The Use of Nutritional Ergogenic Aids in Sports: Is It an Ethical Issue?

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As nutritional technology advanced, scientists have been able to synthesize and manufacture all known nutrients, and many of their metabolic by-products, essential to human physiology. Many of these substances are theorized to possess ergogenic potential when taken in quantities or forms normally not found in typical foods or diets. Research, although limited in most cases, supports the ergogenicity of some nutrients (e.g., creatine) when consumed in substantial amounts, suggesting such nutrients may function as drugs or nutraceuticals. The International Olympic Committee (IOC) doping legislation stipulates that any physiologic substance taken in abnormal quantity with the intention of artificially and unfairly increasing performance should be construed as doping, violating the ethics of sport performance. Given this stipulation, the IOC and other athletic-governing organizations should consider the legality and ethics underlying the use of ergogenic nutraceuticals in sport.

Key Words: doping, drugs, energy, ethics, exercise, nutraceuticals

Sports popularity is a worldwide phenomenon, and athletic success may lead to substantial fame and fortune. In order to be successful at the national or international level of competition, athletes must possess the genetic anthropometrical, biomechanical, physiological, and psychological characteristics appropriate for mastery of their particular sport. Moreover, they need specific state-of-the-art coaching and training to maximize this genetic potential.

Numerous specific genetic factors influence performance potential, but a major key to optimal sport performance is the proper production and control of energy. For example, in track events, optimal energy production is paramount, and inherited metabolic and neuromuscular capacities influence the rate at which energy may be produced, and endogenous (and sometimes exogenous) energy supplies may influence the duration of energy production at the optimal rate, a contributing factor in the regulation of fatigue processes.

The human body possesses several physiological systems for producing energy at varying rates. In brief, to be successful in an event such as the 60-meter dash,
athletes must possess the ability to produce energy anaerobically at a very fast rate, presumably via high-energy phosphagens, adenosine triphosphate (ATP) and creatine phosphate (CP). To be successful in somewhat longer high-intensity exercise tasks, such as a 400-meter dash, athletes must possess the ability to generate energy via anaerobic glycolysis because ATP and CP stores are insufficient to sustain this high energy production for more than approximately 6 seconds. However, factors associated with excess production of lactic acid may precipitate fatigue during prolonged anaerobic glycolysis. In order to perform exercise for a longer period of time, such as in a 27–28 minute 10-kilometer race or in longer endurance events, athletes must have the potential to produce energy rapidly via aerobic oxidation of glucose, glycogen, and fatty acids, necessitating a highly developed cardiovascular-respiratory system to provide adequate oxygen.

Proper biomechanical, psychological, and physiological training specific to the nature of the athletic event will help the body improve its control and utilization of the human energy systems to maximize energy efficiency and production. The adaptations that the body cells, tissues, and organs make in response to chronic exercise training are specific to the imposed demands and are fairly well documented (4). In essence, nuclei in the body cells that are affected by the exercise stressor will stimulate the formation of appropriate proteins (enzymes, hormones, neurotransmitters, or structural proteins) to help reduce the stress response, that is, to help preserve homeostasis during similar subsequent exercise bouts.

Chronic exercise training will induce beneficial changes in each energy system that is stressed. Many of these adaptations are specific to the muscle cells and the type of exercise task. For example, chronic aerobic endurance exercise training will improve functional capacity of the myocardium, increase blood volume and production of red blood cells, and increase quantitatively mitochondria and oxidative enzymes within exercised muscle groups, all adaptations that will facilitate the utilization of oxygen by the muscle tissues. Standardized aerobic exercise tasks will impose less stress to the muscle following these adaptations, thus helping to mitigate deviations from homeostasis. Many of these natural adaptations of the muscles to training are enhanced by various endogenous hormones, such as epinephrine, testosterone, human growth hormone (HGH), and erythropoietin (EPO), whose production and secretion may be enhanced during exercise.

Deviations from homeostasis may contribute to developing fatigue. In relation to physical performance, fatigue may be defined as decreased functional ability of organs, tissues, or cells after excessive exertion or stimulation, leading to impaired performance. Although there is a wide variety of factors that may induce mental and/or physical fatigue in athletes and impair performance, the most common causes theorized are insufficient metabolic substrate (phosphocreatine, blood glucose, muscle glycogen), decreased oxygen delivery (decreased cardiac output or arterial oxygen content), acid–base disturbances (decreased pH due to increased hydrogen ion concentration), hyperthermia, and an increased ratio of free tryptophan to branched chain amino acids (BCAA) in the blood (30, 31, 46).

