How an interest in sport can be used to encourage good glycaemic control in adolescence: A case report

Sarah Goodwin

This case study will present an example of how an adolescent's interest in sport motivated him to take a more active role in the management of his diabetes. The 14-year-old boy was keen to improve his performance levels and sought advice about his diet. This presented an opportunity to provide information on the risks of exercising without paying due attention to glycaemic levels. The impact of exercise on blood glucose levels is discussed and the author gives dietary recommendations for young people with diabetes. The author also provides practical ideas and suggestions for people with diabetes who regularly participate in physical activity on how to maintain glycaemic control effectively and avoid hypo- or hyperglycaemic episodes.

James (not his real name) was 14 years old and was very passionate about sport, playing competitively for a local rugby league team. James had been disappointed with his recent sporting performance and this led him to take more interest in his diet. At an appointment with a dietitian it was discovered that his diabetes was not being well controlled. Hanas (2010) has reported that poor aerobic capacity is linked to high HbA_{1c}, which will have an impact on performance. James had not realised that poor glycaemic control could affect his sporting performance but this realisation motivated him to take a more active role in the management of his diabetes.

James was diagnosed with type 1 diabetes when he was 4 years old. His diabetes had been well managed when he was younger but, over the previous few years, he had poor glycaemic control and his HbA_{1c} was measured at 143 mmol/mol (15.2%). At the time of this reading in October 2012, James was using continuous subcutaneous insulin infusion therapy (CSII). It had become apparent that James was not using his insulin pump effectively and was not regularly testing his blood glucose levels or bolusing for his meals. Bitsko et al (2013) have reported that adolescents often have reduced adherence to their medical regimen, resulting in poor glycaemic control. One of the reasons behind James' non-adherence was that he did not want his friends to be aware of his diabetes. This has been found to be common as adolescents want to fit in with their peers (Spencer et al, 2012).

In November 2012, James was taken off his insulin pump and placed back onto a twice-daily insulin regimen. This was done to ensure that James did not develop diabetic ketoacidosis owing to the fact that only fast-acting insulin is used (Wolfsdorf et al, 2006). In January 2013, his HbA_{1c} still remained high with a reading of 124 mmol/mol (13.5%). He was then placed on a three times daily insulin regimen, taking a mixed insulin before breakfast, a fast-acting insulin with evening meals and a long-acting insulin overnight. In February 2013, James arranged for a dietetic appointment

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Article points

1. People with type 1 diabetes need to monitor their glucose levels when exercising.
2. Exercising can precipitate a hypoglycaemic event if glycaemic levels are not monitored.
3. Poor glycaemic control can effect sporting performance.
4. An adolescent's interest in sport can be used to encourage them to improve their glycaemic control.

Key words

- Adolescence
- Exercise
- Glycaemic control
- Motivation
- Regimen adherence

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Page points

1. Exercise is recommended as part of the management of diabetes, although vigorous physical exercise can make managing blood glucose levels more difficult during and after the activity.
2. In people with type 1 diabetes, exercise can improve insulin resistance and macrovascular risk.
3. Exercise may offer a glycaemic benefit for the young when undertaken for longer periods.

to request dietary advice related to his exercise regimen.

Dietetic consultation

James attended the appointment with his mum. He reported improved blood glucose levels since starting his new insulin regimen. Initially when he started the regimen, he was not having a mid-morning snack, but he found that he needed one to prevent hypoglycaemia. Seaquist et al (2013) have reported that patients on fixed insulin regimens need to follow a set meal pattern that may include snacks to prevent hypoglycaemia. James requested a meal plan, as he was really keen to eat the right type of food to improve his rugby performance. This is in keeping with the advice from Iafusco (2006) who reported that people with type 1 diabetes need adequate amounts of macronutrients to sustain sporting performance. *Table 1* shows an example of a meal plan. It is based on healthy eating recommendations and includes three balanced meals plus healthy snacks that are high in fibre and low in fat. James also asked for advice regarding protein supplements as he felt he needed them to build muscle. This is a commonly held belief among male athletes (Buell et al, 2013). His mother, however, did not allow him to have any supplements. There is, in fact, a lack of evidence to support the use of supplements to aid performance (Annan, 2013).

