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## Sports nutrition and ergogenic aids

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### Abstract

Sports nutrition is a constantly evolving field with hundreds of research papers published annually. For this reason, keeping up to date with the literature is often difficult. This paper is a five year update of the sports nutrition review article published as the lead paper to launch the JISSN in 2004 and presents a well-referenced overview of the current state of the science related to how to optimize training and athletic performance through nutrition. More specifically, this paper provides an overview of: 1.) The definitional category of ergogenic aids and dietary supplements; 2.) How dietary supplements are legally regulated; 3.) How to evaluate the scientific merit of nutritional supplements; 4.) General nutritional strategies to optimize performance and enhance recovery; and, 5.) An overview of our current understanding of the ergogenic value of nutrition and dietary supplementation in regards to weight gain, weight loss, and performance enhancement. Our hope is that ISSN members and individuals interested in sports nutrition find this review useful in their daily practice and consultation with their clients.

**Keywords:** Sports nutrition, ergogenic aids, athletic success, enhance recovery, separate marketing

### Introduction

Sports nutrition is the foundation of athletic success. It is a well-designed nutrition plan that allows active adults and athletes to perform at their best. It supplies the right food type, energy, nutrients, and fluids to keep the body well hydrated and functioning at peak levels. A sports nutrition diet may vary day to day, depending on specific energy demands. Sports nutrition professionals need to know how to evaluate the scientific merit of articles and advertisements about exercise and nutrition products so they can separate marketing hype from scientifically-based training and nutritional practices. In order to help ISSN members keep informed about the latest in sports nutrition, we have updated the ISSN Exercise & Sports Nutrition Review that was used to help launch the JISSN (originally called the Sports Nutrition Review Journal). This paper provides an overview of: 1.) The definitional category of ergogenic aids and dietary supplements, 2.) How dietary supplements are legally regulated, 3.) How to evaluate the scientific merit of nutritional supplements, 4.) General nutritional strategies to optimize performance and enhance recovery; and, 5.) An overview of our current understanding of the ergogenic value in regards to weight gain, weight loss, and performance enhancement supplements. We have also categorized nutritional supplements into 'apparently effective', 'possibly effective', 'too early to tell', and 'apparently ineffective' as well a description of our general approach into educating athletes about sports nutrition. Over the last five years there have been many changes to our original categorization of supplements. In addition, a number of new supplements have been introduced to the market are reviewed in this article. While some may not agree with all of our interpretations of the literature and/or categorization of a particular supplement, and some classifications may change over time as more research is forthcoming, these interpretations are based on current available scientific evidence and have been well received within the broader scientific community. Our hope is that ISSN members find this information useful in their daily practice and consultation with their clients.

### Ergogenic aids

An ergogenic aid is any training technique, mechanical device, nutritional practice, pharmacological method, or psychological technique that can improve exercise performance capacity and/or enhance training adaptations. This includes aids that may help prepare an individual to exercise, improve the efficiency of exercise, and/or enhance recovery from exercise. Ergogenic aids may also allow an individual to tolerate heavy training to a greater degree by helping them recover faster or help them stay injury-free and/or healthy during

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intense training. Although this definition seems rather straightforward, there is considerable debate regarding the ergogenic value of various nutritional supplements. Some sports nutrition specialists only consider a supplement ergogenic if studies show that the supplement significantly enhances exercise performance (e.g., helps you run faster, lift more weight, and/or perform more work during a given exercise task). On the other hand, some feel that if a supplement helps prepare an athlete to perform or enhances recovery from exercise, it has the potential to improve training adaptations and therefore should be considered ergogenic. In the view of the ISSN, one should take a broader view about the ergogenic value of supplements. While we are interested in determining the performance enhancement effects of a supplement on a single bout of exercise, we also realize that one of the goals of training is to help people tolerate a greater degree of training. Individuals who better adapt to high levels of training usually experience greater gains from training over time which can lead to improved performance. Consequently, employing nutritional practices that help prepare individuals to perform and/or enhance recovery from exercise should also be viewed as ergogenic.

