Physical activity and diabetes – health benefits and management strategies for children and young people

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Article points

1. In this article, the author reviews important considerations and health benefits associated with physical activity in children and young people with diabetes.
2. The author explores the differences between planned and unplanned activity, and the current recommendations for carbohydrate, protein and fluid intake.
3. It is concluded that managing diabetes and physical activity presents a range of challenges that require individual solutions based on a sound understanding of the physiology of exercise, diabetes management and the needs of the children and young people.

Key words

- Blood glucose
- Carbohydrate
- Physical activity

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The global recommendations for physical activity and health set a target of 60 minutes of moderate-to-vigorous intensity exercise per day up to the age of 17 years (World Heath Organization, 2010). The long-term health benefits of physical activity and fitness in the general population are clear, including improved cardiovascular health and a reduced risk of long-term chronic health conditions. The impact of physical activity on glycaemic control in children and young people with type 1 diabetes is less clear. In this article, the author highlights the different health benefits and management strategies for physical activity in children and young people with diabetes.

Physical activity is defined as any movement of skeletal muscle that results in energy expenditure above resting levels, whereas exercise is a subset of physical activity where the engagement of skeletal muscle in movement is planned, structured and repetitive, and for the purpose of training, fitness or developing a sports skill (World Health Organization, 2010). Physical activity in children and young people includes a variety of types of movement, ranging from walking to school to more structured sports training sessions (see *Box 1*).

Current data on the levels of physical activity in children with diabetes is variable, partly owing to the different activity assessment tools in use, a majority of which appear to be questionnaires. A number of studies have shown similar or lower levels of physical activity in children with diabetes compared with their peers (Herbst et al, 2007; Øverby et al, 2009; Younk et al, 2009; Benevento et al, 2010; Schweiger et al, 2010). Generally, it has been found that girls are less active than boys, and those with type 2 diabetes less likely to meet physical activity guidelines. The Hvidøre study group demonstrated no association between levels of glycaemic control and physical activity in children and young people with type 1 diabetes (Aman et al, 2009). In contrast, a large cross-sectional analysis by Herbst et al (2006) showed an association between improved glycaemic control and an increased frequency of physical activity. Physical activity has also been associated with a reduction in cardiovascular risk (Herbst et al, 2007). Lukács et al (2012) recently reported measures of physical fitness in a Hungarian cohort of children and young people with diabetes as lower than that of people without diabetes. Similar results have been reported in other studies (Maggio et al, 2010; Williams et al, 2011). Adolescents who are more physically active generally become active adults (Graham et al, 2011). Physical fitness in adults with type 1 diabetes appears to be a protective factor, independent of glycaemic control, reducing cardiovascular risk in the population (Reddigan et al, 2011). Although evidence to support the benefits of physical activity in terms of glycaemic control is lacking, the benefits of in improving bone and cardiovascular health, as well as reducing the risk of chronic disease, are not disputed. Children and young people with diabetes should be encouraged to complete at least 60 minutes of moderate to vigorous activity per day.

Box 1. Examples of types of physical activities.

Aerobic activities
- Running
- Swimming
- Cycling

Intermittent activities
- Football
- Hockey
- Rugby
- Basketball

Anaerobic activities
- Sprinting
- Gymnastics
- Weight lifting

Physical activity and diabetes management

The management of the effects of physical activity on blood glucose levels is challenging for both the individual and the diabetes team. Exercise disrupts homeostasis and requires complex physiological responses to maintain the internal environment of the body. Diabetes management strategies therefore need to encompass the complexity of normal physiology and account for the types of activity that may be undertaken, from unplanned play to structured sports and training for performance, and the range of physiological responses that should occur. It is not possible to apply a "one size fits all" approach to the management strategies. Avoidance of hypoglycaemia is often the main driver for physical activity management strategies. Unplanned and spontaneous exercise may require additional snacks to prevent hypoglycaemia depending on the preceding blood glucose levels, and the type and duration of exercise, In contrast, planned activities can have an activity management plan accounting for the type and duration of activity, blood glucose responses, nutritional requirements and, in some cases, sports performance (Robertson et al, 2009).

