# CME Article

# Nutritional Supplement Use by Young Athletes: An Update

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## Target Audience

*This CME activity is intended for physicians, medical students and nurse practitioners. Pediatric emergency department physicians, emergency physicians, pediatricians, and family practitioners will find this information especially useful.*

## Learning Objectives

*After completion of this article, the reader will be able to:*

1. *Identify the most popular supplements used by young athletes.*
2. *Summarize risks and benefits of substances commonly used by adolescents.*
3. *Describe the importance of the timing of protein ingestion.*
4. *Discuss the serious side effects of ephedra and ephedrine.*
5. *State the relationship between leucine and the central fatigue theory.*

***Editor's Note**: This is the first of four articles to be published in 2005 for which a total of up to 4 Category 1 CME credit hours can be earned. Instructions for how credit hours can be earned appear after the Table of Contents. Exam questions will appear after the article.*

## Abstract

Various dietary supplements are widely and legally available in the United States. Though research on the use of these supplements is limited in the adolescent age group, there is a high prevalence of their use among adolescents, especially athletes. Clinicians should be familiar with the risks and benefits of commonly used substances in order to appropriately guide their young patients who are experimenting with them. Commonly used supplements include: protein and amino acids, creatine, ephedra and ephedrine, androstenedione, antioxidants and chromium. Recent studies suggest that there may be an increased need and specific role for protein in those engaged in athletic activities. Creatine, when used with regular resistance training, has been shown to improve short-term intermittent activities. Ephedra and ephedrine products have been linked to serious side effects, prompting a ban by the Food and Drug Administration (FDA) on their sale in over-the-counter products. *Int Pediatr. 2005;20(1):15-24.*

*Key words: Nutritional supplements, creatine, ephedrine, protein, antioxidants, glutamine*

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## Introduction

A dietary supplement, as defined by the 1994 Dietary Supplement and Health Education Act (DSHEA), is a product (other than tobacco) that bears or contains one or more of the following dietary ingredients: a vitamin, mineral, amino acid, herb or other botanical; or a dietary substance for use to supplement the diet by increasing the total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any ingredient described above; and intended for ingestion

in the form of capsule, powder, softgel, or gelcap, and not represented as conventional food or as sole item of a meal or the diet.[1]

## Epidemiology

Nutritional supplements are legally sold and widely available. Adolescents obtain supplements mainly from local health food stores, drug stores, friends, parents, and the internet.[2,3] There is a very high prevalence of dietary supplement use in the general population in the United States. Supplements such as vitamins, minerals, proteins and herbs in various forms are used by 70% of the population. Their consumption among young athletes is also high (60%-80%), especially in those engaged in body building, weight loss, and endurance activities.[2,4,5] By some estimates, the supplement industry is more than $12 billion strong, an increase of almost 250% since the enactment of the DSHEA in 1994.

Media influence, through television and sports and fitness magazines, is also significant to its young viewers and readers.[6,7] One survey of sports and fitness magazines of a local community found 183 nutritional supplement products advertised in 12 different magazines that were reviewed for one month.[6] The top five products (comprising 27.15% of total number of advertisements) were: Hydroxycut, Nitrotech, Xenadrine EFX, Mesotech, and Celltech. Out of 405 advertisements, only 253 (62.47%) listed the ingredients. The top ten listed ingredients were: protein, creatine, *Garcinia cambogia*, glutamine, conjugated linoleic acid, arginine, methoxyflavone, beta ecdysterone, ephedrine, testosterone, and *Tribulus terrestris*. In addition to the media, the use of supplements is also highly influenced by friends and parents.

There are no national prevalence data available for supplements used by adolescents in general. Several studies have looked at local or community prevalence of supplement-use by athletes in various parts of United States. These studies suggest prevalence of supplement-use in the range of 30-40% for popular supplements such as creatine, protein and amino acids, and various weight loss products.[2,5] Studies suggest no major difference in type, prevalence, and patterns of use among those who participate in sports and those who do not.[5] Also, there seems to be no significant gender difference.

## Research

There is a paucity of well controlled studies in adolescents on the use, risks, or benefits of various supplements.[2] Most studies are done in adult, elite, or male athletes and generally evaluate short-term use. Risks and benefits of high-dose continuous use have not been clearly elucidated. Current research suggests that a given supplement in the laboratory setting may result in a measurable effect on body composition, energy system or a given study parameter. It is not clear though, if this change translates into improved sports performance on the field. General health and nutritional status, genetic factors, and effects of regular training are confounding variables in any potential gain.[2,4]

## Commonly Used Supplements

There is an enormous array of products that are marketed with the promise of health, fitness, improved sport performance, improved mental abilities, and other desired goals of youth. Popularity of a given supplement may vary regionally, and the type of supplement used may depend upon the personal experience of the athlete and the type of activity he or she prefers. Brief summaries of substances popular with athletes are now discussed, highlighting salient features and recent developments.