Table 1. An example of a meal plan for an adolescent athlete with type 1 diabetes.

Time	Ideas
Breakfast	Wholemeal or granary toast/cereal/porridge; plus fruit
Mid-morning snack	Cereal bar/banana/ yoghurt/oat cakes/rice cakes
Lunch	Wholemeal or granary bread/wrap/pitta; lean meat/fish/egg; yoghurt and fruit or soup and bread or jacket potato with filling or pasta
Mid-afternoon snack	Dried fruit/fruit/custard/ rice pudding
Evening meal	Lean meat/fish/egg/ pulses; wholemeal pasta/rice/potato/bread; vegetables/salad; fruit

The following areas of concern were discussed with James during the dietetic consultation.

Exercise and diabetes

Exercise is recommended as part of the management of diabetes, although vigorous physical exercise can make managing blood glucose levels more difficult during and after the activity (DirecNet [The Diabetes Research in Children Network Study Group] et al, 2005). Leclair et al (2013) state that exercise can worsen glycaemic control due to the hyperglycaemia and hypoglycaemia it can cause. However, a number of studies in children and adolescents have shown that exercise can have beneficial effects on control. In a recent meta-analysis, Tonoli et al (2012) concluded that exercise had an overall beneficial effect on lowering acute and chronic glycaemic control.

Taking part in regular exercise has many benefits. It promotes development of muscular and skeletal systems as well as improving cardiovascular fitness (Riddell, 2008). Exercise also has psychological benefits including an increased sense of well-being, improved quality of life and an increased ability to cope with stress (Norris et al, 1990). Taking part in a team sport is particularly important for children and young people as it can be both recreational and social (Guelfi et al, 2005). It was, therefore, important to support James' participation in physical activity as this could help maintain his long-term mental and physical well-being.

In people with type 1 diabetes, exercise has also been shown to improve insulin resistance and macrovascular risk (Chimen et al, 2012). Although a conclusive glycaemic benefit of exercise has not been found, a recent meta-analysis suggests that exercise may offer a glycaemic benefit for the young and for all ages when undertaken for longer periods (Kennedy et al, 2013). In order to understand the impact exercise has on blood glucose control, it is

essential to look at the physiology of different types of exercise.

James was weight training and had sprint sessions as part of his rugby training programme. These types of exercise are anaerobic and they take place over a short period of time (20–30 seconds) and they are characterised by high-intensity muscle contraction (Riddell and Perkins, 2006). The main fuel source during anaerobic exercise is adenosine triphosphate (ATP). The production of ATP is not dependent on glucose and, therefore, blood glucose levels are unlikely to fall during this type of exercise. In fact, blood glucose levels may actually rise due to the response of counter-regulatory hormones (adrenaline, noradrenalin and cortisol) (Riddell, 2008).

As part of James' training programme, he was also doing some aerobic exercise. Aerobic exercise takes place over a longer period of time and involves lower rates of muscle contraction. Types of activity include endurance events such as running, cycling and rowing (Riddell and Perkins, 2006). Muscle glycogen is the main fuel source during aerobic exercise and, once depleted, an alternative fuel source is required. Glucose from the bloodstream is used and the liver breaks down its glycogen stores (Riddell and Perkins, 2006). Sports can involve a mixture of both anaerobic and aerobic exercise within them, and the more intensive the activity the greater the body's reliance on carbohydrate as its main fuel source becomes (Riddell and Perkins, 2006). This would be important for James, as rugby involves both aerobic and anaerobic exercise, and he often has varied training sessions and matches where he must work at a high intensity level. In my experience, this is particularly difficult to manage on a fixed dose of mixed insulin that contains medium- and short-acting insulin, as the dose cannot be easily altered according to blood glucose levels and correction doses cannot be given.

