Nutrition and Hydration Issues for Combat Sport Athletes

Jay R. Hoffman, PhD, CSCS*D, FNSCA† and Carl M. Maresh, PhD‡

†Sport and Exercise Science Program, University of Central Florida, Orlando, Florida; and ‡Department of Kinesiology, University of Connecticut, Storrs, Connecticut

SUMMARY

TO OPTIMIZE PERFORMANCE IMPROVEMENTS AND TO ENHANCE SKELETAL MUSCLE RECOVERY FROM HIGH-INTENSITY TRAINING, THE ATHLETE NEEDS TO ENSURE ADEQUATE ENERGY AND PROTEIN CONSUMPTION. PROTEIN INTAKE MAY HAVE EVEN GREATER RELEVANCE DURING PERIODS OF WEIGHT LOSS OFTEN ASSOCIATED WITH THE COMBAT SPORT ATHLETE. COMBAT SPORT ATHLETES OFTEN USE WATER RESTRICTION TO ACCOMPLISH DESIRED WEIGHT LOSS. THIS HAS SEVERAL IMPORTANT PERFORMANCE AND PHYSIOLOGICAL IMPLICATIONS THAT POSE SIGNIFICANT HEALTH RISKS. THIS PAPER WILL FOCUS ON SEVERAL NUTRITIONAL AND HYDRATION STRATEGIES AND HOW THEY SPECIFICALLY RELATE TO COMBAT SPORTS WITH REGARD TO TRAINING AND COMPETITION.

INTRODUCTION

For competitive athletes to maintain a high level of training and perform optimally during competition, their energy intake will need to equal their high-energy expenditures. The nutritional requirements for athletes are much greater than that needed for the average population (4,33). Depending on the needs of the athlete (i.e., size, gender, requirements of the sport), their energy intake may be 3- to 4-fold higher than that recommended for the average person (33). The nutritional needs of the athlete have been the focus of much research concerning questions on what to eat, when to eat, and which nutritional supplements to take to maximize athletic performance. For example, for most people, a recommended balance of 55–60% carbohydrates, 30% fat, and 10–15% protein appears to provide a sufficient dietary composition (33). However, for many athletes, this may not meet their specific nutritional needs and may require them to alter both protein and carbohydrate intake.

To optimize the athlete’s potential for training and competition, it is also imperative that the athlete stays well hydrated. In combat sports, this can sometimes be a challenge because many athletes withhold water as part of a strategy to reduce weight and compete in a desired weight class. Unfortunately, this habit can have dire consequences on the athlete’s health. Water is second only to oxygen in the necessity for maintaining life. Although the body can withstand a 40% loss in body mass due to starvation, a 9–12% loss of body mass due to fluid loss can be fatal. Clearly, if proper precautions are not taken and an appreciation for the physiological adjustments that surround inappropriate nutritional intake and/or rehydration strategies is not observed, undesirable outcomes may be the result. In consideration of these issues, this article will focus on nutrition and hydration strategies and how they specifically relate to combat sports in relation to training and competition.

GENERAL UNDERSTANDING OF NUTRIENTS AND THEIR FUNCTION

There are 6 classes of nutrients that are required for the energy and health needs of the individual. These nutrients include carbohydrates, fats, proteins, vitamins, minerals, and water. Carbohydrates, fats, and proteins are the principle compounds that comprise our food and provide the energy needs for our body. They are referred to as macronutrients. Vitamins and minerals play an important role in energy production but provide no direct source of energy. As such, they are deemed micronutrients. Water may be the most important nutrient available. It is involved in most physiological reactions in the body, including nutrient transport, waste removal, and body cooling.

THE IMPORTANCE OF THE MACRONUTRIENTS

Carbohydrates play a critical role in fueling exercise, either by being the primary energy source to fuel anaerobic exercise via glycolysis or as a gateway to oxidative phosphorylation. The body can only store a limited amount of carbohydrates in both the skeletal...
muscle and the liver. Thus, during high-intensity training (similar to what is typically performed by combat sport athletes), carbohydrates can provide energy for only a relatively short duration of time. This places a large emphasis on maximizing carbohydrate storage before training and competition and replenishing them after exercise and competition (41,60). There are several types of carbohydrates available, all of which are metabolized differently by the body. Differences between simple (composed of 1 or 2 sugar molecules) and complex carbohydrates (chain of sugar molecules) are related to their ability to be absorbed and to be used either as a source of quick energy or as a source of providing a more gradual increase in energy availability.

