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Dietary supplements in the sport

Suplementy diety w sporcie

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Abstract

In recent years, the popularity of dietary supplements among athletes has surged, often aimed at enhancing sports performance and improving training outcomes. However, along with this popularity comes an increasing risk of using substances classified as doping in sports. This article examines the current state of knowledge regarding dietary supplements used by athletes, considering the potential risk of violating anti-doping regulations. The article discuss popular ingredients such creatine, beta-alanine, branched-chain amino acids and others.

Aim of the study: The aim of the study is to provide reliable and up-to-date knowledge about various dietary supplements used in sports. The article aims to identify popular supplement ingredients, discuss their potential benefits for sports performance, and understand the risks associated with their use, including potential violations of anti-doping regulations. Additionally, the goal is to emphasize the need for a proper approach to supplementation, considering both effectiveness and ethical and health aspects. Through education about supplementation, the article serves to support both athletes and medical personnel in promoting a conscious and safe approach to enhancing sports performance.

Material and methods: Our review is based on the analysis of materials collected in „Pubmed", „Google Scholar" and other scientific articles using keywords: "supplements in sport", "sport"

Key words: supplements in sport, sport

Streszczenie

W ostatnich latach wzrosła popularność suplementów diety wśród sportowców, których celem często jest zwiększenie wyników sportowych i poprawa wyników treningowych. Jednak wraz z tą popularnością rośnie ryzyko stosowania w sporcie substancji sklasyfikowanych jako doping. W artykule dokonano przeglądu aktualnego stanu wiedzy na temat suplementów diety stosowanych przez sportowców, mając na uwadze potencjalne ryzyko naruszenia przepisów antydopingowych. W artykule omówiono popularne składniki takie jak kreatyna, beta-alanina i inne.

Słowa kluczowe: suplementy diety w sporcie, sport

Introduction

Physical activities, sport, well-balanced diet play an important role in reaching a state of well-being and being healthy person.
Nowadays, everyone wants to be better, achieve better results. These trends also apply in the world of athletes. Athletes use various supplements, and sometimes even doping, to improve their performance.

Creatine

Creatine is one of the most popular supplement for athletes.
As evidenced by studies, creatine supplementation leads to higher levels of creatine within muscle tissue, which can result in improved exercise performance and training adaptations.
Moreover, studies suggest that creatine supplementation may have additional benefits such as enhancing post-exercise recovery, preventing injuries, regulating body temperature, aiding in rehabilitation, and providing neuroprotective effects in cases of concussion or spinal cord injuries. Furthermore, various clinical investigations have explored the potential applications of creatine supplementation in treating neurodegenerative diseases. [1]
As for chemical structure, creatine belongs to guanidine phosphagen family. [2]

This non-protein amino acid compound naturally occurres in red meat and seafood. [3]
In human's body approximately 95% of creatine is located in skeletal muscle, smaller amounts are present in the brain and testes.
The body requires 1-3 g of creatine daily to maintain normal levels, with approximately half of this amount obtained from dietary sources.
Research has shown that vegetarians tend to have lower levels of creatine stored within their muscles. [4]
As a result, they may experience more significant increases in muscle creatine content when supplementing creatine. On the other hand, larger athletes who engage in rigorous training

regimens may require higher daily doses of creatine to ensure optimal or maximum storage of creatine throughout their bodies.

Phosphagens are widely distributed across various species and play a crucial role in maintaining energy availability. Creatine's primary metabolic function involves combining with a phosphoryl group to produce phosphocreatine (PCr) through the enzymatic action of creatine kinase (CK). According to the studies, the multifaceted effects of creatine are largely associated with the functions of CK and PCr, collectively referred to as the CK/PCr system. During metabolic activity, adenosine triphosphate (ATP) is converted into adenosine diphosphate (ADP) and inorganic phosphate (Pi) to release energy. The energy liberated from the breakdown of PCr into creatine and Pi can serve as a buffer to regenerate ATP, particularly during high-intensity anaerobic exercise. The CK/PCr system also facilitates the transport of intracellular energy from mitochondria to the cytosol, linking sites of ATP production with those of ATP consumption. Creatine enters the cytosol through a specific transporter and, along with cytosolic CK isoforms, helps maintain glycolytic ATP levels, cytosolic ATP/ADP ratio, and ATP consumption. Moreover, creatine enters mitochondria, where it associates with ATP produced from oxidative phosphorylation via mitochondrial CK. This coupling enables ATP and PCr to return to the cytosol, where they support energy requirements and mitigate the formation of reactive oxygen species, thereby acting as antioxidants. The CK/PCr system serves as a vital regulator of metabolism, which may elucidate the ergogenic and potential therapeutic benefits of creatine supplementation. [1]

