# The Art of Refueling

**Current research shows that post-exercise nutrition plays an important role in recovery.**

By Jean Storlie

While many student-athletes are inclined to grab pizza, French fries, burgers, and chips as they dash home from practice or celebrate a victory on the bus ride home, these foods may not be providing the nutrients they need to recover from the hard exercise and refuel their muscles for the next workout. Even those who pay careful attention to what they eat before and during exercise may neglect their post-exercise eating habits, thinking, "Who cares, I'm done for the day."

While their minds might be ready for rest and rewards, their bodies have a lot of work to do to repair tissues that took a beating during exercise and replenish energy stores that are depleted. In addition, during periods of intense training and competition, when there is little time to recover between workouts, post-exercise nutrition becomes an even more important factor in enhancing performance and preventing injury.

### Why is nutrition more important after exercise?

The metabolic changes that occur during exercise are similar to what happens during trauma and metabolic stress: catabolism and hypermetabolism. According to Belinda Jenks, PhD, RD, senior nutrition scientist for Protein Technologies International, "during exercise, heat, free radical production, and cell breakage cause muscle damage. But unlike stress, exercise provides an anabolic stimulus which results in the muscles becoming stronger when they repair the damage caused by training."

The body needs time, as well as key nutrients, to recover from each bout of exercise. When athletes are pursuing intense training and/or competitive programs, their bodies have little time to recover between workouts, and the repetitive stress of exercise can take its toll. Therefore, post-exercise nutrition can help athletes train more aggressively by supplying the nutrients needed to curtail exercise-induced damage and promote muscular repair.

### What nutrients are needed?

**Fluids:** The most important nutrient to replace after a workout is water. Intense and/or long-lasting workouts in hot, humid conditions can cause tremendous fluid losses; as much as three quarts an hour. Since exercise dulls thirst, athletes cannot rely on this sensation to guide their fluid intake. They must make a conscious effort to replace the fluids they lose during exercise. The most accurate way to determine post-workout fluid needs in to weigh before and after exercise. For every pound of weight lost, drink a pint of fluid.

If a second bout of exercise must be performed in a relatively short interval, rapid rehydration strategies should be employed to ensure the completeness of rehydration before the next workout. For athletes who engage in two workouts a day (e.g., swimmers who double, triathletes), the fluid replacement guideline is modified; drink at least one pint of fluids for every pound of weight lost. Some evidence shows that these situations may require as much as 1.5 pints per lost pound to achieve rehydration.

**Electrolytes:** In addition to replacing the fluids lost during exercise, the electrolytes (sodium and potassium) lost through sweat, need to be replenished. Since a pound of sweat contains approximately 400-700 mg of sodium and 80-100 mg of potassium, large fluid losses can be accompanied by substantial electrolyte losses. Sodium and potassium also enhance fluid uptake. Therefore, a post-exercise rehydration regimen should include sources of sodium and potassium.

Although sports drinks contain these electrolytes, they are formulated for consumption during exercise with dilute concentrations of electrolytes to speed emptying from the stomach. After exercise, more concentrated sodium and potassium sources are needed. Some research suggests that post exercise rehydration solutions may need a sodium concentration of 50-90 mmoles/liter, while sports drinks only contain 10-25 mmoles/liter of sodium.

Fortunately, these electrolytes are readily found in food sources. Sodium is abundant in salty foods, including spaghetti sauce, pretzels, crackers, soup, and cheese. Potassium is concentrated in fruits and vegetables: a medium potato contains 750 mg, a medium banana has 500 mg, and a cup of orange juice contains 420 mg. Sodium and potassium-rich foods can be combined with plain water, juices or sports drinks to replenish electrolyte and fluid losses.

**Carbohydrates:** In sports that tax glycogen (the body's fuel) stores, such as endurance exercise and repetitive power workouts, carbohydrate intake is very important after exercise. This applies to athletes who engage in the following types of exercise: one hard competition (e.g., marathon), multiple events in one day (e.g., swim meet), exhaustive daily training, and/or two-a-day workouts (e.g., pre-season football workouts, triathletes).

