Role of Carbohydrates and Sugars in Sports Nutrition

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Understanding of the physical demands and dietary requirements of athletes has increased considerably in the last 10-15 years and this has informed the development of evidence-based sports nutrition guidelines from authoritative bodies, including Dietitians of Canada[1]. Emphasis in these guidelines is often placed on ensuring that adequate energy, carbohydrate and protein are consumed to optimize the performance of athletes. Nonetheless, ongoing public health discussions along with new developments in the understanding of exercise adaptation have resulted in a need to clarify the role of carbohydrates and sugars for athletes.

Key points:

- Carbohydrate is the predominant fuel used by most people during intense sporting activities
- Adequate carbohydrate availability is important for performance optimization in sustained intense sporting activities
- Daily and within-event carbohydrate goals for athletes will vary as a function of the energetic demands of training or competition
- Sugars feature in the diets of athletes, most likely as part of the normal pattern of food consumption and can be regarded as one of a variety of options to help athletes achieve their specific carbohydrate-intake goals

Carbohydrates as fuel for exercise

Carbohydrates, along with proteins and fats, are one of the main nutrients in our diets and provide the body with an essential source of energy. The body can store consumed carbohydrates as glycogen in the muscles and liver, but the storage capacity is limited (e.g. liver glycogen is depleted after about 28 hours of fasting). As exercise intensity increases, so does the reliance on carbohydrate fuel stores (Figure 1). Therefore keeping these stores adequately stocked is crucial for athletes who often need to perform at high exercise intensities (i.e., ≥70% of maximal aerobic power, VO_{2max}). When body carbohydrate stores are inadequate they cannot meet the energy needs of the activities being performed. For an athlete, this can result in: fatigue, reduced training ability, impaired performance and reduced immune system function, which can impact on recovery.

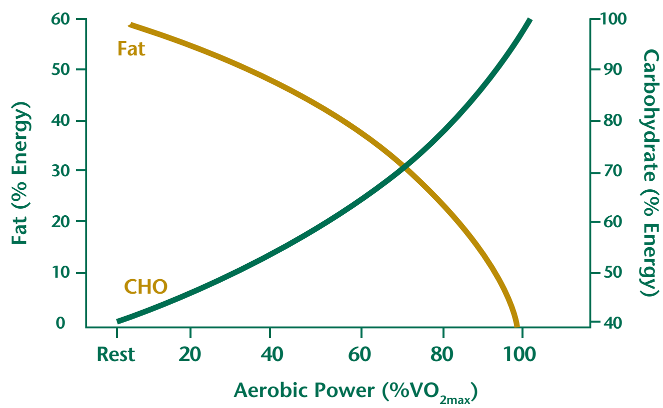

Figure 1: The relationship between the relative contribution of carbohydrate and fat utilization to energy expenditure as a function of relative power output. CHO denotes carbohydrate. Data redrawn from Reference 2.

How much carbohydrate do athletes need?

What is considered an adequate carbohydrate intake depends on the fuel requirements of an athlete's training and competition program, and also should take into account the frequency, duration and intensity of the activity being performed. Training and activity levels often change from day-to-day, week-to-week or month-to-month and an individual's carbohydrate intake should also fluctuate to reflect this. Figure 2 (next page) provides some general guidance for daily carbohydrate intake goals for athletes based on exercise context and intensity. Generally, as the energetic demands of training or competition increase so does the dietary carbohydrate requirement, although these guidelines should be fine-tuned to take into account individual energy requirements, other training needs and athlete feedback.

Given the body's limited ability to store carbohydrates, for athletes seeking to optimize intense endurance performance during competition carbohydrate loading is often practiced, which typically involves consuming carbohydrate in the "High" or "Very High" range indicated in Figure 2 (next page) for 1-2 days prior to the event. Also, athletes preparing for training or competition are recommended to consume between 1-4 grams of carbohydrates per kilogram body mass in the 1-4 hours before exercise to ensure adequate fuelling. Performance can be further optimized by consuming carbohydrates during exercise with the amounts recommended dependent upon the nature of the activity. If training or competition is strenuous and lasts ~1 hour duration then small amounts of carbohydrates (15-30 grams per hour) can be considered. For endurance exercise or 'stop and go' sports such as half-marathon running or soccer lasting 1-2.5 hours, moderate amounts of carbohydrates are recommended (30-60 grams per hour) and for ultra-endurance exercise lasting over 2.5-3 hours such as marathon running or long bicycle events, larger amounts of carbohydrates (up to 90 grams per hour) could help to optimize performance[3]. Finding carbohydrate sources that provide ~20-30 grams of carbohydrates per portion, such as whole foods (e.g. bananas) and carbohydrate-based sports drinks/gels/bars will enable athletes to simply tailor their intake by taking 1, 2 or 3 portions per hour depending on the nature of the exercise.

