Carbohydrates in sports nutrition
Impact of the glycemic index

INTRODUCTION

It is generally accepted that exercise-induced energy expenditure has to be restored by carbohydrates (CHO) and that athletes should ingest a diet high in CHO. Most controlled studies support the view that CHO improves endurance capacity and should be the predominant source of energy within the athlete’s diet. According to current guidelines athletes should aim at increasing the amount of CHO within their diet to at least 60-65 percent of total energy intake or 6-10 g CHO/kg bodyweight/d (1). These recommendations are based on the following facts:

1. CHO yield a higher energy flux in skeletal muscles and an increased energy output/l oxygen consumed.
2. Compared to fat stores, the amount of CHO that can be stored as glycogen in the muscle and liver is limited (approx. 1500-2000 kcal). A high CHO diet improves the restoration of glycogen stores in between training sessions and competition.
3. CHO feeding during endurance exercise has been shown to improve exercise performance, particularly when exercise duration is longer than 1 hour.

In most recent years, the role of CHO in sports nutrition has been studied with a focus on the glycemic index of CHO ingested. The glycemic index (GI) provides a method to classify foods rich in CHO based on their actual postprandial blood glucose response compared to a reference food (i.e. 50 g glucose or white bread).

Foods with a low GI have a low postprandial blood glucose response and generally also a low postprandial insulin response (Figure 1). It has been demonstrated that the GI of a test meal has a significant effect on the subsequent fuel metabolism both under resting conditions as well as during exercise (2, 3). Most investigations found that the consumption of a low glycemic meal prior to physical exercise increased fat oxidation during endurance exercise irrespective of relative exercise intensity. Therefore, there is a rationale to consider the GI in CHO feeding in athletes since increased fat oxidation could promote endurance stamina and enhance glycogen sparing in liver and muscles (4, 5). The following text will give a short review of data related to the effect of GI in sports nutrition including own data dealing with the effects of a CHO solution with either a high or a low GI on energy metabolism during exercise.

CARBOHYDRATE INGESTION PRE-/POST-EXERCISE

From a nutritionist point of view, the replenishment of glycogen stores is one of the most important issues for endurance athletes. Bergstrom and Costill have clearly shown that a high CHO content in foods is a prerequisite for a sufficient glycogen resynthesis which in turn is directly related to the time to exhaustion (6-8). An amount of 10-12 g CHO/h ingested within 24 h is an adequate CHO supply for complete glycogen resynthesis in athletes (180 mmol/kg) (9). Immediately after exercise (in the first 2 hours) current knowledge favours a high GI of ingested CHO (10) as this results in higher glycogen replenishment. This is based on the well documented increase in muscular glucose uptake directly following exercise mainly due to an enhanced activity of muscular GLUT-4 glucose transporters and glycogen-synthase activity within skeletal muscles. In contrast to the post-exercise condition, there is evidence that a low GI may be more advantageous for pre-exercise meals in endurance type of sports. It is recommended that athletes consume a meal rich in CHO (200-300 g of CHO) 3-4 h before exercise (1). It has been found that the course of blood glucose and insulin levels following ingestion of a low GI meal favoured a higher level of free fatty acids during exercise, enhanced fat oxidation and was associated with an improved blood glucose homeostasis (2, 11, 12). At a predefined intensity, the increase in fat oxidation may lead to a sparing of glycogen in muscles and particularly in the liver leading to enhanced endurance capacity. However, some (3, 11, 13-15) but not all studies (12, 16, 17) have shown an improved performance following a low GI meal. This may be due to differences in quantity and timing of CHO ingested as well as the type of exercise employed. Therefore, there is a need for more controlled studies in this particular issue. In their current guidelines, the American College of Sports Medicine stated that consuming 0.7 g CHO/kg bodyweight/h (approx. 30-60 g/h) during prolonged exercise has been shown to extend endurance performance (1). This is even more important when pre-exercise glycogen stores are low (1). In addition, the most recent guidelines on exercise and fluid replacement recommend an amount of 0.4-0.8 l/h with a CHO content of 5-10 percent.

ABSTRACT

Carbohydrates (CHO) are an important energy source during muscular activity and physical exercise. An enhanced performance by carbohydrate feeding has been reported for endurance exercise and high-intense intermittent exercise. In the past years several groups have examined the effects of CHO in pre-exercise meals with different glycemic indices (GI). Meals with a high GI have shown to be associated with high postprandial insulin levels leading to a decrease in fat oxidation which is often undesirable during extensive exercise. It has been speculated that an increase in fat oxidation could enhance endurance performance mainly as a consequence of glycogen sparing. In the present paper we will summarise some of the data related to the GI and CHO during exercise with the inclusion of data dealing with the effects of a CHO solution differing in GI on energy metabolism during exercise.
INFLUENCE OF GI IN BEVERAGES DURING EXERCISE

In a randomized trial we investigated the metabolic effects of a CHO solution containing either Palatinose, a disaccharide with a low glycemic index vs the respective effects of the high glycemic CHO maltodextrin (MD) given both before and during exercise. 21 endurance trained triathletes (37±8 y, 64±4 ml/kg/min VO2,max) consumed 250 ml of the respective CHO (10 percent CHO solution) containing either maltodextrin (red dotted line) or palatinose (blue line) during prolonged endurance exercise. Therefore, we investigated the metabolic effects of a CHO solution with a low GI given both before and during exercise. The need to test this combination is stressed in light of the results of Burke et al. showing that the effects of a low GI pre-exercise meal is abolished by a high GI beverage during exercise (18).

Figure 2. Postprandial alterations from baseline values (Delta) in glucose, insulin, respiratory exchange ratio (RER) and free fatty acids before and during exercise. The arrows indicate the time of ingestion of the beverage (250 ml 10 percent CHO solution) containing either maltodextrin (red dotted line) or palatinose (blue line)

CONCLUSIONS

The amount of CHO in the athlete’s diet should add up to 60-65 percent of total energy intake or 6-10 g CHO/kg bodyweight/d. During intense endurance exercise (30 min), carbohydrate and fat ingestion: effects of the glycemic index, “J. Appl. Physiol., 89, pp. 165-185 (2000).


9. D. E. Thomas, J. R. Brotherhood et al., “Carbohydrate loading during prolonged exercise: application of metabolic effects of a CHO solution containing either Palatinose, a disaccharide with a low glycemic index vs the respective effects of the high glycemic CHO maltodextrin (MD) given both before and during exercise. The need to test this combination is stressed in light of the results of Burke et al. showing that the effects of a low GI pre-exercise meal is abolished by a high GI beverage during exercise (18).

During prolonged exercise.

In summary, the results of this study indicate that a high glycemic index meal increases muscle glycogen storage at rest but augments its utilisation during subsequent exercise. Burke et al. (2).

REFERENCES AND NOTES