### Classifying and categorizing supplements

Dietary supplements may contain carbohydrate, protein, fat, minerals, vitamins, herbs, enzymes, metabolic intermediates (like amino acids), and/or various plant/food extracts. Supplements can generally be classified as convenience supplements (e.g., energy bars, meal replacement powders, ready to drink supplements) designed to provide a convenient means of meeting caloric needs and/or managing caloric intake, weight gain, weight loss, and/or performance enhancement. Based on the above criteria, we generally categorize nutritional supplements into the following categories:

- I. **Apparently Effective.** Supplements that help people meet general caloric needs and/or the majority of research studies in relevant populations show is effective and safe.
- II. **Possibly Effective.** Supplements with initial studies supporting the theoretical rationale but requiring more research to determine how the supplement may affect training and/or performance.
- III. **Too Early To Tell.** Supplements with sensible theory but lacking sufficient research to support its current use.
- IV. **Apparently Ineffective.** Supplements that lack a sound scientific rationale and/or research has clearly shown to be ineffective.

When a sports nutrition specialist counsels people who train, they should first evaluate their diet and training program. They should make sure that the athlete is eating an energy balanced, nutrient dense diet and that they are training intelligently. This is the foundation to build a good program. Following this, we suggest that they generally only recommend supplements in category I (i.e., 'Apparently Effective'). If someone is interested in trying supplements in category II (i.e., 'Possibly Effective'), they should make sure that they understand that these supplements are more experimental and that they may or may not see the type of results claimed. We recommend discouraging people from trying supplements in category III (i.e., 'Too Early to Tell') because there isn't enough data available on their ergogenic

value. However, if someone wants to try one of these supplements, they should understand that although there is some theoretical rationale, there is little evidence to support use at this time. Obviously, we do not support athletes taking supplements in categories IV (i.e., 'Apparently Ineffective'). We believe that this approach is a more scientifically supportable and balanced view than simply dismissing the use of all dietary supplements out of hand.

### General dietary guidelines for active individuals

A well-designed diet that meets energy intake needs and incorporates proper timing of nutrients is the foundation upon which a good training program can be developed. Research has clearly shown that not ingesting a sufficient amount of calories and/or enough of the right type of macronutrients may impede an athlete's training adaptations while athletes who consume a balanced diet that meets energy needs can augment physiological training adaptations. Moreover, maintaining an energy deficient diet during training may lead to loss of muscle mass and strength, increased susceptibility to illness, and increased prevalence of overreaching and/or overtraining. Incorporating good dietary practices as part of a training program is one way to help optimize training adaptations and prevent overtraining. The following overviews energy intake and major nutrient needs of active individuals.

#### Energy Intake

The first component to optimize training and performance through nutrition is to ensure the athlete is consuming enough calories to offset energy expenditure. People who participate in a general fitness program (e.g., exercising 30-40 minutes per day, 3 times per week) can typically meet nutritional needs following a normal diet (e.g., 1,800 - 2,400 kcals/day or about 25 -35 kcals/kg/day for a 50 - 80 kg individual) because their caloric demands from exercise are not too great (e.g, 200-400 kcals/session). However, athletes involved in moderate levels of intense training (e.g., 2-3 hours per day of intense exercise performed 5-6 times per week) or high volume intense training (e.g., 3-6hours per day of intense training in 1-2 workouts for 5-6 days per week) may expend 600-1,200 kcals or more per hour during exercise. For this reason, their caloric needs may approach 50-80 kcals/kg/day (2,500- 8,000 kcals/day for a 50-100 kg athlete). For elite athletes, energy expenditure during heavy training or competition may be enormous. For example, energy expenditure for cyclists to compete in the Tour de France has been estimated as high as 12,000 kcals/day (150-200 kcals/kg/d for a 60-80 kg athlete). Additionally, caloric needs for large athletes (i.e., 100 -150 kg) may range between 6,000-12,000 kcals/day depending on the volume and intensity of different training phases. Although some argue that athletes can meet caloric needs simply by consuming a well-balanced diet, it is often very difficult for larger athletes and/or athletes engaged in high volume/intense training to be able to eat enough food in order to meet caloric needs. Maintaining an energy deficient diet during training often leads to significant weight loss (including muscle mass), illness, onset of physical and psychological symptoms of overtraining, and reductions in performance. Nutritional analyses of athletes' diets have revealed that many are susceptible to maintaining negative energy intakes during training. Susceptible populations include runners, cyclists, swimmers, triathletes, gymnasts, skaters, dancers, wrestlers, boxers, and athletes attempting

