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National Athletic Trainers' Association Position Statement: Evaluation of Dietary Supplements for Athlete Safety and Performance

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Objectives: To (1) support athletic trainers (ATs) as they help athletes and other active individuals navigate dietary supplement use while prioritizing health, safety, legality, performance, and a food-first but not always food-only approach and (2) ensure that ATs have the reliable resources they need to provide general education and evaluate the use of dietary supplements.

Background: While the market continues to expand, the quality of dietary supplements worldwide is poorly regulated. At the same time, many active individuals report consuming multiple dietary supplements to improve health or performance or both. Athletic trainers are well positioned to proactively educate athletes on concerns that arise with taking dietary supplements. In many cases, the AT is the first health care professional asked to review the safety, effectiveness, and legality of a dietary supplement that an athlete is consuming. Our mission with this position statement is to provide ATs with the tools and resources needed to educate tactical operators and tactical athletes and to know when to refer the individual to a Sports Registered Dietitian Nutritionist and Board-Certified Specialist in Sports Dietetics.

Recommendations: An individual's overall dietary pattern and habits should be considered first, but we encourage a food-first but not always food-only approach to dietary supplement education and review. The AT should use reliable resources to understand the risks and benefits of using dietary supplements.

Key Words: Dietary Supplement Health and Education Act, ergogenics, World Anti-Doping Agency

Dietary supplement use is widespread among athletes, with approximately 40% of recreational athletes in the United States reporting use and up to 100% of elite and professional athletes reporting use worldwide.[1,2] Meanwhile, the global dietary supplement market, which was valued at $203.5 billion in 2024, is expected to reach $435.4 billion by 2034.[3] The US Food and Drug Administration (FDA) has estimated that 50 000 to 80 000 dietary supplement products were available on the US market.[4] The population athletic trainers (ATs) serve likely uses a wide variety of dietary supplements, and some may use multiple dietary supplements at the same time.[1,5] Given this information and the amount of time ATs spend with active individuals, ATs may be engaging in frequent conversations about dietary supplements. Although ATs practice globally, the resources and examples in this paper focus on evaluating dietary supplements for health, safety, and performance in the United States. However, because athletes can easily obtain supplements from international sources online, ATs should be prepared to consult additional resources to appropriately evaluate products originating outside the United States.

Dietary supplements and sports foods can be marketed in the United States under either nutrition or supplement facts labels. Dietary supplements are not required to be approved by the FDA before they are sold, and as such, the responsibility for product safety lies with the manufacturing party.[6] Use of dietary supplements involves the risk of unintentionally consuming a substance that may harm one's health or lead to a positive drug test, which can compromise a reputation or cause a loss of financial support.[7] Even though the consumption of dietary supplements carries inherent risks, we do not advocate for discouraging the use of evidence-based supplements that are considered to pose a

minimal risk of contamination. The food-first but not always food-only philosophy (brought forward by Close et al in 2022) acknowledges that, in certain situations, a dietary supplement may be in the best interest of health and performance.[8]

In this position statement, we focus specifically on athletes rather than patients or generally active individuals. For this statement, we define *athletes* as individuals who engage in structured training, competition, or performance activities. This includes traditional sport athletes (eg, collegiate, professional, Olympic), tactical athletes (eg, military, law enforcement, fire fighters), and performance athletes (eg, dancers and performing artists) whose training demands and performance outcomes are comparable with those of competitive sport athletes. When working with recreational exercisers or general fitness patients, ATs should use their clinical judgment to discern which principles in this position statement apply.

Athletic trainers may encounter questions regarding dietary supplements during preparticipation physical examinations, assessments, and routine performance improvement conversations. Therefore, ATs are well positioned to mitigate health, performance, and eligibility risks. This position statement will help ATs navigate conversations and look critically at product labeling and evidence to determine if a dietary supplement is safe, effective, and legal for the athlete's sport based on the prohibited substance list.

RECOMMENDATIONS

The following recommendations were developed as a consensus by the author group, which consisted of experts in performance and clinical nutrition, ergogenic nutritional supplement research, supplement safety, or antidoping. A comprehensive review of the literature on performance nutrition and dietary supplements led to the recommendations. These recommendations are grounded in strong evidence and include supplements that have demonstrated performance-enhancing effects, supported by sufficient data and positive findings from meta-analysis. We categorized the studies and literature using the Strength of Recommendation Taxonomy (SORT) developed by the American Academy of Family Physicians, as adopted by the National Athletic Trainers' Association (NATA).[9,10] The taxonomy grades the quality of the data from the literature (level of evidence) and provides strength ratings for the suggested recommendations with the letter A, B, or C.

This position statement is based on research and literature regarding the evaluation of dietary supplements available at the time of writing; therefore, most of the recommendations reflect studies in adults. As such, our aim is for this information to be generalizable to adult populations. Generalization to children and adolescents should be cautious, as recommendations for these age groups may differ from those for the adult athletic and active populations. For clarity and readability, the term *athletes* will be used to refer broadly to both competitive athletes and other active individuals, such as tactical operators and tactical athletes in a fit or patient capacity. The following recommendations are expert consensus derived and designed to guide ATs as they navigate decisions about dietary supplements.

Recommendations

(1) Athletic trainers should communicate to athletes that modifying and optimizing their fueling pattern can result in performance-related improvements.[11–15] Evidence Category: A

(2) Athletic trainers should inform athletes that dietary supplements carry a risk of contamination or adulteration that may result in a positive doping test.[6,16–18] Evidence Category: A

(3) Athletic trainers should advise against supplementation that goes above the tolerable upper intake level, as defined by the National Institutes of Health, as this level of intake can result in side effects or toxic responses.[19,20] Evidence Category: A

(4) Although nutritional supplements may help to complement the diet, ATs should emphasize overall food intake and fueling patterns needed to support health and performance goals.[8,11,21] Evidence Category: C

(5) The AT should be knowledgeable about the basics of performance nutrition and aware of resources for nutritional information.[22–24] Evidence Category: C

(6) Athletic trainers should be familiar with resources to identify evidence-based nutritional supplements or ingredients that may improve health or performance. An AT who needs support in this area should establish a team that may include a Sports Registered Dietitian Nutritionist (Sports RDN) and other appropriately trained professionals—such as certified strength and conditioning specialists, physicians, and pharmacists with specific education and experience in dietary supplements—according to state licensure laws (where applicable).[11,23,24] Evidence Category: C

(7) Athletic trainers should advise athletes against the practice of megadosing any vitamin or mineral without consultation with a Sports RDN or undergoing evaluation and receiving a prescription from a licensed health care provider. *Megadosing* is the intake of vitamins or minerals in amounts that far exceed recommended or safe levels.[19,20] Evidence Category: C

(8) When temporary reductions in nutrient intake are anticipated at the individual level, ATs may guide athletes in the use of a third-party–tested multivitamin supplement containing approximately 100% of the daily value (DV) for most nutrients. This type of supplement may help support overall nutrition adequacy and reduce risk for deficiency.[11] Evidence Category: C

(9) Due to the limited opportunity to regulate dietary supplements in the United States before they enter the market, ATs should be aware of resources to identify high-risk products (ie, dietary supplements with an increased likelihood of containing banned substances through intentional adulteration, cross-contamination, or inaccurate labeling).[6,25,26] Evidence Category: C

(10) Athletic trainers should educate athletes about the strict liability that is installed in the World Anti-Doping Agency (WADA) code and National Collegiate Athletic Association (NCAA) regulations. This means that athletes themselves are ultimately responsible for the eligibility risks that may result from using dietary supplements.[27,28] Evidence Category: C

(11) Athletic trainers should educate athletes on the likelihood of contamination, adulteration, mislabeling, and inadvertent positive drug tests without proof of third-party testing for banned substances verification.[2,16,29] Evidence Category: C

