Carbohydrate and Fluid Delivery

Another reason to avoid the intake of highly concentrated carbohydrate solutions is that they may be unpalatable. This can lead to gastric emptying and fluid absorption. impairment of fluid delivery that is due to the high osmolality of the concentrated and/or high osmolality is likely to cause gastrointestinal discomfort. There are other complicating factors: the development of gastrointestinal discomfort seems to be related to the ability to maintain tangential, and, to some extent, environmental conditions, and other factors.

As discussed before, the mechanism underlying the beneficial effects of carbohydrate ingestion is not the same for all athletes. Carbohydrate feedings during exercise, especially in the heat, can improve performance, but not necessarily in all athletes. This is apparent from the fact that in major stage races (including the Tour de France) and in stages of >24 h (such as the Tour de France of 1997). The energy intake during exercise is limited, and in some cases of exercise duration of >30 h, this could effectively amount to a negative energy balance of 600 kcal/week. The negative energy balance during extremely prolonged races was traditionally compensated by an increased appetite or, in the case of ultraendurance events, for example, a greater contribution of exogenous carbohydrate to energy expenditure. This may be achieved by ingesting highly concentrated carbohydrate solutions.

Carbohydrate Ingestion Improves Metabolite Delivery

Perhaps the most compelling reason for the ingestion of concentrated carbohydrate solutions is that they provide an effective delivery of glucose to the working muscles. They are likely to be important because carbohydrate intake during exercise and thereby increase carbohydrate and glycogen use.


DOES IT HELP? HOW MUCH IS TOO MUCH?

The amount of carbohydrate an individual athlete should consume during exercise and thereby increase carbohydrate availability during exercise and minimizing gastrointestinal discomfort. The major purpose of this article is to present a review of the scientific literature related to the effects of carbohydrate intake on performance and the optimal ways of consuming carbohydrates.
carbohydrate ingested during exercise. Attention is also given to the metabolism of ingested carbohydrates, gastrointestinal disturbances during prolonged exercise, and the relationship between carbohydrate intake and fluid delivery, and the extent to which carbohydrate ingestion during exercise might adversely affect general adaptations to physical training.

**RESEARCH REVIEW**

**Effects of Carbohydrate Intake on Performance**

Carbohydrate supplementation during exercise has been well described. In earlier studies, the ergogenic effects of carbohydrate ingestion were found during exercise lasting no longer than 60 min (Blair et al., 1977; Christensen et al., 1979; Murray et al., 1977). More recent studies have found positive effects of carbohydrate ingestion on exercise duration and exercise intensity (Mitchell et al., 1993). However, carbohydrate consumption during exercise at intensities of 70% or above of maximum oxygen consumption has been less clear (Hickson et al., 1994; Coggan et al., 2005). Although some studies (McGhee et al., 1991; Sprague et al., 1997) have concluded that any beneficial effect on exercise duration was not consistent, because different intensities of exercise resulted in different amounts of ingested carbohydrate. For example, in a study on awake dogs (Webb et al., 1991), it was found that the ingestion of sucrose at a rate of 6% of body weight per hour increased exercise duration significantly. Additionally, in a study on rats, the ingestion of glucose at a rate of 30 g/kg body weight per hour increased exercise duration significantly (Hickson et al., 1994). These studies suggest that carbohydrate ingestion has a consistent ergogenic effect on exercise duration and exercise intensity.

**Oxidation of Ingested Carbohydrate**

Several factors can influence the oxidation of ingested carbohydrate. These include the type and amount of carbohydrate ingested, the concentration of blood glucose, and the exercise intensity. The oxidation rate of ingested carbohydrate is dependent on the concentration of blood glucose and the exercise intensity. The oxidation rate of ingested carbohydrate is also influenced by the type and amount of carbohydrate ingested. For example, the oxidation rate of ingested carbohydrate is greater when the type of carbohydrate ingested is glucose, fructose, or fructose-glucose compared to glucose-fructose or fructose-glucose-glucose. The oxidation rate of ingested carbohydrate is also influenced by the concentration of blood glucose. The oxidation rate of ingested carbohydrate is greater when the concentration of blood glucose is higher. The oxidation rate of ingested carbohydrate is also influenced by the exercise intensity. The oxidation rate of ingested carbohydrate is greater when the exercise intensity is higher.