Type and duration of activity, and blood glucose responses

To provide effective advice about the management of blood glucose during physical activity, healthcare professionals must understand the responses to exercise that may occur as a result of the type and duration of activity performed.

Anaerobic activity is typified by bouts of high-intensity muscular contraction followed by longer periods of recovery. This type of exercise is associated with a rise in blood glucose levels, which can be partly attributed to the hormonal responses associated with anaerobic metabolism. During anaerobic exercise, insulin requirements may be increased. During post-anaerobic activity, it is usual to experience persistent hyperglycaemia later followed by a period of hypoglycaemia, also known as "post-exercise hypoglycaemia" (Riddell and Iscoe, 2006).

Aerobic activity, which is performed at a lower intensity than anaerobic activity, is usually associated with a lowering of blood glucose levels (Riddell and Iscoe, 2006). When bouts of anaerobic activity are performed during predominantly aerobic sports, a fall in blood glucose may be attenuated. Physical activity of mixed intensity may maintain blood glucose levels. This type of activity is often undertaken by children in team sports.

Blood glucose responses to exercise can only be identified by regular blood glucose monitoring, at least before and after exercise. If activity bouts are 60 minutes or longer, more frequent monitoring will be needed, ideally every 20–30 minutes (Riddell and Iscoe, 2006). Muscle and liver glycogen stores will fuel exercise for the first 30–45 minutes in a well-fed young person. Following this, blood glucose becomes a major fuel source for the active muscle. For most young people undertaking regular physical activity of moderate intensity lasting up to 60 minutes per day, general guidelines on exercise management can be used and adapted according to blood glucose responses. These guidelines should cover blood glucose levels, type and duration of activity, timing of activity, appropriate amount and type of carbohydrate needed, and post-exercise hypoglycaemia prevention (Riddell and Iscoe, 2006; see *Table 1* for an example of such guidelines). Nutritional considerations in exercise and diabetes management include energy balance, and carbohydrate, protein and fluid intake.

Energy balance

Any nutritional advice concerning the management of physical activity should account for its associated impact on energy balance, and dietary choices should not increase the saturated fat content of the habitual diet.

Page points

1. The management of the effects of physical activity on blood glucose levels is challenging for both the individual and the diabetes team.
2. Anaerobic activity is typified by bouts of high-intensity muscular contraction followed by longer periods of recovery.
3. Aerobic activity, which is performed at a lower intensity than anaerobic activity, is usually associated with a lowering of blood glucose levels.
4. Any nutritional advice concerning the management of physical activity should account for the impact on energy balance.

A balanced diet consisting of 50–60% energy from carbohydrate and 10–15% energy from protein is recommended for young athletes with diabetes (Steen, 1996; Meyer et al, 2007; Jeukendrup and Cronin, 2011).

Unplanned activity

Most dietary reference values include a physical activity level, recommending 60 minutes of activity of moderate-to-vigorous intensity per day. Nutrition advice for unplanned physical activity usually focuses on hypoglycaemia prevention. When exercise is unplanned and additional carbohydrate is used to prevent hypoglycaemia, this should not lead to an increased intake of saturated fats, disrupt the energy balance or encourage weight gain (Smart et al, 2009).

Planned activity

For children or adolescents undertaking regular physical activity as part of an exercise training programme, the appropriate intake will be increased accordingly to meet the greater energy requirements for optimal growth and sports performance ability (Petrie et al, 2004).

Carbohydrate

Energy expenditure and the amount of carbohydrate required to prevent hypoglycaemia will vary with age and weight. In a review by Riddell and Iscoe, it is suggested that carbohydrate requirements for young people with diabetes are of the magnitude of 1.0–1.5 g/kg body weight/hour of exercise during peak insulin action (Riddell and Iscoe, 2006). The amount of carbohydrate required to maintain blood

Table 1. Examples of recommendations for children and young people with diabetes undergoing physical activity and exercise (Matyka and Annan, 2012).

