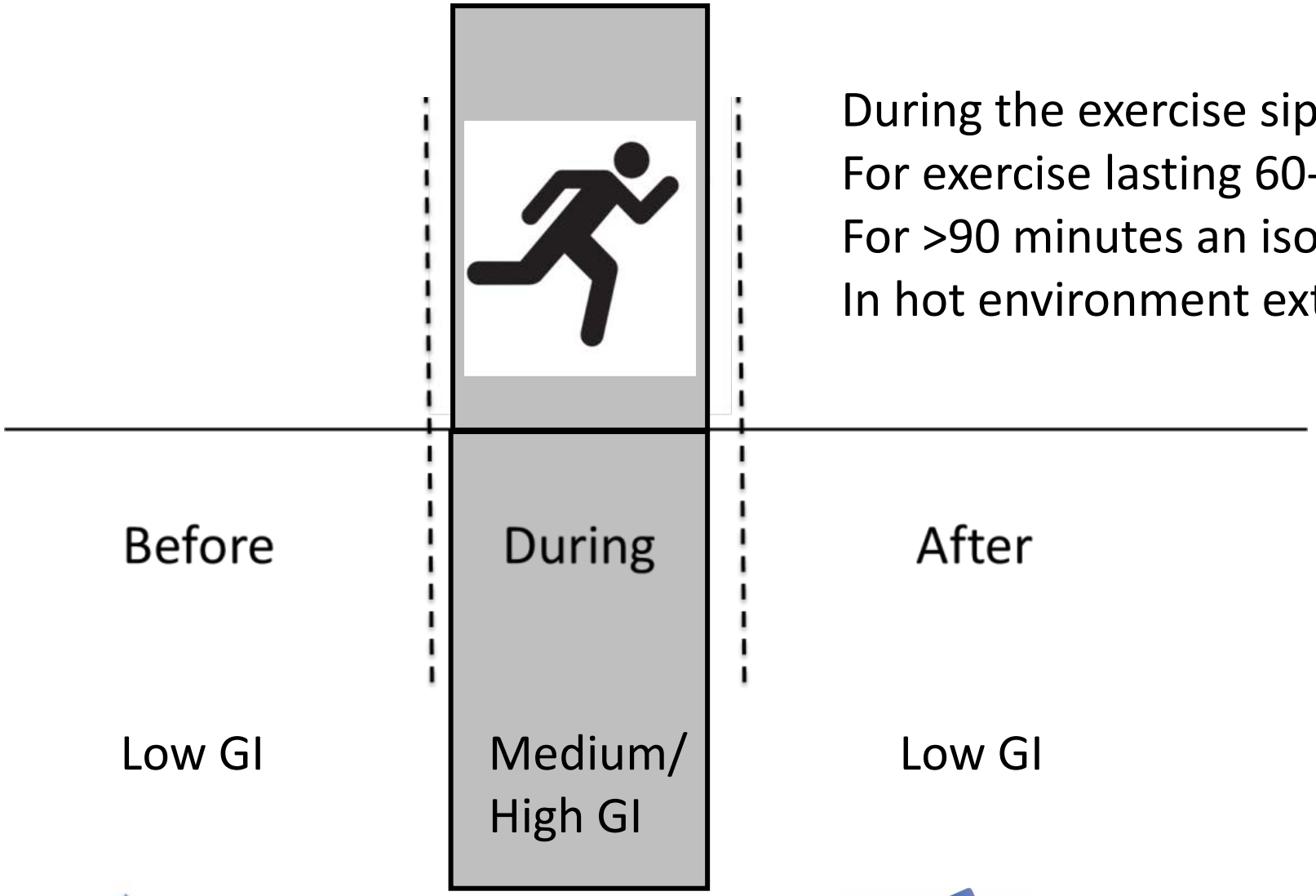



Type & Timing of fluid



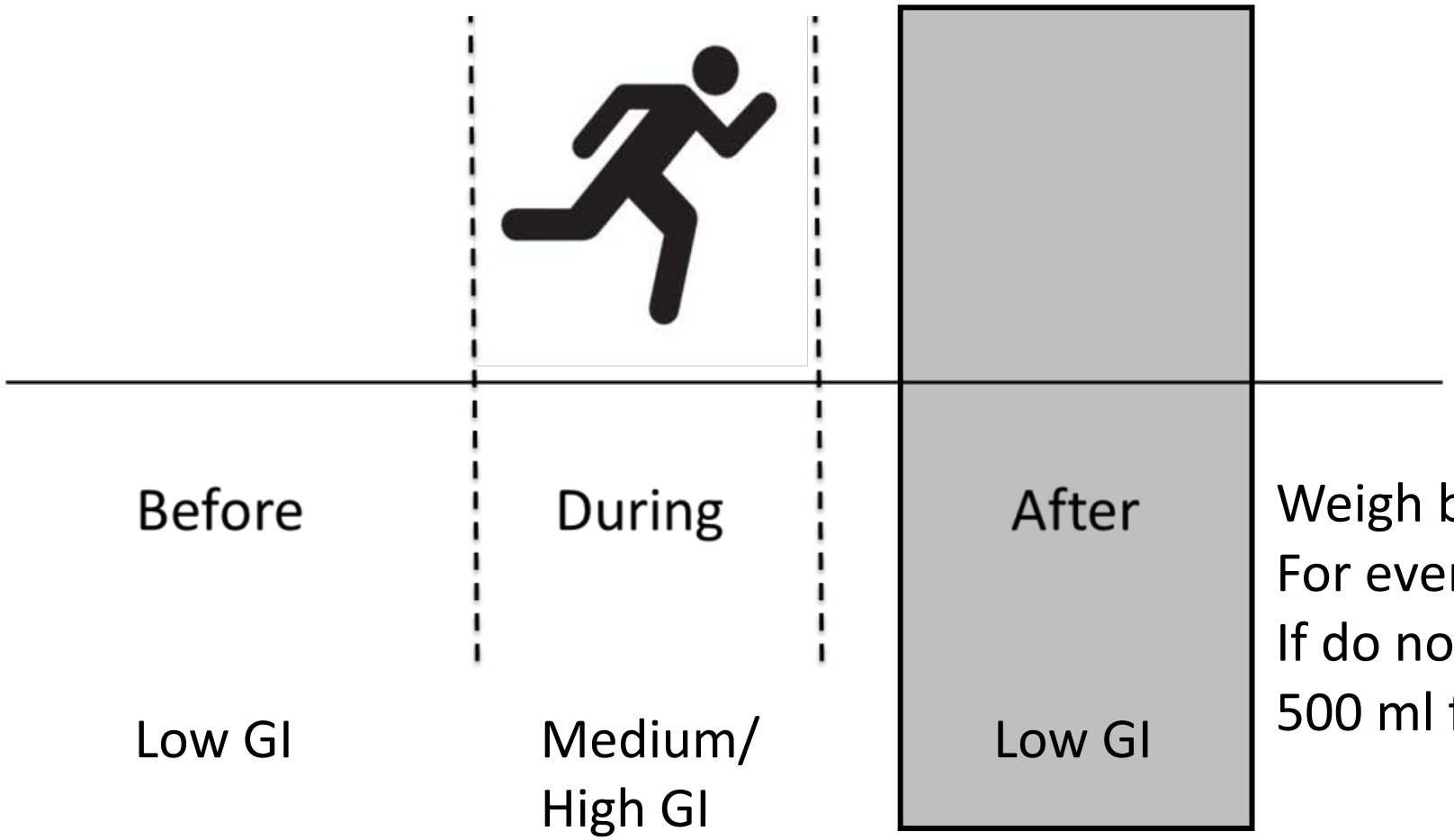
Start exercise well hydrated.
Drink 200-300 mls water or sugar-free squash in the hour before exercise

Type & Timing of fluid



During the exercise sip fluid every 20 minutes.
For exercise lasting 60-90 minutes water is fine
For >90 minutes an isotonic sports drink is best.
In hot environment extra salt may be needed.

Type & Timing of Fluid



Weigh before and after exercise.
For every 0.5 kg lost drink 500 ml
If do not know weight lose then
500 ml for every hour of sport

Preventing hypoglycaemia overnight – Bedtime snacks

If blood glucose <10 before bed then suggest have protein and carbohydrate snack (30 grams carb + 15 gram protein).