to lose weight too quickly. Additionally, female athletes have been reported to have a high incidence of eating disorders. Consequently, it is important for the sports nutrition specialist working with athletes to ensure that athletes are well-fed and consume enough calories to offset the increased energy demands of training, and maintain body weight. Although this sounds relatively simple, intense training often suppresses appetite and/or alters hunger patterns so that many athletes do not feel like eating. Some athletes do not like to exercise within several hours after eating because of sensations of fullness and/or a predisposition to cause gastrointestinal distress. Further, travel and training schedules may limit food availability and/or the types of food athletes are accustomed to eating. This means that care should be taken to plan meal times in concert with training, as well as to make sure athletes have sufficient availability of nutrient dense foods throughout the day for snacking between meals (e.g., drinks, fruit, carbohydrate/protein bars, etc). For this reason, sports nutritionists often recommend that athletes consume 4-6 meals prepay and snacks in between meals in order to meet energy needs. Use of nutrient dense energy bars and high calorie carbohydrate/protein supplements provides a convenient

### **Carbohydrate**

The second component to optimizing training and performance through nutrition is to ensure that athletes consume the proper amounts of carbohydrate (CHO), protein (PRO) and fat in their diet. Individuals engaged in a general fitness program can typically meet macronutrient needs by consuming a normal diet (i.e., 45-55% CHO [3-5 grams/kg/day], 10-15% PRO [0.8-1.0 gram/kg/day], and 25-35% fat [0.5-1.5 grams/kg/day]). However, athletes involved in moderate and high volume training need greater amounts of carbohydrate and protein in their diet to meet macronutrient needs. For example, in terms of carbohydrate needs, athletes involved in moderate amounts of intense training (e.g., 2-3 hours per day of intense exercise performed 5-6 times per week) typically need to consume a diet consisting of 55-65% carbohydrate (i.e., 5-8 grams/kg/day or 250-1,200grams/day for 50-150 kg athletes) in order to maintain liver and muscle glycogen stores. Research has also shown that athletes involved in high volume intense training (e.g., 3-6 hours per day of intense training in 1-2 workouts for 5-6 days per week) may need to consume 8-10 grams/day of carbohydrate (i.e., 400-1,500 grams/day for 50-150 kg athletes) in order to maintain muscle glycogen levels. This would be equivalent to consuming 0.5-2.0 kg of spaghetti. Preferably, the majority of dietary carbohydrate should come from complex carbohydrates with a low to moderate glycemic index (e.g., whole grains, vegetables, fruit, etc). However, since it is physically difficult to consume that much carbohydrate per day when an athlete is involved in intense training, many nutritionists and the sports nutrition specialist recommend that athletes consume concentrated carbohydrate juices/drinks and or consume high carbohydrate supplements to meet carbohydrate needs.

### **Protein**

There has been considerable debate regarding protein needs of athletes [27-31]. Initially, it was recommended that athletes do not need to ingest more than the RDA for protein

(i.e., 0.8 to 1.0 g/kg/d for children, adolescents and adults). However, research over the last decade has indicated that athletes engaged in intense training need to ingest about two times the RDA of protein in their diet (1.5 to 2.0 g/kg/d) in order to maintain protein balance. If an insufficient amount of protein is obtained from the diet, an athlete will maintain a negative nitrogen balance, which can increase protein catabolism and slow recovery. Over time, this may lead to muscle wasting and training intolerance.

### **Fat**

The dietary recommendations of fat intake for athletes are similar to or slightly greater than those recommended for non-athletes in order to promote health. Maintenance of energy balance, replenishment of intramuscular triacylglycerol stores and adequate consumption of essential fatty acids are of greater importance among athletes and allow for somewhat increased intake. This depends on the athlete's training state and goals. For example, higher-fat diets appear to maintain circulating testosterone concentrations better than low-fat diets. This has relevance to the documented testosterone suppression which can occur during volume-type overtraining. Generally, it is recommended that athletes consume a moderate amount of fat (approximately 30% of their daily caloric intake), while increases up to 50% of kcal can be safely ingested by athletes during regular high volume training. For athletes attempting to decrease body fat, however, it has been recommended that they consume 0.5 to 1 g/kg/d of fat. The reason for this is that some weight loss studies indicate that people who are most successful in losing weight and maintaining the weight loss are those who ingest less than 40 g/d of fat in their diet although this is not always the case. Certainly, the type of dietary fat (e.g. n-6 versus n-3; saturation state) is a factor in such research and could play an important role in any discrepancies. Strategies to help athletes manage dietary fat intake include teaching them which foods contain various types of fat so that they can make better food choices and how to count fat grams.

