JDRF PEAK
T1D Performance in Exercise and Knowledge

PEAK PARTICIPANT CURRICULUM

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JDRF PEAK
T1D Performance in Exercise and Knowledge

GETTING INTO THE GAME

Participant Curriculum
Breakout Session

Developed by:
Rob Andrews & Peter Adolfsson

Presented by: Rob Andrews

Session agenda

- A bit of physiology
- Tips for exercising safely
- Blood glucose control before exercise
- Blood glucose control during exercise
- Insulin management and exercise
- Blood glucose control after exercise
- Bringing it all together

A BIT OF PHYSIOLOGY

A BIT OF PHYSIOLOGY

Hormones that affect blood glucose levels

Hormones that raise blood glucose:

Glucagon

Stress hormones:

- Adrenaline
- Noradrenaline
- Cortisol
- Growth hormone

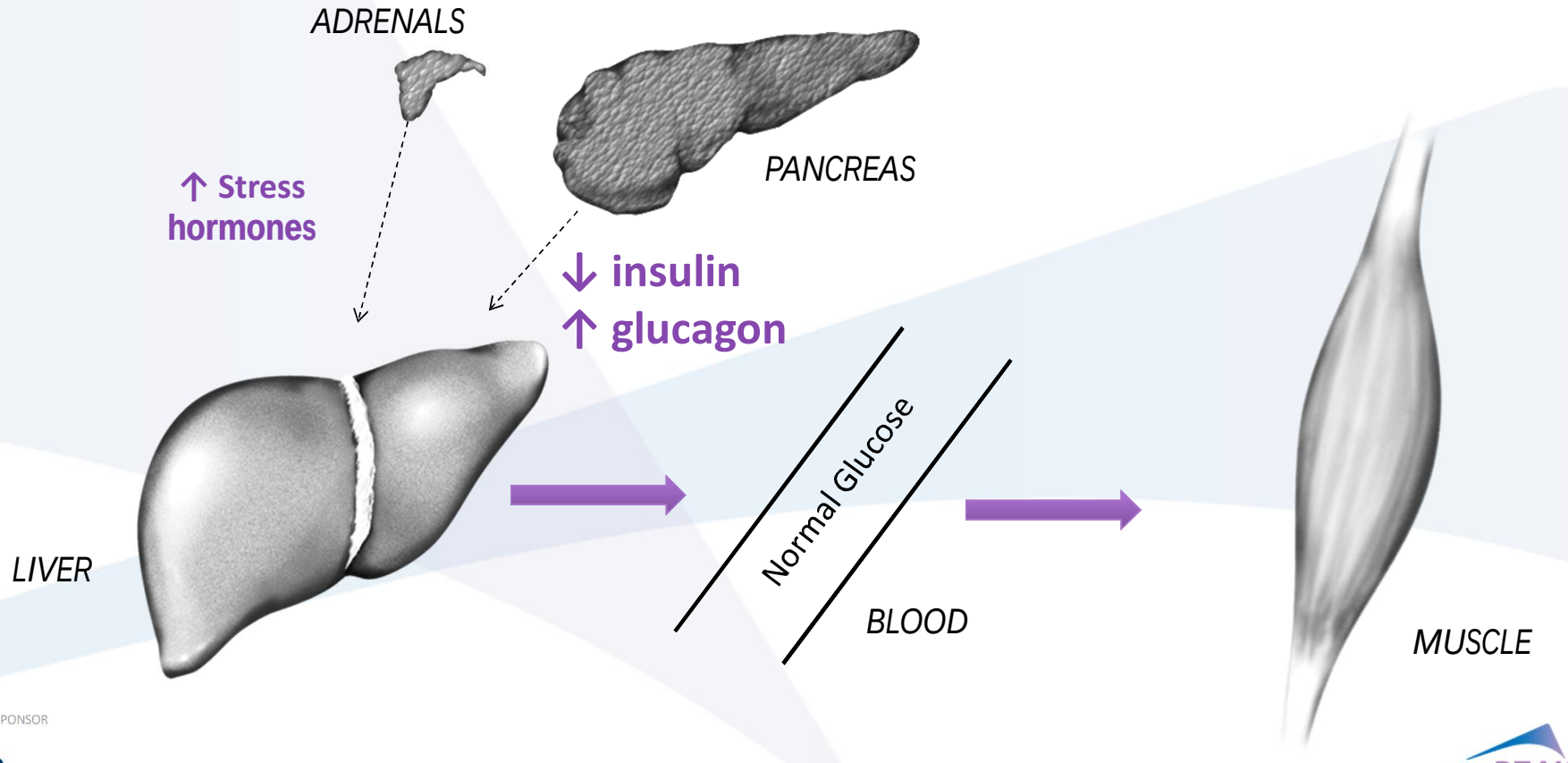
Hormones that lower blood glucose:

Insulin

Endocrine and metabolic responses to exercise. Chapter 1 in Type 1 diabetes (2012), Clinical Management of the Athlete. Editor Ian Gallen.

A BIT OF PHYSIOLOGY

Normal glucose control during aerobic exercise



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A BIT OF PHYSIOLOGY

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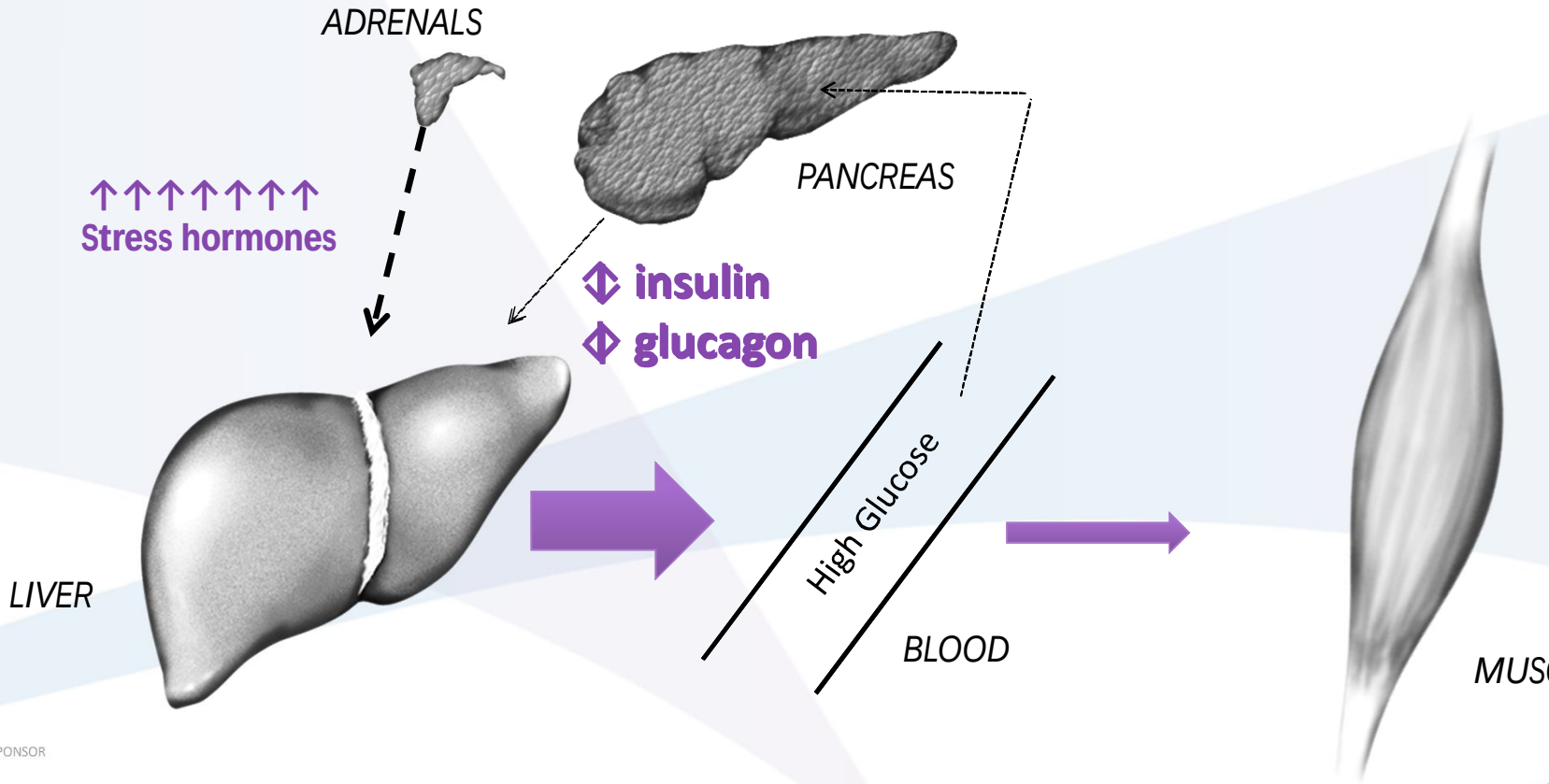


Endocrine and metabolic responses to exercise. Chapter 1 in Type 1 diabetes (2012), Clinical Management of the Athlete. Editor Ian Gallen.