(12) Athletic trainers, tactical operators, and tactical athletes should know which dietary supplements are legal and illegal according to sport governing bodies.[30,31] Governing bodies such as the United States Olympic & Paralympic Committee, NCAA, National Federation of State High School Associations, and US Department of Defense provide athletes and support personnel with their philosophy and rules regarding dietary supplements. These rules are often comparable with or the same as those listed in the WADA code.[32] Evidence Category: C

(13) If a dietary supplement is recommended by a physician or other health care provider, the athlete and AT should carefully research the safety and regulatory risks of the supplement. In the United States, dietary supplements are not classified as medicines, which limits the possibility of obtaining a Therapeutic Use Exemption (TUE). In rare cases, the use of a prohibited substance in a dietary supplement may warrant a TUE if it is medically necessary to treat a well-documented health condition and all WADA criteria are met.[33] Evidence Category: C

(14) If an athlete experiences an adverse event from taking a dietary supplement, the AT should encourage the individual to report the incident to the FDA through the MedWatch program.[34,35] Evidence Category: C

(15) When an AT is speaking to athletes about dietary supplements, other nutritional concerns (eg, relative energy deficiency in sport, eating disorders, food allergy or intolerance, dietary restrictions, gastrointestinal [GI] problems) may arise. The AT should work with an interprofessional team, including a registered dietitian, to ensure that athletes who would benefit from medical nutrition therapy can receive that care.[24] Evidence Category: C

(16) The list of sports foods and nutritional supplements supported by substantial scientific research is limited.[7,11,21] The following performance supplements may have been investigated sufficiently to permit SORT classifications for ATs:

(a) Sports foods as a source of carbohydrates or protein or both:

(i) When whole foods are impractical for athletes, ATs should recommend sports foods (eg, bars, gels, chews, sports drinks with or without electrolytes) to provide carbohydrates and fluids to support training fuel availability and optimal hydration in line with current recommendations.[11,30,36–40] Evidence Category: A

(ii) Athletic trainers should recommend protein-containing foods or sports foods (eg, bars, powders, ready-to-drink shakes) to help athletes meet daily protein needs. Intake should be distributed across the day to promote muscle recovery and protein synthesis.[11,30,41–46] Evidence Category: A

(b) Micronutrients and other bioactive supplements:

(i) In collaboration with a Sports RDN or physician, ATs may recommend supplementation of micronutrients or ω-3's when a deficiency is identified or dietary intake is likely to be inadequate based on a nutrition assessment by a sports dietitian.[20,47–50] Evidence Category: A

(ii) In conjunction with a Sports RDN or physician, ATs may recommend long-term probiotic supplementation with evidence-supported strains for athletes at high risk of illness to help reduce the frequency, duration, or severity of GI and upper respiratory tract infections.[51,52] Evidence Category: B

(c) Performance supplements:

(i) Athletic trainers may guide athletes in the evidence-based, safe, and strategic use of caffeine to increase the time to exhaustion and improve endurance performance as well as to enhance (isometric) strength, anaerobic power, reaction time, and anaerobic metabolism.[22,53,54] Evidence Category: A

(ii) To increase the ability to resynthesize adenosine triphosphate in the muscle and promote increases in muscle strength and hypertrophy as part of a progressive strength training program, ATs may advise athletes in the evidence-based use of creatine monohydrate.[55–60] Evidence Category: A

(iii) For athletes who are performing high-intensity efforts lasting 30 seconds to 10 minutes, ATs may inform the evidence-based use of β-alanine supplementation. This supplementation may support buffering capacity, delaying the onset of neuromuscular fatigue and improving exercise capacity.[61–64] Evidence Category: B

(iv) Athletic trainers may guide athletes in the evidence-based use of dietary nitrate sources (including beetroot juice) to improve endurance performance and reduce exhaustion over time.[34,65,66] Evidence Category: B

(v) For athletes who are performing short, high-intensity bouts of exercise, ATs may advise regarding the evidence-based use of sodium bicarbonate supplementation. This supplementation may have a buffering effect on the blood and improve the endurance of large and small muscle groups.[7,67,68] Evidence Category: B

BACKGROUND AND LITERATURE REVIEW

What Is a Dietary Supplement?

No single definition of a dietary supplement exists across the global reach of athletics. In the United States, dietary supplements are regulated under the Dietary Supplement Health and Education Act (DSHEA) of 1994. The DSHEA defines a *dietary supplement* as a product meant to supplement the diet that contains ≥1 of the following dietary ingredients: vitamins, minerals, herbs and other botanicals, amino acids, enzymes, live microbials, concentrates, metabolites, constituents, or extracts or a combination of these ingredients.[69]

However, this definition is often considered too narrow for use in athletic populations. The widely accepted definition of dietary supplements in the athletic population was written in a 2018 consensus statement from the International Olympic Committee (IOC): "food, food component, nutrient, or nonfood compound that is purposefully ingested, in addition to the habitually consumed diet, with the aim of achieving a specific health and/or performance benefit."[7(p439)] Note that, unlike the DSHEA, the IOC definition of a dietary supplement includes sports foods and other bioactive substances.

The IOC classifies dietary supplements into 4 categories: functional foods or fortified foods, formulated foods and sports foods, single nutrients and other components of foods or herbals provided in isolated or concentrated forms, and multi-ingredient products containing various combinations of the other forms.[7] These categorizations not only broaden the definition of dietary supplements, but they also ensure that ATs understand where individuals may be obtaining excess, novel, or other dietary ingredients in their fueling patterns. An example is foods fortified with isolated protein ingredients (such as whey or soy protein), such as those found in protein-rich sports foods and beverages.[70] Examples of these food products are protein bars, granola bars, waffle and pancake mixes or premade frozen products, prebottled fruit smoothies, oatmeal, cold cereals, bottled waters, breads, cookies, pasta, and ice cream. These foods can assist with following a fueling pattern that provides an adequate, well-distributed protein intake, which supports muscle recovery and muscle protein synthesis.[41,43,44]

Caffeine is also widely consumed in energy drinks, sodas, gums, and dietary supplements (such as preworkouts).[71] Given the increased popularity of energy drinks with a caffeine content $>$ 80 mg/serving, up to 300 mg/serving, exceeding the recommended upper limit of 200 mg/serving for children and 400 mg/d for adults has become more likely.[72–74] When consuming caffeine from a variety of sources (known and unknown), individuals can unwittingly consume high doses, leading to adverse health and performance effects and, in some cases, a positive drug test. High doses of caffeine (around 9 mg/kg, typically within a 2- to 3-hour window) are associated with negative side effects and may increase the risk of exceeding the NCAA urinary caffeine concentration threshold, which could trigger a positive drug test.[71,75]