## Amino Acids[8-11]

*Arginine*

Intravenously infused arginine has been shown to accentuate an exercise-associated increase in growth hormone secretion.[10]

Growth hormone is one of the major factors that increases muscle mass. Adolescents and young adults who are involved in strength training and body building programs may consume oral arginine to promote growth hormone secretion. Large doses of oral arginine can cause significant gastrointestinal adverse effects. Oral arginine has not been shown to increase growth hormone levels, and there is no evidence that oral arginine improves sport performance.[4,8-10]

*Branched chain amino acids*

Leucine, isoleucine, and valine are branched chain amino acids (BCAAs) promoted to improve athletic performance. Increased serotonin in the brain is believed to contribute to fatigue. It is believed that BCAAs block central receptors and prevent the release of serotonin, thereby postponing the onset of fatigue.[4] This central fatigue theory forms the basis for the taking of BCAAs by athletes with the hope of improving long-term endurance performance. There is only limited evidence to support the role of BCAAs in improving overall endurance or sports performance, though no significant side effects have been reported with use of BCAAs.

*Glutamine*

Glutamine is a non-essential amino acid, most abundant in muscle and plasma.[2,4] Generally endogenous production equals 50-120 grams per day. Almonds, soybeans and peanuts are good sources of glutamine. Glutamine is a very popular supplement and has been claimed to have a number of positive effects including: sparing of intramuscular glutamine proteolysis, enhancing gastrointestinal and immune function, releasing of growth hormone, increasing lean body mass as well as strength, and prevention of overtraining syndrome.[2,4,11] Evidence supporting these claims is marginal and equivocal at best. Limited evidence shows some improvement in high intensity resistance training effects.[11] No serious side effects have been reported with glutamine use.

## Androstenedione

Androstenedione is a prohormone and a precursor of testosterone while dehydroandrosterone (DHEA) similarly is a precursor of testosterone. Taken orally, these supplements are believed to promote endogenous secretion of testosterone, thereby leading to increased muscle mass and strength associated with resistance training.[2,4,12,13] Typical doses taken by athletes reported in various studies are in the range of 50-100 mg per day for DHEA and 100-300 mg/d for androstenedione.[4,13,14] The increase in serum testosterone level is transient at best, and there is an associated increase in estrogen as well. Most studies do not find increased muscle mass, increased levels of testosterone or improved sport performance in those who take DHEA or androstenedione supplements.[13-17] One study reported increased serum levels of testosterone in healthy young men following ingestion of 300 mg/d of androstenedione.[18] It is likely that high dosages of DHEA and androstenedione may be associated with serious and long-term side effects similar to that reported with anabolic steroids.[2,4,14]

## Antioxidants

Vitamin C, vitamin E, beta-carotene, copper, magnesium, selenium, and zinc are well known antioxidants. Studies suggest that exercise-induced oxidative stress leads to increased free radicals and lipid peroxidation with resultant subcellular damage.[19,20] Regular training and conditioning mitigate the damage associated with free radicals and lipid peroxidation by promoting increased levels of superoxide dismutase and catalase.[4,19,20] Some studies suggest an increased need for antioxidants in those athletes engaged in intensive training regimens. Evidence is emerging that antioxidants may have subtle effects on the exercise adaptive process. For example, antioxidants may facilitate recovery after intensive training and allow increased

volume of exercise.[20] Consumption of daily recommended doses of antioxidants (such as vitamin C, vitamin E, and beta carotene) appears to be safe.

### Beta-hydroxy beta-methylbutyrate (HMB)

HMB is a metabolite of leucine found in citrus fruits and cat fish. It is not considered an essential nutrient and typical doses reported in athletes taking it in the hope of enhancing their sports performance are 2 to 3 grams a day. HMB is believed to increase muscle mass, decrease protein breakdown, and enhance the repair process following intense resistance training.[2,4] Some evidence suggests enhanced effects of resistance training associated with HMB.[2,4] There is no evidence of serious side effects resulting from HMB ingestion.

### Chrysin

Chrysin, an ingredient of many supplements, is 5,7-dihydroxy-flavone derived from *Passiflora coerulea*. It is promoted as an anti-aromatase agent and as such used for its anabolic effects.[21,22] Chrysin is a partial agonist of central benzodiazepine receptors and thus exhibits anxiolytic and anticonvulsant effects.[22] Chrysin has not been shown to increase testosterone levels in males and there is no conclusive evidence of its effects in improving athletic performance. Also, there are no reports of serious side effects associated with its use.