Factors that may impact negatively on performance vary in different athletic endeavors; for example, excessive anxiety and hand tremor in pistol shooters may impair firing accuracy, and depleted liver and muscle glycogen stores in the marathoner may impair optimal energy production in the latter stages of a marathon. In
these examples, respectively, fatigue may be caused by excessive stimulation of
nervous mental energy resulting in anxiety or by inadequate provision of carbohy-
drate stores to maintain the appropriate fuel for muscle contraction. Thus, most
training methods are designed to counteract these negative factors specific to the
given sport. In these two cases, psychological training to control anxiety may be
useful in pistol shooters, whereas liver and muscle glycogen supercompensation
techniques (carbohydrate loading) may be helpful to the marathoner.

Doping and Ethics in Sport
Since the advent of athletic competition, athletes have utilized a variety of methods
in attempts to enhance performance (43, 47). Two of the earliest drugs used were
alcohol and caffeine, and their effectiveness as ergogenics has been investigated
since the latter part of the 19th century because they were commonly used by
athletes in competition to help mask or prevent fatigue (47). As medical science
progressed, advancing the understanding of human physiology, pharmaceutical
research began to produce drugs or chemicals designed to mimic the action of
endogenous hormones or compounds. For example, amphetamines were designed
as sympathomimetics to the physiologic and psychologic effects of epinephrine,
and anabolic steroids were designed to elicit effects associated with testosterone.
Although both of these agents, and others as well, were developed with medically
therapeutic applications in mind, their potential effectiveness to enhance physical
performance eventually led to their use by athletes.

At various levels of sports competition, genetic endowment and training
levels may be so well matched that the outcome of an event may be determined
by milliseconds or centimeters. Thus, when athletes believe that they have max-
imized the effects obtainable through training, they may try to go beyond training,
to use ergogenic aids as a means to enhance performance and obtain a competitive
edge over their opponent. Beyond personal pursuit of winning, national pride is
often predicated on victory in sport, and several countries enlisted their scientific
elite in full-fledged research efforts to boost athletic performance (20).

Amphetamines and anabolic steroids were two of the first drugs to be used
extensively in sport, being used indiscriminately during the 1950s and 1960s
(35, 36, 42, 44). However, because their use by athletes contravened the ethics
of good sportsmanship under the Olympic ideal, and because they were associated
with significant medical risks, even death, their use by athletes competing in the
Olympic Games was banned by the International Olympic Committee (IOC) in
the early 1960s. Although amphetamines, narcotic analgesics, and anabolic ste-
roids were the first agents to be specifically banned, others, including blood
doping and neuropeptides such as HGH, were added as their ergogenic potential
was revealed. The IOC doping rule reads, in part, as follows:

Doping is the administration of or the use by a competing athlete of any
substance foreign to the body or of any physiological substance taken in
abnormal quantity or by an abnormal route of entry into the body, with
the intention of increasing in an artificial and unfair manner his performance
in competition. When necessity demands medical treatment with any sub-
stance which because of its nature, dosage, or application is able to boost
the athlete's performance in competition in an artificial and unfair manner,
this is to be regarded as doping. (8)
Major categories of drugs banned by the IOC (40), with examples where appropriate, are as follows:

<table>
<thead>
<tr>
<th>Stimulants and related compounds</th>
<th>Beta blockers and related compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphetamine</td>
<td>Metoprolol</td>
</tr>
<tr>
<td>Caffeine(^1)</td>
<td>Propranolol</td>
</tr>
<tr>
<td>Ephedrine</td>
<td>Diuretics and related compounds</td>
</tr>
<tr>
<td>Pseudoephedrine(^2)</td>
<td>Acetazolamide</td>
</tr>
<tr>
<td>Narcotic Analgesics and related compounds</td>
<td>Furosemide</td>
</tr>
<tr>
<td>Codeine</td>
<td>Peptide hormones and analogues</td>
</tr>
<tr>
<td>Morphine</td>
<td>Human growth hormone</td>
</tr>
<tr>
<td>Anabolic steroids and related compounds</td>
<td>Corticotrophin</td>
</tr>
<tr>
<td>Metandienone</td>
<td>Erythropoietin</td>
</tr>
<tr>
<td>Stanozolol</td>
<td>Blood doping</td>
</tr>
<tr>
<td>Testosterone</td>
<td>Alcohol(^3)</td>
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</table>