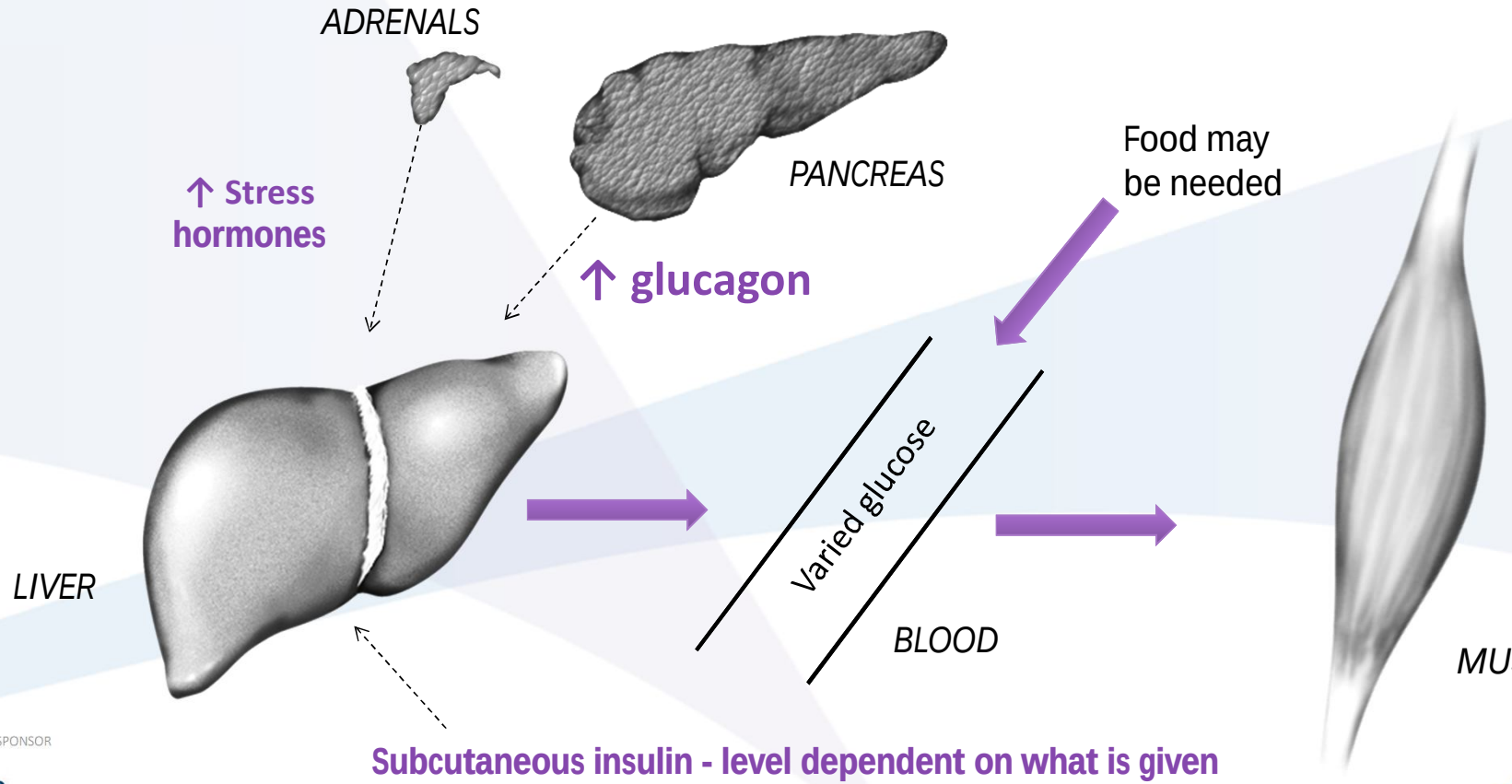
A BIT OF PHYSIOLOGY

Normal control of glucose with exercise

- In people without diabetes:
  - Glucose levels are kept in normal range by automatic changes in glucagon, insulin and stress hormones (adrenaline, noradrenaline, cortisol and growth hormone)
- During **aerobic** exercise:
  - Blood glucose remains stable
- During **anaerobic** exercise:
  - Blood glucose can rise… but!
  - Glucose levels are quickly brought down by an increase in insulin

A BIT OF PHYSIOLOGY

Glucose control during aerobic exercise in Type 1 diabetes

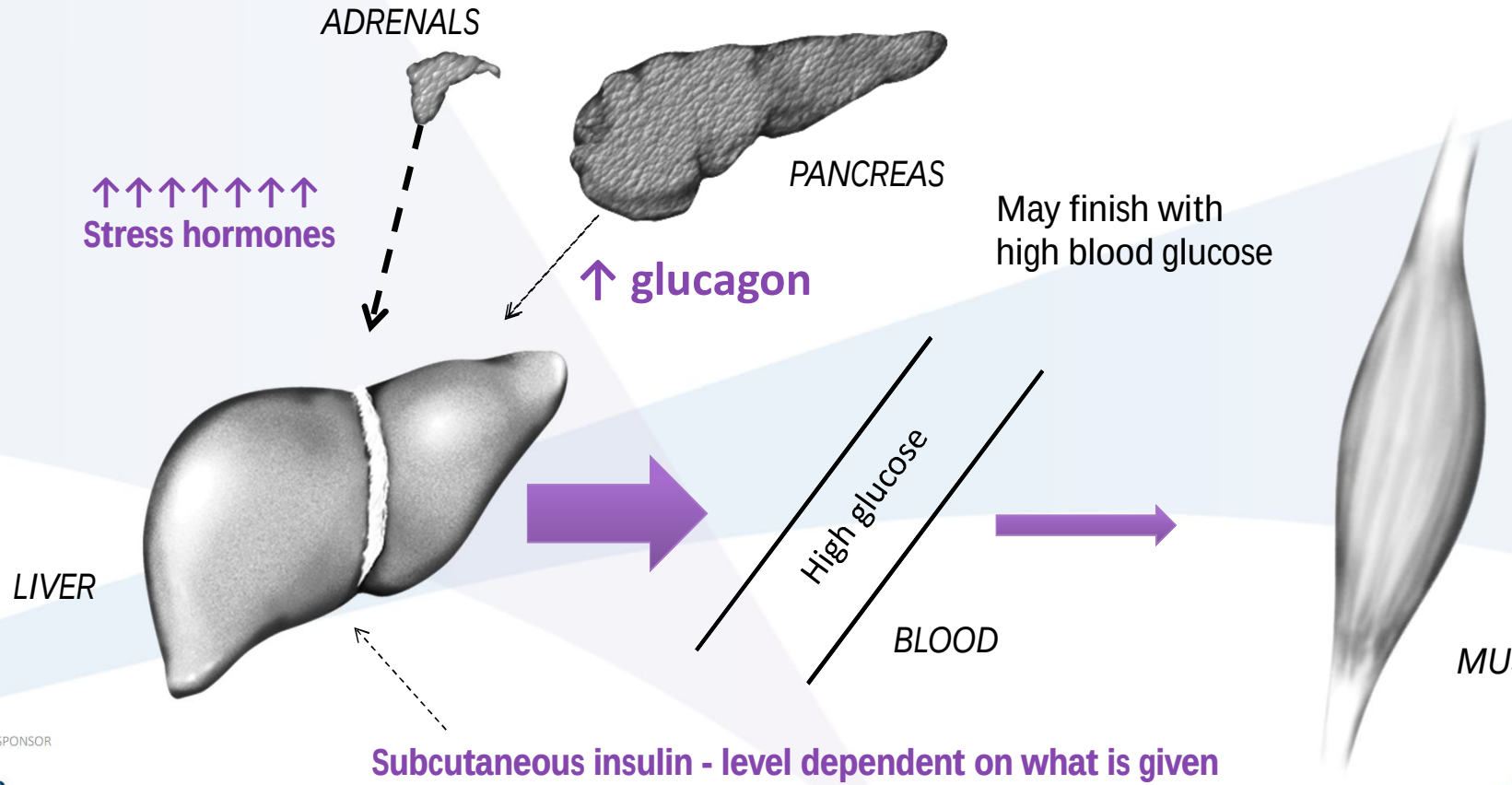


Subcutaneous insulin - level dependent on what is given

The impact of Type 1 Diabetes on the physiological responses to exercise. Chapter 2 in Type 1 diabetes (2012), Clinical Management of the Athlete. Editor Ian Gallen.

A BIT OF PHYSIOLOGY

Glucose control during anaerobic exercise in Type 1 diabetes



Subcutaneous insulin - level dependent on what is given

The impact of Type 1 Diabetes on the physiological responses to exercise. Chapter 2 in Type 1 diabetes (2012), Clinical Management of the Athlete. Editor Ian Gallen.

A BIT OF PHYSIOLOGY

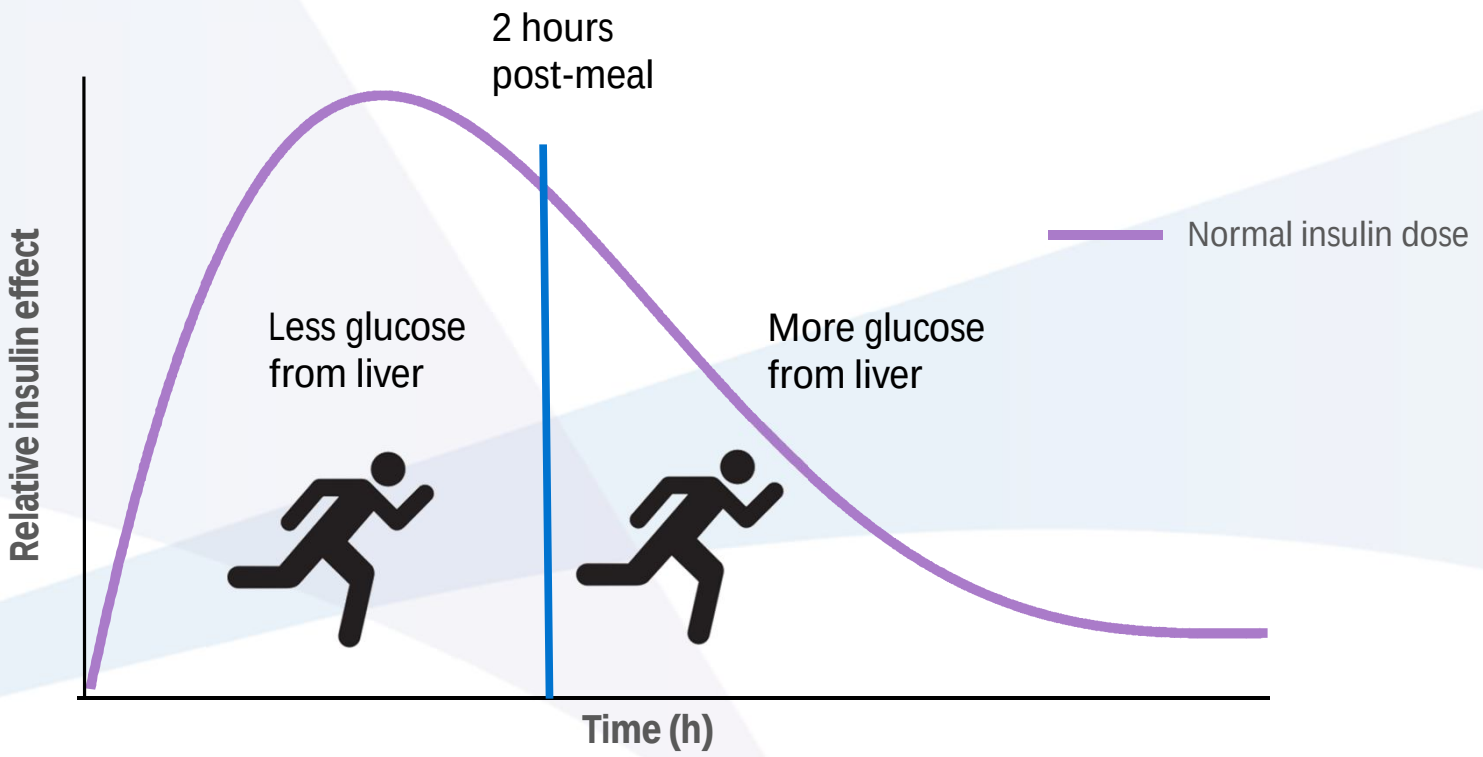
Exercise on glucose control and Type 1 diabetes

