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DIETARY SUPPLEMENTS AND SPORTS PERFORMANCE

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Abstract

The use of dietary supplements among athletes has increased significantly in recent years, primarily to enhance performance and gain a competitive advantage. However, the efficacy and safety of these supplements remain widely debated. This review examines current evidence regarding the performance-enhancing potential and health implications of creatine, beta-alanine, and iron, among the most commonly used supplements in sport. A comprehensive literature search was conducted to identify studies evaluating their effects on athletic performance. Findings suggest that, when appropriately used, these supplements can improve exercise capacity by 5-15% and enhance performance outcomes. Nevertheless, variability in individual responses and potential health risks underscore the importance of a cautious and evidence-based approach. Athletes, coaches, and sports organizations are advised to consider the scientific validity and safety of supplementation practices. Consultation with healthcare professionals or registered dietitians is essential to ensure responsible and effective use. Individualized assessment and monitoring are crucial, as athletes' nutritional needs and health status can vary significantly. By adopting a cautious and informed approach, athletes can maximize the benefits of supplementation while protecting their health and minimizing risks. Ultimately, evidence-based practices and professional guidance are key to optimizing performance.

Keywords: Athletes, Creatine, Dietary Supplements, Iron, Sports Performance

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Introduction

Sports nutrition has gained increasing attention in recent decades, and this focus is expected to intensify as dietary intake is fundamental to athletic performance. Nutrition influences nearly every physiological process related to energy production and recovery (Jagim et al., 2023). A particularly important area of inquiry is the role of dietary supplements, often termed ergogenic aids in enhancing performance and health. Supplement manufacturers frequently claim benefits such as improved strength, endurance, and training efficiency (Jagim et al., 2023). While these products may support energy metabolism, body composition, and adequate macronutrient intake, they should complement and not replace a well-balanced diet (Daher et al., 2022).

However, concerns persist due to widespread contamination of supplements with banned substances. Surveys indicate that 14–50% of sports nutrition products contain undeclared anabolic agents or stimulants, thus exposing athletes to inadvertent doping and health risks (Jagim et al., 2023; Daher et al., 2022). Indeed, one-third of tested supplements in Australia contained substances prohibited by WADA, with most unlisted on labels, highlighting the danger to users (The Guardian Australia, 2025). This issue remains critical for elite athletes, who are held strictly liable for any prohibited substances found in their samples, regardless of intent.

Between 60% and 80% of athletes report using dietary supplements, yet many rely on unverified sources and lack professional guidance (Jagim et al., 2023). This practice increases the likelihood of consuming contaminated or potentially harmful products. Furthermore, evidence shows that supplement usage may act as a gateway toward doping, with users displaying stronger pro-doping beliefs and higher doping intentions (Hurst et al., 2023). Accordingly, it is essential for coaches, sports organizations, and medical staff to engage athletes in informed discussions that address medical, physiological, cultural, and ethical dimensions thereby enabling athletes to make safe, evidence-based decisions about supplement use.

Dietary Supplements

Natural health products, commonly referred to as dietary supplements, are naturally occurring substances intended to complement the diet to support or maintain health. These commercially available products include proteins, herbs, botanicals, vitamins, and minerals (Daher et al., 2022). While certain supplements may enhance overall health or reduce the risk of some conditions, they are not universally safe; inappropriate use can cause adverse effects such as organ or nerve damage (Liu et al., 2023).

There is no single, universal scientific definition of dietary supplements, resulting in variability across studies and complicating comparisons (Australian Institute of Sports (AIS), 2022). According to the IOC consensus, supplements are “a food, food component, nutrient, or non-food compound that is purposefully ingested in addition to the habitually consumed diet to achieve a specific health and/or performance benefit” (Maughan et al., 2018). Likewise, the National Institute of Health (NIH) defines dietary supplements as

orally administered products containing one or more dietary ingredients (e.g., vitamins, minerals, botanicals, amino acids) presented in forms such as pills, capsules, powders, or bars, and labeled as dietary supplements (NIH, 2023).

A large-scale scoping review reported that 60–80% of elite athletes use dietary supplements during the year (Daher et al., 2022; Smith & Jones, 2023). The most frequently consumed are multivitamins, minerals, protein powders, creatine, caffeine, and amino acids (Daher et al., 2022). Prevalence varies by sport, gender, and competitive level (Liu et al., 2023). High usage rates and variable regulation elevate risks of contamination, health complications, and inadvertent doping violations as such highlighting the need for professional guidance in supplement use.

1. Creatine

Skeletal muscle contains only a small pool of ATP that is enough above a few seconds of intense contraction and is rapidly regenerated under aerobic conditions via glycogen and lipid metabolism. However, during maximal effort, phosphocreatine (PCr) acts as the primary high-energy phosphate donor, rapidly resynthesizing ATP from ADP via the enzyme creatine kinase, particularly within type II (fast-twitch) fibers.