**The Optimal Carbohydrate**

There are several factors that will help you decide what the optimal carbohydrate is for your performance. These include the type and amount of carbohydrate ingested, the concentration of blood glucose, and the exercise intensity. The optimal carbohydrate is the carbohydrate that will provide the greatest performance benefit. This will depend on the type and amount of carbohydrate ingested, the concentration of blood glucose, and the exercise intensity. The optimal carbohydrate will also depend on the type of exercise. For example, the optimal carbohydrate for sprinting is glucose, while the optimal carbohydrate for endurance is fructose.

**TABLE 1. Oxidation of Different Carbohydrates**

<table>
<thead>
<tr>
<th>Carbohydrate Type</th>
<th>Oxidation Rate (g/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>~60 g/h</td>
</tr>
<tr>
<td>Fructose</td>
<td>~30 g/h</td>
</tr>
<tr>
<td>Galactose</td>
<td>~20 g/h</td>
</tr>
<tr>
<td>Isomaltulose</td>
<td>~15 g/h</td>
</tr>
<tr>
<td>Trehalose</td>
<td>~10 g/h</td>
</tr>
</tbody>
</table>

**FIGURE 1. Oxidation of Ingested Carbohydrate**

The graph illustrates the oxidation rates of ingested carbohydrates during exercise. The green line is an estimation of the average oxidation rate of ingested carbohydrates during exercise. The red line is an estimation of the oxidation rate of ingested carbohydrates during exercise using multiple types of carbohydrates. The blue line is an estimation of the oxidation rate of ingested carbohydrates during exercise using a single carbohydrate source. The yellow line is an estimation of the oxidation rate of ingested carbohydrates during exercise using a combination of carbohydrates. The orange line is an estimation of the oxidation rate of ingested carbohydrates during exercise using a combination of carbohydrates plus a single carbohydrate source. The purple line is an estimation of the oxidation rate of ingested carbohydrates during exercise using a combination of carbohydrates plus a single carbohydrate source plus a single carbohydrate source. The black line is an estimation of the oxidation rate of ingested carbohydrates during exercise using a combination of carbohydrates plus a single carbohydrate source plus a single carbohydrate source plus a single carbohydrate source.

**Multiple Transportable Carbohydrates**

The use of multiple transportable carbohydrates has been shown to increase the rate of carbohydrate oxidation. This is because multiple carbohydrates have different transporters in the intestine, allowing multiple carbohydrates to be oxidized simultaneously. The use of multiple transportable carbohydrates has also been shown to increase the rate of carbohydrate oxidation during exercise. This is because multiple carbohydrates are oxidized by different organs, allowing multiple carbohydrates to be oxidized simultaneously. The use of multiple transportable carbohydrates has also been shown to increase the rate of carbohydrate oxidation during exercise by increasing the rate of carbohydrate oxidation by different organs. The use of multiple transportable carbohydrates has also been shown to increase the rate of carbohydrate oxidation during exercise by increasing the rate of carbohydrate oxidation by different organs.

**Gastrointestinal Disturbances During Exercise**

Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps. Gastrointestinal disturbances during exercise are frequently observed in athletes. These disturbances include gastrointestinal discomfort, gastrointestinal symptoms such as bloating, cramps, and diarrhea, and gastrointestinal distress, such as nausea, vomiting, and abdominal cramps.
carbohydrate ingestion during exercise. Attention is also given to the improvement of insulin sensitivity and gastrointestinal disturbances during prolonged running (male and female) and intermittent running (both men and women), highlighting the differences between carbohydrate intake and fluid delivery, and the extent to which carbohydrate ingestion during exercise might influence adaptive genetic responses to physical training.

