

## Revisión

# Use of nutritional supplements in sports: risks, knowledge, and behavioural-related factors

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### Abstract

A large number of recreational and elite athletes use nutritional supplements in hopes of improving performance. These aids can be costly and potentially harmful, and the advertised ergogenic gains are often based on little or no scientific evidence. Due to the lack of regulation of the dietary supplement industry, an abundance of supplement products of dubious value, content, and quality are now available around the world. Many supplement products contain substances that are prohibited in sport or that have been associated with significant morbidity and mortality. For athletes, lack of knowledge or misinformation has been established despite numerous sources of information being available, and the reasons for, and implications of, unsupervised and unrestricted supplement use require further attention. In addition to the necessity of an appropriate regulation of dietary supplements, nutritional education and scientifically sound guidance for athletes is required. Intervention and prevention efforts should be particularly targeted to adolescents.

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### Introduction

Since the time people began to participate in sports competition, nutrition has been perceived as an inte-

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### UTILIZACIÓN DE SUPLEMENTOS NUTRICIONALES EN EL DEPORTE: RIESGOS, INFORMACIÓN Y FACTORES CONDUCTUALES

#### Resumen

Una gran cantidad de deportistas, tanto recreacionales como de elite, utilizan suplementos nutricionales con la esperanza de incrementar el rendimiento. Estas ayudas pueden tener un coste económico elevado y ser potencialmente peligrosas para la salud, basándose muchas veces sus supuestos beneficios en un escaso o nulo apoyo científico. Debido a la falta de regulación de la industria de suplementos nutricionales, existe una enorme cantidad de productos en el mercado que son de valor, contenido y calidad dudosos. Muchos suplementos contienen sustancias prohibidas en el deporte y que se han asociado con morbilidades y mortalidades significativas. A pesar de la gran cantidad de datos disponibles, resulta llamativa la información escasa o errónea por parte de los deportistas y se debe prestar especial atención a las implicaciones de un uso de suplementos no supervisado correctamente. Además de la necesidad de una regulación adecuada, los deportistas deben recibir una correcta educación nutricional y una información sustentada en datos científicos rigurosos. Los esfuerzos de intervención y de prevención han de ser especialmente importantes en los adolescentes.

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*Palabras clave: Suplementos nutricionales. Ergogenia. Deporte. Conducta.*

gral component of physical performance. The progress in understanding of human metabolism and exercise physiology made clear in the last few decades that manipulation of nutrient intake had the potential to positively influence sport performance, resulting in and explosion of products with specific applications to exercising individuals. Today, supplement use is a widespread and accepted practice by athletes, with a high prevalence of use and a large range of different types and brands of products. Global supplement use in athletes is estimated to range from 40 to as high as 88 percent,<sup>1,2</sup> with over thirty

thousand supplements being commercially-available in the USA.<sup>3</sup> More than 3 million people in the USA alone use, or have used, ergogenic supplements,<sup>4</sup> and supplement use is also widespread among athletes at high school and collegiate levels.<sup>5,6</sup>

Aggressive marketing has led millions of recreational and elite athletes to use nutrition supplements in hopes of improving performance. Unfortunately, these aids can be costly and potentially harmful, and the advertised ergogenic gains are often based on little or no scientific evidence. No benefits have been convincingly demonstrated for different aminoacids; some supposed ergogenic supplements, such as chromium picolinate and DHEA have adverse side effects, and the safety of the other products remains in question.<sup>7</sup> In spite of potential risks, the retail sale of dietary supplements is generating in Western countries an enormous expenditure, which is largely the result of aggressive advertising aimed at high school, college, and recreational athletes, all eager for anabolic-steroid-like gains through dietary aids.<sup>8</sup> Nutrition supplements appeal to a large number of consumers willing to pay for alleged benefits that are too good to be true.<sup>9</sup>