Creatine monohydrate supplementation increases total intramuscular creatine (free Cr + PCr) by approximately 20%, boosting the muscle's immediate ATP-buffering capacity (Sciencedirect, 2020). The mechanism involves a reversible reaction: $Cr + ATP \rightleftarrows PCr + ADP + H^+$, where PCr donates its phosphoryl group to regenerate ATP during high-energy demand. PCr serves as both a temporal buffer (rapid ATP regeneration) and a spatial shuttle, transporting high-energy phosphates from mitochondria to sites of ATP use in muscle cells. This results in sustained force or power output during high-intensity, short-duration efforts.

Creatine supplementation is particularly valuable in sports requiring explosive power such as sprinting, football, rugby, boxing and weightlifting by enhancing ATP availability and enabling greater training volume (Science Direct, 2020).

Functions of Creatine

Richter (2023), stated that creatine is one of the cheapest, most effective, and safest supplements which support quality of life in older adults, brain health, and exercise performance. Vegetarians who may not obtain enough creatine from their diet and older adults may find supplementing particularly useful. The effects of creatine are noticeable in as little as two weeks, but without a loading phase, it may take up to 4 weeks to observe the effects. According to the Cleveland Clinic (2024), the following are the functions of creatine:

i. **Increase Strength and Power**: Creatine has been shown to increase strength and power, particularly in short-duration, high-intensity activities such as sprinting, weightlifting and jumping.
ii. **Improved Cell Signalling:** It can increase cell signaling, which aids muscle repair and new muscle growth.
iii. **Improved High Intensity Exercise Capacity**: Athletes can perform more repetitions, run faster sprints and sustain peak performance for longer periods.

iv. **Enhance Muscle Mass**: It can lead to a significant increase in muscle mass largely due to improved workout performance and retention in muscles.

v. **Reduce Protein Breakdown:** It may increase total muscle mass by reducing muscle breakdown. In addition to providing more energy and helping to increase muscle growth, creatine helps to speed up muscle recovery, increase anabolic tissue repair which contributes to growth and tissue repairs, boost water retention in muscles and cells and also increase the amount of phosphocreatine in the brain which helps in memory (Cleveland, 2024).

Creatine Supplementation Mechanism of Action

Skeletal muscle contains very little Adenosine Triphosphate (ATP), an amount that can sustain muscle contractions for only a few seconds. Under aerobic conditions, ATP is resynthesised continually from glycogen and triglycerides. During maximal exercise, however, intramuscular creatine phosphate (phosphocreatine [PCr]) provides the high energy phosphoryl groups for ATP resynthesis from ADP. The premise of Creatine supplementation is to increase skeletal muscle concentrations of Creatine though oral ingestion of Creatine monohydrate. During rest, much of the free Cr in skeletal muscle combines with phosphate to form PCr through a reversible reaction catalyzed by the enzyme creatine kinase: creatine kinase Cr + ATP ← → PCr + ADP + H+ Total intramuscular Cr (ie, free Cr + PCr) increases approximately 20% with Cr supplementation. During intense exercise, when the high rate of ATP hydrolysis results in accumulation of ADP and inorganic phosphate in muscle cells, particularly in type II fast-twitch fibers, PCr serves to regenerate ATP from ADP by transferring its high-energy phosphoryl group. This facilitates greater ATP availability to meet the high ATP demand during anaerobic exercise. As a result, force or power may be sustained longer and athletic performance enhanced (Kreider, 2017).

Reaction to Creatine Supplement

Creatine first came to the public's attention in the early 90s, after it was reported that Linford Christie had used it in his training before clinching the 100m gold at the 1992 Barcelona Olympics. Nowadays, it is a staple ingredient for anyone involved in high-intensity sports that require fast and explosive movements, such as sprint events, football, rugby, boxing and weightlifting. Martinez (2024) asserted that creatine is the most commonly used supplement in any level of football. He stated that approximately fifty per cent of all players use creatine in the entire National Football League. According to him, professional athletes who take creatine and also stand behind it are Troy Aikman, Brady Anderson, Michael Johnson, and Chad Curtis. "Michael Johnson claims that creatine helped him win his gold medals, while Curtis claims he gained fifteen pounds from taking the supplement." These athletes are just a small example of professionals who endorse creatine, and their success is a big reason why many younger athletes feel the need to try it (Martinez, 2024)

2. Beta-Alanine

Beta-alanine is a non-essential amino acid that combines with histidine to form carnosine, a dipeptide found in high concentrations in skeletal muscle. Carnosine buffers excess hydrogen ions (H^+), delaying muscle acidosis and fatigue during high-intensity exercise (Rezende et al., 2020; Krings et al., 2021).