- During **aerobic** exercise:
  - Blood glucose tends to fall (unless insulin dose reduction is perfect – difficult to do)
- During **anaerobic** exercise:
  - Blood glucose tends to rise (unless insulin has been increased by correct amount)
- During **mixed** exercise:
  - Blood glucose levels can go ↑ or ↓

Checking your blood glucose before, during and after exercise will enable you to see your own response to different sports

A BIT OF PHYSIOLOGY

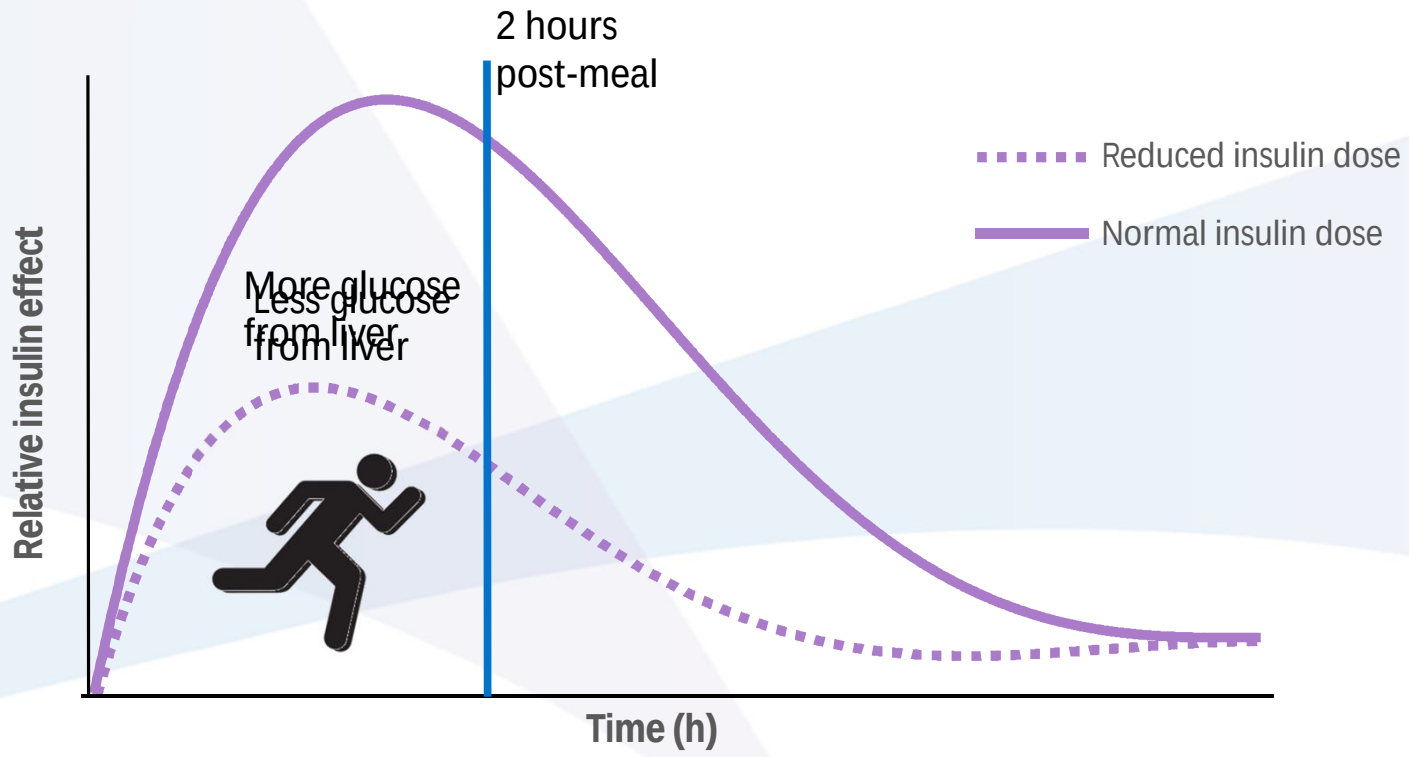
Effect of bolus insulin on liver glucose production over time



Adapted from: Lumb AN & Gallen IW. *Curr Opin Endocrinol Diabetes Obes*. 2009 Apr;16(2):150-5.

A BIT OF PHYSIOLOGY

Effect of reducing bolus insulin dose on liver glucose production when exercising



Adapted from: Lumb AN & Gallen IW. *Curr Opin Endocrinol Diabetes Obes*. 2009 Apr;16(2):150-5.

A BIT OF PHYSIOLOGY

Effect of insulin on liver glucose production during exercise

- Exercising within 2 hours of taking bolus insulin will result in less glucose being produced by the liver when exercising
  - Blood glucose is more likely to fall more quickly when exercising during this period
- Reduce bolus insulin **within 2 hours prior to exercise** to enable more glucose to be produced from the liver during exercise
  - Blood glucose will fall less quickly during the exercise period

TIPS FOR EXERCISING SAFELY

TIPS FOR EXERCISING SAFELY

Exercise recommendations for people with Type 1 diabetes

Population	Recommended activity level
Adults with Type 1 diabetes[1]	• At least 150 minutes per week of moderate-intensity or 75 minutes per week of vigorous-intensity aerobic physical activity, or an equivalent combination of the two • This should spread over 3 days with no more than 2 consecutive days without exercise • Additionally, muscle-strengthening activities that involve all major muscle groups should be performed on 2 or more days of the week • Reduction in sedentary time is also recommended • Engage in daily physical activity
Children and teens with Type 1 diabetes[1]	• At least 60 minutes of physical activity daily • This should include vigorous-intensity aerobic activity, muscle-strengthening activities and bone-strengthening activities at least 3 days of the week • Engage in daily physical activity
Pregnancy in adults with Type 1 diabetes[2]	• At least 30 minutes or more of moderate exercise daily if there are no medical or obstetric complications • Engage in daily physical activity

1. Riddell MC, *et al. Lancet Diabetes Endocrinol* 2017 Published Online January 23, 2017 http://dx.doi.org/10.1016/
2. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Report. Washington, DC: U.S. Department of Health and Human Services; 2008
3. Pate RR *et al. JAMA*. 1995;273(5):402-7

TIPS FOR EXERCISING SAFELY

Exercise and the complications of diabetes

Complication	Advice
Heart disease	• If you have heart disease (angina, heart failure) then do not exercise without confirmation from your GP or diabetes team • If you have chest pain then do not exercise without being checked out by your GP
Loss of sensation (neuropathy)	• Wear appropriate shoes and check feet regularly • Do not exercise when you have a foot problem, such as an ulcer, that is under review by your GP or diabetes team until problem resolved
Eye problems (retinopathy)	• Avoid vigorous exercise if under review by your eye team or asked to have eye photos (screening) taken more than once a year
Kidney problems (nephropathy)	• No restrictions • There is evidence that regular exercise can protect kidneys

GP, general practitioner
Chapter 26, Textbook of Diabetes. Lifestyle Issues: Exercise. MZ. Chen & R.C. Andrews.

TIPS FOR EXERCISING SAFELY

Checklist for safe exercise practices

Item	Individual without Type 1 diabetes	Individual with Type 1 diabetes
Carbohydrate supplements (drinks and snacks)	✓	✓
Mobile phone (if exercising alone)	✓	✓
Water or electrolyte (calorie free) sports drinks to maintain hydration	✓	✓
Appropriate footwear and clothing for the specific exercise	✓	✓
Suitable hypoglycemia treatment	✗	✓
Medical card and/or bracelet/necklace	✗	✓
Glucose monitoring system	✗	✓

TIPS FOR EXERCISING SAFELY

Helpful tips to consider

1. **Do something you enjoy!**
   - If you enjoy it, you are more likely to keep it up
2. **Start slow**
   - Doing just a little bit more than you did before will still make a difference
   - Build up gradually, giving your body time to adapt as your muscles strengthen
   - If you have any medical conditions, do speak to your healthcare team before starting any new activity
3. **Warm UP and DOWN**
   - This will reduce your chances of injury
4. **Make small changes**
   - Walking is a free and a simple way to improve your fitness
   - Beat the traffic and leave the car at home for small trips, or get off the bus/train one or two stops earlier and walk the rest of the way

TIPS FOR EXERCISING SAFELY

Helpful tips to consider

5. **Set goals for yourself**
   - You are more likely to stick to an active lifestyle if you set goals
   - Set realistic short-term and long-term targets and keep an exercise diary to track your achievements
   - Reward yourself when you reach a goal
6. **Variety is the spice of life**
   - Once you are exercising regularly, shake things up and vary your routine
   - Swap cycling on an exercise bike for cycling outdoors or try a new class at the gym
   - Always check with your healthcare team before starting a new activity to see how it will affect your diabetes
7. **Make it social**
   - Instead of meeting friends for a drink, do something active like going for a walk or playing tennis or golf
8. **Don't give up**
   - Although your body benefits as soon as you become more active, you may not see all the benefits right away
   - It can take time for your body to adapt to a new activity - stick with it and you will see the positive results

BLOOD GLUCOSE CONTROL BEFORE EXERCISE

CASE #1 – BLOOD GLUCOSE CONTROL BEFORE EXERCISE

John

- John is 32 years old
- Type 1 diabetes since age 15
- Last HbA_{1c} = 54 mmol/mol (7.1%)
- Takes rapid insulin with each meal and long-acting insulin before bed
- Training for his first 10k run
- Currently running 3 times/week for 60 min each time