In a recent review of doping in sports, Smith and Perry (36) noted that athletes view ergogenic drugs as an essential component for success. Thus, although drugs were first banned for use in competition during the early 1960s, athletes continued to use them because drug testing was neither in effect nor very effective. With the implementation of drug testing in the 1968 Olympic Games, primarily via testing of urine samples, athletes began to use a variety of techniques to avoid detection, such as physical (catheterization of the urinary bladder) and pharmacologic (use of drugs such as diuretics and probenecid) manipulation of urine samples. However, as drug testing became more sophisticated and diuretics and probenecid were banned, athletes were less likely to avoid detection. Given the severe penalties associated with a positive drug test—up to a 2-year ban on athletic competition for a first offense (40)—and increasing evidence that certain drugs carried substantial health risks (14, 53), athletes began to search for ergogenics that could not be detected or for alternative legal nonpharmacologic ergogenics (10, 21, 42, 43).

There are some important ethical considerations relative to the use of various ergogenic aids to enhance athletic performance. The term ethics may be defined in a variety of ways, one definition being the moral principles of a particular school of thought. In relation to sport, the ancient Greek belief that athletes should succeed through their own unaided effort is embraced by the IOC as the Olympic ideal. Another definition of ethics is the rules of conduct recognized in certain associations. Within the IOC, certain associations establish specific rules for conduct within their sport, such as track and field, to ensure that athletes adhere to the Olympic ideal and do not obtain an unfair advantage. Yet another definition of ethics is the moral principles by which an individual is

\(^1\)Limited amounts are acceptable.

\(^2\)Commonly found in decongestant cold and sinus medicines.

\(^3\)May be banned by specific international federations or national governing bodies (NGB).
guided. The athlete whose primary motivation is to win at all costs may be guided by his or her own moral principles to attempt to gain an unfair advantage and thus violate the ethics underlying the Olympic ideal.

Most of the focus of the antidoping legislation has been on the prevention and detection of banned pharmacologic ergogenics, because their use by athletes violates the ethical principles of the Olympic ideal and the rules of most athletic governing federations within the IOC. But, there also may be ethical concerns relative to the use of some nonpharmacologic ergogenics.

**Nonpharmacologic Ergogenic Aids**

In addition to pharmacologic ergogenics, four other classifications of ergogenic aids have been proposed: mechanical or biomechanical, psychological, physiological, and, nutritional (49).

Although most of the improvement in sports performance over the past half-century may be attributed to improved coaching and training methods, mechanical/biomechanical ergogenics have enhanced performance considerably in a variety of sports. One of the most notable examples involves the conversion to the fiberglass pole in the pole vault. Other examples include the application of aerodynamic materials and clothing to such events as cycling and downhill skiing and changed components of materials in racing shoes. In regards to the latter, although few research data were provided, the designer of the Springbok racing flat has predicted that the use of this shoe will lower the world’s record for the marathon from 2:06:50 to 2:00:30 for men and from 2:21:06 to 2:14:02 for women (32). Clearly, mechanical/biomechanical ergogenics may enhance sport performance by improving energy efficiency and are legal if not specifically prohibited by the rules governing equipment for a specific sport.

Psychologic ergogenic aids, such as imagery, hypnosis, mental dissociation, and others are designed to optimize psychological arousal (17, 49). In some sports, such as pistol shooting and archery, excessive arousal or anxiety could cause nervousness and hand tremor, resulting in impaired accuracy, so imaging techniques could be used to induce a state of relaxation. In contrast, power events such as weightlifting might benefit from increased psychological arousal, so stimulative imaging techniques could be employed. Psychologic ergogenic aids are legal and may be helpful to some athletes.