If blood glucose <7 before bed as well as a snack may need to make reduction in background insulin/basal rate of 10%.

ABCD Association of British Clinical Diabetologists
JDRF PEAK T1D Performance in Exercise and Knowledge
extod education

Using exercise to manage glucose post exercise

Using exercise to lower glucose post exercise

Weightlifting, Tag

Sprinting, Diving, Swimming, Gymnastics,

Wrestling, Dodge ball, Volleyball, Ice hockey, Track cycling

Basketball, Football, Tennis, Lacrosse

Skating

Skiing (slalom & downhill), Field hockey

Rowing (middle distance)

Running (middle distance)

In-line skating

Cross country skiing

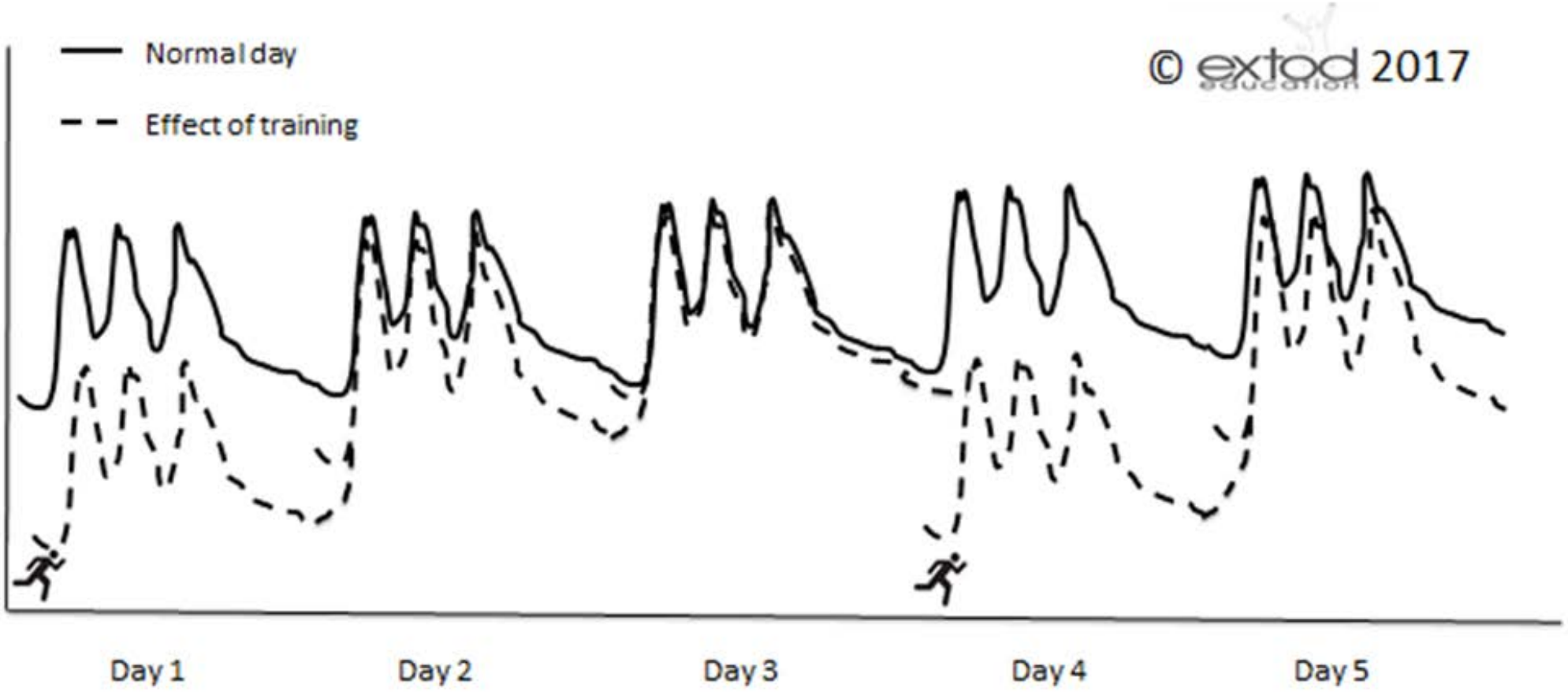
Brisk Walking

Jogging

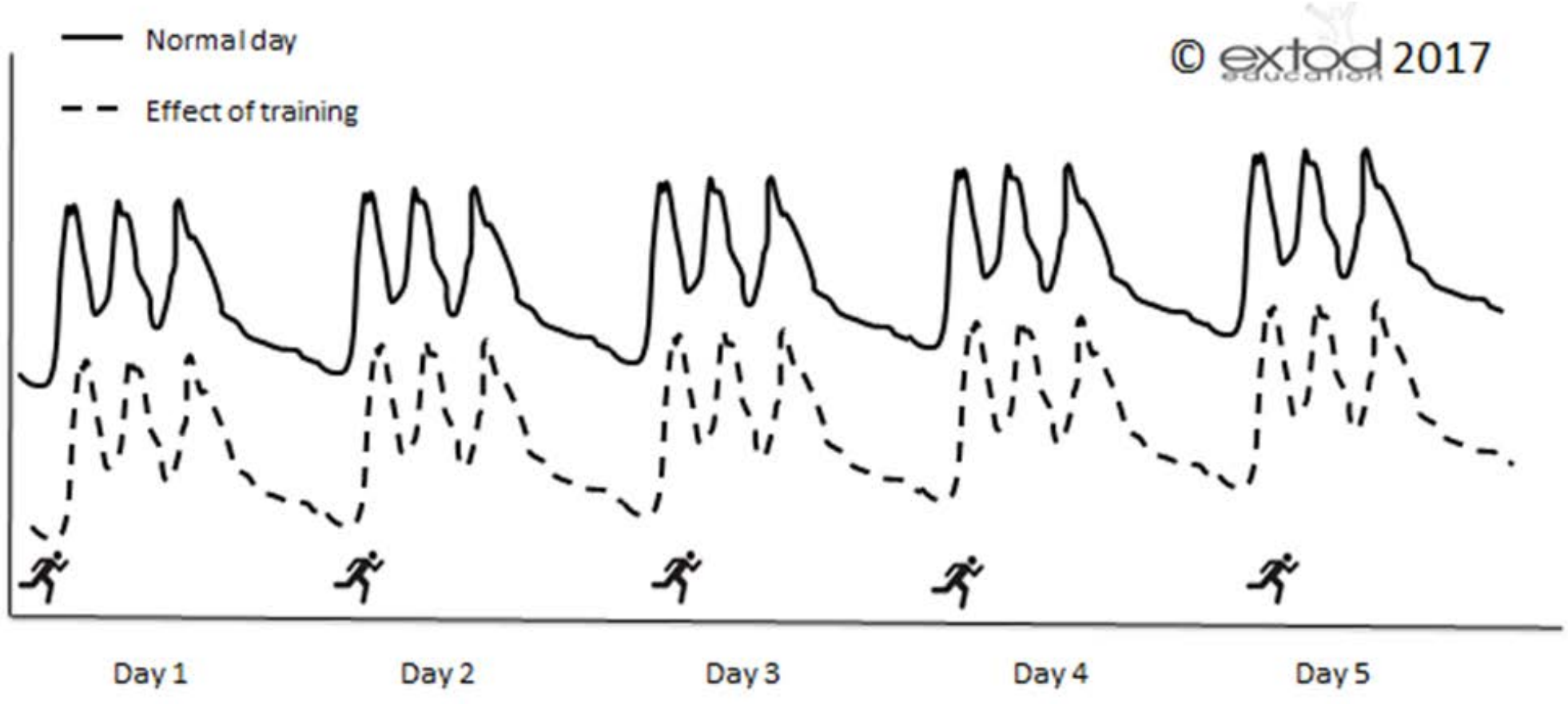
Cycling

} Warm down

Effect of exercising 2 times per week on insulin levels required for glucose control