### **Strategic eating and refueling**

In addition to the general nutritional guidelines described above, research has also demonstrated that timing and composition of meals consumed may play a role in optimizing performance, training adaptations, and preventing overtraining. In this regard, it takes about 4 hours for carbohydrate to be digested and begin being stored as muscle and liver glycogen. Consequently, pre-exercise meals should be consumed about 4 to 6 h before exercise. This means that if an athlete trains in the afternoon, breakfast is the most important meal to top off muscle and liver glycogen levels. Research has also indicated that ingesting a light carbohydrate and protein snack 30 to 60 min prior to exercise (e.g., 50 g of carbohydrate and 5 to 10 g of protein) serves to increase carbohydrate availability toward the end of an intense exercise bout. This also serves to increase availability of amino acids and decrease exercise-induced catabolism of protein.

### **Vitamins**

Vitamins are essential organic compounds that serve to regulate metabolic processes, energy synthesis, neurological processes, and prevent destruction of cells. There are two primary classifications of vitamins: fat and water soluble.

The fat soluble vitamins include vitamins A, D, E, & K. The body stores fat soluble vitamins and therefore excessive intake may result in toxicity. Water soluble vitamins are B vitamins and vitamin C. Since these vitamins are water soluble, excessive intake of these vitamins are eliminated in urine, with few exceptions (e.g. vitamin B6, which can cause peripheral nerve damage when consumed in excessive amounts). Describes RDA, proposed ergogenic benefit, and summary of research findings for fat and water soluble vitamins. Although research has demonstrated that specific vitamins may possess some health benefit (e.g., Vitamin E, niacin, folic acid, vitamin C, etc), few have been reported to directly provide ergogenic value for athletes. However, some vitamins may help athletes tolerate training to a greater degree by reducing oxidative damage (Vitamin E, C) and/or help to maintain a healthy immune system during heavy training (Vitamin C). Theoretically, this may help athletes tolerate heavy training leading to improved performance. The remaining vitamins reviewed appear to have little ergogenic value for athletes who consume a normal, nutrient dense diet. Since dietary analyses of athletes have found deficiencies in caloric and vitamin intake, many sports nutritionists' recommend that athletes consume a low dose daily multivitamin and/or a vitamin enriched post work out carbohydrate/protein supplement during periods of heavy training. An article in the Journal of the American Medical Association also recently evaluated the available medical literature and recommended that Americans consume a one-a-day low-dose multivitamin in order to promote general health. Suggestions that there is no benefit of vitamin supplementation for athletes and/or it is unethical for a sports nutrition specialist to recommend that their clients take a one-a-day-multi-vitamin and/or suggest taking other vitamins that may raise HDL cholesterol levels and decrease risk of heart disease (niacin), serve as antioxidants (Vitamin E), preserve musculoskeletal function and skeletal mass (vitamin D), or may help maintain a health immune system (Vitamin C) is not consistent with current available literature.

### Minerals

Minerals are essential inorganic elements necessary for a host of metabolic processes. Minerals serve as structure for tissue, important components of enzymes and hormones, and regulators of metabolic and neural control. Some minerals have been found to be deficient in athletes or become deficient in response to training and/or prolonged exercise. When mineral status is inadequate, exercise capacity may be reduced. Dietary supplementation of minerals in deficient athletes has generally been found to improve exercise capacity. Additionally, supplementation of specific minerals in non-deficient athletes has also been reported to affect exercise capacity. Describes minerals that have been purported to affect exercise capacity in athletes of the minerals reviewed, several appear to possess health and/or ergogenic value for athletes under certain conditions. For example, calcium supplementation in athletes susceptible to premature osteoporosis may help maintain bone mass. There is also recent evidence that dietary calcium may help manage body composition. Iron supplementation in athletes prone to iron deficiencies and/or anemia has been reported to improve exercise capacity. Sodium phosphate loading has been reported to increase maximal oxygen uptake, anaerobic threshold, and improve