Physiologic ergogenic techniques are designed to directly enhance specific physiological processes important to sport. Altitude training may be construed to be a physiological ergogenic aid because it may induce the kidney to increase its secretion of EPO, which may subsequently stimulate the bone marrow to produce more red blood cells (RBCs), increasing the hematocrit. The increased hematocrit following altitude acclimatization would increase the oxygen carrying capacity per unit of blood, and would lead to improved performance at altitude in comparison to the nonacclimatized state. Theoretically, the increased hematocrit also should improve performance at sea level beyond normal levels, but altitude training has not been shown consistently to increase subsequent performance at sea level. Other techniques used to increase the hematocrit, such as induced erythrocythemia (blood doping) and injection of recombinant EPO (rEPO) have proven to be effective ergogenics for aerobic endurance exercise tasks (12, 37), but use of either technique may induce serious health risks that are potentially fatal. Consequently, the use of
blood doping and EPO has been banned by the IOC; blood doping is in a category by itself, and rEPO is a banned peptide.

The classification system used here is rather arbitrary. For example, various nutritional practices or specific nutrients may be classified into several categories depending upon their application. Weight loss to enhance body composition may be classified as a biomechanical ergogenic; BCAA supplementation is theorized to reduce psychological sensations of fatigue, a psychologic ergogenic; caffeine, a food drug, may enhance performance in aerobic endurance events, a pharmacologic ergogenic; and, sodium bicarbonate may help mitigate acidosis during anaerobic exercise, a physiologic ergogenic.

Nutritional Ergogenic Aids

The science of nutrition is relatively young. During the early part of this century, nutritional research was devoted to discovering specific nutrients essential to life, their chemical structure, their concentration in foods, and how much of these humans need to prevent deficiency disease. More recently, increasing research attention is being devoted to the role of specific nutrients to function as drugs, so-called nutraceuticals, with possible medical applications (2). Recent research suggests that high doses of some specific nutrients may exert health effects above and beyond simple prevention of deficiency diseases. For example, niacin, vitamin E, and omega-3 fatty acids may, respectively, reduce serum cholesterol levels (25), prevent oxidation of LDL-cholesterol (9), and decrease platelet aggregation and stickiness (45), all factors that may reduce the risk of cardiovascular disease.

Other health benefits have been associated with other nutrients found in the foods we eat. Much of the research data that suggests a protective role for these nutrients is epidemiological and based upon natural dietary intake rather than the use of supplements. However, in the case of niacin, vitamin E, and omega-3 fatty acids, megadose supplements may be helpful, and increasing research is being devoted to supplement use with many other specific nutrients to determine their medical efficacy as nutraceuticals.

Many nutrients also may be theorized to be ergogenic if taken in megadoses. Studies with athletes suggest many consume nutrient supplements, often in doses much greater than those obtained in normal diets, in the belief they do possess ergogenic potential (7). Because nutrients are considered legal ergogenics (10, 21), research also has been devoted to the biochemical, or nutraceutical, role of specific nutrients or their metabolic by-products that may enhance sports performance. In general, research has shown that many nutritional supplements are ineffective as ergogenic aids. However, some research suggests others may be effective, although in most cases confirmatory studies are needed. No detailed review of specific nutritional ergogenics is presented here, because extensive reviews may be found elsewhere. But, for the purpose of this paper, consider the following examples from each of the six major classes of nutrients: carbohydrates, fats, protein, vitamins, minerals, and water.

Carbohydrates

Carbohydrates are the main energy substrate for prolonged endurance exercise at a relatively high percentage of one’s aerobic power (e.g., greater than 65-70% \( V_O^2_{max} \)). In an event such as the 42.2 kilometer (26.2 mile) marathon, depletion
of muscle glycogen may be one of the factors contributing to the premature onset of fatigue (i.e., a slowing of optimal pace in the latter stages of the race). Marathoners have attempted to maximize their muscle glycogen stores through various supercompensation protocols known popularly as ‘‘carbohydrate loading.’’

In the past, consuming foods rich in complex carbohydrates, such as pasta, was the preferred means to supercompensate liver and muscle glycogen levels, but in the early 1980s, glucose polymers became available commercially to facilitate the supercompensation process without added bulk in the intestinal tract. More recently, dihydroxyacetone and pyruvate (DHAP), a combination of metabolic by-products from the glycolytic process, has been shown to increase muscle glycogen stores more effectively compared to a glucose polymer (polycose). In two well-designed studies, Stanko and his colleagues (38, 39) reported that DHAP significantly improved arm and leg ergometer performance compared to polycose, the effect being attributed to either enhanced muscle glycogen storage or increased blood glucose extraction by the exercising muscle.