The form of creatine that has been most extensively researched in scientific studies is creatine monohydrate. [5]
As evidenced by studies, creatine supplementation increases the muscle availability of creatine and phosphocreatine (PCr), thereby enhancing acute exercise capacity and training adaptations in adolescents [6] younger adults [7], and older individuals. [8]
These adaptations enable athletes to perform more work over multiple sets or sprints, resulting in greater gains in strength, muscle mass, and performance due to improved training quality. [9,10]
Supplementation of creatine has been reported to be beneficial in sports like:
sprints, basketball, volleyball, water sports, soccer, tennis
Creatine is mainly recommended as an ergogenic aid for power and strength athletes to optimize their training adaptations, as well as for athletes who need to perform intermittent sprints and recover quickly during competitions, such as in American football, soccer, basketball, and tennis.[11]

Benefits of creatine supplementation have been reported for both men and women, although most studies have focused on men. Some research suggests that women may not experience as much strength and muscle mass gain during training as men do in response to creatine supplementation. However, there are several other applications in sports where creatine may benefit athletes engaged in high-intensity intermittent and endurance events. Regarding performance, the International Society of Sports Nutrition (ISSN) has stated that creatine monohydrate is the most effective ergogenic nutritional supplement available to athletes for enhancing high-intensity exercise capacity and lean body mass during training. [12]
What's more, supplementation of creatine during trainings may lower the risk of injury, and accelerate the recovery process from injuries. [13]

In addition, creatine is abundant in many foods and is not banned by any sports organization. [14]

Both short-term and long-term studies across healthy and diseased populations, ranging from infants to the elderly, with dosages from 0.3 to 0.8 g/kg/day for up to five years, have consistently shown that creatine supplementation poses no health risks and may offer numerous health and performance benefits. [15] [16]
The most effective continuously mentioned aspect impact of creatine supplementation withinside the literature has been weight gain. [11]
Additionally, research examining creatine's effects on renal function has found no adverse impact. [17]
The extensive and consistent findings support that creatine monohydrate is well-tolerated and safe for consumption by healthy individuals of all ages, including those with various health conditions. The potential medical uses of creatine supplementation continue to grow, providing therapeutic benefits without significant risks or adverse events. [18]

To sum up, there is a broad consensus in the scientific community that creatine supplementation is an effective ergogenic aid for athletes in various sports and for individuals involved in exercise training, the supplementation of creatine is safe and there have been reported several therapeutic benefits across a range of populations, from infants to the elderly, both healthy and diseased.

Beta-alanine

Beta-alanine is among the most widely used sports supplements globally. It is known as a precursor to b-alanyl-L-histidine (carnosine), which naturally occurs in meat products, asparagus, white mushrooms and green peas. The consumption of carnosine needs to be metabolized to enhance its synthesis. Supplementing with beta-alanine appears to be essential to reach the effective daily dose needed to significantly increase intramuscular carnosine levels. [19]
During high-intensity exercise, anaerobic glycolysis is the primary source of energy. The progress of exercise leads to decrease in muscle pH, as a result of the formation of hydrogen ions during the dissociation of lactic acid. [20] Carnosine is a crucial physiological buffer as it can readily accept protons during contraction-induced acidosis, what maintains pH balance.[19]
The role of carnosine is also being an antioxidant. By scavenging free radicals and singlet oxygen, it helps to reduce oxidative stress. Carnosine is also involved in chelating transition metals. It influences the regulation of calcium levels in muscle cells . It reduces the rate of cell aging by effect on telomerase activity. Carnosine also inhibits glycolysis and enhances mitochondrial activity that regulates metabolism. [21]
The standard period for b-alanine supplementation to significantly boost intramuscular carnosine content is 4 weeks, using doses of 4-6 g per day, potentially increasing

intramuscular carnosine content by 64.2%. [22] [23] Unfortunately, the factors contributing to the increase in intramuscular carnosine content are not yet fully known. [23] Studies indicate that beta-alanine necessitates a prolonged initial dosage of 4 to 6 grams each day, divided into doses of 2 grams or fewer, for at least two weeks to maximize effects of the supplementation. [22] Research shows that taking a dose greater than 800 mg per day was associated with occurrence of symptoms of paresthesia. Studies on this side effect have shown that the skin sensations caused by b-alanine ingestion are mediated by MrgprD, which is expressed in cutaneous sensory neurons. [19] The use of sustained-release formulations appears to result in a significant reduction in paresthesia symptoms. According to current data, beta-alanine is considered safe for healthy individuals when taken in recommended amounts. [22] Based on the current data, it can be concluded that β-alanine supplementation has a significant performance-enhancing effect on high-intensity exercise, especially in exercise capacity tests and activities lasting between 1 and 4 minutes. [20]
However, further research is necessary to understand the effects of beta-alanine on strength, endurance performance beyond 25 minutes, and other health benefits related to carnosine.