The regulation of supplements and sports foods is a contentious area. There is no universal system of regulation of sports foods and supplements, and countries differ in their approach and practice. A dietary supplement is defined in the USA under the Dietary Supplement Health and Education Act of 1994<sup>10</sup> (DSHEA) as a product that is intended to supplement the diet and contains any of the following dietary ingredients: a vitamin, a mineral, an herb or other botanical (excluding tobacco), an amino acid, a dietary substance for use by people to supplement the diet by increasing the total dietary intake, or a concentrate, metabolite, constituent, extract, or combination of any of the above. Furthermore, it must also conform to the following criteria: intended for ingestion in pill, capsule, tablet, powder or liquid form not represented for use as a conventional food or as the sole item of a meal or diet labelled as a "dietary supplement". Therefore, following the DSHEA, the Food and Drug Administration (FDA) regulated dietary supplements as foods, and not as drugs. Supplement manufacturers were not required to prove the safety or effectiveness of their products, and the FDA could take action only after a dietary supplement had been proven harmful.<sup>10</sup> As a result, a new group of products flooded the USA and international market: the "pro-hormones" or compounds including androstenedione, DHEA, 19-norandrostenedione and other metabolites found in the steroid pathways that can be converted in the body to testosterone or the anabolic steroid nandrolone,<sup>11</sup> and which have generated an important polemic in the context of doping and inadvertent doping outcomes. By June 2010, new FDA rules will ensure dietary supplements to comply with current good manufacturing practices, and be manufactured with "controls that result in a consistent product free of contamination, with accurate labelling".<sup>12</sup>

In the European Union, The Food Supplements Directive 2002/46/EC<sup>13</sup> requires that supplements be demonstrated to be safe, both in quantity and quality, and, only those supplements that have been proven to be safe may be sold without prescription. Although to a degree that differs from one member state to the other, there is an established view that food supplements should not be labelled with drug claims but can bear health claims. Under the EU Directive, a so-called "positive list" has been created listing the allowable vitamins, minerals and permitted chemical forms (sources) of these vitamins and minerals that may be used in food supplements and has been widely criticised for its inconsistent inclusion/exclusion criteria and for the costs involved with adding items to the list. The industry in some European countries has opposed the Directive, and the Advocate General subsequently said that the EU's plan to tighten rules on the sale of food supplements should be scrapped, although it was overruled by the European Court, which decided that the Directive was necessary and appropriate to protect public health. The Food Standards Agency of the United Kingdom has successfully rebutted the EU's attempt and, by virtue of the derogation in Article 4.6 of the Directive, which permits the continued use of vitamins and minerals not on the "positive lists", the UK supplement market will remain semi-regulated at least until 2009.<sup>14</sup> Unless strong evidence is found for adverse effects, health warnings are therefore not likely to be placed on nutritional supplements.<sup>15</sup> The problem is how to obtain the strong evidence in the absence of rigorous regulation which severely limits the validity of data collected.<sup>16</sup>

The range of products that collectively form the sports supplement industry are described by terms such as "dietary supplements", "ergogenic aids", "therapeutic nutritional supplements" or "sports supplements". They are supposed to provide a known nutrient requirement to optimise training or competition performance (sports drinks or bars, carbohydrate gels), to contain nutrients in large quantities in order to treat a known nutritional deficiency (iron supplements) or to directly enhance performance or maintain/restores health and immune function (creatine, caffeine, ginseng).<sup>17</sup> There is an ever-increasing range of supplements and sports foods that are easily accessible to athletes and coaches. It is of primary importance for the sports nutrition professional to have a thorough working knowledge of the various sports foods and supplements in order to provide sound advice about appropriate situations of use, possible benefits, potential side effects and risks associated with use. The current focus of the sports supplement industry is on compounds and nutrients that act as cofactors, intermediary metabolites or stimulants of key reactions in exercise metabolism, assuming that an extra-charge of the system with additional amounts of these compounds will optimize metabolic and will result in enhanced sports performance. Scientific theories are hyped into persuasive marketing tactics