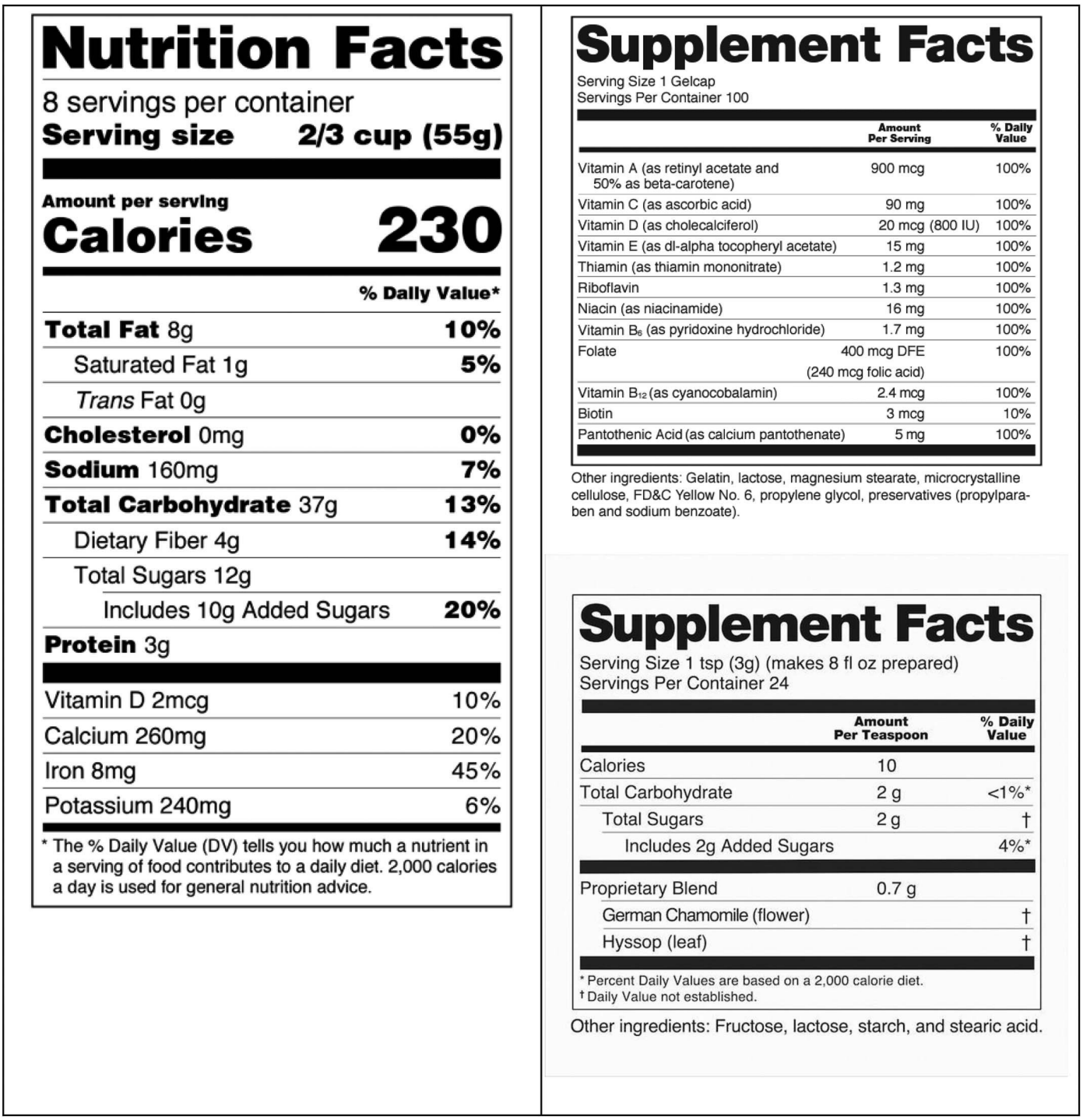
Protein-fortified and caffeine-containing foods and drinks are examples of the increased use of dietary supplement ingredients in the food supply to enhance the nutrient-profile of certain foods due to consumer-driven desires. Athletic trainers must be aware of foods that may help to replace certain dietary supplements as part of a food-first approach and help determine the risks and benefits of using these products.[22] In summary, dietary supplements are products intended to complement the diet. For this position statement, we have adopted the IOC definition of products including fortified or functional foods, isolated nutrients, herbal extracts, and complex multi-ingredient formulations.

How is a Dietary Supplement Labeled?

As mandated by the DSHEA, dietary supplements must provide a supplement facts label, which carries different requirements than a nutrition facts label (Figure 1).[76] Supplement facts labels contain the same components (when present in the supplement) as nutrition facts labels found on foods, plus the added active ingredients.[77,78] Furthermore, a dietary supplement product must be identified as such on the front of the packaging. The types of claims manufacturers can make regarding the effect a dietary supplement may have on health, performance, or a specific disease state are also limited by the DSHEA.[69] Three types of claims may be made on labels: nutrient, health, and structure or function. Products must meet specific guidelines for nutrient and health claims; however, structure or function claims can be misleading. By definition, a *structure or function claim* "describes the role of a nutrient or dietary ingredient intended to affect the structure or function in humans or that characterize the documented mechanism by which a nutrient or dietary ingredient acts to maintain such structure or function, provided that such statements are not disease claims."[79] This broad definition means that almost any claim is legally permissible on a supplement label; therefore, ATs and athletes should review the available scientific literature to confirm claims on a label before recommending or using a product. Any printed claims on the packaging must include the disclaimer, "This statement has not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease."[80] Consumers often assume that, because a supplement is on the market, it is FDA approved, yet this is never the case.[6] We cannot overstate that claims on dietary supplements do not equal evidence. Athletes and ATs should cross-check all claims with peer-reviewed sources.

Extra attention must be paid to identifying dietary supplements and bioactive substances because athletes may use a variety of pills and powders, sports foods, sports drinks, and functional foods to meet the demands of training. Sports foods, sports drinks, and functional foods could carry either a supplement facts or nutrition facts label, depending on whether the product is deemed a dietary supplement or conventional food.[76] The US Federal Food, Drug, and Cosmetic Act does not provide a separate, formal definition of conventional food, but it defines *food* broadly as articles used for food or drink, whereas a supplement falls under the earlier DSHEA definition.[69,81] Quality processes are more likely when a product is labeled with nutrition facts and marketed as a food because the FDA requirements are stricter for foods than for dietary supplements.[6,82] However, when bioactive substances are used in foods (eg, herbal ingredients, protein powders), contamination or adulteration may occur. Foods, supplements, or drugs that are manufactured in the same facility increase the risk for cross-contamination.[82]

Dietary supplements frequently contain *proprietary blends*, defined as mixtures of ingredients listed under a single collective name without disclosure of the individual ingredient amounts.[11,30] This lack of transparency limits the ability of athletes and practitioners to assess safety, effectiveness, and compliance and has been identified as a concern in high-performance sports.[31] Active individuals may use a variety of dietary supplements and sports foods to ensure adequate consumption of calories, protein, carbohydrates, fats, fluids, electrolytes, vitamins, minerals, and other bioactive substances, further complicating the evaluation of dietary supplements for an athletic population. When in doubt, ATs should consider products that athletes bring forward as dietary supplements and review them accordingly.



Nutrition Facts

8 servings per container
Serving size **2/3 cup (55g)**

Amount per serving
Calories **230**

	% Daily Value*
Total Fat 8g	**10%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**13%**
Dietary Fiber 4g	**14%**
Total Sugars 12g	
Includes 10g Added Sugars	**20%**
Protein 3g	
Vitamin D 2mcg	10%
Calcium 260mg	20%
Iron 8mg	45%
Potassium 240mg	6%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Supplement Facts

Serving Size 1 Gelcap
Servings Per Container 100

	Amount Per Serving	% Daily Value
Vitamin A (as retinyl acetate and 50% as beta-carotene)	900 mcg	100%
Vitamin C (as ascorbic acid)	90 mg	100%
Vitamin D (as cholecalciferol)	20 mcg (800 IU)	100%
Vitamin E (as dl-alpha tocopheryl acetate)	15 mg	100%
Thiamin (as thiamin mononitrate)	1.2 mg	100%
Riboflavin	1.3 mg	100%
Niacin (as niacinamide)	16 mg	100%
Vitamin B_6 (as pyridoxine hydrochloride)	1.7 mg	100%
Folate	400 mcg DFE (240 mcg folic acid)	100%
Vitamin B_{12} (as cyanocobalamin)	2.4 mcg	100%
Biotin	3 mcg	10%
Pantothenic Acid (as calcium pantothenate)	5 mg	100%

Other ingredients: Gelatin, lactose, magnesium stearate, microcrystalline cellulose, FD&C Yellow No. 6, propylene glycol, preservatives (propylparaben and sodium benzoate).