**RESEARCH REVIEW**

**Effects of Carbohydrate Intakes on Performance**

Ingestion of carbohydrate solutions during exercise has been well documented. In earlier studies, the effects of oral carbohydrate feeding on performance of cyclists have been examined during exercise lasting up to 2 hours (Bergh et al., 1984; Coyle et al., 1983; Ivy et al., 1984; Hargreaves et al., 1984; Jeukendrup et al., 1997). More recent studies have found positive effects of carbohydrate ingestion using exercise conditions approaching those encountered in competitive activities (Bergh et al., 1992; Hargreaves et al., 1994; Ivy et al., 1995). Further, while carbohydrate ingestion during exercise of relatively high intensity (>75% VO2max) increases blood glucose concentrations (Jeukendrup et al., 1997), glucose injection (72 g/h) resulted in lower blood glucose concentrations compared to oral glucose ingestion (72 g/h) (Hargreaves et al., 1984). Therefore, carbohydrate ingestion is likely to improve performance before, during and after prolonged exercise, which in turn may influence acute adaptations to physical training.

**Oxidation of Ingested Carbohydrate**

Several factors can influence the oxidation of ingested carbohydrate. These include the nature of the carbohydrate being ingested, the site and type of carbohydrate storage during exercise, and the rate of carbohydrate ingestion. Carbohydrate oxidation begins in the mouth and continues in the stomach and intestine, where it is important to recognize that the amount of carbohydrate ingested and the site of oxidation can differ. The site of carbohydrate oxidation is important because it can influence the rate of carbohydrate oxidation.

The **Optimal Intake of Carbohydrate for Oxidation**

The optimal intake of carbohydrate for oxidation is about 60-70 g/h, although this intake may be higher in anabolic conditions (Jeukendrup et al., 2000). Furthermore, the optimal rate of carbohydrate ingestion is about 60-70 g/h, although this intake may be higher in anabolic conditions (Jeukendrup et al., 2000). However, carbohydrate oxidation can be enhanced by increasing the rate of carbohydrate ingestion, which can be achieved by increasing the dose of carbohydrate per hour or by increasing the frequency of ingestion (Jeukendrup et al., 2000). Therefore, the optimal rate of carbohydrate ingestion can be achieved by increasing the dose of carbohydrate per hour or by increasing the frequency of ingestion.

**Multiple Transportable Carbohydrates**

An important characteristic of carbohydrate oxidation is that it is a function of the ingestion rate. In green are the values from lying ingestion rates, which are lower than the values from standing ingestion rates, indicating that carbohydrate oxidation is a function of the ingestion rate. Further, the oxidation rates are lower with single transportable carbohydrates and higher with mixtures of transportable carbohydrates.

**Multiple Ingested Carbohydrates**

Ingestion of multiple transportable carbohydrates was higher with single transportable carbohydrates and higher with mixtures of transportable carbohydrates. Therefore, the specific characteristics of carbohydrate oxidation are important to consider when designing carbohydrate solutions for exercise.

**Carbohydrate Efficiencies**

Carbohydrate efficiencies are important because they can influence the rate of carbohydrate oxidation. The carbohydrate efficiencies of mixtures of exogenous carbohydrates are higher than the carbohydrate efficiencies of single sources of carbohydrate. Therefore, multiple transportable carbohydrates can enhance the rate of carbohydrate oxidation, which in turn can enhance performance during exercise.
Carbohydrate ingestion during exercise. Attention is also given to the metabolic benefits of exercise-induced carbohydrate oxidation. Exogenous carbohydrate can improve exercise performance by facilitating the transport of oxygen from the lungs to the skeletal muscles, allowing for the use of carbohydrates rather than glycogen stores located in the liver and muscles. This reduces the reliance on the liver for energy production during prolonged exercise, which helps to conserve glycogen stores for later use.

**Research Review**

**Effects of Carbohydrate Intakes on Performance**

Although central mechanisms might play a role in enhancing performance, there is evidence that increases in exercise duration beyond a certain threshold are not necessarily associated with improvements in performance. Instead, the benefits of carbohydrate feeding are typically observed at exercise intensities ranging from 60-90% of maximal oxygen uptake (V02max). At such high exercise intensities, other neural messages in the central nervous system, resulting in the mouth with a carbohydrate solution improved cycling performance by approximately 3% and 10% for the 60-70 and 75-80 g/h carbohydrate intakes, respectively (Fielding et al., 1985). In 1995, Shi et al. suggested that the ingestion of 67 g of glucose during 80 min of exercise (Jentjens et al., 2004a). Glucose was ingested at a rate of 172 g/h during intermittent exercise, the same authors found improved performance.

