DIETARY SUPPLEMENTS IN SPORTS AND SPECIAL PHYSICAL EDUCATION

Review Article

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Abstract: Athlete nutrition attracts significant attention from both sports science and sports practitioners, while the use of supplements is an indispensable practice not only for athletes and recreational exercisers but also for professionals in law enforcement and the military. Special physical education represents a system of applied combat training that is studied (under various names) in police, military, and security agencies worldwide. The majority of the Special Physical Education program focuses on the identification and mastery of techniques from multiple martial arts systems and their application in diverse, specialized conditions of life and work of police officers, military personnel, and other security professionals. It is indisputable that a balanced diet and additional supplementation of vitamins, minerals, trace elements, low-molecular protein preparations, amino acids, and fatty acids constitute a factor for optimal performance and health for both athletes and law enforcement officers. This paper aims to present the safe use of certain dietary supplements, based on available literature, providing a starting point for specific future studies.

Keywords: Sports nutrition, supplements, sports performance, police.

INTRODUCTION

Sports nutrition has gained significant importance over the past few decades and is likely to receive even more attention, given that quality and balanced nutrition play a crucial role in an athlete's performance (Hoffman & Maresh, 2011; Amanović et al., 2020; Januszko & Lange, 2021). Based on its roles in our body, food can be divided into categories that include structural, energetic, protective, and regulatory functions (Kilibarda, 2021). While food contains numerous chemical compounds, only a few are essential for human

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life, specifically macronutrients (carbohydrates, proteins, fats, and water), as they are needed in large amounts by the body. This group also includes micronutrients (vitamins, minerals, and essential trace elements), which are necessary in smaller quantities. In certain cases (increased physical exertion, sports activities, stress, illness), in addition to a natural, quality, fresh, and varied diet based on plant-based foods, dietary supplements play an important role. Dietary supplements can have various goals, including managing micronutrient deficiencies, providing additional sources of energy and macronutrients, and offering direct benefits for athletic performance or indirect benefits such as supporting intense training regimens. In this context, the terms "competitive nutrition" and "training nutrition" are increasingly used as two distinct entities, with the former focusing on performance and the latter having an adaptable focus (Close et al., 2016).

Therefore, by emphasizing current developments in sports nutrition while discussing both traditional and new strategies for improving exercise performance and training adaptations, we this paper aims to present, based on scientific literature, certain indications for dietary supplementation in sports and Special Physical Education. This involves a structural and functional analysis of the activities within Special Physical Education, highlighting how these strategies can be effectively integrated to enhance performance and outcomes in these specific fields.

SPECIAL PHYSICAL EDUCATION

Special Physical Education (SPE) represents a complex system of applied self-defense, distinct from other employed systems (Amanovic et al., 2015). SPE combines elements from various martial arts (judo, karate, jujitsu), specifically structured into a system of activities tailored to the needs of police officers and other security personnel (Milošević et al., 2005; Milošević & Milošević, 2014; Гужвица & Паспаљ, 2020). Police activities are unique, involving varying intensity and duration of SPE techniques, utilizing different motor skills and energy mechanisms. The effectiveness of SPE techniques largely depends on the amount of adenosine triphosphate (ATP) in the muscles and the rate of its breakdown and resynthesis. Given the relatively short duration of SPE techniques, ATP resynthesis is achieved exclusively through anaerobic mechanisms: the phosphocreatine (alactic) and glycolytic (lactic) pathways. Most attacks are exhausted within a second, ranging from 0.11 seconds (hand and foot strikes) to one second (multiple consecutive strikes). Defense, therefore, requires maximum intensity, lasting from 0.8 seconds for dodging an attack to over three seconds for combinations of various techniques. Consequently, while defense can often be completed in less than two seconds, there are frequent instances requiring more than 30 seconds. Given the high intensity of these actions, the primary energy process supplying the necessary energy depends directly on the

duration of the action. In most scenarios, only one or two processes operate simultaneously. When the energy from one process is depleted, another energy production process takes over (Milošević & Milošević, 2014). The type of energy process determines the substances used to supply energy, forming the basis for considerations about nutrition and potential supplementation needs.