Supplement Facts

Serving Size 1 tsp (3g) (makes 8 fl oz prepared)
Servings Per Container 24

	Amount Per Teaspoon	% Daily Value
Calories	10	
Total Carbohydrate	2 g	<1%*
Total Sugars	2 g	†
Includes 2g Added Sugars		4%*
Proprietary Blend	0.7 g	
German Chamomile (flower)		†
Hyssop (leaf)		†

* Percent Daily Values are based on a 2,000 calorie diet.
† Daily Value not established.

Other ingredients: Fructose, lactose, starch, and stearic acid.

Figure 1. **Nutrition facts and 2 dietary supplement facts labels (including 1 label with a proprietary blend).**

The State of Dietary Supplement Regulation

The FDA is tasked with regulating dietary supplement products and dietary ingredients by the DSHEA. The FDA can take action against any misbranded or adulterated dietary supplement only after it has reached the market.[6] If a product is found to be unsafe or noncompliant with the law, the FDA has the authority to ensure that the product either becomes compliant or is removed from the market. Many times, consumers have already purchased and used the product. Postmarket regulation of dietary supplements creates a risky environment for athletes participating in high-level sports and can affect athlete health, well-being, performance, and eligibility.

Some dietary ingredients (such as certain vitamins, minerals, or food-derived substances) may be designated as Generally Recognizable as Safe (GRAS) by the FDA, meaning that they are considered safe for use in food based on a long history of use or expert scientific consensus.[83,84] However, GRAS applies only to individual ingredients, not to entire dietary supplements, and does not ensure that a

Table 1. Resources for Safety, Efficacy, and Regulation Related to Evaluation of Dietary Supplements for Performance Nutrition

Governmental Agencies
US Centers for Disease Control and Prevention: https://www.cdc.gov
US Department of Agriculture: https://www.nutrition.gov/
Dietary supplements: https://www.nutrition.gov/topics/dietary-supplements
US Food & Drug Administration: https://www.fda.gov/
MedWatch: https://www.fda.gov/safety/medwatch-fda-safety-information-and-adverse-event-reporting-program
Center for Drug Evaluation and Research: https://www.fda.gov/about-fda/fda-organization/center-drug-evaluation-and-research-cder
Warning letters: https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/compliance-actions-and-activities/warning-letters
Recalls, market withdrawals, & safety alerts: https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts
Nutrition Affiliates
Academy of Nutrition and Dietetics: https://www.eatright.org/
American Sports and Performance Dietitians Association: https://www.sportsrd.org
Sports and Human Performance Nutrition Dietetic Practice Group: https://www.shpndpg.org/
TrueSport: https://truesport.org/
Sport Organizations
International Olympic Committee: https://olympics.com/ioc
National Association of Intercollegiate Athletics: http://www.naia.org
National Collegiate Athletic Association: https://www.ncaa.org/
National Federation of State High School Associations: http://www.nfhs.org
United States Olympic & Paralympic Committee: https://www.teamusa.org
Anti-Doping Organizations
Athletics Integrity Unit: https://www.athleticsintegrity.org/
Drug Free Sport AXIS: https://axis.drugfreesport.com/login (member login required)
Drug Free Sport International: https://www.drugfreesport.com
International doping tests & management: https://idtm.se/
International Testing Agency: https://ita.sport/
US Anti-Doping Agency: https://www.usada.org/
Global drug reference online: https://www.globaldro.com/Home
Supplement Connect: https://www.usada.org/athletes/substances/supplement-connect/
HealthPro Advantage: https://www.usada.org/resources/healthpro
World Anti-Doping Agency: https://www.wada.org/
Databases and Dietary Supplement Resources
ConsumerLab: https://www.consumerlab.com/
Examine: https://examine.com/
National Institutes of Health Office of Dietary Supplements: https://ods.od.nih.gov/
NatMed: https://naturalmedicines.therapeuticresearch.com/
Operation Supplement Safety: https://www.opss.org/
Resources for Reporting Adverse Effects of Dietary Supplements
Food and Drug Administration Consumer Complaint Coordinators: https://www.fda.gov/safety/report-problem-fda/consumer-complaint-coordinators
The Safety Reporting Portal: www.safetyreporting.hhs.gov

supplement is safe, effective, or free from contamination.[83,84] Athletic trainers should be certain that athletes are aware of the safety concerns surrounding dietary supplement intake and provide the appropriate education. The resources listed in Table 1 can help ATs stay up to date on the safety of dietary supplements.

Understanding the current regulatory environment and dietary supplement industry is important so that practitioners can convey the seriousness of consuming risky products. Because of the vast size of the dietary supplement industry and the projected market growth, the FDA has proposed several amendments to the DSHEA to modernize the act and increase regulatory oversight for the ever-changing and lucrative dietary supplement landscape. These amendments would allow the FDA to know when new products are introduced, quickly identify dangerous or illegal products on the market, and take appropriate action to protect consumers when necessary.[4] At this time, we do not know if these proposed amendments will be approved or when new regulations will be put into place, making it imperative that practitioners understand the current regulatory environment. Resources for staying current with FDA regulations are also available in Table 1.

Preparticipation Physical Evaluation Dietary Supplement Use Screening Questions

Athletic trainers are encouraged to frequently ask and remind athletes to keep them informed of changes in supplement usage as they occur. An AT may consider asking the questions in Table 2 as part of the preparticipation physical evaluation process or as follow-up questions after the evaluation. Questions 1 and 2 in Table 2 are taken directly from the fifth edition of the American Academy of Pediatrics monograph *Preparticipation Physical Evaluation*.[86]

Dietary Supplement Review Process

Few athletes are skilled at navigating the key questions that need to be asked regarding dietary supplement use, which include (1) "Is it safe?" (2) "Is it effective?" and (3) "Does the potential exist for a positive doping test?"[85] This section is intended to help ATs lead athletes through the steps that should be taken when deciding whether to ingest a dietary supplement. The order in which the AT walks through these steps will depend on the athlete's original

Table 2. Potential Questions for Athletes Regarding Dietary Supplement Use for the Preparticipation Physical Evaluation and Follow Up

(1)	Have you ever taken anabolic steroids or used any other performance-enhancing supplement?[85]
(2)	Have you ever taken any supplements to help you gain or lose weight or improve your performance?[85]
(3)	Are you currently taking any dietary supplements? If so, what is (are) the specific brand name(s) and doses?
(4)	Are you using any foods or beverages that may act like a supplement, such as energy drinks or electrolyte replacements? What are the brand names?
(5)	How and when are you taking this (these) product(s)? Are you taking them daily or as needed?
(6)	Did a physician or medical professional prescribe or advise use of this supplement? If not, where did you hear about this (these) product(s)?
(7)	What is (are) the reason(s) for taking this (these) product(s)?
(8)	What effects have you experienced? Any adverse effects?
(9)	Do you have the means and resources to continue to purchase this (these) product(s)?
(10)	Would you be willing to learn about supplementing in a safer and more effective way with lower risk?

question, medical history, health and performance goals, and level of knowledge. The AT should consider individuals' health and performance goals and how their diet and dietary supplement behavior do or do not align with those goals. The AT should also help the athlete determine if a dietary supplement is safe, effective, and legal (ie, permitted) for the athlete's sport.

Understand the Individual's Motivation for Supplementation

An athlete asking an AT about taking a supplement presents an opportunity to discuss supplement interest and use. Many people seek guidance about supplements from unreliable sources and may be unaware of the dangers associated with supplement use.[87,88] Instead of shutting down the conversation and advising against all dietary supplements, the AT should ask the athlete questions to assess the interest in a particular supplement (Table 3). Keeping the lines of communication open and understanding the individual's motivation improves the chances that the AT can educate and guide the athlete toward a nutritional or dietary supplement intervention that is safe, effective, and legal. Because athletes are ultimately responsible for the supplements that go into their bodies, we advise ATs to focus on educating on safe, effective, and legal options instead of recommending that an individual take a specific dietary supplement.