CASE #1 – BLOOD GLUCOSE CONTROL BEFORE EXERCISE

John

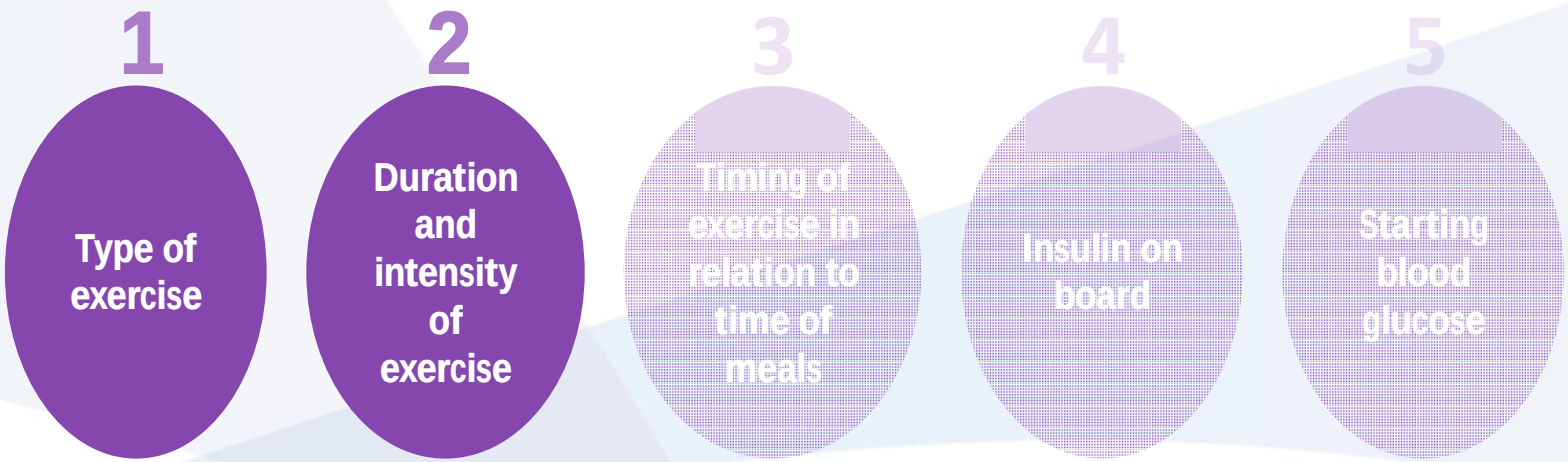
- What factors should John consider when planning for his run?

CASE #1 – BLOOD GLUCOSE CONTROL BEFORE EXERCISE

Factors for John to consider

CASE #1 – BLOOD GLUCOSE CONTROL BEFORE EXERCISE

What will happen to his blood glucose when John starts to exercise?



CASE #1 – BLOOD GLUCOSE CONTROL BEFORE EXERCISE

Types of exercise

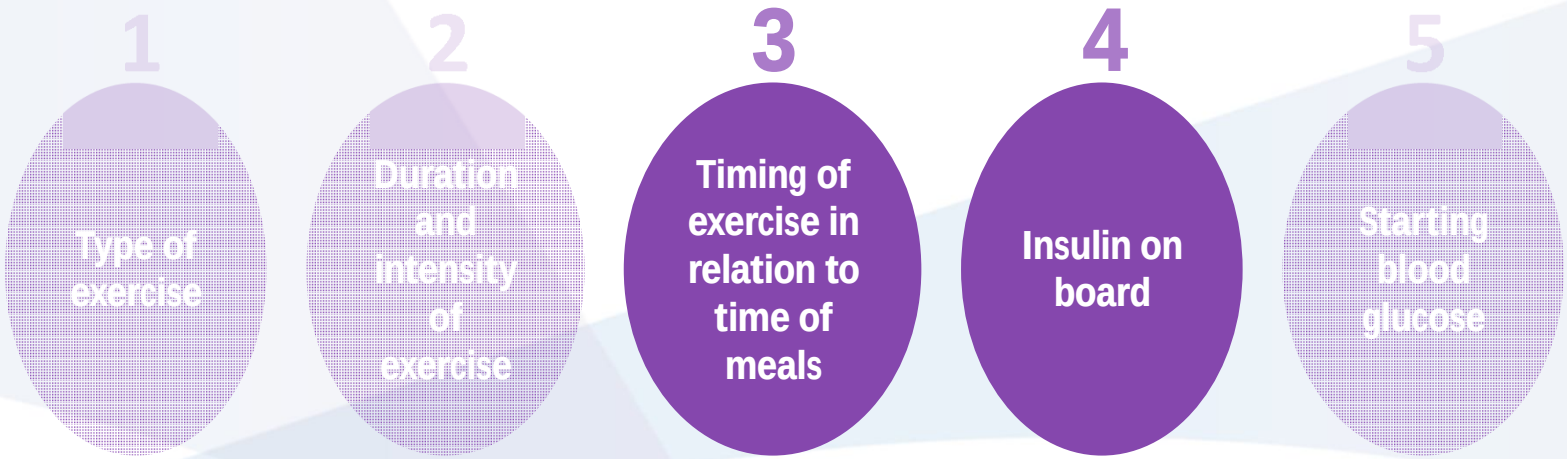
Weightlifting, Tag
Sprinting, Diving, Swimming, Gymnastics,
Wrestling, Dodge ball, Volleyball, Ice hockey, Track cycling

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

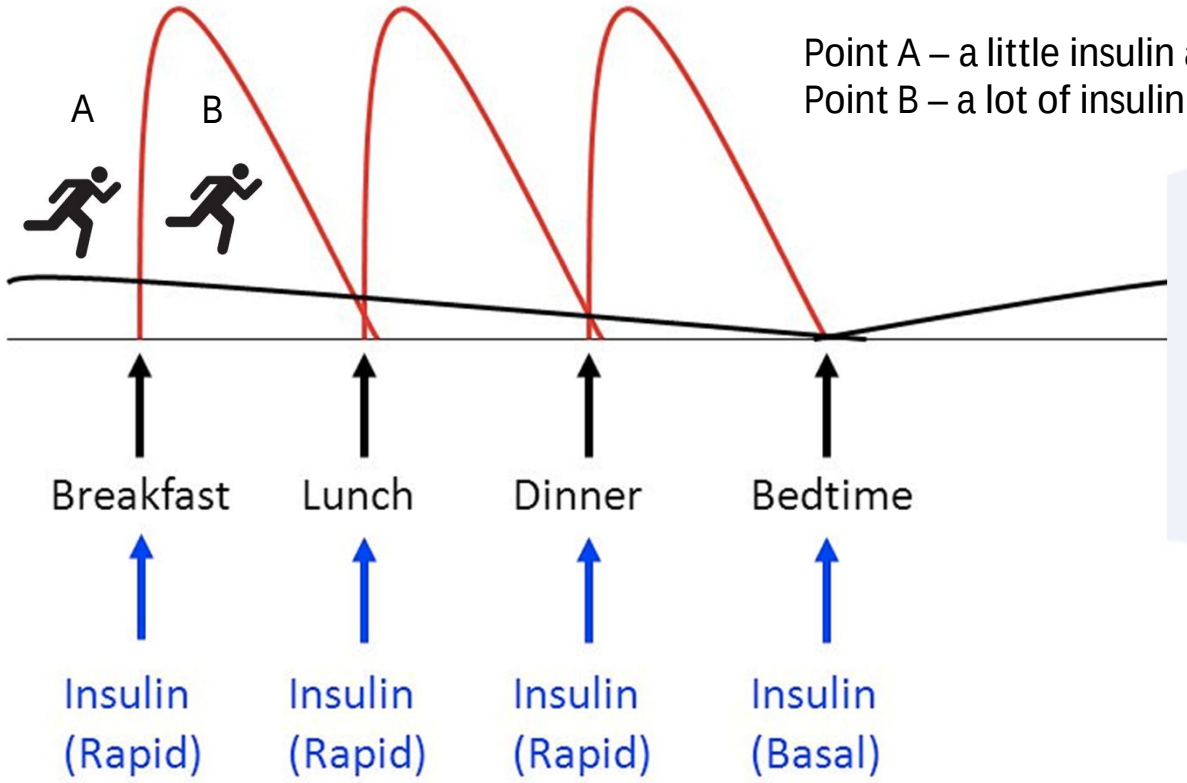
CASE #1 – BLOOD GLUCOSE CONTROL BEFORE EXERCISE

When is the safest time for John to exercise?



BLOOD GLUCOSE CONTROL BEFORE EXERCISE

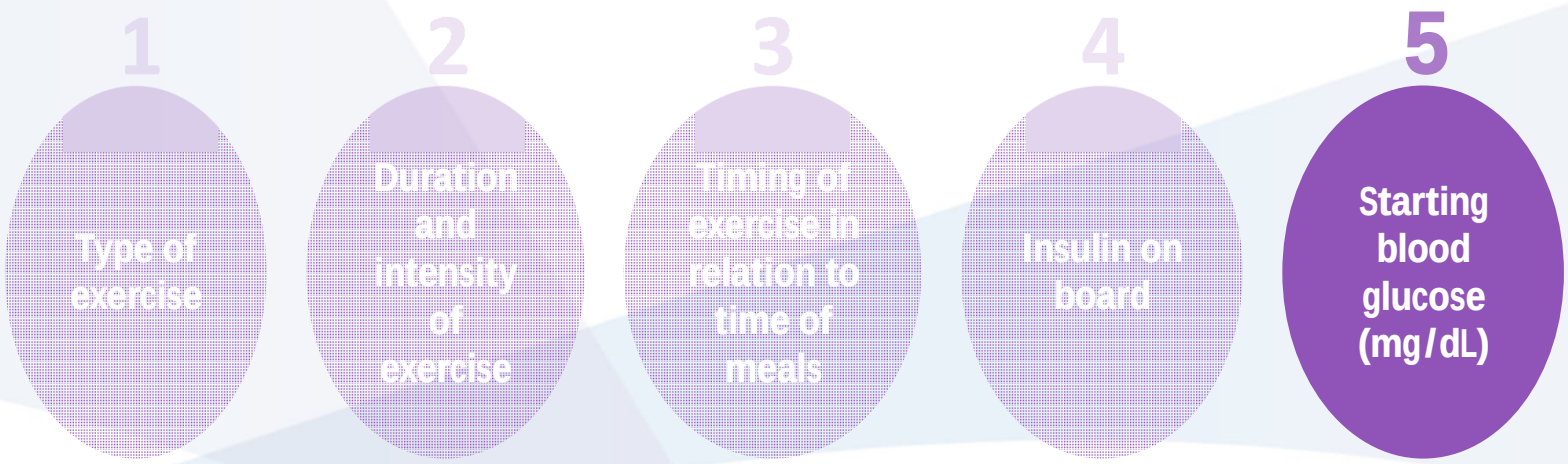
Amount of insulin on board



Point A – a little insulin around
Point B – a lot of insulin around

BLOOD GLUCOSE CONTROL BEFORE EXERCISE

What is a safe blood glucose level to start with?