Fats are a highly concentrated fuel that has limited water solubility. The basic unit of the fat molecule is the fatty acid, which is also the part of fat that is used for energy production. In contrast to carbohydrates, fats have unlimited availability. During light to moderate exercise, the energy needs of the muscle are met by free fatty acids released from adipose sites around the body, which bind to the protein albumin in the blood for transport to the active muscle, and triglycerides from within the muscle itself. During exercise, energy will be used from carbohydrate and fat sources. However, as duration of exercise is prolonged, a greater reliance on fat utilization is seen. As exercise duration exceeds more than an hour, the carbohydrate reserves become quite limited until they are eventually depleted. The utilization of stored fat as the primary source of energy increases further, and as long as the intensity of exercise is of moderate intensity, it will supply the vast majority of total energy required by the end of the exercise session (33).

Proteins are composed of amino acids and serve as the major structural component of muscle and other tissues in the body. In addition, they are used to produce hormones, enzymes, and hemoglobin. Although protein can be used as a source of energy, it is not desirable as it likely means that the body is metabolizing lean tissue to compensate for an energy deficit. The primary role of dietary protein is to enhance and stimulate various anabolic processes in the body. In studies examining resistance-trained individuals, high protein intakes have generally been shown to have a positive effect on muscle protein synthesis, lean tissue gains and increases in strength (35,45,54,68). Tarnopolsky et al. (63) have shown that for strength-trained individuals to maintain a positive nitrogen balance, they need to consume a protein intake equivalent to 1.8 g·kg⁻¹·day⁻¹. This is consistent with other studies showing that protein intakes between 1.4 and 2.4 g·kg⁻¹·day⁻¹ will maintain a positive nitrogen balance in resistance-trained athletes (36,45). As a result, daily protein intake for combat sport athletes, who are classified as strength/power athletes, should range between 1.4 and 2.0 g·kg⁻¹·day⁻¹ (4,16). Recent research has suggested that protein intakes exceeding 2.0 g·kg⁻¹·day⁻¹ may provide an even greater advantage for these athletes by enhancing strength performance (34).

Another aspect of protein intake that may take on greater importance to the combat sports athlete is the issue with protein intake and caloric restriction. Recent research has demonstrated that during prolonged situations of inadequate energy intake, greater protein consumption appears to defend lean body mass and prevent or minimize the catabolic consequence of low caloric diets (55). Thus, athletes who are reducing their energy intake to achieve a desired body weight should maintain a high protein intake to minimize and prevent lean tissue degradation.

**NUTRIENT STRATEGIES TO ENHANCE TRAINING AND PERFORMANCE**

To optimally prepare for training and competition, the athlete needs to ensure appropriate energy and protein intakes. However, there are a number of strategies that can be used to maximize the benefit of these nutrients: controlling the timing of ingestion in relation to the athlete’s workout or competition and selecting the appropriate type of nutrient or combination of nutrients that are consumed at those times.

**NUTRIENT TIMING**

One of the more interesting areas of research within sport nutrition has been in nutrient timing. In regards to protein, the time of ingestion appears to have a significant impact on maximizing skeletal muscle adaptation during resistance training programs (24,30) and may also be beneficial in enhancing muscular recovery in trained athletes after an acute exercise session (37). These effects appear to be related to an enhanced delivery of amino acids to exercising muscle that provides an immediate availability of nutrients at the end of workouts. This is thought to stimulate greater muscle protein synthesis and adaptation resulting from heightened muscle sensitivity from the exercise stimulus. In support of this hypothesis, several studies have demonstrated that, when essential amino acids are consumed immediately before a workout, the rate of delivery and uptake of these amino acids to skeletal muscle is significantly greater than when these nutrients are consumed after the workout (66,67). Although protein consumption within an hour after the training session can enhance protein synthesis within skeletal tissue to a greater degree than later feedings (56), there does appear to be a greater benefit in a pre-exercise ingestion.