Although ATs can be valuable sources of information, whether athletes view them as their primary source depends on the sport setting, structure of sports medicine support, and presence of specialists such as sports dietitians. For example, in NCAA Division I collegiate athletics, sports dietitians were reported to be the primary source of information for 89% of athletes (n = 410).[89] However, when comparing collegiate divisions, sports dietitians were less frequently reported as primary sources at the Division III level (8.8%) compared with the Division I level (58.1%), and ATs most often filled this gap (51.1%).[90] At the high school level (n = 210), parents were the most prominent influencers (45%), with ATs at 24% and sport dietitians at 8%.[91] A total of 17% of the high school athletes reported being influenced in their supplement behavior by social media posts.[91]

Table 3. Questions to Ask an Athlete Who Inquires About a Dietary Supplement

Assessing the source of information:
How did you learn about this dietary supplement?
Who recommended that you take this dietary supplement?
Assessing the hopeful effect:
Why do you want to take this dietary supplement?
What do you hope this dietary supplement will do for you?
How do you think this dietary supplement will help you reach your goal?

Consider Overall Diet and Lifestyle Factors

Those wishing to use dietary supplements need a basic nutritional assessment of medical history, diet and weight history, and medication use as well as consideration for nutrient and fluid requirements in the context of training schedules.[92] Additionally, sleep, hydration, and work-rest balance should be considered. Athletic trainers are well positioned to provide education about a fueling pattern that supports athletic performance.[93] A *fueling pattern* refers to the habitual intake of foods and fluids, including the quantity, quality, and timing of energy and nutrient consumption relative to training and recovery demands. For valuable resources on general nutrition principles, see Table 1.

If a more detailed nutrition assessment is indicated based on medical history, injury status, allergy or intolerance, eating disorder or other condition for which medical nutrition therapy is needed, or when more detailed performance nutritional advice is warranted, referral to a Sports RDN is advisable. A Sports RDN will consider the various factors affecting an athlete's nutritional needs (including age, sex, stage of physical maturity, sport, intensity and duration of training, dietary restrictions, personal and cultural preferences, access to food, and, for example, the interactions among medication, the diet, and dietary supplements) and develop an appropriate plan of care.[92,94] After assessing the diet, the Sports RDN may recommend more comprehensive diagnostic testing to determine the proper supplementation and dosage as well as steps for monitoring and evaluating the dietary supplement intervention.[92] These may include biochemical evaluations, such as bloodwork and urinalysis. Athletic trainers can find a Sports RDN in their area by using online resources and directories from organizations such as the American Sports & Performance Dietitians Association (https://sportsrd.org) and the Sports and Human Performance Nutrition practice group of the Academy of Nutrition and Dietetics (https://community.eatrightpro.org/shpn/home).

In certain instances, an AT, Sports RDN, or health care provider may determine whether the use of a dietary supplement is in the best interest of an athlete's health and performance. The traditional point of view of Sports RDNs has been to advocate for a food-first approach to meet nutrient needs, but in some cases, food alone may be inadequate.[8,11] Close et al identified several reasons why a food-first approach does not indicate that only food should be recommended. Some nutrients, such as vitamin D, are limited in

the food supply, making it difficult to meet needs without excessive intake of particular foods.[47] Access to desirable, nutrient-dense foods may be limited for some athletes due to personal preferences, physical access, and financial constraints.[8] Deficiencies of common nutrients, such as iron, may require dosages too large to be supplied in the diet.[88,95] Also, the timing of nutrient intake is critical to optimizing performance. For example, an athlete may be trying to consume a significant amount of carbohydrates in the hours before a competition.[11] In some situations, consumption of a supplemental nutrient may be easier and more convenient in the proper time frame.

A frequent scenario is an athlete who tells the AT about finishing practice at 5 PM but, because of classroom or study obligations, is unable to eat a meal until 8 PM and is therefore looking to supplement with a protein powder. If the AT and athlete determine that eating or drinking protein-rich food to promote muscle recovery is not feasible, the AT can guide the athlete to choose a lower-risk, third-party–certified protein powder. Protein powders are among the supplements athletes use the most.[5,96] These powders are often perceived as superior to food and can be a safe, effective replacement for regular protein from food to optimize muscle protein synthesis or recovery or both.[97] Athletic trainers are encouraged to review the supplement to ensure that it is low risk (ie, safe), effective, and legal for the sport.

Evaluating Product Safety Regarding Banned Substances

"Is it safe?" is one of the most important questions that should be asked about dietary supplements.[85] Practitioners may be challenged to encourage safe practices around supplementation while also assisting those who wish to pursue evidence-based supplementation. Athletic trainers should share the studies in this section to illustrate the risk and lack of safety surrounding dietary supplements. Next, ATs should educate on how third-party testing of dietary supplements mitigates health, safety, and eligibility risks. Despite common belief, dietary supplements can come with high risks to health, safety, and eligibility. It is important to recognize that supplements are ingested at the athlete's risk.[28,32]

Dietary supplements can be contaminated, adulterated, and mislabeled. The consumer never knows which supplement contains substances that can lead to a positive doping test, so technically, all supplements can be considered high risk. Dietary supplements and their raw ingredients are manufactured in different countries around the world. Because raw ingredients can go through many different brokers before being incorporated into the final product, there may be sources of contamination or adulteration in the form of exposure to heavy metals, herbicides, pesticides, mold, bacteria, viruses, yeast, or the inclusion of controlled substances and prescription drugs or their analogs.[25] The supplement industry has expanded quickly over the last 20 years, which has resulted in upscaling the production of raw ingredients without proper oversight. Regulatory bodies have not been able to analyze supplements and their raw materials to ensure quality, safety, and purity.[98]

In a 2022 review, approximately 28% of the dietary supplements analyzed contained undeclared substances; the most common were sibutramine, a controlled substance that has been withdrawn from the US market due to cardiovascular risks, and adulterants, with anabolic-androgenic steroids being the most frequent.[99] In a 2015 report, approximately 23 000 US emergency department visits annually were attributed to adverse events related to dietary supplement use. The most consequential adverse events were cardiac symptoms (associated with weight loss and energy products), swallowing problems (such as choking, due to older adults taking large multivitamins), allergic reactions, and GI symptoms.[99] In 2021, the FDA received >2400 adverse event reports related to dietary supplement use, issued 11 warning letters regarding unsafe dietary supplements on the market, and posted 69 public notifications about products that were tainted with undeclared drugs.[34]

Dietary supplements may also be mislabeled when not all ingredients are listed on the label or the listed quantities of ingredients are inaccurate. Recently, authors found that the actual melatonin content of some popular melatonin gummies was 74% to 347% of the labeled quantity, and 88% of these products were inaccurately labeled.[100] Manufacturers of dietary supplements often include ingredient amounts that exceed label claims.[101] Although this is consistent with the FDA Good Manufacturing Practices to ensure that the claimed ingredient amount is valid through the product's expiration date, it is also a cause for concern because individuals may unknowingly consume high doses of active ingredients, which could lead to serious health and safety concerns.[101,102]

Some dietary supplements may be contraindicated or interact with certain medications. After assessing the athlete's full health and nutritional picture, the AT must be able to appropriately educate and guide the athlete pursuing supplementation. For instance, vitamin C use is higher among athletes than among the general US population.[74] A typical vitamin C dietary supplement marketed as boosting immune health or preventing illness usually contains doses around 1000 mg/serving, well above the recommended DV. Vitamin C may also be used to increase iron absorption and improve iron levels in athletes.[103] However, vitamin C may reduce the absorption of certain amphetamine-based attention-deficit/hyperactivity disorder medications (eg, Adderall and Vyvanse [Takeda Pharmaceuticals USA, Inc]) due to acid-base interactions that render the medication less bioavailable. Although this interaction does not affect medications such as methylphenidate (Concerta [Janssen Pharmaceuticals, Inc]), recognizing that common nutrients can influence drug effectiveness is important.[104] Athletic trainers should engage in a comprehensive conversation about athlete health before recommending supplements and, if needed, connect with a Sports RDN or well-trained pharmacist.[105]