Beta-Alanine Supplementation and Performance Enhancement

Supplementing with 4–6.4 g/day of beta-alanine for 4–10 weeks can increase muscle carnosine content by 40–80%, improving performance in activities lasting between 30 seconds and 10 minutes (Krings et al., 2021; Saunders et al., 2017). These effects are particularly useful for sports like boxing, football, rowing, and sprint events that require repeated high-intensity bursts.

Dosage and Timing of Beta-Alanine Supplementation

The recommended dosage of beta-alanine varies depending on the goals of the individual, but research suggests that a daily intake of 3 to 6 grams for several weeks can significantly increase muscle carnosine concentrations (Saunders et al., 2017). It is important to note that beta-alanine supplementation requires a loading phase, as carnosine levels in the muscle take time to build up. A typical supplementation regimen involves consuming beta-alanine for a period of 4 to 10 weeks, after which maintenance doses can be taken to sustain elevated carnosine levels.

One side effect associated with beta-alanine supplementation is a condition known as *paresthesia*, which is a tingling sensation commonly experienced in the skin after ingesting high doses of beta-alanine. While this sensation is harmless, some individuals may find it uncomfortable. To minimize paresthesia, it is recommended to split the daily dose into smaller amounts taken throughout the day (Trexler, Smith-Ryan & Stout, 2015).

Beta-alanine is often combined with other performance-enhancing supplements to maximise its benefits. For example, it is commonly included in pre-workout formulations alongside ingredients such as creatine, caffeine, and nitric oxide boosters. The combination of beta-alanine with creatine, in particular, has been shown to provide synergistic benefits for strength and endurance (Saunders et al., 2017)

Beta-alanine is well-tolerated. The most common side effect is mild paresthesia (tingling), especially at single doses over 0.8 g. Sustained-release formulations can minimize this. Long-term supplementation (up to 24 weeks) at clinical doses shows no harmful health effects (Saunders et al., 2017; Teixeira et al., 2021).

Applications in Various Sports and Populations

Beta-alanine is beneficial across a wide range of sports and physical activities, particularly those that involve anaerobic performance. For endurance athletes, such as runners and cyclists, beta-alanine helps improve time to exhaustion and overall performance by buffering lactic acid buildup (Saunders et al., 2015). In team sports, such as soccer and basketball, where players are required to perform repeated sprints, beta-alanine supplementation has been shown to enhance sprint performance and reduce fatigue during critical phases of competition (Saunders et al., 2015).

Additionally, beta-alanine supplementation is not limited to elite athletes. Research suggests that older adults may also benefit from beta-alanine, as muscle carnosine levels tend to decline with age. A study by Smith-Ryan, Fukuda, Stout and Kendall in 2015, found that beta-alanine supplementation improved physical working capacity and reduced fatigue in elderly participants, highlighting its potential use for improving quality of life in aging populations (Smith et al., 2015)

3. Iron

Iron is vital for transporting oxygen via hemoglobin and myoglobin and is involved in enzymatic activity, DNA synthesis, and energy metabolism. Athletic performance, especially in endurance sports, depends heavily on adequate iron stores. Deficiency impairs muscle function and aerobic capacity.

Dietary iron intake averages around 10–15 mg/day, but only ~10% is typically absorbed; losses occur through epithelial shedding and minor bleeding. In athletes, iron loss is amplified via mechanisms like hemolysis (particularly in runners), sweating, gastrointestinal bleeding, hematuria, and inflammation-induced sequestration.

Iron deficiency affects approximately 15–35% of female athletes and 5–11% of male athletes. Endurance athletes such as cyclists, marathoners, and triathlete are especially susceptible to decreased hemoglobin and iron stores. Risk factors include menstrual bleeding, low energy availability limiting dietary iron, and exercise-induced losses. (Garvican-Lewis et al., 2016)

Iron Deficiency among Athletes

Iron is an essential micronutrient for athletes, intricately linked to their performance, by regulating cellular respiration and metabolism. Impaired iron levels in the body can significantly hinder athletic performance. The increased demand for iron due to exercise, coupled with potential dietary iron insufficiencies, particularly among endurance athletes, amplifies the risk of iron deficiency. Moreover, prolonged exercise can impact iron absorption, utilisation, storage, and overall iron concentrations in an athlete. Iron deficiency in athletes is normal, and they are prone to it due to several mechanisms, including increased losses of iron during training caused by micro-ischemia, haemolysis, sweating, etc. Furthermore, women are more prone than men because of menstrual bleeding (Clenin et al. 2015). A link between low energy availability (LEA) and poor iron status in athletes is likely, as the dietary intake of iron may not be sufficient (Badenhorst, Black & Obrien, 2019).