The prevailing evidence is quite convincing regarding the importance of ingesting protein immediately before and/or after a training session. Although pre-exercise ingestion enhances delivery of these nutrients, most studies have actually compared feedings surrounding the workout to morning and evening ingestion times (24,30,37). The evidence provided by these studies indicate that skeletal muscle may be more sensitive after an acute resistance exercise session than at other times of the day. Adding further support, Hulmi et al. (40) showed that protein consumption before and immediately after a resistance exercise session can increase messenger...
Interestingly, this does appear to be the case. Evidence has been published that reports that milk consumption can stimulate amino acid uptake by skeletal muscle and result in an increase in net muscle protein synthesis (27). Whole milk appears to be more beneficial than fat-free milk, unless the quantity of fat-free milk consumed is similar in caloric value as whole milk. Whole milk and isocaloric fat-free milk ingested 1-hour after a resistance exercise session stimulated significant elevations in amino acid uptake that was 80 and 85%, respectively, greater than fat-free milk. These results demonstrate that a food source, such as milk, appears to be suitable for ingestion during recovery from resistance exercise and may be a cheaper and effective alternative to protein supplements. The primary benefit from taking a supplement as a post-workout drink is the ease of preparation and the ability to provide a large intake of protein that is quickly absorbed within the time frame that the exercising tissue is at a heightened sensitivity.

**Nutrient Timing as it Relates to Carbohydrate Ingestion**

A major emphasis in the nutritional strategy of combat sport athletes is in maintaining and replenishing carbohydrate stores. Carbohydrates are the primary fuel used by these athletes during training and competition. Considering that these athletes may be competing in several competitions per day, the ability to maintain sufficient energy stores can often be the difference in their success or failure. Thus, a strategy focusing on maximizing carbohydrate storage and consuming sufficient quantity of carbohydrates between competitions and training sessions needs to be used. In addition, the type of carbohydrate consumed also has an important effect on the rate of absorption. Thus, careful selection of food in relation to time of exercise or competition becomes critical for maximizing energy availability and avoiding a hypoglycemic response that can impede performance.

To help determine the appropriate carbohydrate to consume, a glycemic index was developed to help classify food on their acute glycemic impact (42). Foods with a high glycemic index will be digested quickly and raise blood glucose levels fairly rapidly. Examples of foods with a high glycemic index are baked potato, rice cakes, waffles, and instant rice. Foods with a lower glycemic index will take longer to be digested. Examples of such foods include nuts, fruits, dairy products, and pasta.

**Pre-exercise or precompetition.** Pre-exercise or precompetition feedings should occur approximately 3–4 hours before the workout or event. Some recommendations suggest that the meal should contain 1–2 g/kg body mass of carbohydrate (64), whereas others have suggested that 200–300 g of carbohydrate be consumed (58,59). More often than not, it is generally the athlete’s personal perception of how they respond to a particular meal that will determine its content. Interesting to note is that the meal before competition contributes very little to the glycogen content of the muscle. However, it will help to ensure blood glucose levels and prevent feelings of hunger. As the athlete gets closer to practice or competition, any snack should comprise a low glycemic carbohydrate to prevent the occurrence of a premature fatigue due to a hypoglycemic response. Despite this, a number of studies have suggested that higher glycemic feedings close to competition may not be as detrimental as once thought (2,38).

**Exercise feedings.** During exercise or competition, the use of a high-glycemic carbohydrate will not pose the same risk as that seen before exercise. During exercise, the elevation in catecholamines will inhibit the insulin response and maintain normal blood glucose concentrations. Several studies have shown that providing carbohydrates during exercise will maintain blood glucose levels and improve exercise performance (11,25, 43). Liquid ingestion may be the best route of delivery in these situations. A 6–8% solution in 8–16 ounces of water is often recommended for exercise feedings (44). This may become quite
important especially on days with multiple bouts of competition.

**Postworkout or postcompetition feedings.** It is generally recommended that after a workout or competition, carbohydrates with a high glycemic index be consumed. Considering the anaerobic nature of combat sports, it is likely that the glycogen reserves after the competition or workout will be reduced. A postexercise carbohydrate feeding with a high glycemic index will result in a greater muscle glycogen replenishment in comparison with a similar amount of carbohydrate provided with a lower glycemic index (15). A delay in carbohydrate ingestion after the workout or competition may reduce glycogen resynthesis by approximately 50% (41).

**HYDRATION**

The human body’s level of hydration is constantly challenged by water lost through respiration, sweating, and excretion. Replacement of this fluid mostly depends on drinking behavior, but it has been known for decades that a person’s desire to drink does not normally occur until water loss reaches 1–2% of body mass (1). As a result, athletes commonly train and compete in an unrecognized state of mild to moderate hypohydration (5). Even this mild degree of dehydration will impair both exercise (22,51) and cognitive performance (26,69), while increasing the physiological strain (i.e., heart rate and core body temperature) (46) associated with a given intensity of exercise. Hypohydration also impairs and delays the thermoregulatory benefits that characterize heat acclimatization and physical fitness (19). It is not uncommon for combat athletes to withhold fluid as part of a strategy to further reduce body weight for competition in lower weight classes. This practice imposes greater levels of dehydration and thermal strain that may lead to the least desirable of outcomes, more dramatic performance impairments.