In order to achieve maximum sporting performance, the blood glucose level needs to be within the normal range (Hanas, 2010). Maintaining a good blood glucose level before activity reduces the risk of dehydration or lethargy and hypoglycaemia, which would all have a negative effect on performance (Riddell and Perkins, 2006). James' main concern was to improve his performance when playing rugby; however, his diabetes was not being adequately controlled and he had not been motivated to improve it. The link between good diabetes management and sporting performance was used as a motivating force for James to improve his glycaemic control.

The ideal insulin regimen for a sports person with diabetes would, in my opinion, be a multiple-daily injection regimen that would allow the dose of insulin to be altered daily to meet the needs of the athlete.

Exercise and hypoglycaemia

The risk of hypoglycaemia during exercise is high due to the amplified absorption rate of subcutaneously injected insulin as a consequence of an improved blood flow and a rise in body temperature combined with an increased muscle sensitivity to insulin (Riddell and Perkins, 2006). The effect of increased insulin sensitivity and the delay in replenishing liver and muscle glycogen stores following exercise means that hypoglycaemia can occur several hours after exercise, especially when activity has been prolonged and of moderate to high intensity (Robertson et al, 2008).

In the past, the fear of hypoglycaemic episodes often meant that children with diabetes were excluded from physical activities (Burr and Nagi, 1999). This is not the case today, but careful management is required to prevent hypoglycaemia. Hypoglycaemia and its onset during exercise is very dangerous owing to the difficulty of detecting it and the risky nature of some sports. It can also decrease a young person's performance during the sport, causing premature fatigue (Komatsu et al, 2010). It can be difficult to recognise the warning signs of hypoglycaemia when exercising because sweating and tachycardia due to activity can mask similar warning signs (Burr and Nagi, 1999). A suspected hypoglycaemic event, therefore, should always be treated during exercise. It is important for people with diabetes to prevent the risk of having a hypoglycaemic episode during exercise (Riddell and Perkins, 2006). Hypoglycaemia during exercise can be avoided by checking pre-activity blood glucose levels and taking additional carbohydrate, if required. James' diet was assessed during the dietetic consultation to ensure he was routinely eating enough to meet his nutritional requirements and fuel his training.

Hypoglycaemic events after exercising are extremely common, making it important to

Page points

1. During anaerobic exercise, such as weight training and sprinting, blood glucose levels are unlikely to fall.
2. During aerobic exercise, such as running, cycling and rowing, glucose from the bloodstream is used as a fuel once muscle glycogen is depleted.
3. The risk of hypoglycaemia in someone with diabetes is high during exercise and it can occur several hours afterwards.

Page points

1. High blood glucose levels before exercise can impair performance due to dehydration and exhaustion.
2. It is inadvisable for individuals with type 1 diabetes to take a protein supplement as glutamine can increase the risk of post-exercise overnight hypoglycaemia.
3. Altering carbohydrate intake before and during exercise may be more important than adjusting insulin.

modify diabetes management to reduce the risk (Tansey, 2006). It is important, therefore, that James and his family are aware of this and know how to treat a hypoglycaemic attack and how to prevent it when possible. The majority of James' training sessions were in the evening, meaning he was at risk of having night-time hypoglycaemia. DirecNet et al (2006) demonstrated that if hypoglycaemia does occur during exercise, greater amounts of carbohydrate are required to treat it (30–45 g glucose, rather that the standard 10–15 g). James was, therefore, advised to carry additional carbohydrate with him when training to account for this.

Hyperglycaemia

High blood glucose levels during exercise need to be considered as they can negate the metabolic and vascular benefits of taking part in physical activity (Tansey et al, 2006). If blood glucose levels are high before exercising they can also impair performance, as the body may already be dehydrated due to an increased urine volume. Additionally, high blood glucose levels trigger the release of beta-endorphins, which are associated with increased exhaustion (Hanas, 2010). This can be dangerous because when there is too little insulin in circulation when exercising, counter-regulatory hormones are released that can cause already high blood glucose levels to increase further, resulting in the production of ketones (Wasserman and Zinman, 1994). It has been shown that a high HbA_{1c} has been linked to a poor maximal aerobic capacity (Hanas, 2010). This may explain why James felt that his rugby performance had decreased when he had poor blood glucose control.

