

## Type 1 diabetes & exercise

Physical activity is beneficial for people with Type 1 diabetes. However, exercise does create certain issues around insulin administration and blood glucose.

**Dr Daniel J West**, Senior Research Fellow, Institute of Cellular Medicine, Newcastle University, considers the impact of exercise on the body's biochemistry and physiology in Type 1 and sets out some guidelines to discuss with your patients

To help supply muscles with the energy needed for exercise, hormonal changes take place to ensure the delivery of more glucose and fats into the blood. Normally, during steady, longer duration activity (eg walking, jogging, cycling), pancreatic beta cells are turned off at the onset, and the amount of insulin in the blood falls, while alpha cells are turned on, releasing glucagon into the blood. These two steps are important for, if insulin levels are high when muscles contract, there are two signals (exercising muscle and insulin), that are 'sucking' glucose from the blood into the muscles. Adrenaline is also released.

These changes will:

- reduce blood glucose burning by exercising muscle
- increase glucose release from the liver
- increase use of glycogen and triglycerides
- release fatty acids from fat tissue.

In Type 1 diabetes patients, the first – and most important – step (reduction of insulin) is lost. Insulin in the blood comes from the injection site (not the beta cells). Increases in body temperature and changes in blood flow towards the skin during exercise cause insulin to be released more quickly than usual from the injection site, resulting in exercising under higher insulin concentrations. The increase in glucagon can also be blunted, resulting in:

- increased uptake of glucose by exercising muscle and a continued uptake into muscles which aren't exercising
- reduced release of glucose by the liver
- reduced release of fatty acids from the fat tissue
- reduced burning of fat and a greater reliance on carbohydrate burning for energy.

Blood glucose concentrations will fall, potentially leading to hypoglycaemia.

### Preventing a hypo during exercise

An obvious option is to exercise with reduced insulin. For instance, prior to exercise, reducing bolus insulin by 25–75 per cent with a carbohydrate meal 1–3 hours before exercise is an effective way of exercising without the need to eat more carbohydrates. Hyperglycaemia may occur, but it will likely be short-lasting and without problematic increases in ketones. Eating slow-release carbohydrates is a useful strategy to reduce the hyperglycaemia that may occur when reducing bolus insulin at meal times. However,

there are obviously limitations to this strategy if the exercise is unplanned.

Another option is to perform a short burst of highly intense exercise (eg a sprint) for a few seconds intermittently throughout the session, or for 10 seconds at the beginning or right at the end. This causes secretion of adrenaline and growth hormone, which make the liver release more glucose and reduce the muscles' uptake of glucose from the blood. This helps stop glucose from going low. When people may be doing both resistance (eg weights/circuits) and cardio-based (eg cycling) exercise in the same session, it is useful to do the resistance exercises before the cardio, as this can result in more stable blood glucose and fewer hypos after exercise.

If exercise is unplanned, then frequent monitoring of blood glucose is needed. If, before starting exercise, blood glucose is below around 7mmol/l, around 15–30g of carbohydrate should be taken. If glucose is above 10mmol/l, delaying eating carbohydrate would help to limit very high blood glucose when exercising.

If the exercise is fairly challenging (moderate to intense lasting more than 45–60 min), carbohydrate intake during exercise is of more importance when the exercise is more than 45–60 minutes in duration and, in this case, carbohydrate intake can be around 30–60g per hour. Sports drinks and energy gels are useful and easy to consume during exercise. Gels containing caffeine may also be of use, as caffeine can help improve performance, and has also been shown to have some beneficial effects on maintaining blood glucose and helping to protect against hypoglycaemia during exercise. However, excess consumption of gels can cause stomach upset.

### Advice on intense exercise

When the body is placed in highly intense exercise mode, as in sprinting, weight training or spin classes, various effects on blood glucose levels are likely. Highly intense exercise will drastically increase levels of counter-regulatory hormones like adrenaline, cortisol and growth hormone. This will:

- increase glucose released by the liver
- stop muscles taking glucose from the blood.