Both the American College of Sports Medicine (3) and the National Athletic Trainer’s Association (NATA) (18) have prepared position statements that identify the negative effects of dehydration on health and performance. These documents also provide important guidelines regarding the rate at which fluids should be consumed and methods to evaluate hydration state. A measurement of urine specific gravity (sometimes called urine density) is most commonly used to evaluate the body’s water balance or hydration state. It is easily obtained and is a measure of the number of chemical particles in the urine. The National Collegiate Athletic Association (49) and the National Federation of High School Associations (50) use measurements of urine specific gravity greater than 1.020–1.025 to indicate dehydration. In this regard, for example, wrestlers are not allowed to have their minimal weight determined for competition unless an appropriate urine specific gravity is verified. This guideline is required to deter the potential health risks associated with acute dehydration–related weight loss and to promote competitive equity among athletes (52). Similarly, the NATA supports that a urine specific gravity greater than 0.020, a body mass loss greater than 3%, and a urine color greater than 4 indicate dehydration (18). Obviously, the assessment of an athlete’s state of hydration can have several implications. However, given the absence of a sufficient number of studies on human hydration indices, the recommendations of some sports medicine and sport governing groups may not be fully supported at this time by normative values from adequate studies of athletes or by research describing the day-to-day variability in these measures (10). That is not to say that these guidelines have not been extremely helpful in promoting athlete and sporting safety.

**ENVIRONMENTAL AND HOST FACTORS**

Before designing hydration strategies for training and competition, the following environmental and host factors (9), as summarized below, should be considered as possibly influencing the fluid intake of a combat sport athlete before, during, and after exercise.

1. Environmental stressors, such as temperature and humidity, cause physiological changes that tend to increase or decrease fluid consumption (13,32).
2. Individual differences in learned behaviors may influence fluid replacement, such that people can be instructed to drink in the absence of thirst (39) or may learn through experience that physical and mental performance are enhanced by drinking (8).
3. Societal customs and mores may influence fluid consumption, as evidenced by the differences in beer drinking preferences between American and British citizens (13,32).
4. Fluid palpability affects consumption (62) and consists of beverage characteristics, such as saltiness, temperature, sweetness, flavor, color, viscosity, and carbonation (29,31,62).
5. Personal opinions regarding the effect of a fluid on one’s health, body weight (13), cost (32), or exercise performance (7) affect beverage choice and the amount consumed.
6. Thirst increases during eating. Generally, between 69 and 78% of fluid replacement during normal daily activities occurs at meals (28).
7. Fluid restriction for 24 hours increases subjective ratings of thirst, mouth dryness, and the unpleasantness of the taste in the mouth (53), suggesting that specific sensations are associated with dehydration and may enhance fluid replacement.
8. Gastrointestinal distension inhibits fluid consumption, before tissue repletion of lost fluid occurs (13). Reduced sensations of mouth dryness have a similar effect (57).
9. Humans tend to drink less when they are preoccupied or are performing physical or mental tasks (1). Therefore, frequent rest periods in the midst of training or competition will likely increase fluid intake. Similarly, if a fluid is readily available, it is more likely to be consumed (1).
10. People consume a greater quantity of fluid when they are calm than when they are excited (32).

**PRE-EXERCISE HYDRATION STRATEGIES**

Proper pre-exercise hydration is necessary for safe and effective training and competition. The following strategies should be considered for optimal hydration before exercise.

- Before exercise, the athlete should be well hydrated, with replenished muscle glycogen stores.
- Chronic dehydration may occur in athletes who perform repeated bouts of intense training or competition on the same day or on consecutive days (12). Remember that athletes will often need assistance in recognizing this problem, and a prescribed, mandatory pre-exercise hydration regime may be useful.
- If possible, athletes should eat regular meals and a nutritionally balanced diet during the 24 hours before exercise because a large portion of rehydration occurs during meals. In most cases, water is an appropriate pre-exercise beverage because sufficient carbohydrate and electrolytes are provided in a normal U.S. diet.
- Electrolytes will help the athlete regain and retain fluid-electrolyte balance after exercise-induced dehydration via sweating.
- The athlete should drink 500–600 mL of fluid 2–3 hours before exercise, providing ample time to urinate excess fluid. Then, 10–20 minutes before exercise, an additional 200–300 mL of fluids should be consumed (18).
- Changes in body weight, urine color (5,6), and urine specific gravity are each valid indicators of hydration status, and athletes, coaches, and trainers should routinely use these methods to assess pre-exercise hydration status.