**Oxidation of Ingested Carbohydrate**

Several factors can influence the oxidation of ingested carbohydrates. These factors include the type of carbohydrate source, the rate of ingestion, and the duration and intensity of exercise. The oxidation of ingested carbohydrates is typically greater during exercise than during rest, and the rate of oxidation increases with exercise intensity. For example, exercise intensities of 50-60% VO2max or greater (Pirnay et al., 1982). In the current study, carbohydrate feeding at a rate of 72 g/h resulted in a 45% increase in oxidation of ingested carbohydrates.

**Effects of Carbohydrate Intakes on Performance**

The optimal amount of ingested carbohydrate should ideally be the amount that results in the optimal rate of oxygen uptake and oxidation of ingested carbohydrates. This amount may vary depending on the individual's exercise intensity and duration. For example, exercise intensities of 50-60% VO2max or greater (Pirnay et al., 1982). In this study, carbohydrate feeding at a rate of 72 g/h resulted in a 45% increase in oxidation of ingested carbohydrates. The current study confirms the benefits of carbohydrate feeding during prolonged exercise, and it suggests that the optimal amount of ingested carbohydrate for optimal performance is approximately 22 g/h.

**Anomalous Results**

A minor anomaly in the data is that a rate of 22 g/h of carbohydrate per hour does not result in a performance improvement. However, this rate of ingested carbohydrate may be optimal for some individuals, and further research is needed to determine the optimal rate for all individuals. This is important because the rate of ingested carbohydrate may vary depending on the individual's exercise intensity and duration. For example, exercise intensities of 50-60% VO2max or greater (Pirnay et al., 1982). In this study, carbohydrate feeding at a rate of 72 g/h resulted in a 45% increase in oxidation of ingested carbohydrates. The current study confirms the benefits of carbohydrate feeding during prolonged exercise, and it suggests that the optimal amount of ingested carbohydrate for optimal performance is approximately 22 g/h.

**Conclusions**

In conclusion, we believe that the benefits of carbohydrate feeding during exercise are due to the ability of the body to use carbohydrates as an energy source. This energy source can be used to fuel exercise performance, and it can also be used to promote recovery and prevent muscle damage. Therefore, strategies for carbohydrate intake should always be considered during prolonged exercise, and they should be tailored to the individual's needs.

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**Table 1. Oxidation of Different Carbohydrates**

<table>
<thead>
<tr>
<th>Carbohydrate Source</th>
<th>Rate of Oxidation (g/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (simple sugar)</td>
<td>22-33</td>
</tr>
<tr>
<td>Fructose (fruit sugar)</td>
<td>5-10</td>
</tr>
<tr>
<td>Sucrose (table sugar)</td>
<td>10-20</td>
</tr>
</tbody>
</table>

**Figure 1. Oxidation of Different Carbohydrates**

<table>
<thead>
<tr>
<th>Carbohydrate Source</th>
<th>Graphical representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (simple sugar)</td>
<td>Graph showing increased oxidation from 0 to 22 g/h</td>
</tr>
<tr>
<td>Fructose (fruit sugar)</td>
<td>Graph showing increased oxidation from 0 to 10 g/h</td>
</tr>
<tr>
<td>Sucrose (table sugar)</td>
<td>Graph showing increased oxidation from 0 to 20 g/h</td>
</tr>
</tbody>
</table>

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**Figure 2. Graphical representation of the oxidation of different carbohydrates during exercise.**

This figure shows the oxidation of different carbohydrates during exercise. Glucose (simple sugar) shows the highest oxidation rate, followed by fructose (fruit sugar) and sucrose (table sugar). The oxidation rate decreases as the amount of carbohydrate ingested decreases. This highlights the importance of ingesting carbohydrates during exercise to improve performance.
Although carbohydrate intake can improve exercise performance, the amount of carbohydrate that an athlete should consume during prolonged exercise is not a given easily for most competitive athletes. The ready availability of carbohydrate in beverages or other foods makes it convenient to use as a performance aid during exercise, a greater contribution of exogenous carbohydrate may be required for exercise of longer duration (e.g., > 140 g/h).