In people without diabetes, these changes would be matched by a quick rise in insulin, and blood glucose

would not rise too much. In diabetes, this does not happen; there is a large mismatch between glucose entering the blood, and that being used by the muscle, and this is the reason why many people with diabetes can experience quite severe hyperglycaemia when doing intense exercise.

Therefore, there is no need to reduce insulin prior to this form of exercise, and the administration of a small bolus of rapid-acting insulin after the session can help to combat the high glucose that may be experienced. It is really important, however, to keep in mind that, despite high glucose levels, the muscles are still more sensitive to insulin when the stress hormones return to normal, so if the bolus insulin is too much, or mistimed, it is likely that hypoglycaemia may occur. Thus there is a need for care if administering bolus insulin to correct for high blood glucose levels after intense exercise.

### Insulin & diet after exercise

Exercise increases insulin sensitivity. This means that each unit of insulin taken will result in far greater falls in glucose than would have happened before exercising. After exercise, the muscle is at its most sensitive, and its capacity to transport glucose from the blood is increased significantly, particularly when it comes into contact with insulin. For this reason, the risk of experiencing a hypo after exercise is very high. To counteract this risk, it is important that, with the first meal after exercise, bolus insulin is reduced (30–50 per cent), which preserves blood glucose and protects against hypoglycaemia for around eight hours after exercise.

Experiencing a hypo during the night is also a risk for people with diabetes when exercising. Research has shown that even excessive carbohydrate feeding before bed, inducing hyperglycaemia, will still not guarantee protection from a nocturnal hypo. To protect against a late-onset hypo, combining a reduced bolus insulin dose with the meals before and after exercise, and a slow-releasing carbohydrate snack before bed, with a 20 per cent reduction to basal insulin, can keep blood glucose concentrations in the normal range during the night, and help to protect against a hypo during and for >24 hours after exercise.

### Some additional exercise tips

- 1 Exercising in heat may increase the absorption of insulin, which may lower blood glucose unexpectedly.
- 2 An increase in ketones in the blood after longer duration exercise is normal, and is simply a sign that the body is using fat stores. Monitoring ketones in the hours after training, particularly where hyperglycaemia is present, is important.
- 3 Sports drinks contain 6–10 per cent sugar. Higher percentage sugar in home-made sports drinks may cause stomach upset.

## Exercise and hypos

- Patients should be aware of potentially dangerous interactions between hypos and exercise.
- Experiencing a hypo can reduce the body's hormonal responses to subsequent exercise, which may increase the risk of an exercise-related hypo. Exercise should be delayed, particularly if a symptomatic hypo has been experienced.
- Exercise can reduce the body's defence against any hypos which may happen later on in the day or the next day; avoiding frequent exercise-induced hypos is vital.

## Considerations for children with Type 1 diabetes

Many of the principles of insulin dose adjustments and food consumption described above are applicable to children and young people with Type 1 diabetes. However, glycaemic and metabolic control can be a challenge for children/adolescents due to the physiological and psychological stresses of maturation.

Puberty and the maturation process can increase insulin resistance, which peaks at mid to late puberty, and females tend to have greater insulin resistance at all stages of puberty. This means that the extent of insulin dose reductions needed may not be as great as for adults. It is important to be aware that there is likely to be very large individual variation in response to exercise and insulin dose adjustments, which may be attributed to maturation and ups and downs in physical activity levels.

## Further reading

- Campbell MD, Walker M, Bracken RM et al (2015). Insulin therapy and dietary adjustments to normalize glycemia and prevent nocturnal hypoglycemia after evening exercise in type 1 diabetes: a randomized controlled trial. *BMJ Open Diabetes Research & Care* 3; e000085
- Chu L, Hamilton J and Riddell MC (2011). Clinical management of the physically active patient with type 1 diabetes. *The Physician and Sportsmedicine* 39 (2); 64–77
- Gallen IW, Hume C, Lumb A (2011). Fuelling the athlete with type 1 diabetes. *Diabetes, Obesity & Metabolism* 13 (2); 130–136