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Does the type of carbohydrate that athletes consume matter?

Athletes are generally advised to obtain their carbohydrates from a variety of foods including bread, cereals and grains, legumes, milk/alternatives, vegetables and fruits[1] where the predominant carbohydrate, other than in milk and fruits, will be starch. Dietary surveys show sugars (mono- and disaccharides occurring naturally or added to food/drink in the diet) contribute 4-25% of total energy and 5-60% of carbohydrate intake in the diets of athletes[4]. Clearly, sugars feature in the diets of athletes and given their high levels of physical activity and caloric needs, it seems reasonable that sugars can be regarded as one of a variety of options to help athletes achieve their specific carbohydrate-intake regimens as part of a normal pattern of food consumption[4].

Day-to-day carbohydrate intake can usually be obtained from normal food and drinks but specialty sports products such as sports drinks, energy gels and bars can be used to supplement food intake or as a convenient energy source during or for rapid recovery from intensive or prolonged training and competition. In these situations, the types of carbohydrate ingested can affect the speed at which energy is made available to the body and emphasis should be placed on consuming carbohydrates that can be rapidly absorbed and assimilated by the body, such as glucose, maltose and sucrose (Table 1).

Table 1: Examples of Fast and Slow carbohydrate types.

'Fast' Carbohydrates	'Slow' Carbohydrates
Glucose	Fructose alone
Maltose	Galactose
Sucrose	Isomaltulose
Combined glucose and fructose	Starches rich in amylose
Maltodextrins	
Starches rich in amylopectin	

'Fast' and 'Slow' refer to the speed at which these carbohydrate types are generally digested, absorbed, and made available to the muscles and body for energy provision or storage during and after exercise. Table modified from References 5 and 6.

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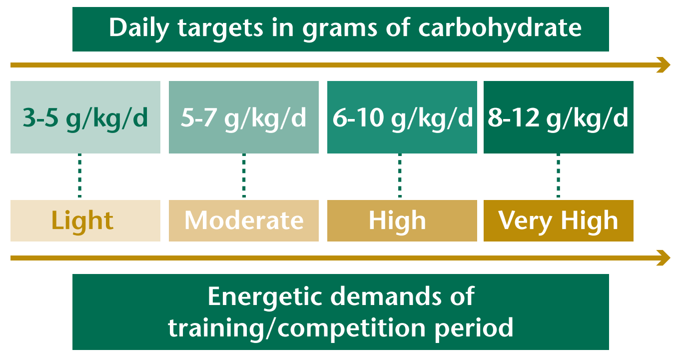

Figure 2: Daily carbohydrate intake goals for athletes. Values expressed as grams of carbohydrate per kilogram body mass per day (g/kg/d). Light – low intensity or skill based activities; Moderate – moderate exercise programme (~1 hour per day); High – endurance programme (e.g., moderate to high intensity exercise of 1-3 hours per day); Very high – extreme commitment (i.e., moderate to high intensity exercise of >4-5 hours per day). Data from Reference 3.

Strategic restriction of carbohydrates and exercise adaptation

There is emerging evidence suggesting that the strategic restriction of carbohydrates during training sessions (such as occasionally training in the overnight-fasted state or training twice daily with limited carbohydrates consumed during recovery) may increase the activation of the molecular signals that trigger training adaptation in the exercise muscles[7]. Although this adaptation may reduce the reliance on muscle glycogen as a fuel source during exercise, there is no clear evidence that this adaptation can eventually enhance exercise performance *per se,* and the impact/safety of repeated high-intensity training with low carbohydrate status needs to be further explored.

However, this does not mean that athletes should avoid carbohydrates in favour of high-fat diets, which seem unlikely to benefit most athletes engaged in high intensity sports. **Given the critical role of carbohydrates in the optimization of sustained intense performance, it is still suggested by sports nutrition guidelines that key training sessions and competitions be undertaken with adequate carbohydrate fuel availability to meet energy needs and replenish glycogen stores.**