Caffeine

Caffeine passes for utility goods, it is widespread both in professional athletes and people practicing sports recreationally. Plant-derived, easily accessible, swift action - all those features make caffeine notably appealing for sportsmen. Its primary mechanism of action bases on an adenosine-like chemical structure, which makes this compound willing to block adenosine receptors located in CNS. This action's outcome remains an increased level of other neurotransmitters such as acetylcholine and norepinephrine. Eventually, they enhance mental abilities, provide excitement, reduce pain and exhaustion. Furthermore, there is also a peripheral component in caffeine functioning, resulting in boosting calcium level to provoke muscle contraction. Caffeine assists also in mobilizing fatty acids for energy, reducing dependence on glycogen, and increases heat production. [24,25] Like any supplement, caffeine can cause side effects. Commonly reported issues include tachycardia, heart palpitations, anxiety, headaches, insomnia, and poor sleep quality. For instance, a study found that consuming caffeine before an evening rugby game delayed sleep onset and reduced sleep duration. [26] Experience anxiety can potentially worsen performance, especially in sports requiring precision, such as tennis or biathlon shooting. Conversely, athletes in strength and endurance sports might benefit from caffeine's stimulating effects. The severity of side effects seems to be dose-dependent, increasing with higher doses and can be minimized with doses tailored to individual needs. [27] Due to metanalyses a recommended caffeine dose varies between 3 to 6 mg/kg and should be taken 30–90 min before exercise to escalate effects and the final one strictly depends on the type of activity.[28] Additionally, there are sex-based differences in caffeine metabolism and its effects. For instance, women showed higher post-exercise caffeine concentrations than men, which might influence the performance benefits and side effects experienced. Studies also indicated that caffeine might reduce pain perception during exercise, potentially allowing for more intense training in women.[29,30] Which is also emphasized, caffeine frequently goes hand in hand with other ergogenic supplements like taurine or citrulline malate, whose mechanisms of action may potentiate efficiency. [27,31]

Nitrates

A different plant-derived compound is inorganic nitrate which is mostly sourced from beets or beetroot juice. It is also present in other root and green vegetables, like spinach, lettuce or even cellery. [32] The Chemical compound which we absorb while eating these vegetables is NO3-. Its way into our organism begins at oral cavity, where local bacteria convert it to NO2-. [33] The other chemiolysis takes place in our gut, the final product of those transitions is nitric oxide. It serves various biological functions, including promoting the widening of blood vessels, which enhances the delivery of oxygen to muscles. Additionally, dietary nitrate supplementation has been found to improve oxygen absorption during physical activity, potentially by restraining the disruptive effects on the oxidative phosphorylation process and directing membrane potential towards ATP production to enhance mitochondrial efficiency. [30,34] It proves itself in long-lasting moderate-intensity workouts as well as in high-intensity, intermittent, short exertions. Nitrates should be taken 2-3 hours before exercise in the dose of 5-9 mmol, preferably regularly for at least 3 days in a row.[32] On the other hand, in terms of anaerobic performance, some studies showed no significant improvements in sprint performance despite increased plasma nitrate levels. [35,36] It is worth emphasizing that likelihood of experiencing beeturia and passing reddish stools increases during supplementation, similarly to overhydration and GI distress.

Conclusions

In the realm of sports, dietary supplements play a significant role in enhancing athletic performance, recovery, and overall health. Our review of the current literature reveals that certain supplements, such as creatine monohydrate, have consistently demonstrated ergogenic benefits, improving high-intensity exercise capacity, muscle mass, and strength. These benefits extend across various age groups and athletic disciplines, making creatine a valuable tool for both amateur and professional athletes.

Moreover, the therapeutic potential of supplements like creatine is notable, offering advantages for healthy individuals as well as those with certain medical conditions. The safety profile of creatine, supported by numerous well-controlled clinical trials, suggests that it is a safe and effective supplement when used appropriately.

However, the use of supplements should be guided by scientific evidence rather than anecdotal reports or misinformation. It is crucial for athletes, coaches, and sports organizations to rely on research-backed data to make informed decisions about supplement use. Policies regarding supplements should be formulated based on robust scientific findings to ensure the safety and well-being of athletes.

In conclusion, while dietary supplements can offer significant benefits in sports, their use must be carefully managed and supported by scientific research. By adopting evidence-based practices, the sports community can maximize the advantages of supplements while minimizing potential risks.

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All authors have read and agreed with the published version of the manuscript.

Conflict of interest

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