**Fats**

In general, dietary fat supplementation is not recommended for athletes because of potential adverse health effects and also because there are no theoretical ergogenic effects. However, some research suggests that omega-3 fatty acids, extracted from fish oils, may possess ergogenic properties. Bucci (5) theorized omega-3 fatty acids may stimulate the release of HGH, possibly enhancing muscle growth during training. Bucci cites several studies noting that Eicomax, a commercially available blend of fish oils and vegetable oils, enhanced strength and speed performance in university football players when used as a dietary supplement. However, none of these studies appear to have been published in a peer-reviewed scientific journal.

**Protein**

Strength/power athletes have considered protein their most essential nutrient in attempts to accrue muscle mass. High-meat diets were first used as dietary sources of protein, but later various isolated protein (milk protein, soy protein) supplements appeared in the market in powder and pill form. In more recent years specific amino acids (such as arginine, ornithine, and lysine), or combinations thereof, have been advocated as a means to induce muscle growth similar to that seen with anabolic hormones. Comparable to omega-3 fatty acids, one proposed mechanism is an increased release of HGH (5), although increased stimulation of insulin release has also been suggested to induce anabolic effects (6). Although these are interesting hypotheses, the most recent research data are not very supportive of an increased HGH secretion following amino acid supplementation (13, 24).

BCAA supplementation has been hypothesized to prevent fatigue in the latter stages of prolonged endurance events by preventing the formation of neurotransmitters that may induce fatigue. As noted earlier, an increased serum ratio of free tryptophan to BCAA has been postulated as one cause of fatigue, primarily in prolonged endurance events (30). Theoretically, BCAA supplementation will
decrease the free tryptophan:BCAA ratio and mitigate the formation of serotonin, a neurotransmitter that might induce central nervous system fatigue. In a recent review Kreider et al. (23) cite several studies indicating BCAA supplementation may possess some ergogenic potential, but they conclude that additional research is necessary to resolve some of the conflicting data.

**Vitamins**

As a putative ergogenic, vitamin supplementation has been used by athletes for decades. Although most reviews (41, 50) conclude that vitamin supplementation does not increase physical performance capacity in athletes who have a balanced diet, some data suggest megadoses of several B vitamins (3) may influence neurotransmitter function to induce relaxation, a potential ergogenic effect for sports in which performance may be hampered by excess anxiety, for example, marksmanship in pistol shooting and archery.

Several studies have reported ergogenic effects when megadoses of vitamin E were used at altitude, although additional corroborative data are needed (52). As an antioxidant, vitamin E also has been suggested to attenuate muscle tissue damage during training, which might be ergogenic if more effective training leads to enhanced performance in competition. This issue is unresolved (15), but Simon-Schnass (34) indicates that it is malpractice not to recommend vitamin E supplementation to athletes at a dose of 100–200 IU daily, much greater than may be obtained in the normal diet.

**Minerals**

Large doses of certain mineral complexes, such as sodium phosphate and sodium bicarbonate have been suggested to be ergogenic. Although the research data are equivocal, several studies have shown improvements in VO2max and/or performance when sodium phosphate was ingested in amounts approximating 4,000 mg/day (22), and there is substantial scientific support underlying an ergogenic effect for sodium bicarbonate (26, 28, 51). A recent study with horses suggested the ergogenic effects may be elicited by the sodium content (19).

**Water**

Water supplementation has been shown to be an effective ergogenic, as compared to no hydration. Both rehydration and hyperhydration techniques may increase performance capacity when exercising under warm or hot environmental conditions, but hyperhydration normally has not been shown to be as effective as rehydration techniques (48). However, some recent studies combining glycerol and water as a hyperhydration method have reported significantly greater fluid retention or performance compared to water hyperhydration alone (27, 29, 33).

