Food and Fluid Intake After Exercise

When athletes finish a training session, nutrition is rarely the first thing on their minds. The intensity of the exercise often decreases appetite, so while they may be thirsty they are not necessarily hungry. They are tired and may want to sleep. Some are rushing off to class or to work. Competition is stressful, and some athletes like to “zone out” after competing and just relax. Post-competition activities can include meeting with a coach, talking with the media, and celebrating with friends and family, so there are many demands on an athlete’s time. But there is work to be done immediately after training or competition. The nutritional goals are clear: rapid and complete muscle and liver glycogen resynthesis, repair of muscle tissue, and rehydration. The solution is consuming the proper foods and fluid in a timely manner.

*Eating properly after training or competition is important because carbohydrate, water, and electrolytes lost during exercise must be replaced.*

**CARBOHYDRATE INTAKE AND MUSCLE GLYCOGEN RESTORATION**

Exercise training depletes glycogen stores, and they must be restored before the next training session (see figure 1.2 on page 6). Athletes strive to have muscle and liver glycogen levels at their maximum before competition. A number of physiological factors influence the rate and extent to which glycogen is resynthesized. These factors include the extent of glycogen depletion, presence of insulin, presence of the enzyme glycogen synthase, degree of muscle damage, and amount and timing of carbohydrate intake.

Trained male athletes consuming sufficient carbohydrate daily have muscle glycogen stores of approximately 130 to 160 mmol/kg wet weight before exercise. If these male athletes carbohydrate-loaded (see page 48), muscle glycogen stores could increase to as high as 220 mmol/kg wet weight. Exercise depletes muscle glycogen, and stores may drop to less than 60 mmol/kg wet weight at the end of a hard training session or competition.
The depletion of muscle glycogen stimulates the activation of the enzyme glycogen synthase. The greater the depletion, the greater the enzyme activation. Insulin is also a glycogen synthase stimulator. Glycogen synthase increases muscle glucose uptake and resynthesis of muscle glycogen. Exercise creates conditions favorable to post-exercise glycogen storage, such as increased cell permeability to glucose and increased sensitivity to insulin.

Glycogen resynthesis is also influenced by the extent of muscle damage. Repair of muscle cell damage requires glucose, so the amount of glucose available to be stored as muscle glycogen is temporarily reduced. Maximum glycogen resynthesis is delayed when muscle is damaged during exercise.  

One of the most important factors in muscle glycogen resynthesis is the presence of carbohydrate. Both the amount of carbohydrate consumed and the timing of carbohydrate intake are important. Consuming carbohydrate immediately after exercise provides glucose at a time when cellular glucose permeability and sensitivity are optimal, and the rate of muscle glycogen resynthesis may be 7 to 8 mmol/kg wet weight per hour initially. However, the high initial rate slows, and muscle glycogen resynthesis usually occurs at the rate of 5 to 6 mmol/kg wet weight per hour. On average, it takes about 20 hours to completely resynthesize muscle glycogen. Consequently, continuous consumption of carbohydrate (6 to 10 grams/kg body weight in a 24 hour period) is necessary.  

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The consumption of high to moderate glycemic index carbohydrate foods is recommended because these foods raise blood glucose and insulin levels and provide glucose rapidly to muscles immediately post-exercise. Low glycemic index carbohydrate foods result in a slow, sustained rise in blood glucose and insulin. A high concentration of glucose and insulin favors rapid muscle glycogen resynthesis. A two-hour delay in post-exercise carbohydrate consumption can reduce the amount of glycogen resynthesized by almost 50%. Studies suggest that maximal rates of muscle glycogen resynthesis are in the range of 0.75 to 1.5 g of carbohydrate per kilogram of body weight each hour for the first four hours after exercise that depletes substantial muscle glycogen. Because the higher end of the range can result in gastrointestinal distress, a popular recommendation to athletes is to consume at least 1 gram of carbohydrate per kilogram of body weight in the first hour after exercise, predominantly from foods with a high to moderate glycemic index. Carbohydrate consumption should continue over the next four to six hours. As mentioned earlier, complete restoration of muscle glycogen takes about 20 hours, so athletes need to take in carbohydrate throughout the day, not just immediately after exercise. A daily carbohydrate intake of 6 to 10 grams of carbohydrate per kilogram of body weight will provide the carbohydrate needed for complete glycogen resynthesis. Note that the carbohydrate consumed immediately after exercise is included in this total. Attention to dietary carbohydrate intake is necessary for rapid and complete glycogen resynthesis, which enables athletes to maintain their training on a daily basis.  

Many scientific studies have helped identify the amount and timing of carbohydrate needed to support training and performance. However, studies of trained athletes have found that many do not consume an adequate amount of carbohydrate daily and that, in particular, post-exercise carbohydrate consump-
tion is not optimal. Athletes may not be hungry after exercise, may find eating inconvenient, or may feel satisfied quickly, before sufficient carbohydrate is consumed. Meal-replacement beverages may be a convenient way for athletes to consume sufficient carbohydrate immediately after exercise.

Some athletes compete more than once during the day, so the post-exercise feeding is also the pre-exercise meal. High to medium glycemic index carbohydrate foods should be consumed immediately following exercise to aid in the restoration of muscle glycogen, but the volume of food and drink that can be consumed will be affected by the length of time before the next competition. Trial and error will be needed to help athletes determine the best post-exercise intake.

PROTEIN INTAKE AND MUSCLE ANABOLISM

The intake of carbohydrate immediately after exercise is widely recommended, but studies suggest that consuming some protein post-exercise is also beneficial. The first 1 to 2 hours after exercise is sometimes referred to as the “anabolic window,” a time when favorable hormonal conditions exist for both glycogen and muscle protein resynthesis. Insulin influences both the uptake of glucose to form glycogen and the uptake of amino acids to build and repair muscle. Research studies have used amino acid infusions, amino acids added to carbohydrate beverages, and protein/carbohydrate-containing foods such as chocolate milk. Including 8 to 10 grams of protein as part of post-exercise intake seems to be beneficial.