DIETARY SUPPLEMENTS

During intense training and increased exertion, the body is subjected to higher energy release, and regular diet often fails to meet the demands for quality nutrients. In such cases, dietary supplements become significant. The intake of macro and micronutrients can have numerous desirable effects for both athletes and security professionals: enhanced performance (Knapik et al., 2014), faster recovery after exertion (Kerksick et al., 2009), protection from injuries, and quicker rehabilitation (Burgerstein & Zimmermann, 2009). There are also numerous studies on this topic that classify dietary supplements from various perspectives. The Australian Institute of Sport (AIS) expert panel has categorized dietary supplements into four groups based on scientific evidence. Group A includes substances scientifically proven to support and enhance sports performance and prevent or treat clinical issues (caffeine, creatine, beta-alanine, vitamins, multivitamin/mineral complexes, electrolytes, and various sports drinks). Group B substances are based on emerging scientific support and warrant further research (food polyphenols, fish oil, carnitine, echinacea, glutamine, probiotics, amino acids). Group C comprises supplements without clear evidence of efficacy. Group D substances are prohibited for use either due to harmful effects or the risk of resulting in a positive doping test (Dikić, Suzić, & Radivojević, 2008). An interesting classification by Close et al. (2016) divides supplements into those that enhance endurance performance, those that increase strength/power, and those that improve general health (Table 1).

Finally, in combat sports and Special Physical Education, the benefits of using supplements can be categorized into two strategies. The first, acute supplementation strategy, involves the consumption of supplements that have the ability to optimize performance improvements when used before training, competition, or intervention (such as caffeine and sodium bicarbonate). The second, chronic supplementation strategy refers to the consumption of supplements (such as creatine, beta-alanine, and protein supplements) that are used over a period of several days or weeks to enhance performance (Campbell et al., 2011).

*Table 1. Summary of some of the most common supplements grouped as **green** – strong evidence of performance enhancement, **yellow** – moderate or emerging evidence, and **red** – lack of evidence, high risk of contamination, and/or currently banned by the World Anti-Doping Agency (Close et al., 2016).*

	Green	Yellow	Red
Endurence	Caffeine Carbohydrate gels/drinks Beta-Alanine Beetroot juice Sodium bicarbonate/ citrate Antioxidants	Taurine Cherry juice L-Carnitine	Ephedrine Methylhexanamine Herbal supplements Citrulline Malate L-Arginine Synephrine (Oxedrine)
Strength or Power	Creatine Proteins	Leucine BCAAs	ZMA Anything 'Anabolic' Testosterone Boosters Herbal Supplements Colostrum
Health status	Probiotics Electrolytes Vitamin D	Vitamin C Multivitamin Glucosamine Quercetin Glutamine Fish Oil Collagen	Magnesium Herbal Supplements

However, although supplements remain an integral part of the daily routine for elite athletes, there is a growing shift in priorities, with many athletes adopting a "food first" approach. Given the risk of contamination and the potential for failed drug tests, supplements are now often used only when there is a clear reason for their use (Dikić, Suzić, & Radivojević, 2008). Dietary supplements with scientific justification for use in sports will be analyzed further, reporting on specific studies and/or discussing publications related to the use of supplements and their support in combat sports and Special Physical Education.

Creatine

Research and information on creatine monohydrate supplementation, which is widely used, are continually expanding, making it arguably the most popular sports dietary supplement, effective and safe across various sports and age groups. Creatine plays a fundamental role in maintaining energy homeostasis, particularly in skeletal muscles, when the training goal is hypertrophy, strength, or power (Bogdanis et al., 2022), as well as enhancing recovery ability (Kerksick et al., 2009). It is also used in pathological conditions (Bonilla et al., 2021). Creatine supplementation can have significant clinical roles and benefits for older adults (Gualano et al., 2012). In combat sports (Januszko &

Lange, 2021; Cannataro et al., 2022), creatine is strongly justified in performing defense and attack at maximum intensity, which can last from 0.8 seconds, if it involves dodging, to 3 seconds or more in the case of technique combinations, during a period that does not allow for complete recovery of ATP reserves (Franchini et al., 2014). The effects of two-week creatine monohydrate supplementation and a specially designed training program on the anaerobic capacity and body composition of judokas showed significant improvements in anaerobic capacity and body composition (Radovanović et al., 2008). Additionally, some studies have indicated potential benefits in anaerobic power, muscle hypertrophy, and maximal muscle strength or power when combining protein with creatine (Beck et al., 2007). It appears that combining creatine monohydrate with carbohydrates or carbohydrates and proteins yields optimal results (Buford et al., 2007).

Traditional supplementation protocols involve either short-term (approximately 5-7 days) high-dose (around 20 g/day or 0.3 g/kg of body weight/day) supplementation (Harris et al., 1992) or long-term (approximately 4-6 weeks) low-dose (around 3 g/day or 0.03 g/kg of body weight/day) supplementation (Hultman et al., 1996). Both protocols have proven effective in increasing muscle creatine content by about 20%, as well as improving exercise performance. However, some studies suggest that high doses of creatine may not be necessary, and that lower, daily doses of creatine supplementation (i.e., 3-5 g/day) are effective in increasing intramuscular creatine stores, enhancing muscle mass, muscle performance, and recovery (Gualano et al., 2012; Antonio et al., 2021).