72? 153? 315?

BLOOD GLUCOSE CONTROL BEFORE EXERCISE

Blood glucose levels that say “no”

LOW BLOOD GLUCOSE

- Severe hypoglycemia
  - Don’t exercise for 24 hours
- Self treated hypoglycemia
  - 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 >270 mg/dL
- Ketones present:
  - Take insulin by injection and hydrate
  - Wait until ketones diminish before exercising
- No ketones:
  - If bolused <2 hours: just monitor
  - If bolused >2 hours: take “extra conservative” dose of correctional insulin, less insulin on board

BLOOD GLUCOSE CONTROL BEFORE EXERCISE

Starting blood glucose

Blood glucose concentrations	Recommendations (rule of thumb)*
<90 mg/dL†	▪ Ingest 10–20g of glucose before exercise ▪ Delay exercise until blood glucose >90 mg/dL
90 – 144 mg/dL†	▪ Ingest 10g of glucose ▪ Exercise can be started
144 – 270 mg/dL†	▪ Low intensity exercise can be started
>270 mg/dL	▪ Check blood ketones and perform low intensity exercise, or give small corrective dose of insulin ▪ Low intensity exercise may be okay if blood ketones are <27 mg/dL, or <2+ urine ketones; consider small corrective dose of insulin

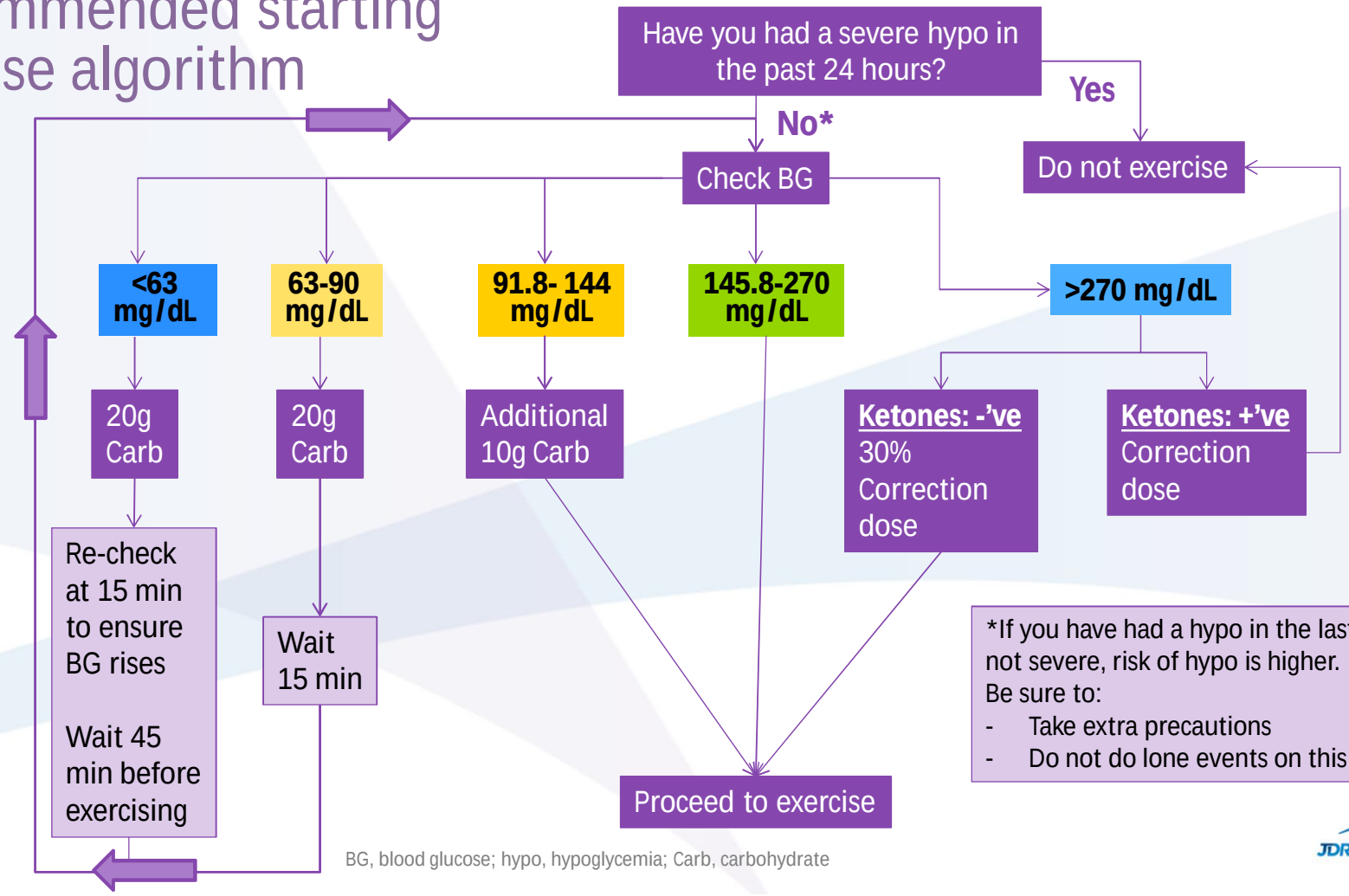
People with type 1 diabetes should aim to start exercise with blood glucose between 90 and 144 mg/dL. Please note that these recommendations apply about 10 minutes before exercise.

†90 mg/dL = 5 mmol/L; 144 mg/dL = 8 mmol/L; 270 mg/dL = 15 mmol/L

Riddell MC, *et al. Lancet Diabetes Endocrinol* 2017 Published Online January 23, 2017 http://dx.doi.org/10.1016/S2213-8587(17)30014-1

BLOOD GLUCOSE CONTROL BEFORE EXERCISE

Recommended starting glucose algorithm



*If you have had a hypo in the last 24 hours but not severe, risk of hypo is higher.
Be sure to:
- Take extra precautions
- Do not do lone events on this day

BG, blood glucose; hypo, hypoglycemia; Carb, carbohydrate

BLOOD GLUCOSE CONTROL DURING EXERCISE

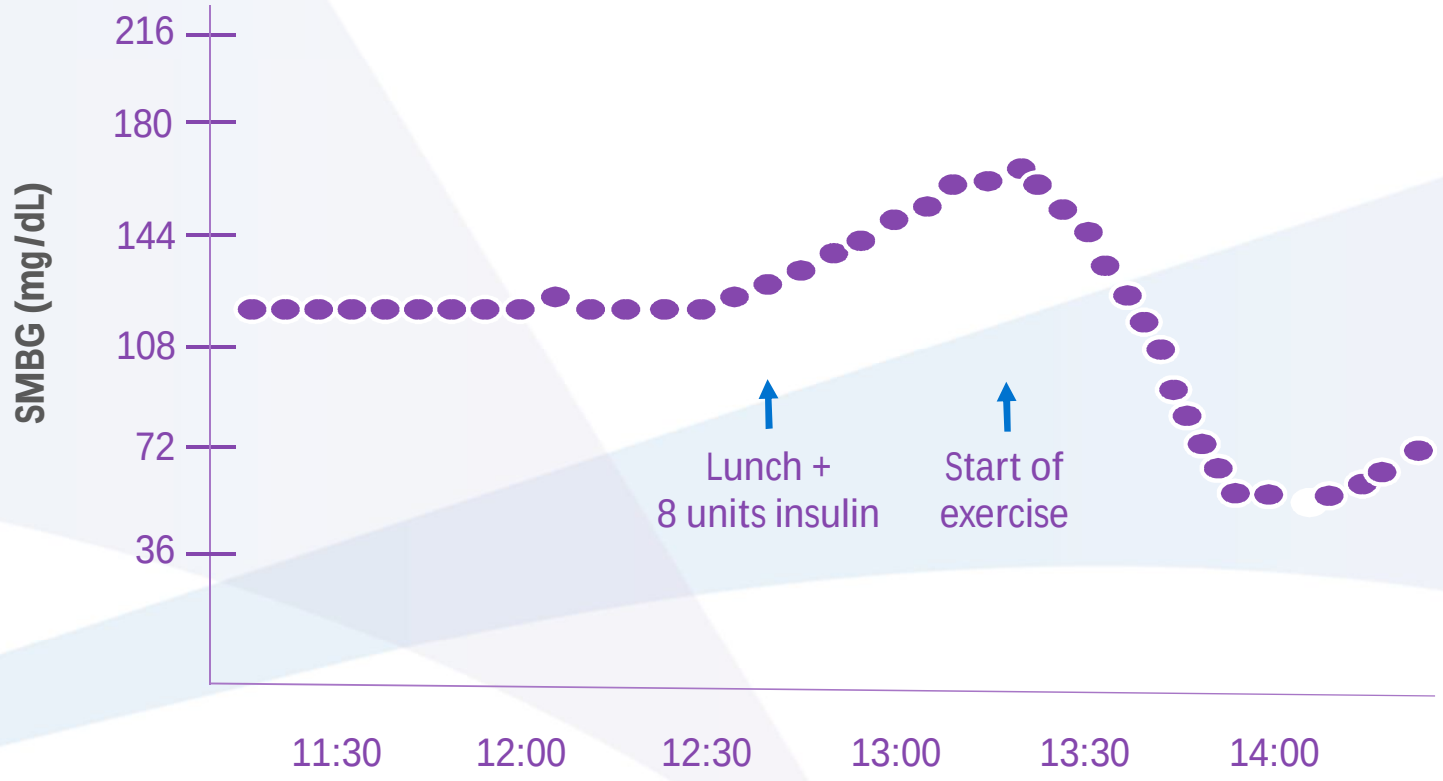
CASE #1 – BLOOD GLUCOSE CONTROL DURING EXERCISE