announcing an amazing “scientific breakthrough”. However, while a scientific theory should be developed in preparation for a study (or to explain the data collected in a study), it cannot be accepted as proof of the efficacy of a supplement until verified by actual research, conducted under a special code of rules and published only after a review process by other scientists. Obviously, this process costs time and money, and most supplement companies don’t invest in this research because they can successfully sell their products to a public who do not appear to demand real proof of their claims. The process of substantiating the performance benefits or outcomes from nutrient supplementation is difficult and has a series of requirements which are rarely accomplished: appropriated subject population, valid and reliable performance tests, use of an appropriate placebo, control of extraneous factors and the test environment that might influence test performance, or maintenance of normal dietary and exercise training habits, use of appropriate statistical techniques to minimise the chance of statistical error.<sup>18</sup> Scientific studies which follow those guidelines have demonstrated that under specific conditions ergogenic aids can have some positive effects on performance, lean body mass, strength and changes in body composition.<sup>19</sup> For some supplements there are sound trials demonstrating efficacy in the laboratory setting but not in the sports setting. Furthermore, most of the research that has been undertaken has failed to support the claims of the majority of nutritional ergogenic aids.<sup>20</sup>

### Risks of nutritional supplements in sports

The absence of compelling regulation has led to considerable variation in concentrations, terminology and combinations of supplements, even within the same country, making it extremely difficult to conduct detailed studies commensurate with pharmaceutical industry type clinical trials. Thus, side effect profiles are yet to be fully elucidated. In any case, information from medical registers<sup>21</sup> shows that while the overall risk to public health from the use of supplements is low, cases of toxicity and side effects include allergic reactions to some products (i.e. royal jelly), overexposure as a result of self-medication and poisoning due to contaminants. During the 1980s, deaths and medical problems resulted from the use of tryptophan supplements;<sup>22</sup> products containing *Ephedra* and caffeine are a more recent source of medical problems, sometimes causing deaths in susceptible individuals.<sup>23</sup> Moreover, the problems of doping in sport and the increasing use of nutritional supplements by athletes are issues that intersect, and there is evidence that some of the apparently legitimate dietary supplements on sale contain ingredients that are not declared on the label but that are prohibited by the doping regulations of the International Olympic Committee and of the World Anti-Doping Agency.<sup>24</sup> These include pro-hormones (ste-

roid-related compounds such as androstenedione, DHEA, 19-norandrostenedione) and stimulants such as ephedrine or related substances. Athletes consuming such supplement products may jeopardize their sporting status, and their health. The principle of strict liability that applies in sport means that innocent ingestion of prohibited substances is not an acceptable excuse, and athletes testing positive are liable to penalties. Although it is undoubtedly the case that some athletes are guilty of deliberate cheating, some positive tests are likely to be the result of inadvertent ingestion of prohibited substances present in otherwise innocuous dietary supplements.<sup>21</sup> In any case, sport practitioners have particular responsibilities in addressing this issue, and athletes need to be aware of the problems that can follow supplement.<sup>25</sup> Athletes should make enquiries at the anti-doping agencies within their countries for advice on the specific risks identified with supplement use, and any initiatives to reduce this risk.<sup>26</sup>

Although there is some evidence of deliberate adulteration of products, presence of undeclared banned products may be the result of contamination or poor labelling within lax manufacturing processes. In a study carried out some years ago,<sup>27</sup> 634 supplements from 215 suppliers in 13 countries were analysed, with products being sourced from retail outlets (91%), the Internet (8%) and telephone sales. Although none of these supplements declared pro-hormones as ingredients, ninety-four of the supplements were found to contain hormones or pro-hormones that were not stated on the product label, and a further 10% of samples provided technical difficulties in analysis such that the absence of hormones could not be guaranteed. Of the “positive” supplements, 68% contained pro-hormones of testosterone, 7% contained pro-hormones of nandrolone, and 25% contained compounds related to both. In relation to the total number of products purchased per country, most of the positive supplements were bought in the Netherlands (26%), in Austria (23%), in the UK (19%) and the USA (19%). According to the label, all positive supplements were from companies located in only five countries: the USA, the Netherlands, the UK, Italy and Germany. More recently, products intentionally faked with high amounts of “classic” anabolic steroids such as metandienone, stanozolol, boldenone, dehydrochloromethyl-testosterone, oxandrolone etc. have been detected on the nutritional supplement market. The sources of these anabolic steroids are probably Chinese pharmaceutical companies, which sell bulk material of anabolic steroids. In the last few years new ‘designer’ steroids such as prostanazol, methasterone, androstatrienedione etc. have been offered on the nutritional supplement market, and in the near future also cross-contaminations with these steroids are expected.<sup>28</sup> Paper-based quality systems are still prone to possible contaminations, which leads to the conclusion that the best possible solution for athletes who wish to use nutritional supplements must include laboratory-based analysis for doping substances, preferably repea-