Beta-alanine (ß-alamine)

Beta-alanine is a non-essential amino acid with ergogenic potential primarily based on its role in synthesizing carnosine, a key intramuscular buffer composed of histidine and beta-alanine. Carnosine is found in high concentrations in skeletal muscles, particularly in type II (fast-twitch) fibers, which are predominantly used in activities requiring rapid force or power generation. Beta-alanine is considered particularly effective in timeframes ranging from 1 to 10 minutes (Saunders et al., 2017), as high-intensity training within this duration may enhance adaptive responses by accumulating greater workload during each session. This effect is likely due to several interconnected factors, including improved pH buffering (Baguet et al., 2010; Artioli et al., 2019), which may allow greater reliance on aerobic metabolism, thereby reducing the build-up of glycolytic metabolites at the same exercise intensity (Gross et al., 2014). According to some studies, beta-alanine can increase strength and work capacity, reduce feelings of fatigue and exhaustion, positively affect body composition, elevate carnosine levels, and decrease lactic acid accumulation in muscles (Artioli et al., 2010; Todorovic et al., 2022). One study reported that a 4-week beta-alanine supplementation (6.4 g; 33 judokas) significantly improved performance in a special judo fitness test accompanied by simulated fights (de

Andrade Kratz et al., 2017). Another study tested 40 judo and jiu-jitsu athletes with 6.4 g of beta-alanine per kg of body weight and 500 mg of sodium bicarbonate, showing significant differences in lactate levels and overall ergogenic effect, both with beta-alanine alone and more so in combination with bicarbonate (Tobias et al., 2013).

Daily supplementation with 4 to 6 grams of beta-alanine for at least 2 to 4 weeks has been shown to improve exercise performance. A maintenance dose of approximately ~1.2 grams per day is effective in maintaining elevated muscle carnosine levels (30%-50% above baseline) after supplementation (Stegen et al., 2014). The common side effect of paresthesia (tingling of the skin) can be managed by taking smaller doses throughout the day, with 2-4 doses of approximately 1.6 grams or 3.2 grams (Smith et al., 2009).

Protein supplements

Protein powders derived from various sources are among the most commonly used dietary supplements, not only among athletes but also among military personnel and recreational exercisers (Zangelidis et al., 2008; Šoškić et al., 2016; Bukhari et al., 2021). In sports, protein intake often needs to exceed the normal recommended daily intake, which is approximately 0.8 g per kg of body weight, or around 45-55 g per day. Proteins are nitrogen-containing substances that are more complex than carbohydrates and fats. They form the main structural component of muscles and other tissues in the body, making up about ~15-20% of total body mass. Proteins are also essential for the production of hormones, enzymes, and hemoglobin. Although proteins are not the primary or preferred energy source, they can be used for energy production during periods of nutrient deficiency. For the body to utilize proteins, they must first be broken down into their simplest forms, known as amino acids. Consuming an adequate amount of essential amino acids, particularly leucine, leads to muscle mass synthesis (Hoffman et al., 2015). It is well established that consuming essential amino acids in free form or as part of a protein supplement, ranging from 20-40 g after exercise, stimulates muscle protein synthesis and can increase strength and improve body composition by increasing lean body mass (Jäger et al., 2017). Supplementing dietary proteins, combined with resistance exercises and mixed training (e.g., striking or grappling techniques), will provide a muscle system that is physiologically better prepared to generate force during technique application (Campbell et al., 2011). Increased protein consumption has also been observed among karate practitioners (Teshima et al., 2002) and judokas (Zangelidis et al., 2008).

The recommended daily protein intake for athletes ranges from 1.2 to 2 g per kg of body weight (Campbell et al., 2011). If this amount of protein is not consistently obtained through diet, protein supplements (such as whey protein, casein, or soy protein) are recommended. Excess low-molecular-weight proteins contribute to energy production, with surplus nitrogen being excreted.

There is no doubt about the use of low-molecular-weight proteins, as they are derived from edible sources and their degradation methods are physiological (Burgerstein & Zimmermann, 2009).