**Ethics of Nutritional Ergogenic Aids**

A plethora of nutritional supplements is marketed for athletes and physically active individuals as a means to enhance sport or exercise performance. Advances in nutritional biochemistry and biotechnology have permitted the mass production
of all nutrients essential to human metabolism, various metabolic by-products formed in the body, and many phytochemicals derived from plants; supplements such as mega-vitamins, carnitine, and ginseng have been marketed as nutritional ergogenics.

Food supplements marketed for athletes as potential ergogenic aids include the following:

- Amino acids
- Ginseng
- Borage
- Glucosamine polymers
- Bee pollen
- Inosine
- Beta-sitosterol
- Medium chain triglycerides
- Boron
- Octacosanol
- Branched chain amino acids
- Omega-3 fatty acids
- Caffeine
- Pangamic acid
- Carnitine
- Smilax (sarsaparilla)
- Chromium picolinate
- Sodium bicarbonate
- Citrulline
- Sodium phosphate
- CoQ10
- Tryptophan
- Desiccated liver
- Vitamins
- Dibencozide (cobalamide)
- mixtures
- Eicosanoids
- individual
- Ferulic acid
- Yohimbe
- Gamma-hydroxy butyrate
- Whey germ oil
- Gamma oryzanol

The availability of specific nutritional supplements in amounts not commonly attainable in a normal diet, such as single capsules containing 1,000 IU of vitamin E, has stimulated debate as to whether such supplements should be classified as nutrients, or as drugs. The United States Food and Drug Administration is currently evaluating the status of food supplements under the 1993 Nutrition Labeling Education Act, and indications are that many will not be classified as either a food or a drug, but simply as chemicals, and will be subject to stricter regulations than if classified as a food.

Should the IOC include some nutritional supplements under the jurisdiction of its anti-doping legislation? Consider the part of the IOC doping rule that reads, “Doping is the administration of or the use by a competing athlete of . . . any physiological substance taken in abnormal quantity . . . with the intention of increasing in an artificial and unfair manner his performance in competition” (8). Do nutritional supplements meet these criteria?

Let us look at one recent development, the isolation of creatine as a nutritional supplement targeted almost exclusively to athletes (1, 11). Recent research has suggested that creatine supplements, taken orally, may increase muscle levels of creatine phosphate and enhance performance (16, 18). The doses that have been studied and that have shown performance enhancement approximate 30 g of creatine per day. The best dietary source of creatine is meat and fish, and in order to obtain an equivalent amount, an athlete would need to consume about 7 kg (15 pounds) of raw meat or fish; creatine is unstable in heat, so cooking reduces the creatine content (11).
Although creatine is not foreign to the body and may be a normal constituent of the diet, an intake of 30 g would appear to contravene the doping law because the amount consumed may be abnormal in comparison to normal dietary intakes and may be taken with the primary intent of enhancing performance. Additional research is needed to confirm the preliminary data suggesting creatine may be an effective ergogenic aid. But if creatine supplements are shown to be effective, should they be considered parallel to carbohydrate loading, or blood doping?

Might the same question be applied to sodium bicarbonate, vitamin E, sodium phosphate, amino acids, omega-3 fatty acids, or plant phytochemicals that might prove ergogenic for certain athletic endeavors? No answer is provided here, but the issue of nutraceuticals that prove effective ergogenics when taken in amounts substantially exceeding those found in the normal diet should be considered by appropriate athletic governing bodies. As the IOC doping rule now stands, it would appear the use of such purported ergogenic nutraceuticals, if proven effective, would be contrary to its underlying ethical principles. The IOC has banned some phytochemicals that may contain agents on the banned list, such as the herbal combination Ma Huang (Chinese ephedra) that contains the banned stimulant substance, ephedrine. Additionally, although the IOC has not totally banned the use of caffeine by athletes prior to competition, it has limited the amount that may be consumed. Should the IOC apply the same type of reasoning to nutrients or derived by-products that are proven to be ergogenic?

References

12. Ekblom, B. Effects of iron deficiency, variations in hemoglobin concentration, and erythropoietin injections on physical performance and relevant physiological parame-


34. Simon-Schnass, I. Vitamin requirements for increased physical activity: Vitamin E. In Nutrition and Fitness for Athletes, A.P. Simopoulos and K.N. Pavlou (Eds.), Basel: Karger, 1993, pp. 144-153.