Exercise within peak insulin action	Consider decreasing pre-exercise insulin food bolus by up to 50%–75%.
	If exercise is aerobic or the duration of exercise is greater than 45 minutes, consume 1 g/kg/h carbohydrate at 20-minute intervals to maintain blood glucose levels.
	Check blood glucose levels before, during and after activity. If blood glucose levels are below 5 mmol/L, consume 10–20 g of additional carbohydrate before starting exercise.
	If blood glucose levels are >10 mmol/L, delay carbohydrate intake until 20 minutes into activity.
	If blood glucose level are >14 mmol/L, check for ketones and manage high blood glucose levels before exercise commences.
	Consume adequate fluids.
Anaerobic activities	Check blood glucose levels to assess responses to exercise.
	If activity lasts longer than 45 minutes, consume carbohydrate during exercise for fuel and adjust insulin according to the blood glucose response. Additional insulin may be needed for competition.
	Consume appropriate meal or snack within 1 hour of finishing exercise to reduce the risk of post-exercise hypoglycaemia.
Aerobic activities	Consume additional carbohydrate and/or adjust insulin when exercise lasts 45 minutes or longer.
Team sports	Monitor blood glucose levels during and after activity.
	If within peak action of insulin, consider reducing insulin doses.
	Consume appropriate snack and fluid at half-time, and if competition stress increases blood glucose levels, consider small corrective dose of insulin.
Post-exercise	Consume carbohydrate snack or meal with fluids after exercise.
	If blood glucose levels are raised post-exercise, treat with caution, i.e. administer no more than a 50% correction dose, or replace the missing basal insulin if the exercise is completed with the insulin pump off.
	Consume pre-bed snack whenever the duration of exercise is 60 minutes or longer.
	If exercise is to be performed the next day, reduce basal insulin on injected therapy.

glucose levels will fall with diminishing insulin levels. One method of estimating carbohydrate requirement is to calculate the energy cost of the activity using the metabolic equivalent of task (MET) value and an estimate of individual resting energy expenditure. Tables of standard MET values for children's activities are available (Harrell et al, 2005). If the energy cost of the exercise is known, assuming that 60% of total energy is provided by carbohydrate, the carbohydrate cost of the activity can be estimated.

Carbohydrate advice should include guidance on the amount and type of carbohydrate to be consumed before and after exercise in order to maximise muscle glycogen stores and maintain blood glucose levels. Insulin management needs to be adjusted according to food intake and blood glucose responses. The carbohydrate consumed during exercise should be evenly distributed throughout the activity wherever possible – for example, consuming a snack or mouthful of drink every 10–20 minutes throughout exercise rather than all at the start of the activity. The appropriate quantity of carbohydrate that should be consumed during exercise would depend on the age and weight of the individual, and the type and duration of activity.

Protein

Children and young people have higher protein requirements than adults to support their growth and development. Protein recommendations in diabetes management decrease to 0.8–1 g protein/kg body weight in the later stages of adolescence, though this level of protein intake would not be sufficient for competitive athletes (Steen, 1996; Meyer et al, 2007; Jeukendrup and Cronin, 2011). However, the actual intake of protein in young people is often higher than that recommended, and aiming for a protein intake of 10–15% of the total energy requirements will usually meet the protein needs associated with training and development (Phillips et al, 2007). Protein requirements in adult athletes vary between 1.2 and 1.7 g/kg/day with endurance athletes having lower protein requirements than strength or power athletes (Tipton and Witard, 2007). Adolescent athletes are unlikely to need more than 2 g protein/kg/day (Petrie et al, 2004). Overall, it is important that a varied diet is consumed, and that additional advice is provided where needed – for example, special consideration for vegetarian athletes and those with dietary restrictions (Barr and Rideout, 2004). Consuming protein mixed with carbohydrate (recovery snacks) post-exercise may be beneficial in the prevention of late-onset hypoglycaemia. See *Box 2* for examples of appropriate snacks when exercising.