**DURING EXERCISE HYDRATION STRATEGIES**

Proper hydration during exercise reduces cardiovascular strain, optimizes heat dissipation, and helps to maintain plasma volume and cardiac output, thus the ability to maintain exercise intensity. Therefore, athletes are advised to carefully consider the following hydration strategies during training and competition.

- If possible, fluid should be readily available, and athletes should consume as much as is comfortable, stopping regularly to drink. Understandably, this may not be easy to accomplish in some events that lack frequent breaks, but this is generally not the case with combat sports.
- Athletes should attempt to optimize, not maximize, fluid intake without overhydrating. Athletes who know their rate of sweat production can then match intake during training and competition with sweat losses. This can be challenging to measure, but with practice, athletes can learn to consume the correct amount of fluid (23).
- To optimize gastric emptying, 400–600 mL of fluid should be in the stomach at all times (23). If the fluid contains carbohydrates, the carbohydrate concentration should be between 4 and 8%. The rates of gastric emptying and intestinal absorption are similar for water and dilute carbohydrate solutions, but carbohydrates assist in fluid replacement and concurrently provide energy replenishment (48).

**POSTEXERCISE HYDRATION STRATEGIES**

The period after exercise provides the opportunity to rest and replenish nutrients, including fluids that have been depleted during training or competition. A rehydration strategy after exercise is critical and should be addressed independently of hydration before and during exercise (17). If the athlete was adequately hydrated at the start of exercise, reductions in body weight can be assumed to reflect body water loss during exercise. Also, the importance of proper rest after intense training or competition cannot be overemphasized. The body recovers best if provided with adequate rest and sleep. The following strategies will help the athlete prepare for upcoming training sessions or competition.

- Body water can be replenished after exercise by drinking fluids with or without carbohydrates and electrolytes. However, water alone may not be the optimal rehydration beverage at this time because it decreases osmolality (a measure of solute concentration), limits the drive to drink, and may increase urine output. Salt (sodium or sodium chloride) in a rehydration beverage or food will better conserve fluid volume and increase the drive to drink (9). For the athlete who must rehydrate between training of competitive sessions without meal consumption, choosing a rehydration beverage with electrolytes is an important consideration.
- The volume of fluid consumed during recovery should exceed the volume of sweat that was lost during exercise. Otherwise, the athlete will remain somewhat dehydrated because of urinary fluid losses. Consumption of fluid equal to 150% of weight loss, and using fluid that contains sodium, will optimize the body’s retention of fluid (61).
- Because replacement of expended glycogen stores is also a postexercise goal, the rehydration solution should contain carbohydrates. Carbohydrates may also help to improve the intestinal absorption of sodium and water (47). However, the amount of carbohydrate in a sports drink supplies only a small portion of the total carbohydrate content of a 2,000-kcal diet. Therefore, athletes should incorporate the needed carbohydrate in their eating habits.
- Some athletes use intravenous fluid infusion for rehydration between exercise sessions in the absence of clinical indications to do so. However, scientific studies (20,21) that have assessed the efficacy of this practice reported no performance differences between this practice and oral rehydration techniques when the rehydration and rest periods ranged from 20 to 75 minutes between exercise sessions.
PRACTICAL APPLICATION

To optimally prepare for exercise or competition, the athlete should consume a meal with 1–2 g/kg body weight of carbohydrate 3–4 hours before. In addition, a preworkout supplement consisting of low-glycemic carbohydrate with essential amino acids would benefit from maintaining blood glucose concentrations and enhance delivery of amino acids to exercising muscle. Postexercise feedings should occur as soon as after the conclusion of exercise as possible (perhaps a liquid meal) consisting of both protein (whey) and carbohydrates. Chocolate milk can serve as a good postrecovery drink.

The primary postexercise nutritional strategy for combat sport athletes is to focus on maximizing muscle glycogen content and enhance muscle protein synthesis. Combining carbohydrate and protein feedings immediately after exercise may not only enhance glycogen replenishment but also increase protein synthesis. Greater protein accretion appears to enhance muscle recovery, quite relevant for a contact sport athlete. Dietary strategies should also provide appropriate levels of hydration at the start of, and during, intense training or competitive sessions and recovery approaches to replenish fluid losses and other depleted nutrients.

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is Department Head of Kinesiology and Director of the Human Performance Laboratory at the University of Connecticut.

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