FLUID INTAKE AND REHYDRATION

With few exceptions, athletes are dehydrated after training and performance. Immediately after exercise and for the next six to eight hours, rehydration is imperative so athletes do not begin the next training session or competition in a compromised state. After exercise, sodium is beneficial because its presence influences the body to retain fluid and helps to maintain the drive to drink. Sodium and water are found in sports beverages, but the amount of sodium is low. After exercise, athletes who lose a lot of sodium in sweat should also lightly salt their food.

Traditionally, athletes have determined the volume of post-exercise fluid by taking a scale weight after exercise and comparing it to their pre-exercise weight. “A pint a pound” is a common slogan used to remind athletes that for each pound (or .5 kilogram) of water weight lost, a pint (2 cups or 16 ounces) of fluid should be consumed. This adage should be considered a minimum intake. The important point is that athletes replenish the fluid that has been lost so a state of hypohydration is reversed before the next exercise session.

Taking a scale weight before and after exercise helps the athlete estimate how much fluid needs to be consumed.

Coaches may require that team members remain in the locker room until post-exercise weight has been restored to pre-exercise levels, a sign that the athlete has consumed fluid nearly equal to that which has been lost. This may not be enough fluid if the athlete was not fully hydrated at the start of exercise, but it is a good way to ensure that athletes are rehydrating immediately after
exercise. However, most athletes are on their own during the recovery period, and many fail to consume the proper amount of fluid (and carbohydrate). A simple approach to assess hydration status is to consider three factors: 1) thirst, 2) darker urine color, and 3) lower than usual body weight. If all three are present it is very likely that the athlete is hypohydrated. Athletes should strive for the absence of all three factors.

**ELECTROLYTE REPLACEMENT**

When athletes sweat the loss of body water is apparent but the loss of electrolytes may not be as obvious. Sweat contains sodium, potassium, and chloride and these electrolytes need to be replenished after exercise. For those who do not sweat heavily the loss is small and food will provide enough electrolytes for adequate replacement. Those who sweat heavily may experience substantial losses of sodium and chloride (salt). “Salty” sweaters may lose 1.5 grams of sodium per liter of sweat. Sweat stains on shirts and hats are a simple way to identify those who lose a lot of sodium.

Relatively more sodium and chloride is lost than other electrolytes so the primary focus for salty sweaters is to salt their food or consume some salty snacks after exercise. Eating fruits and vegetables should provide a sufficient amount of potassium for replenishment.

**FOOD AND FLUID INTAKE FOR RECOVERY**

For most athletes, recovery time is limited because they train or compete daily. During recovery, the two most important nutrients are carbohydrate and water, although other nutrients are needed too. Protein (amino acids) helps repair muscle damage that has occurred in response to exercise. Fat provides flavor, essential nutrients, and is a source of energy. Sodium that has been lost in sweat should be replenished.

*Studies have shown that athletes do not voluntarily rehydrate after exercise.*  
*They need to have a plan to replenish fluid lost during exercise.*

As mentioned, food and beverage intake should begin immediately after exercise. Within the first hour at least 1 gram of carbohydrate per kilogram of body weight should be consumed. Carbohydrate and fluid consumption should continue for at least the next four to six hours. Athletes who are nearly glycogen depleted after exercise and will be exercising again that same day need rapid glycogen replenishment. These athletes should consume 1.5 grams of carbohydrate per kilogram of body weight during the first 30 minutes post-exercise and every two hours after for the next four to six hours. During the first six hours post-exercise, carbohydrate foods with a moderate to high glycemic index are better than low glycemic index carbohydrate foods. Figure 4.1 shows the recommended post-exercise intake for a 100-pound (45.5 kilograms) female figure skater. Note that following intense exercise appetite may be depressed, and the athlete may not feel like eating. Studies also show that most athletes don’t voluntarily rehydrate after exercise. They voluntarily consume more fluids if they are flavored.
Exercise ends

This post-exercise meal contains 66 grams of carbohydrate, or approximately 1.5 grams of carbohydrate per kilogram of body weight.

High-carbohydrate sports beverage (8 oz.)*
One small bagel (2 in.)*

1 hour post-exercise
Nonfat yogurt (8 oz.)
Carrot sticks*
Fruit juice (8 oz.)*
Water (8 oz.)

2 hours post-exercise
Carbohydrate sports beverage (16 oz.)*

5 hours post-exercise
One bean burrito
Small green salad with dressing
Apple
Soft drink (8 oz.)*
Water (8 oz.)

Figure 4.1 Post-exercise intake for a 100-pound female figure skater.
* = medium or high glycemic index food.
and contain sodium, so sports beverages are an excellent choice. Eating and
drinking on a schedule may be the best way to fully replenish body fluids and
carbohydrate stores to prepare for the next training session.

SUMMARY

Glycogen stores are depleted and body water is lost during training and competi-
tion. Nutrition after exercise is no less important than nutrition before and during
exercise. The recovery period allows athletes to rest and to replenish some of the
nutrients lost during exercise, such as carbohydrates, water, and electrolytes.
Within the first hour after exercise at least 1 gram of carbohydrate per kilogram
of body weight should be consumed. Consumption of a small amount of protein
is also beneficial. Carbohydrate and fluid consumption should continue for at
least the next four to six hours. Taking a scale weight before and after exercise
can help the athlete estimate how much fluid was lost during exercise and de-
termine how much fluid needs to be consumed. Along with weight, monitoring
urine color and thirst are simple ways to evaluate current hydration status.

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