endurance exercise capacity by 8 to 10%. Increasing dietary availability of salt (sodium chloride) during the initial days of exercise training in the heat has been reported to help maintain fluid balance and prevent dehydration. ACSM recommendations for sodium levels (340 mg) represent the amount of sodium in less than 1/8 teaspoon of salt and meet recommended guidelines for sodium ingestion during exercise (300-600 mg per hour or 1.7-2.9 grams of salt during a prolonged exercise bout). Finally, zinc supplementation during training has been reported to decrease exercise-induced changes in immune function. Consequently, somewhat in contrast to vitamins, there appear to be several minerals that may enhance exercise capacity and/or training adaptations for athletes under certain conditions. However, although ergogenic value has been purported for remaining minerals, there is little evidence that boron, chromium, magnesium, or vanadium affect exercise capacity or training adaptations in healthy individual eating a normal diet. Suggestions that there is no benefit of mineral supplementation for athletes and/or it is unethical for a sports nutrition specialist to recommend that their clients take minerals for health and/or performance benefit is not consistent with current available literature.

### Water

The most important nutritional ergogenic aid for athletes is water. Exercise performance can be significantly impaired when 2% or more of body weight is lost through sweat. For example, when a 70-kg athlete loses more than 1.4 kg of body weight during exercise (2%), performance capacity is often significantly decreased. Further, weight loss of more than 4% of body weight during exercise may lead to heat illness, heat exhaustion, heat stroke, and possibly death. For this reason, it is critical that athletes consume a sufficient amount of water and or GES sports drinks during exercise in order to maintain hydration status. The normal sweat rate of athletes ranges from 0.5 to 2.0 L/h depending on temperature, humidity, exercise intensity, and their sweat response to exercise. This means that in order to maintain fluid balance and prevent dehydration, athletes need to ingest 0.5 to 2 L/h of fluid in order to offset weight loss. This requires frequent ingestion of 6-8oz of cold water or a GES sports drink every 5 to 15-min during exercise. Athletes and should not depend on thirst to prompt them to drink because people do not typically get thirsty until they have lost a significant amount of fluid through sweat. Additionally, athletes should weigh themselves prior to and following exercise training to ensure that they maintain proper hydration. The athlete should consume 3 cups of water for every pound lost during exercise in order adequately rehydrate themselves. Athletes should train themselves to tolerate drinking greater amounts of water during training and make sure that they consume more fluid in hotter/humid environments. Preventing dehydration during exercise is one of the most effective ways to maintain exercise capacity. Finally, inappropriate and excessive weight loss techniques (e.g., cutting weight in saunas, wearing rubber suits, severe dieting, vomiting, using diuretics, etc) are extremely dangerous and should be prohibited. Sports nutrition specialists can play an important role in educating athletes and coaches about proper hydration methods and supervising fluid intake during training and competition.

### Dietary supplements and athletes

Most of the work we do with athletes regarding sports nutrition is to teach them and their coaches how to structure their diet and time food intake to optimize performance and recovery. Dietary supplements can play a meaningful role in helping athletes consume the proper amount of calories, carbohydrate, and protein in their diet. However, they should be viewed as supplements to the diet, not replacements for a good diet. While it is true that most dietary supplements available for athletes have little scientific data supporting their potential role to enhance training and/or performance, it is also true that a number of nutrients and/or dietary supplements have been shown to help improve performance industry lose credibility when they do not accurately describe results of various studies to the public. The following outlines several classifications of nutritional supplements that are often taken by athletes and categorizes them into 'apparently effective', 'possibly effective', 'too early to tell', and 'apparently ineffective' supplements based on interpretation of the literature. It should be noted that this analysis focuses primarily on whether the proposed nutrient has been found to affect exercise and/or training adaptations based on the current available literature. Additional research may or may not reveal ergogenic value, possibly altering its classification. It should be also noted that although there may be little ergogenic value to some nutrients, there may be some potential health benefits that may be helpful for some populations. Therefore, just because a nutrient does not appear to affect performance and/or training adaptations, that does not mean it does not have possible health benefits for athletes and or recovery. Supplementation with these nutrients can help augment the normal diet to help optimize performance. Sports nutrition specialists must be aware of the current data regarding nutrition, exercise, and performance and be honest about educating their clients about results of various studies (whether pro or con). With the proliferation of information available about nutritional supplements to the consumer, the sports nutrition specialist, nutritionist, and nutrition.

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