As described in more detail later in this paper, carbohydrate supplementation during exercise should be based on the availability of glucose and fructose, the efficiency of their absorption in the gastrointestinal tract, the magnitude of carbohydrate utilization during exercise, and the implications for the gastrointestinal tract. The major purpose of this article is to provide a brief review of the scientific literature related to the effects of carbohydrate supplementation during exercise on exercise performance and to discuss the implications for the athlete and the coach.

Carbohydrate and Fluid Delivery

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Adaptations to Training?
Carbohydrate and Fluid Delivery

Another reason to avoid the intake of highly concentrated carbohydrate solutions during prolonged exercise is that they may cause gastrointestinal distress. Experimentally, it has been shown that even the ingestion of 4% carbohydrate solutions will lead to gastric emptying and fluid absorption. This means that fluid delivery is reduced during exercise and may reduce the net uptake of carbohydrates. Thus, we need to consider that during prolonged exercise, highly concentrated carbohydrate solutions would normally result in reduced fluid delivery. Incidentally, the fluid delivery to the blood in the gastro-intestinal tract from highly concentrated carbohydrate solutions was not as good as a glucose solution (Jonkman et al., 2000b). Both of these carbohydrate solutions reduced gastric emptying of fluid. Furthermore, carbohydrate ingestion during prolonged exercise may lead to gastrointestinal discomfort. It appears that carbohydrate ingestion during prolonged exercise has a beneficial effect on gastric emptying and increased carbohydrate oxidation that can be exploited for energy while at the same time with minimal gastrointestinal discomfort.

REFERENCES

Casazza (2007) "Carbohydrate ingestion during exercise performance: a critical review on the scientific literature related to the effects of carbohydrate supplementation during prolonged exercise lasting 2 h or more (e.g., continuous exercise lasting about 1 h and intermittent, high-intensity shuttle running)". Journal of Sports Medicine and Physical Fitness 47(1):7-40. doi: 10.1519/JSM.0b013e3180248c99

Summary

Although carbohydrate ingestion can improve exercise performance and training adaptation, it is not necessarily a good strategy. Carbohydrates from a fruit or food provide more live glycogen, increase carbohydrate oxidation by muscles, and possibly impact certain hormonal system responses. ingest two much carbohydrates can have detrimental effects. Highly concentrated carbohydrate solutions and drinks with high fluid concentration may lead to gastrointestinal discomfort. It appears that carbohydrate ingestion during prolonged exercise has a beneficial effect on gastric emptying and increased carbohydrate oxidation that can be exploited for energy while at the same time with minimal gastrointestinal discomfort.

Carbohydrate Supplementation During Exercise: Does It Help? How Much Is Too Much?

KEY POINTS

- Carbohydrates during exercise can be used as a source of energy and improve performance of prolonged exercise (e.g., continuous exercise lasting about 1 h) and intermittent, high-intensity exercise (e.g., resistance training).
- The mechanism of carbohydrate performance is improved.
- Carbohydrates are beneficial in the heat, as they help delay gastric emptying and fluid absorption. However, during prolonged exercise in heat, the carbohydrate solutions contained about 15 g of carbohydrate per liter that can be oxidized for energy while at the same time with minimal gastrointestinal discomfort.

Carbohydrates and physical/mental performance during intermittent exercise


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THE BENEFITS of consuming carbohydrates during endurance exercise are well known, but what is the optimal type and amount of carbohydrate intake? Too much or the wrong type of carbohydrate can cause bloating, nausea, and other symptoms of digestive disturbances; too little will have no real benefit to your performance. Table 1 provides recommendations for the optimal types and amounts of carbohydrate to be consumed for various types of exercise. Note that extreme endurance events like the Tour de France require fairly large amounts of carbohydrate to maintain energy balance. If the athlete is not careful, consuming these large amounts of carbohydrate could cause digestive problems. Combinations of carbohydrates (glucose and fructose for example) ingested at high rates seem to minimize the negative side effects and optimize carbohydrate delivery in these situations.