Iron deficiency is common in physically active individuals and particularly exacerbated in professional athletes (Petkus, Murray-Kolb & De Souza, 2017). Athletes are prone to iron loss due to prolonged physical activity, which puts high physiological demands on their bodies. Apart from menstrual iron loss in women, high physical and environmental stress can increase sweating rate, induce gastrointestinal bleeding, and cause haemolysis due to mechanical forces, haematuria, thermohaemolysis, and lower iron recycling rates due to

inflammation (Badenhorst, Black & Obrien, 2019). Elite athletes, engaged in extremely physiologically demanding sports like cycling, marathon running, or triathlon, commonly exhibit decreased haemoglobin concentrations (Badenhorst, Black & Obrien, 2019).

Iron and Performance

Monitoring menstrual cycle phases is increasingly recognized as essential for optimizing training and iron intake in female athletes. Latorre and Pengelly in their study on elite women soccer players noted significant decreases in external load metrics like high-speed running and total distance during the menstruation phase compared to post-ovulation. Latorre and Pengelly (2023)

Additionally, approximately two-thirds of elite female athletes report menstrual symptoms negatively affecting performance, including fatigue and impaired power output. Regular monitoring of cycles and iron status allows for tailored nutritional and training interventions to address blood loss and energy deficits, (Latorre and Pengelly, 2023)

Athletes with low iron stores exposed to moderate altitude (~1,350–3,000 m) supplemented with ~105–210 mg elemental iron daily experienced a ~3–4% increase in hemoglobin mass compared to ~1% in non-supplemented peers indicating improved erythropoietic adaptation, (Garvican-Lewis et al., 2016)

Conclusion

While a broad array of dietary supplements is used by athletes across competition levels, their overall impact on performance remains relatively small compared with foundational aspects like talent, training, tactics, and motivation. Nutrition plays a critical and overarching role in supporting sport performance, while supplementation should be viewed as a minor, albeit potentially useful, component of the nutritional strategy.

In elite sport environments where every fractional gain matters, a high-performance culture must incorporate clear ethical guidelines and risk education around supplement use. Without these, athletes might be pressured into high-risk behaviors in pursuit of marginal gains.

Effective implementation requires a comprehensive dialogue covering medical, physiological, cultural, and ethical dimensions. Athletes, in collaboration with coaches, sports administrators, physicians, and dietitians, need a strong understanding of:

1. Evidence-based benefits of supplementation;
2. Risks including contamination, inadvertent doping, and adverse health effects;
3. Proper dosing, timing, and trial strategies;
4. Reliable sourcing, prioritizing third-party certification.

A Cautious, informed, and team-based approach to supplements anchored in a sound nutritional foundation supports performance enhancement while minimizing risks to athlete health and integrity.

Recommendations

Based on the findings of this article, the following recommendations are proposed to guide safe and effective dietary supplement use among athletes:

1. Prioritise a Balanced Diet: Supplements should not replace a well-balanced, nutrient-dense diet. Athletes should focus on consuming whole foods rich in essential nutrients, including lean proteins, fruits, vegetables, whole grains, and healthy fats. Supplements are best used to fill specific nutritional gaps, not as substitutes for proper meals.

2. Consult Qualified Professionals: Athletes are encouraged to consult with a certified sports dietitian or nutritionist to assess individual needs based on their sport type, physiological status, and performance goals. Supplement recommendations should be personalized and evidence-based.

3. Choose Certified Products: Supplements should be sourced from reputable manufacturers that adhere to third-party testing and certification standards. Athletes should look for certifications such as: NSF Certified for Sport, Informed-Sport Approval from local agencies like the National Agency for Food and Drug Administration and Control (NAFDAC). These certifications ensure the product is free from banned substances and contaminants and accurately reflects the label ingredients.

4. Follow Proper Dosing and Timing: It is essential to use supplements at the recommended dose and appropriate time to maximize their effectiveness and reduce the risk of adverse effects. Athletes should avoid self-dosing or combining supplements without professional guidance.

5. Stay Hydrated: Adequate water intake is especially important when using supplements such as creatine, which may affect water retention and fluid balance.

6. Monitor for Adverse Effects: Athletes should be vigilant for any signs of side effects and discontinue use immediately if any adverse reactions occur. Reporting such effects to a healthcare professional is advised.

7. Avoid Unnecessary Supplementation: The indiscriminate use of individual vitamins and minerals can create nutrient imbalances and, in some cases, lead to toxicity or interfere with nutrient absorption. Only clinically justified supplements should be used to prevent long-term health risks.

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