Caffeine

The most common dietary sources of caffeine are coffee, tea, chocolate and specialized sports foods and supplements. While caffeine intake has minimal effects on maximal strength (Davis & Green, 2009), its potential benefits are twofold: improving reaction time and increasing explosive strength. Despite the lack of scientific support linking caffeine supplementation to improved sports performance, caffeine is a commonly used supplement among judokas (Campbell et al., 2011). Specifically, 50% of surveyed judokas use caffeine supplementation (Zangelidis et al., 2008). Several studies focusing on the effect of caffeine on reaction time using simple hand movements have shown positive results (Jacobson & Edgley, 1987; Lorino et al., 2006). Another area related to reaction time is agility. Two studies investigating the effects of caffeine on agility have yielded mixed results. In one study, caffeine (6 mg/kg body weight) improved overall average agility performance (3 sprints of 22, 33, and 31 meters performed in a zig-zag pattern) by approximately 2% compared to placebo, although the improvement was not reported as significant (Davis & Green, 2009). In another randomized, double-blind experiment, no significant change in agility test performance was observed after caffeine intake (6 mg/kg body weight) compared to placebo (Stuart et al., 2005). After low (40 mg or 0.5 mg/kg) to moderate (300 mg or 4 mg/kg) doses of caffeine, alertness, reaction time, and attention are improved, but less consistent effects are noted on memory and higher-order executive functions such as judgment and decision-making (McLellan et al., 2016). In conclusion, caffeine is widely used as a performance-enhancing supplement by both athletes and non-athletes.

Regarding dosage, caffeine can enhance performance when consumed 15-30 minutes before exercise in low to moderate doses (~3-6 mg/kg body weight). Moreover, there are no additional benefits when consumed in higher doses (≥9 mg/kg) (Goldstein et al., 2010).

Sodium bicarbonate (sodium hydrogen carbonate or baking soda

Sodium bicarbonate (sodium hydrogen carbonate or baking soda) is an alkalizing agent and a key component of the body's primary pH buffering system. Numerous studies have shown that endogenous bicarbonate levels can be safely and acutely increased after oral consumption of sodium bicarbonate at doses between 0.2 and 0.3 g/kg body weight (Siegler et al., 2010). Supplementation at these levels can lead to improvements of approximately 2% to 3% in various performance measures during single and repeated high-intensity exercises lasting 1-10 minutes (Hadzic et al., 2019). Two studies investigated the effective-

ness of sodium bicarbonate in combat sports athletes. In the first study (Siegler & Hirscher, 2010), 10 amateur boxers participated in 2 competitive sparring sessions. Approximately 90 minutes before the matches, each boxer consumed 0.3 g/kg sodium bicarbonate or placebo in a randomized and balanced manner. This level of sodium bicarbonate supplementation resulted in significant improvements in punch efficiency. In the second study, nine judokas performed 3 sets of a specialized judo fitness test (SJFT) with a 5-minute recovery period between each set (Artioli et al., 2007). Each participant consumed 0.3 g/kg sodium bicarbonate or placebo 2 hours before the test. The results showed that sodium bicarbonate supplementation significantly improved SJFT performance, and lactate levels were significantly lower after sodium bicarbonate intake compared to placebo, indicating a buffering effect of sodium bicarbonate. Another study examined the effects of sodium bicarbonate on performance and assessed energy system contribution during simulated taekwondo bouts. Athletes consumed 0.3 g/kg body weight of sodium bicarbonate or placebo 90 minutes before the simulated fight. After sodium bicarbonate supplementation, there was a significant increase in glycolytic metabolism contribution and thus improved performance during the simulated taekwondo fight (Lopes-Silva et al., 2018).

Current recommendations for sodium bicarbonate supplementation involve consuming between 0.2 to 0.4 g/kg of body weight along with a small carbohydrate-rich meal (~1.5 g/kg body weight) approximately 120 to 150 minutes before exercise (Maughan et al., 2018).

CONCLUSION

A balanced diet can enhance performance and recovery after training for athletes, recreational participants, and law enforcement and military professionals. Additionally, the positive effects of a balanced diet can be amplified by dietary supplements. Some supplements have proven effects on strength, muscle size, endurance, and body composition in combat sports (such as sodium bicarbonate, caffeine, creatine, beta-alanine, and protein supplements); however, no amount of supplementation can compensate for poor nutrition. Generally, dietary supplements are intended to complement the diet to meet macro- and micronutrient needs and other essential components for maintaining health, proper body development, and improving athletic performance.

Despite the growing research in sports nutrition, as highlighted in this paper, there remain many issues about dietary supplements that need to be explored to further improve sports and professional performance in Special Physical Education. These issues primarily concern safety, efficacy, and related legal regulation. To address these questions adequately, further research is needed, particularly within the populations of law enforcement and the military.

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