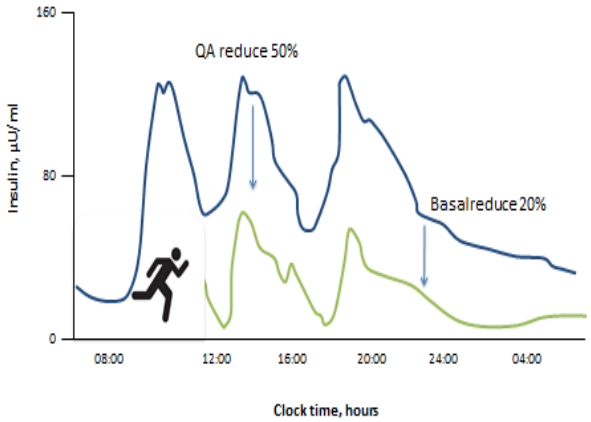


Effect of exercising everyday on insulin levels required for glucose control



Three options for managing glucose after exercise - ICE

Insulin – how much on board / how do you alter it



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

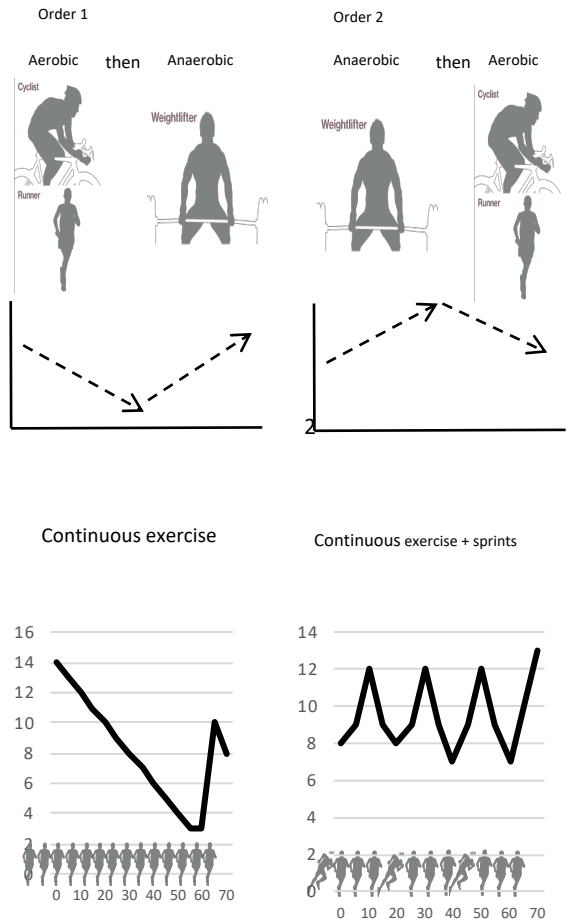
50% of normal quick acting insulin for first 2 meals/snacks after

20% reduction night time background insulin
If exercise after 4 pm or longer than 2 hours

Carbohydrate for exercise

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

Exercise type and intensity



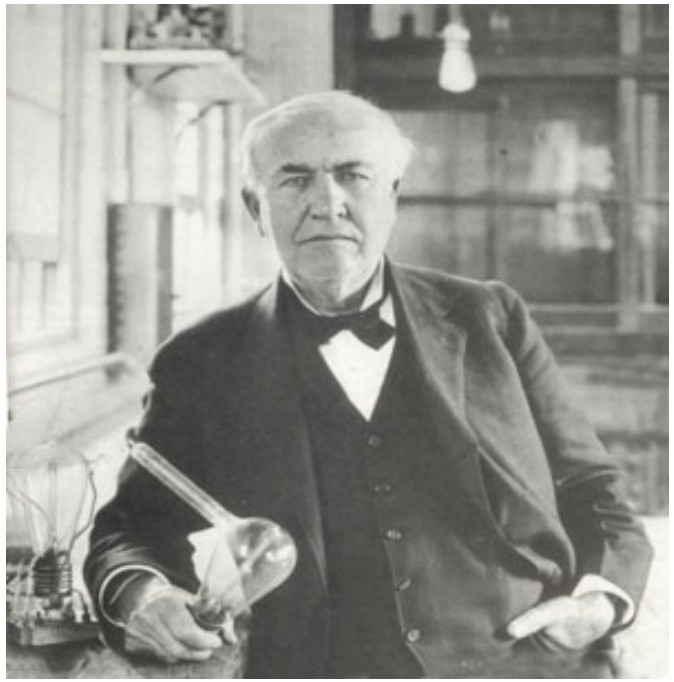
ABCD Association of British Clinical Diabetologists