The age and maturation of the athlete also need to be considered. Many dietary supplements are marketed toward or for children, yet they have not been adequately tested in pediatric populations to ensure safety, effectiveness, and appropriate dosing. The American Academy of Pediatrics defines *pediatric populations* as up to age 21, with practitioner discretion.[106] Other than specific vitamins and minerals that may need to be supplemented (eg, calcium, vitamin D, iron), many developing athletes do not require ergogenic aids or performance supplements because their growth, development, and training adaptations are promoted with an adequate fueling pattern and a food-first approach.[107]

The Case for Third-Party Testing. In third-party testing of a dietary supplement, a company with no vested interest in the product examines the product chemically to ensure

that the contents and purity of the supplement match the label.[29] Nonetheless, third-party testing does not automatically mean the supplement is free of banned substances in sport. Many third-party certifications focus on the purity of supplements (ie, the absence of heavy metals and allergens), but athletes must be concerned about antidoping rule violations. Reputable third-party testing companies can look for banned substances to lower the risk of using adulterated supplements, providing extra insurance that the tested batch does not contain hidden illegal or accidentally included substances. Organizations differ in their testing practices for banned substances, including the number of banned substances tested for, the amounts of the batches tested, and additional screenings to ensure the quality of the manufacturing process. Although the FDA does not control many aspects of dietary supplements, it does regulate the visual appearance and required components of the labels as well as the manufacturing practices of facilities. The appearance of the term *dietary supplement* on a label should alert an athlete to examine the product for third-party assurances and consult with an AT or Sports RDN (or both) before use.

Given that the FDA does not have the premarket authority to determine if the contents of the supplement match the list on the label, a legitimate third-party certification is helpful for consumers. An athlete who lacks information about what is contained in the dietary supplement cannot have an educated opinion about how it may affect performance or adaptation to sport. An IOC landmark study demonstrated the risk associated with adulteration of muscle-building dietary supplements, as an estimated 1 in 5 "nonsteroidal" supplements purchased from US companies contained steroids.[108] More recently, an examination of the FDA's database of issued warnings from 2007–2016 identified 776 adulterated supplements from 156 companies.[109] Notably, 1 in 5 of those supplements had >1 illegal ingredient. The most tainted supplements are used for sexual enhancement (sildenafil), muscle building (synthetic steroids or mimics), and weight loss (sibutramine).[109] Thus, third-party certification should be seen as a safeguard to prevent the accidental consumption of an illegal substance and ensure the appropriate dosage of the intended active ingredient(s).

Third-party certification can happen at many levels during the manufacturing process. Manufacturers may choose to use only third-party–approved ingredients and have their supplement(s) tested by a reputable testing facility and service. This is an additional cost incurred by the supplement company, which may pass the expense on to customers. A list of frequently used and respected third-party certifications and the stamps that indicate quality assurance are provided in Figure 2.

The third-party testing company and its laboratory credentials must be critically assessed. In 2019, Eichner et al provided their expert opinion that third-party organizations should have appropriate credentials, no conflict of interest with the supplement being tested, and the ability to test for active ingredients as well as potential contaminants. Further, most third-party testing organizations will help to ensure Good Manufacturing Practices, examine the production process, and look for substances banned by the WADA.[29] Third-party testing companies must evolve as guidelines change. Resources for information about the laboratory process and credentials are shown in Figure 2.

There is no shortage of cases to review in which an athlete has unknowingly consumed an illegal substance from a dietary supplement. The website of the US Anti-Doping Agency (USADA) provides several case examples that can be shared with athletes to emphasize the importance of third-party testing.[110] To support product traceability, athletes are advised to retain supplement packaging or record the lot number of any product used. Third-party certification programs should link certification status to specific bottles, batches, or lots to ensure that the batch used by the athlete is covered by certification. Retaining this information may aid verification in the event of a product recall, adverse event, or doping inquiry.[29]

In conclusion, ATs should educate athletes on the likelihood of contamination, adulteration, mislabeling, medication interactions, and inadvertent positive drug tests. Athletic trainers should assist athletes in finding third-party–tested dietary supplements to decrease the risk to safety and eligibility. Further, efforts to influence athlete behavior in the use of third-party–tested supplements may require strategies that extend beyond education alone.[111] For instance, providing appropriate supplements through controlled channels has been shown to reduce the likelihood of antidoping rule violations.[112]

Effectiveness of Nutritional Supplements

Determining the efficacy of a dietary supplement requires a high level of understanding about how to interpret sports- and exercise nutrition–related research. Fortunately, tools have been developed to synthesize the state of the evidence for some dietary supplements. One resource for practitioners is the Australian Institute of Sport (AIS) Sports Supplement Framework. The guiding principles for the framework are

(1) Is it safe?
(2) Is it permitted in sport?
(3) Is there evidence that it 'works'?[89]

The AIS Sports Supplement Framework offers an ABCD classification system for sports foods and performance-based dietary supplement ingredients according to scientific evidence and other practical considerations that determine whether a product is safe, permitted, and effective in improving sports performance.[113] Section D lists products that are on the WADA Prohibited Substances and Methods List, and ATs must compare the supplements their athletes use with the list of substances prohibited by the sport governing body.[114] The AIS Sports Supplement Framework can also be used to quickly identify supplements that may have a performance or health benefit, those with little to no scientific backing, and those that have been banned or have a high risk of being contaminated with banned substances.

Other resources are available in which experts have evaluated the current literature and provided evidence-based manuscripts. An IOC consensus statement on dietary supplements and high-performance athletes was published in 2018.[7] Also worth mentioning is the Supplement Use in Sport Position Statement from the Sports and Exercise Nutrition Register.[115] Additionally, the SORT section at the start of this article refers to specific performance

	BSCG: Banned Substances Control Group Tests specific batches based on the wish of the manufacturer, tests raw ingredients and finished products US focused https://www.bscg.org
	Cologne List Tests specific batches of many of the WADA listed substances Germany, focused on Europe https://www.koelnerliste.com/en/
	HASTA: Human and Supplement Testing Australia Tests specific batches against the WADA list Australia focused https://hasta.org.au/
	Informed Sport Tests each batch against the WADA list Tests raw ingredients and finished products Europe and United Kingdom focused Informed Choice Monthly spot testing (not all batches) of finished products only US focused https://sport.wetestyoutrust.com/
	NSF International Tests each batch against the WADA list and beyond Tests raw ingredients and finished products, verifies label accuracy, and conducts audits of manufacturers US focused https://www.nsfsport.com/index.php
	NZVT: Dutch Safeguards System for Dietary Supplements in Elite Sports Specific batches are tested against the WADA list The Netherlands and Flanders focused (Dutch) https://www.dopingautoriteit.nl/nzvt/nzvt-english

Figure 2. Examples of reputable third-party certification entities testing for banned substances in dietary supplements.

supplements that ATs will likely encounter and that we believe have the strongest evidence.

Dietary supplements commonly used by athletic populations with substantial evidence of effectiveness include carbohydrate and protein sports foods, iron, calcium, vitamin D, probiotics, β-alanine, creatine monohydrate, caffeine, sodium bicarbonate, nitrate, and ω-3 fatty acids. Indications, benefits, populations studied, and recommended dosing for these dietary supplements are supplied in Table 4. Items are listed as macronutrients, micronutrients, and probiotics, followed by ergogenic aids. This order reflects our recommendation to athletes and ATs to prioritize macronutrients and micronutrients as the foundation of performance nutrition.