David Costill's classic work in the 1970s showed that when carbohydrate intake is consistently inadequate, glycogen stores become progressively more depleted, leading to fatigue and injury. In contrast, when athletes eat a high-carbohydrate diet, their recovery time after exhaustive exercise is shorter and more complete.

During the 1980s, John Ivy, professor of Kinesiology and Health at the University of Texas and one of the leading researchers on carbohydrate metabolism during exercise, concluded that, "A high carbohydrate diet allows you to train harder by decreasing recovery time."

But even with a high-carbohydrate diet, it can take 24-48 hours for glycogen stores to return to pre-exercise levels after exhaustive exercise. This knowledge spurred much research to explore ways to speed glycogen synthesis, leading to the discovery that the type of carbohydrate consumed post-exercise can make a difference. The glycemic index (GI), which is an indicator of the blood glucose response to a particular food, is one factor to consider. GI tends to be lower for foods that are high in fructose (the sugar found in fruit), high in fiber, less processed, and ingested along with fat and protein. Several studies have shown an improved glycogen synthesis during the first hours after exercise when foods with a high GI are consumed. Foods with a high GI content include: bread, graham crackers, jelly beans, hard candy, potatoes, rice cakes, waffles, and watermelon.

The timing of carbohydrate intake is also critical. When the consumption of carbohydrates is delayed, the rate of glycogen synthesis is almost half the rate of synthesis when carbohydrates are consumed during the first two hours post-exercise. Some evidence even shows that the first 15 minutes are critical. Current recommendations are to consume 0.5 grams of carbohydrates per pound of lean body weight within two hours post-exercise and repeat this amount two hours later.

When carbohydrate intake is increased beyond this level, glycogen synthesis does not accelerate. This suggests that there are internal limits to the body's ability to assimilate carbohydrates for glycogen synthesis.

Mark Tarnopolsky, Department of Kinesiology at McMaster University in Ontario, Canada, has shown that the recommended dose of carbohydrates immediately and at one hour after resistance exercise also has a beneficial effect on protein metabolism by decreasing breakdown and enhancing retention.

**Protein:** Protein intake during the post-exercise phase has received more attention recently. Ivy published a study in 1992 which showed that combining protein with carbohydrate in the post-exercise meal increased glycogen synthesis. "The maximum response from carbohydrates is between 1.2-1.5 g/kg [0.55-0.68 g/lb]," he explains. "By adding protein, you get a more dramatic insulin response which, in turn, stimulates glycogen synthesis."

Consequently, Ivy now recommends including a protein source at 40% of the carbohydrate dose immediately post-exercise and at two-hour intervals to enhance glycogen repletion.

Others are looking at protein's role in tissue repair and anabolism, theorizing that protein intake post-exercise will shorten recovery and stimulate muscle development. Robert Wolfe, PhD, from the Shriners Burn Institute, University of Texas at Galveston, has published several studies which examine the effects of exercise on protein metabolism. His studies found that protein turnover is high, similar to states of trauma and critical illness. However, exercise differs in that synthesis is higher than breakdown, which serves to restrain the net muscle catabolism seen during critical illness. They concluded that exercise needs to interact with other factors, such as feeding, to promote muscle anabolism. In a 1997 study, they showed that the availability of free amino acids immediately after exercise increased muscle anabolism by increasing protein synthesis and decreasing protein breakdown.

Protein intake appears to be particularly important in exercises which result in muscle damage, such as repetitive power workouts to exhaustion (failure repetitively), intense endurance exercise, eccentric exercise (producing force during muscle lengthening), two-a-day workouts, and sports with contact.

According to William Evans, PhD, sports nutrition physiologist at the University of Arkansas, "Exercise which produces muscle damage may also result in impaired glycogen synthesis." This mechanism may help to explain Ivy's finding that consumption of protein with carbohydrates after exercise enhances protein synthesis.

