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Exercise in Type 1 Diabetes

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Introduction

It is well established that regular exercise is beneficial and improves cardiovascular profile both in nondiabetic and people with type 1 diabetes. Regular exercise in adults with type 1 diabetes, can improve health and wellbeing, helps to achieve better glycaemic control, improves lipid profile and blood pressure control, decreases BMI. However, several additional barriers to exercise can exist for a person with diabetes, including fear of hypoglycaemia, loss of glycaemic control, and inadequate knowledge around exercise management. Adequate education about exercise as well as several adjustments have to be made in insulin regimens and carbohydrate intake before and after recovery from exercise in order to avoid hypoglycemia. Recommendations in diabetes, including those living with type 1 diabetes, 150 min of physical activity is recommended each week, with no more than two consecutive days of no physical activity. Resistance exercise is recommended also.

According to the American Diabetes Association Physical Activity Guidelines, for all adults living with diabetes recommended two to three times a week[1].

Physiology of physical activity and exercise

Modes of exercise

Exercise is generally classified as aerobic or anaerobic, depending on the predominant energy systems used to support the activity, although most exercise activities include a combination of energy systems. Aerobic exercise (e.g., walking, cycling, jogging, and swimming) involves repeated and continuous movement of large muscle groups that rely primarily on aerobic energy-producing systems. Resistance (strength) training is a type of exercise using free weights, weight machines, bodyweight, or elastic resistance bands that rely primarily on anaerobic energy-producing systems. High intensity interval training involves alternation between brief periods of vigorous exercise and recovery at low to moderate intensity (e.g., from 20 s to 4 min intervals of exercise and rest, for up to ten cycles). Both aerobic and anaerobic activities are recommended for most people living with diabetes.

Neuroendocrine and metabolic responses to exercise

In a nondiabetic individual, in almost all forms of exercise, regardless of the intensity or duration, blood glucose concentrations are within a narrow range (70-110 mg/dL). During aerobic exercise, insulin secretion decreases and glucagon secretion increases in the portal vein in order to stimulate the release of glucose from the liver to match the rate of glucose uptake into the working muscles[2]. Although the main determinant of glucose production during aerobic exercise is an increase in glucagon concentrations, other counterregulatory hormones also have a supportive role. A longer duration of exercise leads to glycogen depletion in the muscle, and energy fuel depends on lipid oxidation and glucose derived from plasma[3].

In type 1 diabetes, the glycaemic responses to exercise are influenced by the location of insulin delivery, the amount of insulin in the circulation, the blood glucose concentration before exercise, the composition of the last meal or snack, as well as the intensity and duration of the activity[4]. During aerobic exercise, blood glucose concentrations fall in most individuals with type 1 diabetes, because insulin concentrations cannot be decreased rapidly enough at the start of the activity and remain elevated in the systemic circulation. Increased insulin concentrations in the circulation during exercise promote increased glucose disposal relative to hepatic glucose production[5]. Hypoglycaemia develops in most patients within about 45 min of starting aerobic exercise. Individuals with type 1 diabetes typically require an increased carbohydrate intake or an insulin dose reduction, or both, before commencing aerobic exercise[6,7]. Low insulin concentrations due to aggressive reductions in insulin administration or a skipped insulin dose can cause hyperglycaemia before and during aerobic exercise, and even mild activity could lead to development of ketosis[8]. In brief and intense anaerobic exercise (e.g., sprinting, weight lifting, and some competitive sports), or during high intensity interval training, glucose concentrations typically rise[9].

Glucose uptake into muscle decreases immediately after aerobic exercise, but overall glucose disposal remains elevated for several hours in recovery from exercise to help replenish glycogen stores[10]. The risk of hypoglycaemia is elevated for at least 24 h in recovery from exercise, with the greatest risk of nocturnal hypoglycaemia occurring after afternoon activity[11]. Weight lifting, sprinting, and intense aerobic exercise can promote an increase in glycaemia that could last for hours in recovery. Although a conservative insulin correction after exercise might be prudent in some situations, overcorrection with insulin can cause severe nocturnal hypoglycaemia[12].

Contraindications for exercise

Elevated Ketones

Monitoring of blood or urine ketones is necessary before exercise. The cause of elevated ketones should be identified and be corrected appropriately by carbohydrate and insulin administration.

Recent Hypoglycemia

Severe hypoglycemia within the previous 24 hours is a contraindication to exercise because of a more serious episode during exercise. Even a single episode of mild hypoglycemia within 24 hours before exercise may disrupt counterregulatory responses and symptom awareness during exercise[13]. On the other hand a single bout of exercise may decrease counterregulatory responses during subsequent hypoglycaemia[14].

Diabetes complications and Exercise

Vigorous exercise, activities involving lifting of heavy weights, and competitive endurance events are contraindicated, in patients with long standing type 1 diabetes or with high HbA1c concentrations particularly if the patient has unstable proliferative retinopathy, severe autonomic dysfunction, or renal failure[15].

Clinical Treatment

Clinical management strategies depend on the type and duration of exercise. Implementation of the strategies take into account insulin dosage adjustment, carbohydrate intake, blood glucose monitoring or CGM, and insulin sensitivity of the subject. Generally, sustained aerobic exercise requires greater reductions in insulin dose and a higher carbohydrate intake than a short-term high intensity interval training session. By contrast, brief anaerobic exercise could require increased insulin delivery,

recommended to be given in early recovery rather than before exercise to avoid hypoglycaemia[16].

Continuous subcutaneous insulin infusion offers more flexibility to modify basal infusion delivery and obtain a faster effect. Suspension of basal insulin infusion at the onset of 60 min exercise reduces the risk of hypoglycaemia during the activity, but it could increase the risk of hyperglycaemia after exercise[17]. A basal rate reduction, rather than suspension, is recommended 60-90 min before the start of exercise. An 80% basal reduction at the onset of exercise has been shown more effective in preventing hyperglycaemia after exercise than does basal insulin suspension, and is associated with a reduced risk of hypoglycaemia both during and after the activity[18]. To limit the risk of compromised glycaemic control and ketosis, a time limit of less than 2 h for pump suspension is recommended[19].

Latest advances in technology with continuous glucose monitoring, and continuous subcutaneous insulin infusion help patients with type 1 diabetes to perform exercise with safety. Real time CGM may alert the patient about hypo- or hyperglycaemia while they exercise or perform sports. Threshold suspension of insulin delivery in continuous subcutaneous insulin infusion could offer additional protection against exercise-associated hypoglycaemia[20]. The development of the artificial pancreas for exercise remains the ultimate goal[21].

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