### Conjugated Linoleic Acid[23-27]

Conjugate linoleic acid (CLA) is a mixture of positional and geometric isomers of linoleic acid.[23] Heat-treated cheese, milk, yogurt, beef, and venison are good natural sources of CLA. CLA is advertised to have antioxidant as well as anti-catabolic effects and promoted to reduce body fat, increase lean body mass, enhance bone mineral density, and enhance immune function.[23-27] None of these claims have been substantiated.

### Creatine[28-32]

Creatine remains the most popular supplement among all levels of athletes. Creatine is synthesized in the liver, pancreas, and kidneys from arginine, glycine, and methionine; fish, meat, and milk are good natural sources of creatine. Daily turnover of creatine is 2 grams and ninety-five percent of creatine is stored in the skeletal muscles.

Athletes use this substance in attempts to enhance their sports performance. A typical plan in this regard is to take 5 g four times per day for the first 7 days, followed by 2-5 g daily as maintenance dose; some athletes take 15-25 g/d for 1-3 months.[3,32] Creatine uptake is enhanced when taken with glucose while caffeine antagonizes its effects. Greatest uptake is noted during the first 4 days of supplement use.

Creatine has been shown to improve short-term, intermittent high intensity activity.[31,32] It supplies phosphocreatine that generates ATP needed for immediate energy.[8,32] Thus, it is taken especially by those engaged in such activities as weight lifting, body building, football, hockey, track and field, wrestling, swimming and baseball. These sports-enhancing effects of creatine only occur in association with regular resistance training of increasing intensity and frequency.[29,31,32] Taken with regular training, creatine leads to increased muscle mass, strength and power output. Such gains are maintained for more than a month after creatine has been discontinued. Creatine ingestion is associated with faster recovery and thus allows increased volume of training as well.

In general, typical use of creatine by otherwise healthy young athletes has not been associated with serious side effects.[30,31] However, there are case reports of renal function impairment, cardiomyopathy, and hypertension associated with creatine use. Weight gain (2-4 pounds per week), muscle cramps, and predisposition to heat illness associated with dehydration are known side effects of creatine.[3,4,30,32] No studies have been done in adolescents, and effects of long-term

continuous use are not known. Its use by young athletes is strongly discouraged by major sports organizations.[32]

### Ephedra and Ephedrine[33-35]

Ephedra and ephedrine are ingredients present in numerous weight loss and energy supplements. Because of recent reports of sudden death, myocardial infarction, cardiac arrhythmias, hemorrhagic stroke, and seizures linked to ephedra and ephedrine containing products, the United States Food and Drug Administration (FDA) has banned its sale in over-the-counter supplements. It is likely that many individuals consume large doses of ephedra products contributing to serious consequences. There is an increased risk for psychosis, irritability, anxiety, insomnia, headaches and gastrointestinal symptoms with the use of ephedrine products.

A recent meta-analysis reported that evidence was insufficient to support its performance enhancing effects in sports.[35] The same report found sufficient evidence of its effectiveness in promoting modest weight loss of 3-4 pounds per month when taken in the dose of 20 mg per day. This effectiveness was significantly enhanced when used with caffeine. Some recent evidence suggests that a combination of ephedrine, caffeine and aspirin was associated with improved endurance, increased energy level, decreased fatigue and decreased fat mass. [34] However, major sports organizations have banned the use of ephedra and ephedrine products by athletes because of their association with uncommon, but serious side effects.

### *Garcinia Cambogia*[36-38]

*G. cambogia* is an ingredient in many weight loss products and is promoted as an antiobesity supplement; Hydroxycitric acid is the active ingredient. Hydroxycitric acid is promoted to act by suppression of hunger, though there are no studies to show such an effect. At present, data is weak to support any effectiveness as a weight loss agent.

### Minerals

*Chromium picolinate*[2,4,39]

Chromium is an essential trace mineral and its ESADDI (Estimated Safe and Adequate Daily Dietary Intake) is 50-200 mcg.[4] Mushrooms, prunes, nuts, whole grains, bread, cereal, brewer's yeast, asparagus, wine and beer are natural sources of chromium. There is an increased loss of chromium in urine associated with intense exercise and some studies suggest there may be an increased need for this mineral in endurance training.[2,4,39] It is claimed that the use of supplemental chromium picolinate increases lean mass and decrease fat; however, evidence for such effects is lacking and there is no evidence that chromium ingestion actually improves athletic performance. Potential toxicities of chromium supplementation include impaired iron and zinc metabolism, interstitial nephritis, chromosomal damage, and gastrointestinal intolerance.[2,39]

*Vanadium*[40-42]

Vanadium is a non-essential trace mineral with a postulated daily requirement of 10 mcg. No human deficiency state has been recognized and good natural sources of vanadium include mushrooms, shellfish, and parsley. It is believed to have an insulin-like anabolic effect promoting amino acid uptake and protein synthesis. Though it is marketed as a muscle builder, oral vanadyl sulfate has not been shown to increase lean body mass nor decrease fat mass.[41] Studies report typical use in the range of 60 mg per day for up to 3 months. It is associated with gastrointestinal side effects and its ergogenicity remains unsubstantiated.