ted for every new batch. The most important educational message, however, is to use a nutritional supplement only if it is deemed of benefit by a nutritional expert.<sup>29</sup>

An additional risk of reliance on supplements is the displacement of the athlete's real priorities. Long-term training, optimal nutrition, adequate sleep and recovery, state-of-the-art equipment and other factors on which depends a successful performance cannot be replaced by the use of supplements. However, they often appear less exciting or more demanding than claims made for many nutritional supplements. Athletes can sometimes be side-tracked from the true elements of success in search of easy short-cuts from nutrients and drugs. Most sports physicians and dietitians are familiar with individual athletes who fail to address some of the basic elements of good training and lifestyle while are reliant on supplements.<sup>17</sup> The reasons for taking supplements should be further investigated in relation to psychological factors such as blocked or unattainable goals and the extent to which supplement use is perceived as a transitional milestone on the road to becoming a serious athlete.

### **Knowledge and motives for the use of nutritional supplements**

One of the early studies analyzing motives for the use of supplements in sports was carried out by Massad et al in 1995.<sup>30</sup> Factors influencing nutritional supplement use by 509 high school students were assessed by administering The Nutritional Supplement Use and Knowledge Scale. Significant differences between supplement use by gender and sports category were observed, and greater knowledge about supplements was associated with less use, suggesting that education about supplements can be a deterrent to use. Some years later, a survey of 236 university student athletes was conducted to determine supplement use, perceived efficacy of supplements, availability and use of nutrition services, and perceived nutrition knowledge of athletic trainers.<sup>31</sup> Results showed that 88% used one or more nutritional supplements, yet perceived efficacy was moderate. Primary sources of nutrition information were athletic trainers (40%), strength and conditioning coaches (24%), and dietitians (14%). Athletes perceived athletic trainers to have strong nutrition knowledge. Many (24%) did not know whether a dietitian was available, which led to the suggestion that dietitians must accelerate their marketing efforts to student athletes, work closely with athletic trainers to provide sound nutrition information, and provide services that meet the needs of a diverse population of student athletes.

Another survey, conducted to examine the source of information and usage of nutritional supplements in 115 male and 88 female varsity university athletes,<sup>32</sup> found that 89% of the subjects had or were currently

using nutritional supplements. The most frequently used supplements overall were energy drinks (73%), calorie replacement products of all types (61%), multivitamin (47%), creatine (37%), and vitamin C (32%). Many athletes did not consider sports drinks and calorie replacement products as supplements. In this study it was observed that females were more likely to obtain information regarding supplementation from family members, and males from a store nutritionist, fellow athletes, friends, or a coach. Female athletes were more likely to take supplements for their health or because of an inadequate diet, while men reported taking supplements to improve speed and agility, strength and power, or for weight/muscle gain.

The use of the traditional (single and multivitamin/mineral supplements) and non-traditional supplements (herbals, botanicals, and other biologic and nutrient supplements) by female athletes has been investigated in 162 collegiate female varsity athletes.<sup>33</sup> More than half of all athletes used some type of supplement at least once a month (65%). 36% of the sample used a multivitamin and mineral with iron, while 12% reported amino acid/protein supplement use and 17% used an herbal/botanical supplement. The most frequently cited reason for supplement use was "good health" (60%), and a major source of information on supplements reported was family (53%). Reasons for and prevalence of supplement use have also been compared among 247 varsity athletes and 204 nonvarsity (control) athlete Canadian university students.<sup>34</sup> Supplements were used by 99% of varsity athletes and 94% of controls. Varsity men most often reported using sports drinks, and used these (and carbohydrate gels, protein powder, and creatine) more than varsity women. Caffeine products were most often reported by other groups. Health professionals and the Internet were the most reported information sources, while friends most often recommended supplements. Many subjects indicated knowing little about supplements and wanting to learn more.