During competitive sport, blood glucose levels can increase due to psychological stress. This is owing to stress hormones triggering an increase in hepatic glucose production (Riddell and Perkins, 2006). James was advised to monitor his blood glucose readings frequently on match days to help identify a pattern so that treatment can be individualised to him. The results of the blood glucose readings could be reviewed during future consultations. James was advised that if his blood glucose readings were above 15 mmol/L, he should check for ketones and give additional insulin before taking part in exercise.

Protein supplements and protein intake

James was very keen to consume a protein supplement following training, as all his teammates did. The recommended macronutrient distribution for the athlete with diabetes is 55–60% carbohydrate, 25–30% fat and 12–15% protein (Riddell and Perkins, 2006) – this is a slightly higher protein intake than that for a standard diet and equates to 1.1 g protein per kg per day.

Research has shown that the addition of protein to the post-exercise meal increases glucose uptake and stimulates muscle recovery (Roberston et al, 2008), leading to the increased popularity of protein shakes and supplements. However, glutamine (a protein regularly used in supplements) has been shown to increase the risk of post-exercise overnight hypoglycaemia (Mauras et al, 2010). It would, therefore, be inadvisable for individuals with type 1 diabetes to take a protein supplement. During the dietetic consultation, James was informed of the risk of taking a protein supplement and that the additional protein he required could easily be met through food intake.

James was advised to take a snack post-exercise containing carbohydrate and protein, such as milk, to increase glucose uptake and stimulate muscle recovery (Roberston et al, 2009).

Carbohydrate, insulin and exercise

Robertson et al (2008) suggested that it might be difficult to maintain strict blood glucose levels on a fixed insulin regimen, especially when exercise levels vary. It has been proposed that altering carbohydrate intake before and during exercise may be more important than adjusting insulin. This is supported by Riddell and Perkins (2006) who reported that altering carbohydrate intake is a viable option, especially when exercise is spontaneous or when the patient is unable to change their insulin dose. Burr and Nagi (1999) recommended that insulin is reduced by 25–30% before playing rugby and that extra carbohydrate is given before playing, at half-time and after the game, to prevent hypoglycaemia. James was on a fixed insulin regimen, so it would not be easy to reduce his insulin dose before exercise. Additional carbohydrate would, therefore, be required.

Smart et al (2009) recommend that a low glycaemic index (GI) meal or snack should be

eaten 1–3 hours before sport to ensure that the glycogen stores are adequate and that there is carbohydrate available for exercise. A high GI snack is then required immediately prior to activity and during to maintain performance. James was advised to consume 30 g of carbohydrate.

The benefits of giving additional carbohydrate are that it delays fatigue and provides fuel for the muscles, which is essential during long exercise sessions (Riddell and Perkins, 2006). James was advised to have an additional 30 g of carbohydrate for every 60 minutes of activity to ensure that his blood glucose levels did not drop. He was advised to test his blood glucose levels regularly and adjust his intake of carbohydrate, accordingly.

Fluid intake is important during exercise to prevent dehydration, which is associated with impaired performance and hyperglycaemia (Riddell and Perkins, 2006). James was encouraged to consume a drink containing carbohydrate throughout his rugby training to provide him with the additional carbohydrate and fluid he requires. An isotonic drink was recommended, as it would provide optimal absorption without causing delayed gastric absorption or stomach upset (Robertson et al, 2009).

Missed insulin boluses and regimen adherence

Burdick et al (2004) discovered that missed meal boluses were the main reason for poor diabetes control in young people using an insulin pump. The reasons for the missed boluses were because they "forgot" or were "too busy". This was very apparent with James, as he would often forget to take a meal bolus when he was with his friends. It has also been shown that adolescents will often consume an afternoon snack without any insulin, leading to high blood glucose readings (Vanderwell et al, 2010). Again, this is something that was occurring with James, as his pump downloads showed that he was only bolusing with meals taken at home.