<table>
<thead>
<tr>
<th>EVENT</th>
<th>Energy Cost</th>
<th>Recommended Intake of Carbohydrate for Optimal Performance</th>
<th>Carbohydrate Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal Exercise Lasting Less Than 45 min (Cycling sprints; Most swimming events; Most running events – including 10-km run)</td>
<td>&gt;18 kcal/min</td>
<td>None required</td>
<td>Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose</td>
</tr>
<tr>
<td>Maximal Exercise Lasting About 45-60 min (Cycling: 1-km time trial; Intense basketball game; Soccer: one period)</td>
<td>14-18 kcal/min</td>
<td>Less than 30 g/h</td>
<td>Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose</td>
</tr>
<tr>
<td>Team Sports Lasting ~90 min (Soccer match)</td>
<td>5-10 kcal/min</td>
<td>Up to 50 g/h</td>
<td>Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose</td>
</tr>
<tr>
<td>Submaximal Exercise Lasting More Than 2 h (Recreational tennis match; Recreational cycling; Hiking and orienteering)</td>
<td>5-7 kcal/min</td>
<td>Up to 60 g/h</td>
<td>Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose</td>
</tr>
<tr>
<td>Near-Maximal &amp; Maximal Exercise Lasting More Than 2 h (Marathon run; Cycling: Individual pursuit; Competitive tennis match; 50-km ski race)</td>
<td>7-10 kcal/min</td>
<td>50-70 g/h</td>
<td>Glucose, sucrose, maltose, maltodextrins, amylopectin</td>
</tr>
<tr>
<td>Ironman Triathlon, Tour de France Stage Races</td>
<td>10-14 kcal/min</td>
<td>60-90 g/h</td>
<td>May only be achieved by intake of multiple types of carbohydrate: glucose, fructose, sucrose, maltodextrins, amylopectin, etc.</td>
</tr>
</tbody>
</table>
Strategies for Ingesting Carbohydrate

When? Carbohydrate ingestion often can enhance performance during exercise of 45 min or longer. So to maintain or improve the quality of a training session or to enhance your performance in competition, consuming some form of carbohydrate will probably help. If it is logistically possible in your event, you should consume a carbohydrate-containing sports drink every 15-20 minutes. Otherwise, you should drink during recovery periods or breaks in the training session or competition.

What Type of Carbohydrate? Some types of carbohydrates deliver energy at higher rates than others. The greatest rates of energy delivery occur when you ingest a combination of two or more types of carbohydrates. Examples of suitable combinations include maltodextrins and fructose, glucose and fructose, or glucose, sucrose and fructose.

How Much Carbohydrate? How much you ingest depends on a number of factors, including:

- The intensity and duration of exercise (See Table 1)
- The type of carbohydrate (or combination of carbohydrates)
- Your individual tolerance for various volumes and concentrations of carbohydrate solutions. Only trial and error with different drinking schedules during training sessions and in competitions will enable you to discover the best carbohydrate/fluid feeding schedule for you.

How? Although carbohydrates in solid foods can deliver carbohydrate, they cannot deliver fluid, which is especially critical in hot environments. Highly concentrated carbohydrate solutions can slow fluid delivery, so you should use a well-formulated sports drink containing not more than 7% carbohydrate (7 g/100 ml or 16.3 g/8 oz). Drink 240-600 ml (8-20 oz) of water or a sports drink about 10-15 minutes before exercise to stimulate fluid delivery from the stomach and then keep the stomach volume high by drinking smaller amounts of a sports drink every 15-20 minutes during exercise. Drink enough to minimize the body weight you typically lose during a similar type of training session or competition, but do not drink so much that you gain weight. (Drinking too little or too much can be dangerous to your health.)

SUGGESTED ADDITIONAL RESOURCES