Finally, several supplements are specifically not recommended, as they have been repeatedly linked to adulteration or inadvertent contamination with substances prohibited by the WADA. Among the high-risk supplement groups are muscle-building or "weight-gainer" formulas and amino acid blends; thermogenic "fat-burners," including but not limited to ephedra; testosterone boosters and stimulant botanicals; multicomponent herbal preparations; and proprietary preworkout blends.[19,134–138] All of these groups warrant caution because of their documented contamination history.

An AT who needs to research a specific dietary supplement that is not addressed in this statement, analyzed in the AIS Sports Supplement Framework, or discussed in the cited consensus and position statements should use Tables 5 and 6 to identify high-quality research and avoid research interpretation pitfalls.

When we evaluate research on dietary supplement efficacy, a clear limitation is that the effect of nutritional supplements on sports performance is seldom investigated in actual competitive events.[139] Given the specific information that is required by some athletes and their support staff to assess the effectiveness of a supplement (eg, related to a targeted event and its conditions, the specific individual, or the combination with other performance strategies), definitive evidence will not always be available.[7] To draw firm conclusions, the AT should use meta-analyses that contain a large number of participants and data from different laboratories.[140] Examples of these meta-analyses can be found in Table 4.

Is the Dietary Supplement Legal for Sport?

Athletes are subject to doping testing for the use of prohibited substances and prohibited methods by their sports organizations to ensure that the playing field is as equal as possible for all participants while protecting player health. The terms *prohibited substance* and *prohibited method* derive from the United Nations Educational, Scientific and Culture Organization Convention against Doping in Sport, a treaty ratified by the US Senate and, as such, part of US federal law, and agreed to by countries around the world.[141] The Convention identifies the WADA code as the source for these terms. The code's prohibited substance list therefore has legal force.[32] Athletes, health care professionals, and support personnel (parents, coaches, administrators, etc) should contact their sport organizations regarding substances and methods that are banned or restricted and their sanctions in light of antidoping rule violations.[28,75,142,143]

Sport governing bodies do not prohibit athletes from using dietary supplements. However, they warn athletes of the doping and health risks associated with taking dietary supplements. Athletes who are eligible for drug testing should take note and be aware that they are strictly liable for any substance found in their sample, even if it is unintentional from a contaminated dietary supplement. Drug-tested athletes are advised to use only third-party–verified dietary supplements because of the complex, challenging, and evolving regulatory concerns related to specific sports.

For the AT, the USADA offers an online education resource, HealthPro Advantage: Anti-Doping Education for the Health Professional, that addresses the roles and responsibilities of health care professionals working with athletes according to the WADA code.[144] HealthPro Advantage covers topics that are relevant to ATs, including the WADA Prohibited List, TUE form, collection procedures, and antidoping rule violations. The educational unit is offered through the Stanford University Continuing Medical Education portal and linked to the USADA page. All health care providers should comply with WADA code guidelines.

The legality of dietary supplements must be questioned and evaluated. Normally, when a supplement is recommended by a physician or health care provider, the athlete and AT should carefully research the safety and regulatory risks of the supplement. In the United States, dietary supplements are not classified as medicine, which limits the possibility of obtaining a TUE. This can lead to conflicts with WADA regulations because some substances that are legally sold as dietary supplements in the United States—such as dehydroepiandrosterone, a steroid hormone precursor—are on the WADA Prohibited List. In rare cases, the use of a prohibited substance found in a dietary supplement may warrant a TUE if it is medically necessary to treat a well-documented health condition and meets all WADA criteria.[33] Supplement advice should preferably be obtained from a Sports RDN or a well-informed, trusted health care provider. Specifically, when multiple health professionals work with an athlete at the same time, they should confirm compliance with a shared nutritional supplement policy or guidelines. The policy or guidelines could be largely based on information in this position statement.

The AT must adhere to all applicable state and federal laws, such as the Rodchenkov Anti-Doping Act, which outlaws the use of prohibited substances to influence sports competitions.[145] Athletic trainers must also adhere to those standards defined by regulatory boards (ie, federal and state laws, Board of Certification Standards of Professional Practice, NATA Code of Ethics).[146,147] Health care providers must ensure compliance with anti-doping regulations for those athletes who compete in international, collegiate, or interscholastic sports. Athlete support personnel—including ATs—are ethically and professionally obligated to report suspected antidoping rule violations. Educational efforts should ensure that both support personnel and athletes understand how to report concerns through appropriate channels, such as the USADA or their sport's governing body.

When to Consult the Health Care Team

Normally, Sports RDNs and Board-Certified Specialists in Sports Dietetics (CSSDs) are the preferred nutrition

Table 4. Commonly Used Dietary Supplements in Athletic Populations With Substantial Efficacy Evidence **Continued on Next page**

	Indications and Rationale	Benefits
Sports foods: carbohydrate bars, gels confectionary, and sports drinks with or without electrolytes	In some situations, it is impractical for an athlete to consume everyday or normal foods to meet their nutrition goals due to issues around preparation, storage, training schedules, gut comfort, or the challenges of meeting nutrient targets within the available energy budget.[7,21]	Sources of carbohydrate often provide simultaneous fluid and fuel during exercise or postexercise to stimulate rehydration and glycogen resynthesis.[7]
Sports foods: protein bars, powders, and beverages	In some situations, it is impractical for an athlete to meet their protein needs through food alone. Protein sports foods can help athletes achieve positive muscle protein balance (when muscle protein synthesis is greater than muscle protein breakdown), which is necessary for recovery as well as strength and hypertrophy gains.[45,46]	High-quality protein provides (essential) amino acids to support or maximize protein synthesis which may result in optimized recovery, an increase in lean mass, or both.[116]
Omega-3s	Omega-3 fatty acids are 1 of 2 main classifications of polyunsaturated fatty acids. The most notable forms of omega-3 fatty acids are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), known as long-chain omega-3 fatty acids. Omega-3s are known for their anti-inflammatory properties and exerting a positive effect on multiple bodily systems.[117] Moreover, approximately 40% of collegiate athletes had low omega-3 index levels, suggesting supplementation may be necessary to ensure adequate and protective levels of omega-3s.[118]	Omega-3 fatty acids, particularly EPA and DHA, are indicated for athletes to mitigate concussion-related brain injury and support recovery, given their neuroprotective properties.[117,119,120] Evidence may also exist that omega-3 supplementation can enhance endurance capacity and cardiovascular function during aerobic activity, may improve strength when combined with resistance training, decrease subjective measures of muscle soreness, positively affect immune cell responses, and improve sleep quality.[117]
Iron	Iron is an essential trace mineral, meaning that the body cannot produce iron, and humans must obtain it from the diet. Iron is heavily involved in energy metabolism, oxygen transport, cognitive function, and immunity. Those at higher risk of iron deficiency include menstruating athletes, vegans and vegetarians, those training at altitude, and athletes in low energy availability.[95]	Maintaining optimal iron levels avoids the following consequences of iron deficiency: fatigue, suboptimal adaptation to training, and decreased performance.[95]
Calcium	Calcium is especially important for growth, maintenance and repair of bone tissue, regulation of muscle contraction, nerve conduction, and normal blood clotting.[11]	Calcium as a single micronutrient is generally only appropriate for correction of a clinically defined medical issue.[11] Athletes who frequently restrict energy intake, rely on extreme weight loss practices, or eliminate 1 or more food groups from their diet may benefit from micronutrient, such as calcium, supplementation.[121]
Vitamin D	Vitamin D is a fat-soluble vitamin that can be synthesized by the body when it is exposed to ultraviolet B sunlight.[11] Vitamin D regulates calcium and phosphorus absorption and metabolism and plays a key role in maintaining bone health.[11] Vitamin D can be obtained through normal foods such as fatty fish, egg yolks, fortified milk and juice, meat from sun exposed animals, or a supplement.[92] Athletes who live at latitudes >35th parallel or who primarily train and compete indoors are likely at higher risk for vitamin D insufficiency (25[OH]D = 50–75 nmol/L) and deficiency (25[OH]D < 50 nmol/L).[11] Other factors that increase risk for vitamin D insufficiency and deficiency include dark complexion; high body fat content; and training when ultraviolet B exposure is low or blocked by clothing, equipment, or sunscreen lotions.[11]	Vitamin D has a role in mediating muscle metabolic function which may affect athletic performance. Evidence is emerging that vitamin D status is about related to injury prevention and rehabilitation as well as the effect of optimal vitamin D levels on improved neuromuscular function, increased type II muscle fiber size, and reduced inflammation.[11]
Probiotics	Probiotics are live bacteria that are present in some fermented foods and dietary supplements. Probiotics complement normal gut bacteria by enhancing immunity against gastrointestinal (GI) infection.[122]	Authors of studies of active people have shown modest reductions in frequency, severity, or duration of both respiratory and GI illnesses from clinical trials using probiotics.[123] Authors of a systematic review of 70 studies concluded that specific probiotics can provide benefits for people with irritable bowel syndrome and antibiotic-associated diarrhea.[124] Probiotic supplementation may prevent or reduce the symptomology of GI and upper respiratory tract infections in athletes.[52]