Olinder et al (2011) reported that some teenagers felt embarrassed and did not want to show others they have diabetes and, therefore, try to hide their insulin pump. Teenagers often do not want to stand out from the crowd and be different, which is why some of them try to ignore the fact that they have diabetes, which may, in turn, result in insufficient self-management (Olinder et al, 2011). This was the case with James, as he said on a number of occasions that he did not want his friends to know he had diabetes and this led to his poor diabetes control. James' mum became aware of his missed boluses through his clinic visits and she actively encouraged him to bolus regularly. James, however, viewed this as his mum "nagging" and this resulted in conflict. Olinder et al (2011) warned that these conflicts can further impair blood glucose control.

Monitoring

Monitoring blood glucose is key for an active child (Robertson et al, 2008). Burr and Nagi (1999) proposed that personal experience, combined with frequent blood glucose monitoring, is essential to allow individuals to see how exercise affects them and to change their treatment accordingly. Hanas (2010) recommended testing blood glucose levels frequently to see how the body reacts to different situations during training and competitions. James was only testing his blood glucose levels one to two times daily, but he agreed to test it before and after his training and matches to help him improve his glycaemic control, as this would in turn help improve his performance.

Outcomes

When James was reviewed in the diabetes clinic in March 2013, he felt that the dietary advice had helped and his sporting performance had improved, as he had scored a try at his last match. In order to motivate James to continue to improve his performance, small goals were set to help him fully follow the advice given. It was apparent that during the consultation James had accepted his insulin regimen, and the success of his sporting performance reinforced the need to give insulin regularly and improve his diabetes control. He reported doing more regular insulin injections, although he was still not testing his blood glucose levels regularly. His HbA_{1c} had improved and was 75 mmol/mol (9%); he was, however, experiencing some mid-morning hypos. Upon discussing this, it became apparent that James was not always eating breakfast and was, therefore, only partially following his dietary plan. The importance to

Page points

1. Missed meal boluses are the main reason for poor diabetes control in young people using an insulin pump.
2. Teenagers may try to ignore the fact that they have diabetes, which may result in insufficient self-management.
3. Personal experience, combined with frequent blood glucose monitoring, is essential to allow individuals to see how exercise affects them and to change their treatment accordingly.

"When working with young people, it is important to find out what motivates them and to try and use this to help achieve better diabetes control."

his current regimen of having a good breakfast was discussed and emphasis was placed on how having mid-morning hypoglycaemia would affect his performance. He was given ideas for quick breakfasts that can be eaten on the go to ensure that he had a breakfast with carbohydrate every day.

James remained on his three times daily regimen and his insulin doses were altered by the consultant to further improve his HbA_{1c}. James was keen to continue with this regimen, as it fitted better with his lifestyle and meant he did not have to inject insulin while at school. This meant that his improved performance further motivated him to have better diabetes control.

Conclusion

In order to achieve optimal sporting performance, athletes with type 1 diabetes need to attain good glycaemic control. This ensures that they are able to achieve their maximal aerobic capacity and do not experience early fatigue. The case study demonstrates how an adolescent's interest in sport has helped him improve the management of his diabetes. He has been motivated to take an active role in his treatment and, consequently, is giving insulin more regularly and is now doing some blood glucose monitoring. When working with young people, it is important to find out what motivates them and to try and use this to help achieve better diabetes control. During the dietetic consultation, the transtheoretical model of behavioural change (Prochaska and DiClemente, 1984) was used to motivate James. The model focuses on a cycle of change to guide an individual through a series of stages until they are fully in the "action" stage. James was in the earlier "preparation" stage of change and, by highlighting the benefits of changing (i.e. improved sporting performance), James was inspired to make small changes and to progress to the next stage of change. ■

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