Food and Fluid Intake During Exercise

Athletes engaging in continuous exercise for more than one hour (such as marathon runners) or athletes performing high-intensity intermittent exercise for one to four hours (such as soccer or basketball players) are at risk for hypoglycemia, hypohydration, and fatigue, factors known to decrease performance. The ability to delay these conditions is the basis for carbohydrate and fluid intake recommendations. An additional factor is the potential for gastrointestinal upset, as many athletes will be consuming carbohydrate and fluid while performing intense exercise. Protein and fat are usually not consumed during exercise, as they cannot prevent these conditions and, in the case of fat, would actually contribute to gastrointestinal distress. Since both carbohydrate and fluid are needed, as a practical matter many athletes consume carbohydrate beverages. However, the same effect may be achieved with carbohydrate foods and water intake.

Carbohydrate intake during prolonged exercise helps delay fatigue and prevent hypoglycemia.

CARBOHYDRATE INTAKE DURING EXERCISE

Depletion of liver and muscle glycogen is inevitable during prolonged exercise. Glycogen depletion and hypoglycemia limit performance. Figure 3.1 illustrates the use of carbohydrate during continuous exercise lasting for three or more hours. When exercise begins, the majority of carbohydrate fuel is supplied by muscle glycogen. Blood glucose provides a small but steady supply of glucose. Fat also provides fuel. As exercise progresses, muscle glycogen stores begin to deplete. The percentage of energy coming from blood glucose increases as muscles begin to use more blood glucose than before. To keep pace with muscle glucose uptake and prevent hypoglycemia, the liver increases the breakdown of liver glycogen. When the use of blood glucose exceeds the breakdown of liver glycogen, blood glucose levels drop. Muscles must then rely more on muscle glycogen, which hastens
glycogen depletion. Eventually, muscle and liver glycogen stores are nearly depleted (the body guards against their total depletion) and blood glucose is low. The athlete is exhausted, and exercise can't continue.

Research studies show that consuming 30 to 60 grams of carbohydrate per hour during prolonged exercise delays fatigue and improves performance by sparing liver and muscle glycogen. It also helps the body to prevent a fall in blood glucose. When blood glucose is less than 45 mg/dL, athletes often experience light-headedness, lack of concentration, and irritability. Under these conditions, decision making may be impaired, and the athlete may be unable to execute a preplanned racing strategy.

It is well documented that exogenous carbohydrate intake during exercise is beneficial, but several factors influence the amount and timing of carbohydrate intake. The rate of gastric emptying is known to decrease when exercise intensity is greater than 70% of VO_{2max}. For athletes performing at this intensity, small amounts of carbohydrate are necessary.

Figure 3.1 Use of carbohydrate during prolonged exercise.
The rate of intestinal absorption must also be considered. Absorption of carbohydrate-containing fluids (the usual mode of intake during exercise) is not slowed when exercise intensity is less than 75% \( VO_{\text{max}} \). Greater exercise intensities do slow the rate of absorption, and gastrointestinal upset may result in athletes who are consuming carbohydrate and exercising at high intensities.

Concentrated carbohydrate solutions are known to slow gastric emptying. This presents a dilemma for the athlete: concentrated solutions provide more grams of carbohydrate, but the digestion and absorption will be slower. Carbohydrate solutions less than 2.5% are emptied quickly, but the amount of carbohydrate provided is minimal. Most athletes consume sports drinks that contain 6 to 8% carbohydrate. At this concentration, each liter (1,000 ml or a little more than four 8-ounce cups) provides 60 to 80 grams of carbohydrate. The maximum absorption of carbohydrate from the intestinal tract is approximately one gram of glucose per minute (60 grams per hour). Carbohydrate solutions greater than 8% may cause gastrointestinal upset, but ultradistance athletes do experiment with more concentrated solutions because the need for carbohydrate is so great during grueling events such as distance cycling.

Carbohydrate may be provided in liquid form (sports beverages), semi-solid form (sports gels), as energy bars or as fruit (oranges, bananas). Athletes should experiment with various forms of carbohydrate during training to determine the best plan for providing carbohydrate during competition.

During prolonged exercise most athletes consume a beverage containing 6 to 8% carbohydrate.

The glycemic response to carbohydrate consumed during intense exercise has not been well studied, but it is not thought to be a major factor. Glucose, sucrose (white table sugar), maltodextrin (corn sweetener), and glucose polymers (chains of glucose) are absorbed at about the same rate. Fructose is absorbed more slowly (it needs a carrier molecule to cross the gastrointestinal cell membrane) and must be transported to the liver for conversion to glucose, so there is a delay from when fructose is absorbed to when it appears in the blood as glucose. By itself, fructose ingestion is not an effective way to maintain blood glucose levels. Too much unabsorbed fructose in the gastrointestinal tract causes gastrointestinal distress. However, fructose is usually mixed with other sugars in sports drinks, so these problems are avoided.

Some researchers have studied the effects of low glycemic pre-exercise foods (e.g., high-fiber unsweetened cereal, low-fat unsweetened yogurt, and lentils) to determine if such foods provide a slow but sustained source of glucose during exercise.\(^2\) \(^3\) Research results are mixed, with some studies showing no change in performance and others showing improvement. No studies reported that the intake of low glycemic index carbohydrate foods was detrimental.

**FLUID AND ELECTROLYTE INTAKE DURING EXERCISE**

In addition to carbohydrate intake, fluid intake during training or performance is vitally important. All athletes need liquids during training to prevent hypohydration. Athletes competing in events lasting less than one hour may not have any opportunity to ingest fluid during the event. For those who compete
in events lasting more than one hour, fluid intake during exercise is important, especially if the event takes place in the heat. For athletes engaged in prolonged exercise, the goals are clear: prevent hypohydration, delay fatigue, and minimize the risk for heat illness.