Box 2. Examples of appropriate snacks.

Pre-exercise snacks
- Sports drinks
- Jaffa Cakes
- Raisins
- Fruit smoothies and milkshakes
- Jam sandwich

During-exercise snacks
- Jelly sweets
- Sports drinks
- Diluted fruit juices
- Low-fat cereal bars

Post-exercise recovery snacks
- Fruit smoothies
- Low-fat milkshakes
- Yoghurt drinks
- Cereal and milk
- Fruit and yoghurt

Fluid, hydration and thermoregulation

Excess heat production during exercise is lost through the evaporation of sweat and convection of heat from the surface of the skin. The ability to perform exercise is affected by hydration status. Dehydration of 1–2% in adults has been demonstrated to compromise function and performance (Sawka et al, 2007). Studies comparing adults and children have shown similar effects of dehydration on performance. As thirst is a poor indicator of hydration and fluid requirements, children and young people need clear guidance about adequate fluid intake, particularly if their blood glucose levels are elevated. A review by Rowland (2011) has suggested that child athletes (aged 8–13 years) require a fluid intake of 13 mL/kg/hour of exercise and 4 mL/kg in the post-exercise recovery period. Heat stress may exacerbate anaerobic activity and hyperglycaemia, particularly during competition.

Before exercise, sufficient fluid should be consumed throughout the day, including a drink with each meal and snack, to ensure adequate levels of hydration. Drinking plans may help to guide the amount of fluid that is needed, with water as the most appropriate choice before exercise (see *Box 3* for an example of a

Page points

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2. Carbohydrate advice should include guidance on the amount and type of carbohydrate to be consumed before and after exercise in order to maximise muscle glycogen stores and maintain blood glucose levels.
3. It is important that a varied diet is consumed, and that additional advice is provided where appropriate.

"Children and young people with diabetes need to be as active as their peers for long-term health."

drinking plan). As beverages with high concentrations of glucose empty slowly from the stomach, so called "energy drinks" are not recommended as pre-exercise beverages unless hypoglycaemia treatment is needed.

During exercise, fluid should be consumed every 15–20 minutes. Moreover, for exercise that is over 60 minutes in duration or of high intensity, an isotonic sports drink is recommended. This may also help prevent problems with low blood glucose levels. Water is an appropriate fluid choice for exercise lasting less than 60 minutes; however, flavouring the water with sugar-free cordials may improve taste and fluid intake. Consuming food and fluid post-exercise helps rehydration as well reducing the risk of post-exercise hypoglycaemia.

Box 3. Example of a drinking plan.

- Drink 500 mL 1–2 hours before exercise
- Drink 150–200 mL 15 minutes before starting
- Drink every 15–20 minutes (about 100 mL) during exercise

Supplements and ergogenic aids

Adolescent athletes are likely to use supplements, and young athletes with diabetes may require iron, calcium or vitamin D supplements. Popular supplements include whey protein, creatine and caffeine (McDowall, 2007). Most sporting authorities recommend that these supplements are not used in athletes aged under 18 years. Athletes with diabetes require the same guidance as their peers about supplements, including counselling about the risk of contamination of available supplements and the lack of evidence for performance benefits. Counselling should also be provided about anti-doping and insulin use. In some sports, therapeutic use exemption is required under the age of 18 years, and advice should be sought from individual sporting bodies.

Summary

Children and young people with diabetes need to be as active as their peers for long-term health. Managing diabetes and physical activity presents a range of challenges that require individual solutions based on a sound understanding of the physiology of exercise, diabetes management and the needs of the children and young people. Everyday physical activity will require different management strategies to that of the exercise involved in training programmes. ■

Ideas, tips and advice to encourage physical activity in children and young people can be found online at:
www.nhs.uk/change4life
www.bhfactive.org.uk

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