A recent report<sup>16</sup> provided the first analysis of relationships that exist between supplement use and the rationale for their use in the maintenance of health. The study cohort had access to specialist support staff (e.g. team doctors or nutritionists) to receive medical support for their daily training regime and healthy diet. Survey data collected among high performance British athletes were reanalysed for association between the supplement used and the motives for using such substances for health maintenance. Of the 874 respondents, 60% reported supplement use. In some cases, the motives for use and the supplements used show a great deal of incongruence. This suggested a lack of knowledge or understanding of nutritional supplements' effects, except vitamin C, which was associated, but not strongly with preventing illness. No other supplement pairing with motive for use revealed either a strong or intermediate association. Athletes' responses were also inconsistent regarding medical advice informing sup-

plement use. Thus, many athletes apparently did not take supplements because of medical advice; however, when asking about individuals providing information and advice regarding doping issues, medical practitioners appeared to be the most common information source.

Interest in supplements to treat injury, and sources of supplement information has been recently investigated among 145 college athletes<sup>35</sup> who used athletic training room and weight training facilities. The majority of athletes experienced injury during their college athletic career and a part expressed an interest in supplements for injury treatment. Overall, 17% of participants were interested in supplements to improve circulation, 34% for joint and soft tissue repair, and 22% to reduce inflammation. Males were more likely than females to rely on strength coaches (37% vs 20%) for supplement information. Athletic trainers (71%), coaches (60%), and physicians (41%) were the primary professionals, and the internet (79%), magazines (68%), and television (52%) the most popular sources of media for supplement information. It was concluded that future research should identify if athletes are more likely to increase supplement use when they are injured or if supplement use is more prevalent among athletes who are prone to injury.

### **Behavioural-related factors**

Very few authors have examined the psychological benefits of the use of nutritional supplements in sports. A study reported that the consumption of a carbohydrate-containing drink with the additional ingredients of caffeine, taurine and glucuronolactone enhanced the performance of a battery of tests, including psychomotor traits. Unfortunately, this work did not distinguish the contribution of caffeine, and the authors concluded that the results reflected the effects of the combination of ingredients.<sup>36</sup> There are claims that ginseng supplementation may be valuable for athletic training in producing improved levels of psychomotor performance and wellbeing,<sup>37,38</sup> although other studies found a failure of supplementation to improve psychological function.<sup>39</sup>

An only research has investigated the relationship between preadolescents' use of nutritional ergogenic aids (creatine and amino acids) and gender, age, athletic participation, and sport-relevant psychological factors (i.e., sport success motivation, task and ego orientation, self-efficacy). 2,450 children, aged 11-to 13-years, participated in the study. Because sport practice might either be competitive/performance oriented or educational/recreational in nature, it was hypothesized that an association exists between the use of ergogenic aids and the practice of competitive sport, and that the use of substances increase with adolescents' level of training intensity and level of participation in competitive sports. Results suggested that substance

use increases with age, especially among male preadolescents, and that gender differences are particularly marked among older preadolescents. A high commitment to sport training represented a risk factor of ergogenic supplementation only when it was linked to certain psychological dispositions such as a high ego orientation and a low task orientation.<sup>40</sup> Findings were consistent with previous literature suggesting that high levels of ego orientation tend to predict legal or illegal abuse of ergogenic aids and eating disorders.<sup>41</sup> Moreover, it was observed that a high sense of personal confidence appears to enhance the probability that youngsters who were involved in intensive training would resort to nutritional supplements.<sup>40</sup>