John

- John decides to run 1 hour after lunch
- His starting blood glucose levels are between 126-162 mg/dL
- He consumes 80g of carbohydrates for lunch and takes 8 units of insulin
- During the run his blood glucose falls

CASE #1 – BLOOD GLUCOSE CONTROL DURING EXERCISE

John's training day blood glucose levels



BLOOD GLUCOSE CONTROL DURING EXERCISE

Three ways to manage drop in blood glucose

Extra carbs for exercise (ExCarbs)

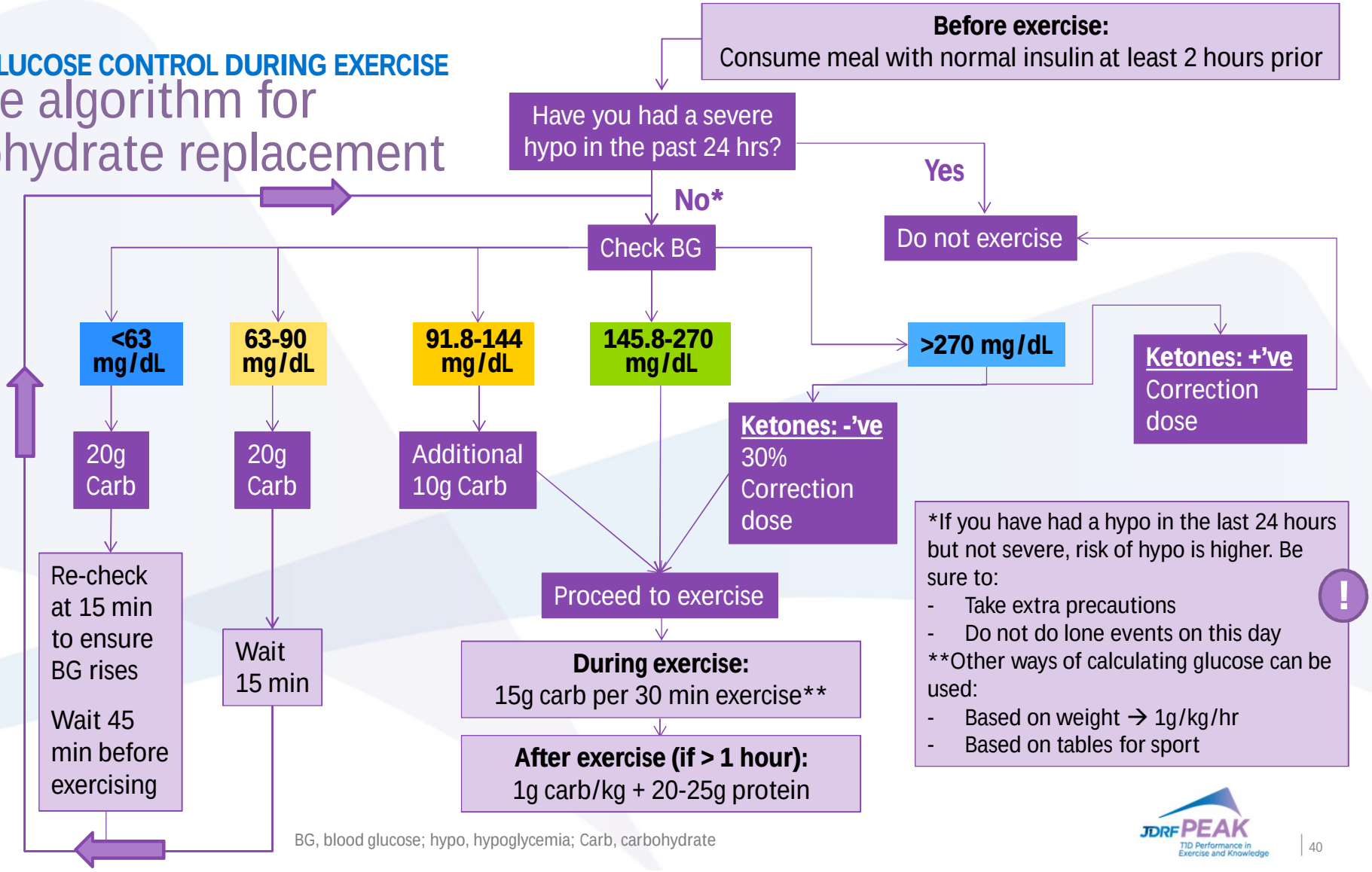
- Basic rule:
  - 30g of carbohydrate per hour of exercise
  - Weight calculated → 1g/kg/hr

- **Basic ExCarb estimate:**
  - 15g carbohydrate per 30 minutes of exercise
  - Example:
    - John exercises for 60 minutes
    - = 15g at start and 15g at 30 minutes

- **Semi-quantitative estimate:**
  - Takes into account body weight
  - 1g carbohydrate/kg/hr exercise
  - Example:
    - John weighs 90 kg (198.4 lb) and exercises for 60 minutes
    - = 30g at start, 30g at 30 minutes and 30g at finish

BLOOD GLUCOSE CONTROL DURING EXERCISE

Simple algorithm for carbohydrate replacement



BG, blood glucose; hypo, hypoglycemia; Carb, carbohydrate

BLOOD GLUCOSE CONTROL DURING EXERCISE

Continous Glucose Monitoring (CGM) and carbohydrate intake algorithm to reduce/avoid hypoglycemia while exercising

CGM Glucose level	Trend arrow(s)	Action	Comments
<90 mg/dL (5.0 mmol/L)	None or downward trending	16-20g CHO	Stop exercise if blood glucose ≤ 70 mg/dL (3.9 mmol/L)
91-110 mg/dL (5.0-6.1 mmol/L)	↓ Medtronic ↘ Dexcom	16g CHO	
91-110 mg/dL (5.0-6.1 mmol/L)	↓↓ Medtronic ↓ or ↓↓ Dexcom	20g CHO	
110-124 mg/dL (6.1-6.9 mmol/L)	Any downward trending arrows (both manufacturers)	8g CHO	

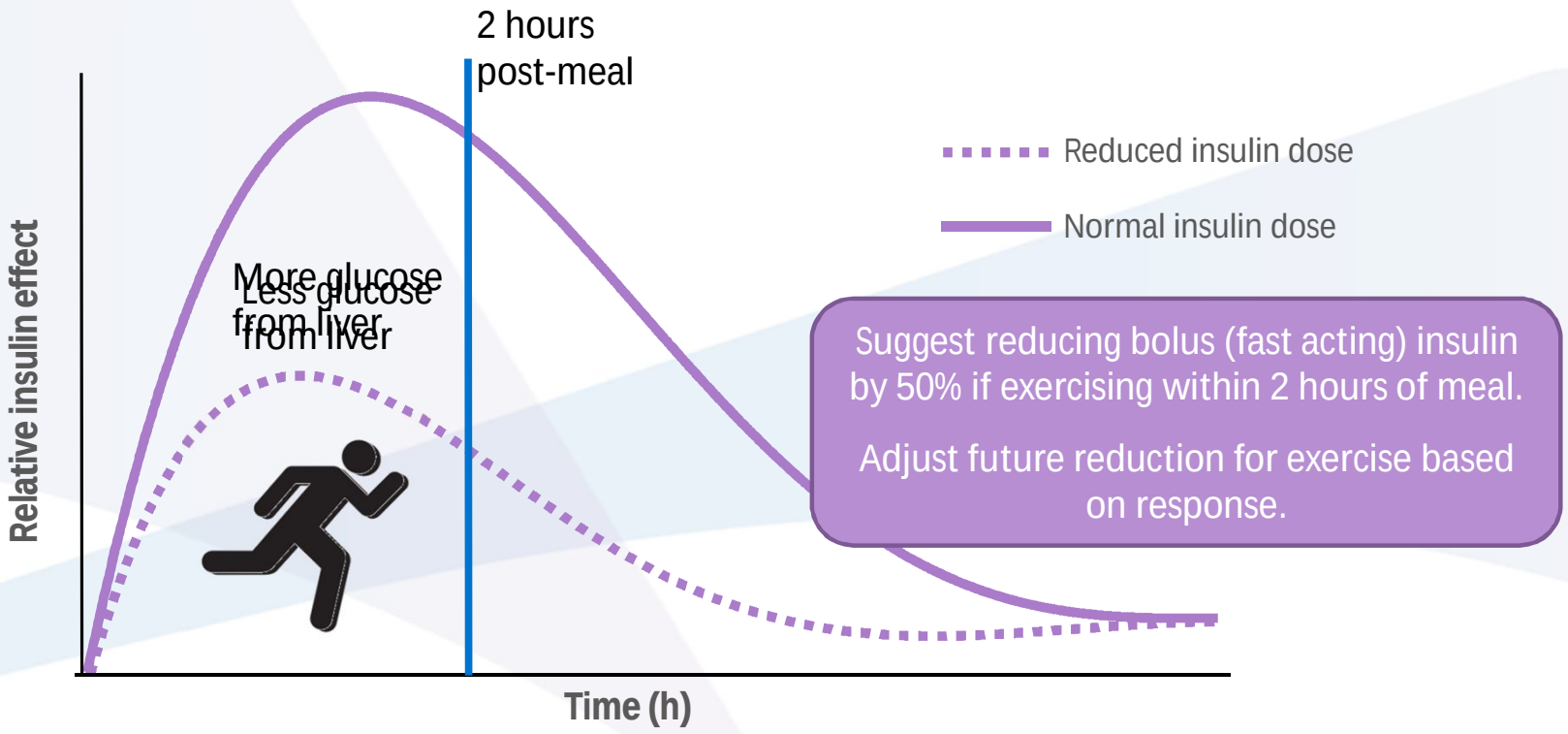
Note: Treatment of hypo or hyperglycemia should not be based solely on CGM. Self monitoring of blood glucose level is recommended. Carbohydrate (CHO) intake is generally recommended for long duration aerobic exercise for performance reasons (~1g/kg body mass per hour). 70.2 mg/dL = 3.9 mmol/L; 90 mg/dL = 5 mmol/L; 109.8 mg/dL = 6.1 mmol/L; 124.2 mg/dL = 6.9 mmol/L