Peter Lemon, PhD, professor of applied physiology at the Research Laboratory at Kent State University, suggests that the Recommended Daily Allowance (RDA) for protein of 0.8 g/kg of body weight is inadequate for athletes involved in both strength and endurance exercise. He recommends that endurance athletes consume about 1.2-1.4 g/kg body weight and that strength athletes consume about 1.4-1.8 g/kg body weight. But he also acknowledges that the typical American diet contains 2-3 times the RDA for protein. Therefore, most athletes do not need to increase their total protein intake, but rather they should target protein consumption during post-exercise recovery.

**Vitamin & Minerals:** According to Jenks, a well-nourished state is a critical factor in preventing exercise-induced damage and promoting anabolism. Several key vitamins and minerals are involved in preventing cell damage and promoting tissue repair: copper, zinc, B-complex vitamins, and the antioxidants, including vitamins A, C, and E. Inadequate intake of these nutrients will impair healing and muscle remodeling.

## Do Elite Athletes Need More?

David Ellis, CSCS, LMNT, Coordinator of Performance Nutrition at the University of Nebraska, believes that elite athletes need advanced tactics during post-exercise recovery, thus he incorporates glutamine, creatine, phosphates, and HMB into the post-exercise supplementation regimen. He acknowledges that these advanced tactics are not for everyone, but maintains that high level collegiate athletes and Olympic hopefuls who train five days and compete two days a week for seven to 11 months of the year need more aggressive support.

Research on critically ill patients has shown that ingestion of glutamine, an amino acid, curtails catabolism and promotes anabolism. Some preliminary evidence shows that glutamine may have a similar effect during post-exercise recovery. Creatine, an amino acid, found primarily in meat and fish, has been shown to enhance repetitive anaerobic performance, promote strength development, and increase muscle mass.

On phosphate, the research is inconclusive, but the theory is that it is used to facilitate performance in high-powered events by neutralizing the acid build-up that limits carbohydrate metabolism and induces fatigue. HMB, an intermediary metabolite of leucine in a patented form, is purported to improve immune function, prevent muscle breakdown, and increase muscle mass/strength.

While some of these tactics are in the fringes of science, Mitchell Kanter, PhD, principle scientist/director of clinical nutrition research for the Quaker Oats Company and former director of the Gatorade Sports Science Institute, points out that you can't argue with success. "In his real world laboratory, Ellis works with some of the best trained athletes in the country," Kanter says. "It's hard to attribute his success to any one factor – genetic endowment, intense strength workouts, and motivation each play a role – but dietary supplementation may be contributing to their success."

## What is the Debate on Food vs. Supplement?

Although certain groups of athletes can benefit from nutritional supplementation during post-exercise recovery, it is not necessary to consume a commercial product. Nancy Clark, MS, RD, a nationally-known sports nutritionist and author of Nancy Clark's Newly Revised Sports Nutrition Guidebook, points out that commercial sports drinks lack vitamins and minerals found in wholesome foods. "They are not the best recovery foods in terms of electrolyte content, carbohydrates, and overall nutritional value."

Many liquid meal-replacement drinks do contain protein and carbohydrates, as well as vitamins and minerals. Since many athletes are not hungry immediately after intense exercise and experience gastro-intestinal distress if they try to eat too soon, these liquid meals may facilitate carbohydrate and protein intake during the crucial recovery period immediately after exercise.

Rather than relying on commercial drinks, Susan Kleiner, PhD, RD, owner of High Performance Nutrition and author of Power Eating, uses a real food approach to "help athletes juice up naturally." She advises her clients to combine a package of Carnation Instant Breakfast with 1 cup of skim milk, 1 tablespoon of peanut butter, and 1 banana, which yields approximately: 440 calories, 70 grams of carbohydrate, 17 grams of protein, and 10 grams of fat. Kleiner recommends drinking this mixture within two hours of an intense workout to boost muscle growth. Using this post-workout supplement, sometimes along with creatine supplementation, she has helped clients break through plateaus in their bodybuilding programs and achieve substantial gains in strength and muscle mass.

## Conclusion

The hours immediately following intense exercise – either exhaustive endurance or repetitive power work – are a critical time for the body to recover from the stress of exercise and replenish the nutrients used during exercise. So when you are picking a place for the team to eat on the road or advising your athletes about what to eat after a hard workout, you may want to give some thought to nutritional factors

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