The American College of Sports Medicine guidelines for fluid replacement during exercise are the consumption of 150 to 350 ml (≈ 5 to 12 ounces) at 15 to 20 minute intervals beginning with the onset of exercise.\(^4\) Athletes performing continuous exercise for more than one hour or high-intensity intermittent exercise for one to four hours typically consume fluid that also contains carbohydrate and electrolytes. The electrolyte sodium helps the body retain fluid and stimulates the drive to drink more fluid. If competition lasts less than 60 minutes, cold or cool water is an excellent choice because it is absorbed rapidly and is well tolerated. If the athlete has consumed proper amounts of dietary carbohydrate, muscle and liver glycogen stores should be sufficient for optimal performance, and only water needs to be consumed during exercise. Sometimes these athletes consume carbohydrate sports drinks because they feel they need additional carbohydrate or they prefer the taste.

*During prolonged endurance exercise, athletes should consume 5 to 12 ounces (150 to 350 ml) of a carbohydrate/electrolyte beverage every 15 to 20 minutes.*

Some loss of electrolytes occurs during exercise because sodium and chloride are lost in sweat. For most athletes the loss of body water is the critical element, and the loss of electrolytes is minor. However, ultraendurance athletes, such as those who run ultramarathons (distances greater than the standard 26.2-mile marathon) or Ironman triathlons or slow marathon runners who are on the course for many hours, must carefully monitor fluid and sodium intake. These athletes are at risk for developing hyponatremia, a condition where levels of sodium in the plasma are too low. The usual cause of hyponatremia is the intake of too much water relative to the intake of sodium. It is important that endurance athletes do not drink an excessive amount of water during exercise.\(^5\) The large amount of water dilutes the blood, and sodium levels fall to below 130mmol/L (normal range is 136-145 mmol/L). Sports beverages with sodium are recommended to prevent the onset of hyponatremia. Balancing fluid intake with loss of fluid through sweat and urine and reducing sodium that is lost during exercise decrease the risk of hyponatremia.

If you want to see effects of hypohydration first hand, just stop by the medical tent after a marathon. This visit should convince every endurance athlete that a hydration strategy including fluid intake before, during, and following endurance events is critical. For many endurance athletes, hypohydration occurs during exercise in the heat despite their best efforts to prevent it. Gastrointestinal absorption of fluid is approximately 30 ml per minute, but the loss of fluid in sweat is approximately 50 ml per minute. For this reason, even the most diligent athlete will find that fluid loss during exercise in the heat will outpace fluid intake. The American College of Sports Medicine recommends that a minimum of 600 ml (20 ounces) of a carbohydrate/electrolyte beverage be consumed each hour. Most athletes, however, do not consume more than 500 ml per hour.
Food and Fluid Intake During Exercise

THE INFLUENCE OF EXERCISE INTENSITY AND DURATION

The intensity and duration of the exercise dictates the need for food, fluid, or both during competition. Some athletes can’t take in food or beverages during competition, while others depend on doing so. The 400-meter runner is obviously not concerned about taking food in during a competition that lasts about a minute but the track athlete who is running 400 meters, performing the long jump, and running in two relays will need small snacks and fluid during the day-long competition.

Football players engage in repeated bouts of high-intensity, short-duration exercise over two to three hours. These athletes are concerned about fluid but not food intake during competition. The focus for football players should be water intake to prevent hypohydration. Basketball and soccer players should attend to both carbohydrate and fluid intake. They engage in sports that require intermittent high-intensity exercise for more than an hour. During competition they can become hypohydrated, and their muscle glycogen stores can be depleted—two factors known to impair performance. Athletes in these fast-paced sports depend on sports beverages during time-outs when there’s no time for food intake. During half-time they may consume a carbohydrate-containing snack such as a banana, orange, or energy bar along with their fluid.

Athletes who perform high- to moderate-intensity continuous exercise for more than an hour rely on carbohydrate and fluid intake during the event to perform well. The type of sport will determine the ease with which the food and beverages can be consumed. Distance cyclists and triathletes are adept at eating foods such as energy bars and bananas while riding, and carbohydrate-containing beverages carried on a rack on the bike are used to delay fatigue and hypohydration. Elite mountain bikers benefit from a back-mounted hydration system, which allows them to rehydrate without drawing their attention from the terrain or the bike. Figure 3.2 illustrates the food and beverage intake of a typical distance cyclist during competition. Distance runners experience more problems than cyclists do. Runners must grab beverages or gels and consume them on the run. It is not uncommon for distance runners to experience intestinal cramping and diarrhea while racing.

SUMMARY

Athletes consume carbohydrate and fluid during exercise to prevent hypoglycemia and hypohydration and to delay fatigue. Recommendations for food and fluid intake during training or performance depend on the sport. Athletes can meet their predetermined plan if foods or beverages are available and they have practiced eating and drinking during training, but it is not always easy. The intensity of exercise, the amount of gastrointestinal distress, and the demands of high environmental temperatures and humidity are some of the reasons that food and fluid intake falls short. For athletes who engage in prolonged exercise in the heat, carbohydrate, fluid, and electrolyte intake is absolutely critical for performance and health. Too much water relative to the amount of sodium lost or consumed can result in hyponatremia.
Figure 3.2  Food and beverage intake during competition for a distance cyclist.

REFERENCES