Medtronic Guardian® Real-time CONTINUOUS GLUCOSE MONITORING SYSTEM User Guide, ©2006, Medtronic MiniMed, Inc.
Dexcom G5™ Mobile CONTINUOUS GLUCOSE MONITORING SYSTEM Quick Start Guide, © 2015 Dexcom, Inc

INSULIN MANAGEMENT AND EXERCISE

INSULIN MANAGEMENT AND EXERCISE

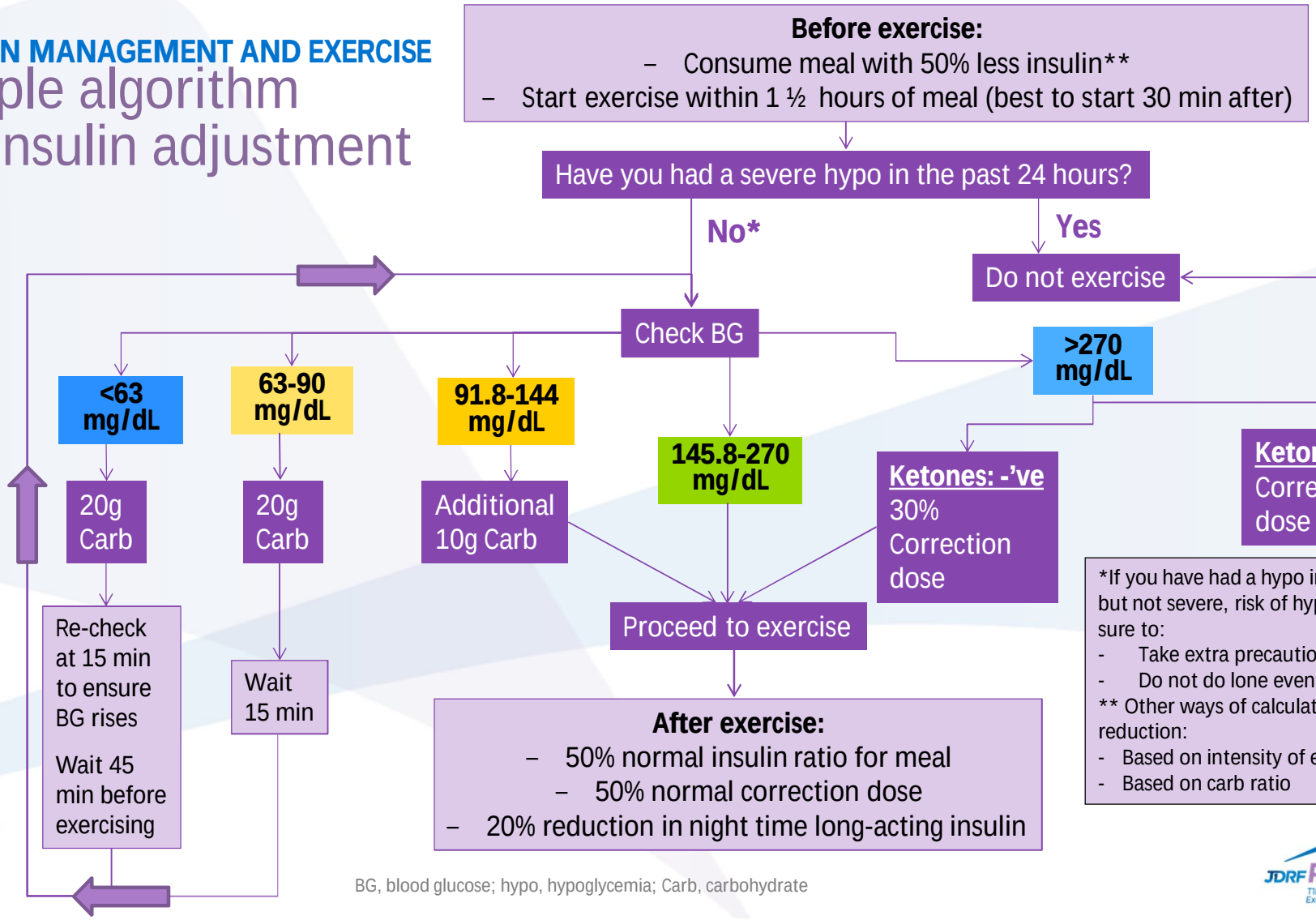
Effect of reducing bolus insulin dose on liver glucose production when exercising



Adapted from: Lumb AN & Gallen IW. *Curr Opin Endocrinol Diabetes Obes*. 2009 Apr;16(2):150-5.

INSULIN MANAGEMENT AND EXERCISE

Simple algorithm for insulin adjustment



BG, blood glucose; hypo, hypoglycemia; Carb, carbohydrate

Reducing pre-meal bolus insulin before exercise

Exercise intensity (% VO2max)	% Dose reduction	
	30 min of exercise	60 min of exercise
25	25	50
50	50	75
75	75	100

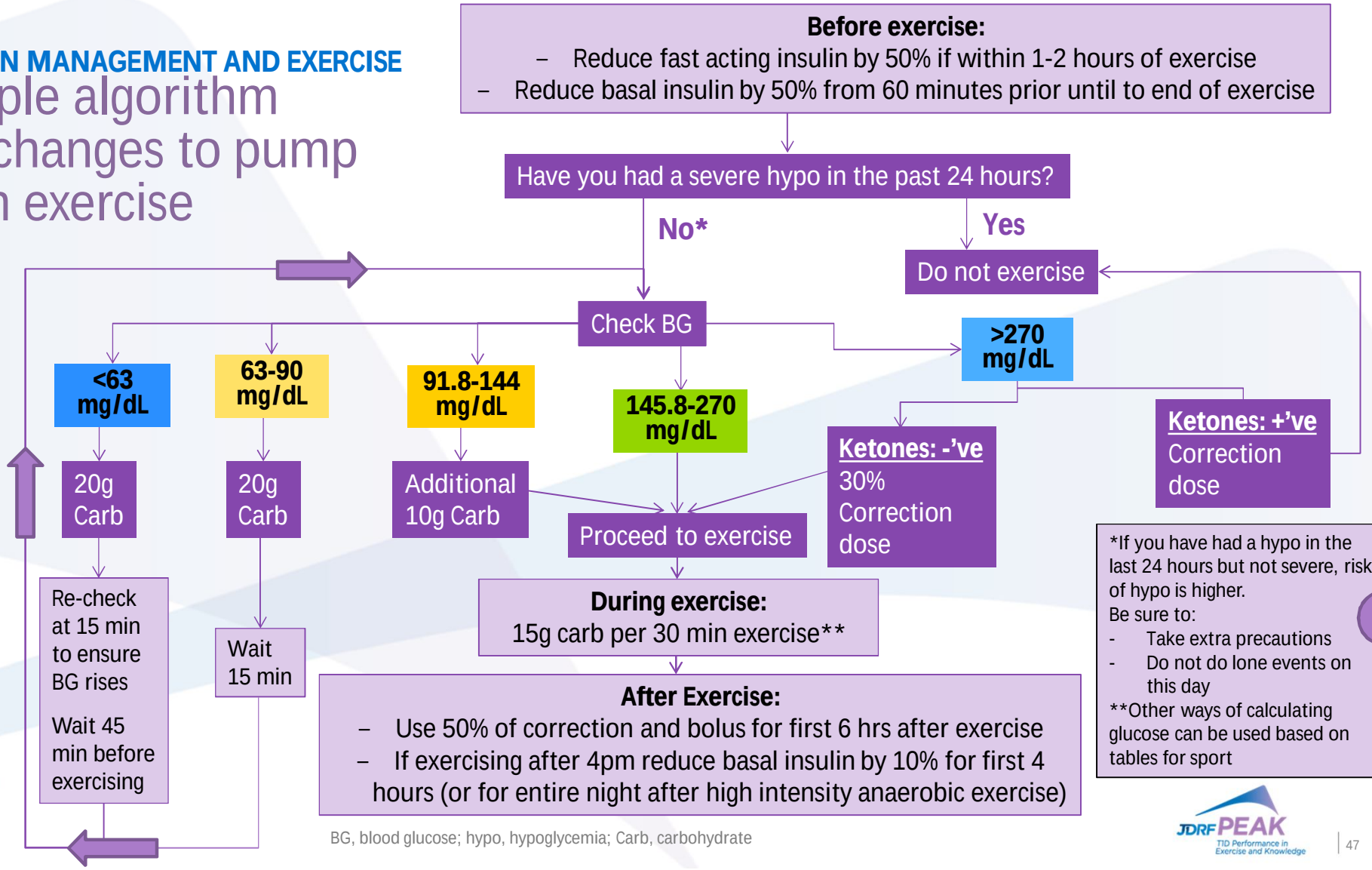
Riddell MC, *et al. Lancet Diabetes Endocrinol* 2017 Published Online January 23, 2017 http://dx.doi.org/10.1016/S2213-8587(17)30014-1

Options for pump users during exercise

Blood glucose	Action
Low blood sugars during exercise	• Temporarily lower basal rate starting 1 hour before by 50% • If eating within 2 hours before exercise also reduce bolus by 50% • Adjustments for future exercise will depend on result
High blood sugar post-exercise (this is rare, but can happen with weight programs or stop-start events like tennis and squash)	• Temporary higher basal rate just before and during • Be sure to reduce once nearing end of event

INSULIN MANAGEMENT AND EXERCISE

Simple algorithm for changes to pump with exercise

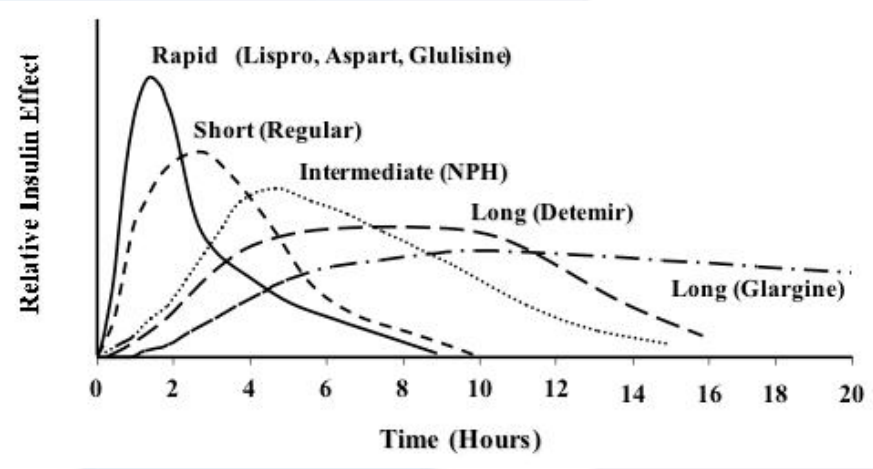


BG, blood glucose; hypo, hypoglycemia; Carb, carbohydrate

INSULIN MANAGEMENT AND EXERCISE

Adapt insulin regime

Exercise > 3 hours after lunch



Do sprints

Rosenstock J. *Clin Cornerstone*. 2001;4(2):50-6.