Table 4. Continued From Previous Page

	Indications and Rationale	Benefits
β-alanine	β-alanine is a nonessential amino acid and is produced naturally in the body. It aids in the production of muscle carnosine. β-alanine supplementation may increase the concentrations of carnosine in the muscle tissue, which can help buffer the acidic pH levels and delay the onset of fatigue during strenuous exercise and improve exercise capacity, particularly in efforts lasting 30 s to 10 min.[62–64]	Authors of a meta-analysis of over 40 studies showed that β-alanine had a significant effect on exercise performance. Greatest ergogenic effects are seen with an exercise duration of 0.5–10 min. Ergogenic effects seem to be greater in untrained versus trained individuals.[63]
Creatine monohydrate	Creatine supplementation increases muscle creatine. This provides more creatine for phosphocreatine resynthesis which can help produce more adenosine triphosphate to fuel short-term, high-intensity bouts of exercise and repeated bouts of high-intensity exercise.[7,125]	A wide-spread consensus exists in the scientific community that creatine can serve as an effective ergogenic aid in increasing high-intensity exercise capacity.[11,30,126,127] Other researchers continue to investigate creatine's role in affecting recovery and injury rehabilitation, injury prevention, and enhanced tolerance to exercise in the heat.[126]
Caffeine	Caffeine is an adenosine-receptor antagonist. When consumed, caffeine facilitates a cascade of positive effects on performance, including improved focus, alertness, mood and vigilance and reduced rate of perceived exertion.[7,71] The main mechanism of action is within the central and peripheral nervous system, not changes in metabolism or fuel availability.[71]	Caffeine may increase time to exhaustion in running endurance performance as well as improving (isometric) strength, anaerobic power, reaction time, and anaerobic metabolism.[21,54] Enhanced benefits are seen when caffeine is consumed with carbohydrates.[7]
Sodium bicarbonate	Sodium bicarbonate acts as a blood buffer and aids in intracellular pH levels which can have ergogenic effects on sustained high-intensity exercise lasting 30 s to 12 min.[7,128]	Performance improvements have been demonstrated in various combat sports (wrestling, judo, karate, taekwondo), high-intensity cycling, swimming, running, and rowing.[68,128–132]
Nitrate	Taking in exogenous nitrate, most commonly in the form of beetroot juice, can enhance the availability of nitric oxide (NO) in the body. NO is involved in several physiological pathways and can lead to lower blood pressure and enhanced blood flow and improved oxygen transport to tissues as well as glucose delivery for energy and mitochondrial adaptations.[133]	Nitrate supplementation is associated with enhanced exercise capacity, improvements in time to exhaustion, and enhancements in type II muscle fiber function of high-intensity intermittent team sport exercise.[66] It has also been shown to increase power and time to exhaustion.[65] The ergogenic effects of nitrate supplementation seem to be greater in nonathletes and untrained individuals than they are in highly trained athletes, particularly for longer duration tests.

service providers within an interprofessional team regarding safe supplement use, but many sport programs lack direct access to a Sports RDN, and therefore, other health professionals may need to take on this role.[24,148] In these situations, ATs and strength and conditioning coaches may be the preferred points of contact for athletes, given their consistent presence and accessibility in the training environment. When other health professionals speak about dietary supplements, nutritional questions may arise (eg, relative energy deficiency in sport or eating disorder concerns, food allergy or intolerance, dietary restrictions, or GI concerns). Athletic trainers play a critical role in identifying and referring those who need sports nutrition education and services or more in-depth consultation on dietary supplements with a Sports RDN.[24] Recognizing nutritional needs and risks to health is part of Domain I: Risk Reduction, Wellness and Health Literacy (including effective education) as described in the Board of Certification Practice Analysis; thus, ATs are encouraged to pursue continuing education on nutritional topics to help screen and refer athletes when appropriate.[58]

Educational resources are available for allied health care professionals to educate athletes, coaches, and support staff in the areas of dietary supplement safety, efficacy, and regulation as they relate to dietary supplements and drug testing (Table 1).

Table 5. Characteristics of High-Quality Dietary Supplement Research as Part of Peer-Reviewed Publications

- Study design allows for the detection of small but potentially meaningful changes or differences in performance or health outcomes or both.
- Adequate sample size with appropriate participant characteristics (eg, level, training status, type of competition, event) for statistical power and application to high-performance athletes.
- Results should preferably include individual data points, more than the mean difference, and any indication that the potential difference found is meaningful.[131]
- Study conditions mimic real-life competition or training conditions as much as possible, while allowing for standardization of variables that might influence the results, such as pretrial exercise, dietary intake, environmental conditions, and external encouragement or distraction.
- In the study, a well-described supplement protocol is used (preferably including a control or reference group) that defines the specific bioactive substance, dose, and timing of intake, which are likely to optimize any effects.
- Investigators verified supplement use or treatment compliance (or both) with participants.[7]
- The results should be interpreted in the context of meaningful effects for real-life sports while also considering the study limitations.

Table 6. Pitfalls to Avoid When Reviewing Dietary Supplement Research and Publications

- Assuming physiological nutritional supplement claims are well validated. Most supplements lack the scientific evidence to prove the work of a suggested mechanism.
- Assuming that all peer-reviewed studies are of high quality.
- Generalizing the results of a specific study to groups not included in the study (eg, a study performed on recreational male athletes may not translate to elite female athletes).
- Translating animal and cell culture studies to a meaningful effect in athletes.
- Weighing 1 randomized controlled study as if it provides a well-established body of knowledge (eg, based on a systematic review or meta-analysis).
- Assuming the standardized protocol used in an efficacy study (which may result in isolated outcomes) reflects the full range of performance in training or competition.
- Considering that many studies focusing on the efficacy of dietary supplements are funded by the industry. The funding source should be noted, but the study quality, methods, and transparency are more appropriate indicators of credibility.
- Always trusting the interpretation of scientific studies by the media, on the internet, from the food or supplement industry, and by friends, family, or culture.[131]

CONCLUSIONS

Athletic trainers will continue to be on the front lines of helping to determine how to incorporate dietary supplements into their athletes' health and performance plans. Ultimately, the athlete assumes the risk for any ingested dietary supplement, but the AT should be prepared to aid in assessing if the supplements taken (or being considered) are safe, effective, and legal for the sport. The AT should have a referral plan in case of nutritional red flags or various factors that warrant additional care from a Sports RDN or another professional involved in diet-related care of the athlete.

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