The association between sports participation and the use of legal and illegal substances has been explored by several authors, which have suggested that athletes are at greater risk than non-athletes for their use.<sup>42,43</sup> However, an only study have examined whether this relationship is a lasting one, by analyzing data on approximately 15,000 adolescents from the USA National Longitudinal Study of Adolescent Health.<sup>44</sup> Use of anabolic steroids and legal performance-enhancing dietary supplement use were assessed six years later. Results obtained indicated that males were more likely than females to use anabolic steroids and legal supplements, and differences were greater for those who participated in sports during high school. Moreover, high school sports participation was associated with increased likelihood that adolescents would use legal supplements in young adulthood. An additional interesting finding was the existence of a positive relationship between the use of legal dietary supplements and anabolic steroids use, which confirmed the Gateway Theory.<sup>45</sup> This theory predicts a positive relationship between the use of licit or legal substances and the use of hard or illicit substances, with a developmental trajectory or sequence of substance use, where the use of illicit substances is preceded by the use of licit substances. Results from the study highlight the important role that the social environment during adolescence has on future health behaviours, and suggests that the sporting context experienced during early adolescence may have lasting effects on the use of performance-enhancing substances.

### **Education and intervention programs**

Physicians who deal with athletes should be aware of the supplements being utilized by athletes, the athletes' desired effects and the efficacy of the supplement, the adverse effects, and whether the supplement is banned by leagues or organizations in which the athletes are competing. When working with athletes they need to ask about drug or supplement use. A basic knowledge of ergogenic substances may help to establish rapport with athletes using these agents. Physicians and dietitians should be aware that doses used by athletes are far in excess of the ones reported by the litera-

ture, and that new substances are constantly being introduced.

Adolescents may be at particular risk, because the pressure to win at all costs, extensive coverage in lay publications, and hype from manufacturers with exciting and emotive claims all favour the use of supplements by young athletes.<sup>46</sup> The American Academy of Pediatrics policy statement on the use of performance enhancing substances (2005)<sup>47</sup> condemns the use of ergogenic aids, including various dietary supplements, by children and adolescents. Nutritional campaigns must inform athletes, their parents and their coaches,<sup>48</sup> and a number of studies have demonstrated that effective education programs can reduce adolescents' intentions to use dietary supplements.<sup>7</sup> Moreover, research conducted in various settings has led to the conclusion that coaches are the most influential persons on athletes' behaviour, being perceived as knowledgeable and credible information sources.<sup>49,50</sup> Education in supplement use advice could become a required part of the accreditation process for coaches.<sup>15</sup>

Two widely used intervention programs are ATLAS and ATHENA. Almost one half of male and female students participate in high school-sponsored athletics, and high school also is a time when classroom health promotion curricula are less effective. The ATLAS (Athletes Training and Learning to Avoid Steroids) program is a sport team-centered prevention which targets adolescent male athletes' use of anabolic steroids, human growth hormone, alcohol and other drugs, and use of sport supplements, while improving health nutrition and exercise practices. Seven weekly, 50-minute class sessions delivered by coaches and student team leaders, and seven weight-room sessions taught by research staff have been reported to induce maintained beneficial effects in adolescent football players, demonstrating the potential of team-based interventions to enhance adolescents' health.<sup>51</sup> The more recently developed ATHENA (Athletes Targeting Healthy Exercise and Nutrition Alternatives) program parallels ATLAS in its school-based, team-centered format and the promotion of healthy nutrition and effective exercise training as alternatives to harmful behaviors.<sup>52</sup> However, ATHENA's objectives are to reduce the young female athlete's disordered eating habits and to deter use of body-shaping substances. The scripted, coach-facilitated, peer-led 8-session programme, is incorporated into a team's usual training activities. The ATHENA program has been reported to significantly alter the targeted risk factors and reduced ongoing and new use of diet pills and body-shaping substances (amphetamines, anabolic steroids, and sport supplements). Very recently, it has been reported that the beneficial behavioral outcomes seem to increase over time and were evident following high school graduation.<sup>53</sup> These findings illustrate the utility of a structured process to define curriculum content, and the program's positive results also confirm the sport team's potential as a vehicle to effectively deter health-harming behaviors.

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