BLOOD GLUCOSE CONTROL AFTER EXERCISE

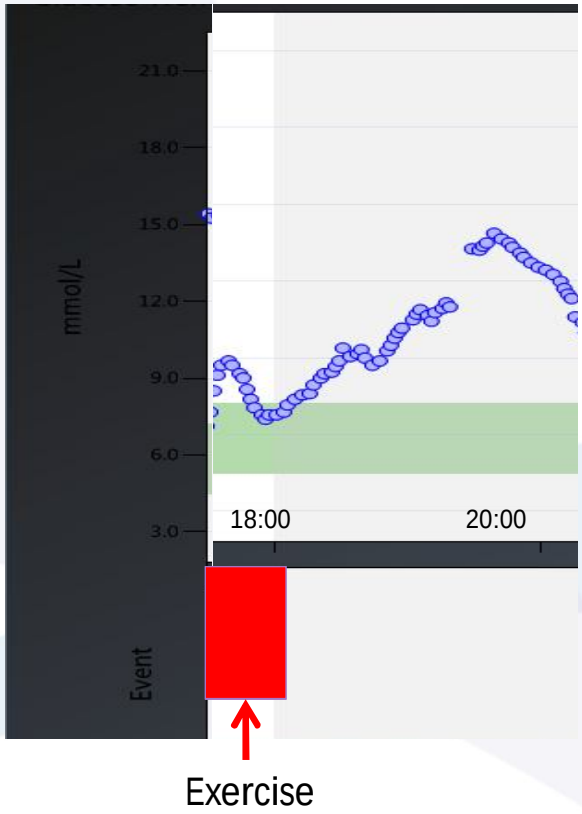
CASE #2 – BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

Tim

- Tim is 22 years old and an avid football (soccer) player
- Type 1 diabetes since age 7
- Last HbA_{1c} = 60 mmol/mol (7.6%)
- On rapid insulin with his meals and long-acting insulin at night
- Complains about significant high glucose after his games

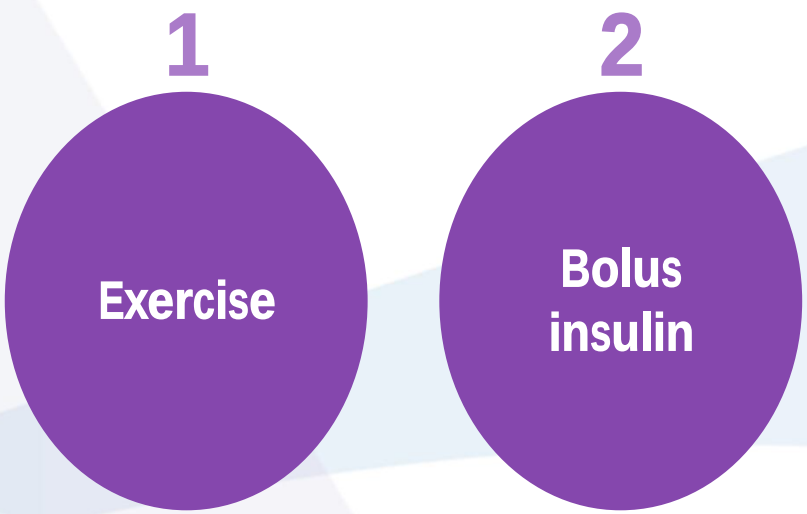
CASE #2 – BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

What options are available for Tim?



CASE #2 – BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

Tim has two options:



CASE #2 – BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

Option 1: 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

CASE #2 – BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

Option 2: Correction bolus

- 50% of normal corrections is the ideal dose to start with
- Adjust depending on how this works

How would you manage if your blood glucose went low post-exercise?

BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

Feeding post-exercise

- Protein and carbohydrate together improve glycogen storage 2 hours post-exercise
  - Ratio = 4 carb : 1 protein
  - 1g/kg/hr carbohydrate
  - 0.2g/kg/hr protein

- Take with ½ normal insulin + ½ correction




BLOOD GLUCOSE CONTROL IMMEDIATELY AFTER EXERCISE

Options for pump users immediately post-exercise

Blood glucose	Action
High blood sugars post-exercise	▪ Temporarily raise basal rate - can start this before finishing exercise to prevent rise; OR ▪ Correction bolus – start with ½ of normal correction
Low blood sugar post-exercise	▪ Temporarily lower basal rate for up to 12 hours post-exercise ▪ Reduced bolus for food – start with ½ of normal dose

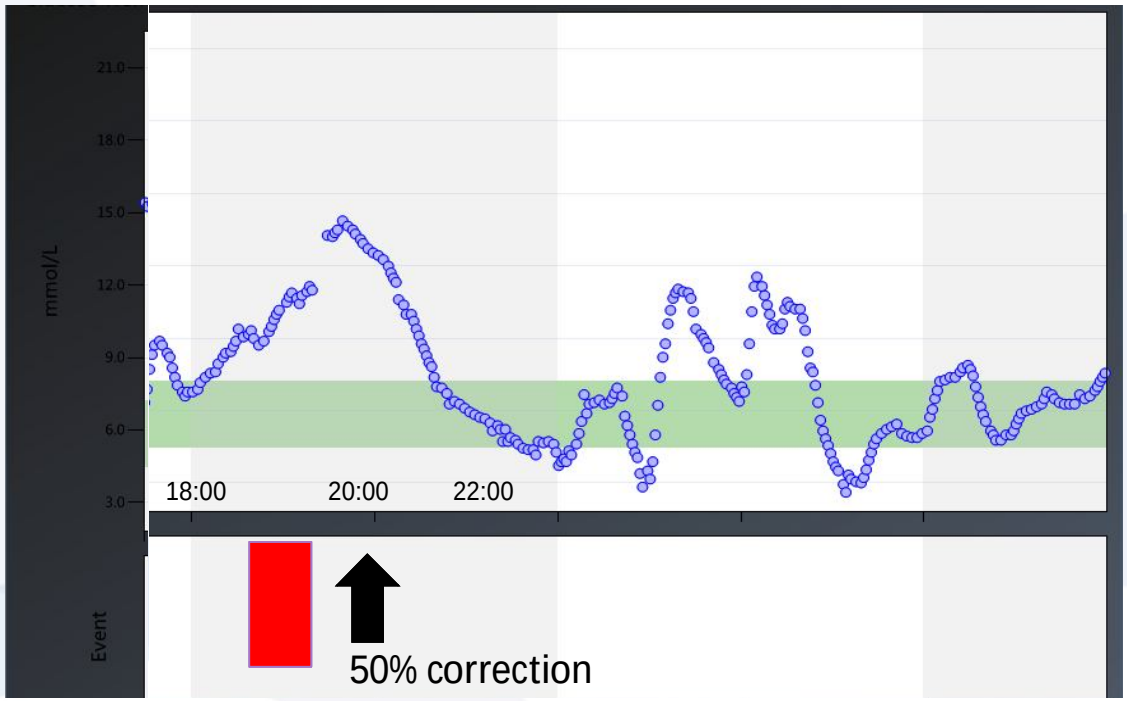
CASE #2 – BLOOD GLUCOSE CONTROL IN THE HOURS/DAYS AFTER EXERCISE

Tim

- Tim's post-exercise hyperglycemia is improved but he is now having problems experiencing hypoglycemia during the night time after his football games

CASE #2 – BLOOD GLUCOSE CONTROL IN THE HOURS/DAYS AFTER EXERCISE

What options are available for Tim?



BLOOD GLUCOSE CONTROL IN THE HOURS/DAYS AFTER EXERCISE

Strategies for nocturnal hypoglycemia

- If long exercise (>60 minutes) – be sure to refuel after exercise
- Have a bedtime snack with protein and starch (such as chocolate milk or porridge/oatmeal)
- Reduce long-acting insulin at night – start with 20% reduction

BLOOD GLUCOSE CONTROL IN THE HOURS/DAYS AFTER EXERCISE

Options for pumps users later after exercise

Blood glucose	Action
General approach	▪ Reduce basal insulin by 20% overnight
Target approach - do this once you have an idea of blood glucose overnight and are accustomed to exercise	▪ Decrease basal insulin at time most likely for blood glucose to fall ▪ This is normally between 2-6 am but depends on when you exercised

BRINGING IT ALL TOGETHER

MANAGING DIABETES FOR EXERCISE

Summary

Before exercise	During exercise	After exercise
✓ If exercise is planned **within 2 hours** of having a meal: • Consider reducing bolus insulin by **50%** for the pre-exercise meal	✓ Take **15-30g** carbohydrate every **30 minutes**	✓ Consider consuming **more carbohydrate** • 1g/kg if exercise for more than 1 hour or have done high intensity exercise
✓ Collect **blood glucose monitoring kit**	✓ Check blood glucose every **30 minutes**	✓ Consider **drinking** plenty of calorie-free fluids
✓ Consider **injection sites** • Avoid any hard lumpy areas	✓ Build up training programme **gradually**	✓ Consider reducing bolus and corrections by ½ for **first 6 hours** after exercise
✓ Check **blood glucose levels** • Follow starting glucose algorithm	✓ Consider using CGM	✓ Consider checking blood glucose **immediately after** exercise and **6 hours** later (or at bedtime, if sooner)
✓ Stretches for **10 minutes** after warm-up		✓ Consider warming down for **10 minutes** after exercise • Extend this period if blood glucose is high
✓ Consider using CGM		✓ Consider eating a **long-acting carbohydrate** or **reducing long-acting insulin** before bed to avoid nocturnal hypoglycemia
		✓ Consider using CGM

CGM, continuous glucose monitoring

Acknowledgements:

Thank you!

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TID Performance in Exercise and Knowledge