### Protein

Protein is a normal part of a healthy, well-balanced diet and it is recommended that 15% of daily caloric intake should be from protein.

It appears that there is an increased need for protein in those engaged in intense resistance or endurance training. Increased protein utilization during resistance training may lead to negative nitrogen balance, while protein is utilized for increased energy needs during endurance training.[8,43] Athletes typically need 1.5 -2.0 g/kg/d of protein and no benefit has been shown with ingestion of more than 2 g/kg/d of protein.[2] No serious side effects have been noted in otherwise healthy persons with normal kidney function taking excess protein.

Emerging evidence suggests that protein consumption may be beneficial in improving exercise performance. The advantages of the numerous commercial protein products that are now available include better bioavailability, convenience of preparation, storage, long shelf life, and the fact that there is no added volume to food as well as no addition of fat. There are 2 types of protein, whey (fast) and casein (slow). Whey protein ingestion results in a rapid, though transient (1-2 h) peak in serum amino acid, while ingestion of casein leads to a prolonged (7h), modest increase in amino acid peak.[8]

Studies have shown that timing of protein ingestion in relation to exercise activity influences its overall utilization and effectiveness.[8,43] It is recommended that for optimal effectiveness, protein consumption occur immediately before and soon after resistance training as well as soon after aerobic activity. Protein ingestion up to the limit of 2 g/kg/d has been shown to be associated with enhanced muscle growth, improved endurance and improved athletic performance.[8-10,43]

### *Tribulus Terrestris*[44]

*T. terrestris* is an herbal product containing steroidal glycosides and saponins. It is believed to increase endogenous secretion of luteinizing hormone and testosterone. It is claimed to induce diuresis, enhance mood, and improve libido. Tribulus supplementation has not been shown to enhance body composition or exercise performance in resistance trained athletes. Its effects as an ergogenic agent in sports remain unsubstantiated. Animal studies have noted phototoxicity, cytotoxocity, neurotoxicity, and hepatotoxicity.[2]

## Conclusion

Prevalence of nutritional supplement use remains high among youth whether or not they are engaged in sports participation. The practicing clinician should routinely inquire which type of supplements the adolescent patient is using and provide currently available information in order for the adolescent and his or her family to make an informed decision about these products. The supplements are not regulated by the FDA and are legally available. Many of the ingredients contained in various products and their potential risks are largely unknown. Recent evidence on commonly consumed supplements such as protein, ephedrine, and creatine should be appropriately discussed with adolescents and young adults. Anticipatory guidance should include the considerable cost of these supplements and the impurities that they may contain.

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***Editor's Note:** Ref. 6 (Patel DR, et al. *Int Pediatr* 2005;20: in press) can be viewed on the Journal's website at www.int-pediatrics.org.

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**March 2005**

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### Nutritional Supplement Use By Young Athletes: An Update.

Donald E. Greydanus, Dilip R. Patel. *Int Pediatr* 2005;20(1)15-24.

### QUESTIONS

1. **The most popular nutritional supplement used by young athletes is:**
   a. Arginine
   b. Creatine monohydrate
   c. Androsteinedione
   d. Dehydroepiandrosterone
   e. Anabolic-androgenic steroids

2. **Central fatigue theory forms the basis for using:**
   a. Arginine
   b. Leucine
   c. Glutamine
   d. Creatine
   e. Chrysin

3. **Evidence suggests enhancement in short term, high intensity, intermittent activity with use of:**
   a. Glutamine
   b. Androsteinedione
   c. Creatine monohydrate
   d. Branched chain aminoacids
   e. Conjugated linoleic acid

4. **There is sufficient evidence to suggest that ephedrine:**
   a. Is effective in enhancing sports performance
   b. Can promote modest weight loss over a short period of time
   c. Improves symptoms of anxiety
   d. Is widely available as an over the counter supplement
   e. Has not been associated with serious side effects

5. **With regard to protein supplements studies suggest that:**
   a. Athletes need more than 2 gram/ kg per day of protein
   b. Serious impairment of renal function even in healthy persons with normal kidneys
   c. Timing of consumption in relation to exercise session is important for optimal utilization and effectiveness
   d. Various protein drinks are more effective than protein bars
   e. Individual amino acids are more effective than protein in enhancing sports performance.

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