JDRF PEAK T1D Performance in Exercise and Knowledge

extod

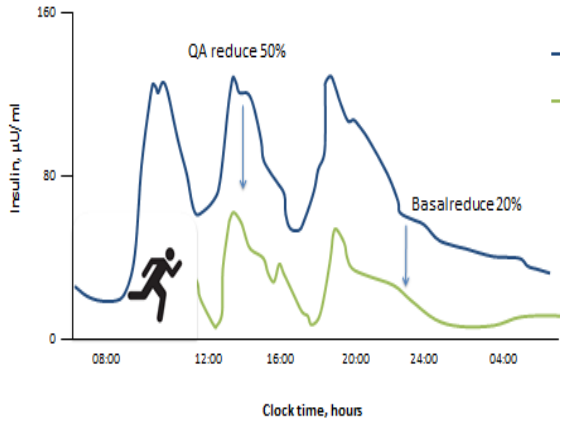
"I have not failed. I've just found 10,000 ways that won't work"

Thomas Edison (1847-1931)



Three options for managing glucose around exercise - ICE

Insulin – how much on board / how do you alter it



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

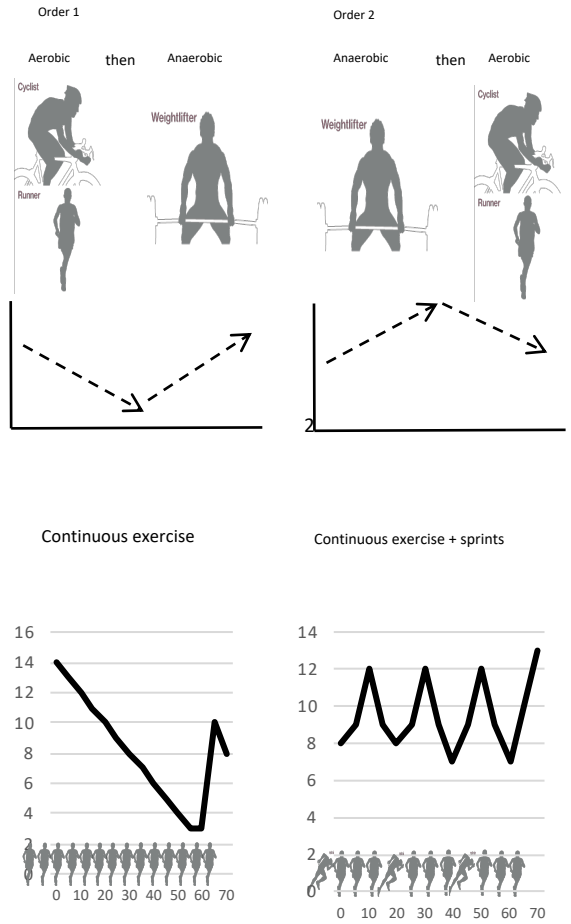
50% of normal quick acting insulin for first 2 meals/snacks after

20% reduction night time background insulin
If exercise after 4 pm or longer than 2 hours

Carbohydrate for exercise

Situation	General CHO Recommendations
Habitual diet	Light training 3-5 g/kg/d
	Mod exercise 5-7 g/kg/d
	High (1-3h/d) 6-10 g/kg/d
	Very high (>4-5h/d) 8-12 g/kg/d
Pre event meal eaten 1- 4 hours pre exercise	A minimum of 1-4g/kg BW for exercise > 1 h duration Consider Low GI choices
During activity (> 1 hour) Ultra Endurance (>3 hours)	30-60 g/h Up to 90 g/h Consider High GI choices
Recovery	1 -1.2g/kg during the first hour

Exercise type and intensity



ABCD Association of British Clinical Diabetologists

JDRF PEAK T1D Performance in Exercise and Knowledge

extod

Further information

Emails

r.c.andrews@exeter.ac.uk

p.narendran@bham.ac.uk

Website

www.extodorg.ipage.com