Dietary Supplement use and their role in Fitness and Sports Performance

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ABSTRACT:

Introduction: Dietary supplements are products that are essential for addressing specific nutritional requirements, promoting overall health, enhancing physical performance, and facilitating optimal recovery. The use of dietary supplements among athletes has become increasingly prevalent, motivated by the urge to enhance performance, support recovery, and address nutritional deficiencies. While they can offer various benefits, it is essential that healthcare professionals guide their use in order to ensure safety and efficacy.

Objectives: This study aims to explore the prevalence of the main types of dietary supplements used within the sports community.

Methods: This scoping review aims to examine the use of dietary supplements in physical activity and sports, analyzing 41 studies from high-impact academic databases, such as PubMed, Google Scholar, and Web of Science, as well as the websites of the World Health Organization (WHO) and the World Anti-Doping Agency (WADA). The focus was on the definitions, categories and usage patterns of dietary supplements among athletes.

Results: The findings indicate significant variability in supplement use, with reported prevalence rate varying from 14% to 97%. This variation is influenced by factors such as age, gender and type of sport practiced. The primary reasons for supplement use in sports, fitness, and recreational activities include performance enhancement, post-exercise recovery, and overall health promotion. The most used supplements are vitamins, minerals, proteins, herbal supplements, and amino acids. Gender differences are evident, with women predominantly using vitamins and minerals, while men tend to favour protein and amino acids. Additionally, the use of supplements significantly affects haematological and biochemical parameters, including liver health and electrolyte balance.

Conclusions: This study provides factual and comparative data on the prevalence of dietary supplements use by physically active individuals and athletes and highlights the importance of professional guidance in supplement use by these subjects. For elite athletes in particular, the controlled use is important in order to mitigate health risks, improve the sport performance and ensure compliance with anti-doping regulations. It also emphasizes the need for educational initiatives to enhance athletes' knowledge of dietary supplements, including their benefits and risks, and to encourage informed and safe usage practices.

1. Introduction

Supplements are products available in various nutritional forms and formulations, designed to enhance nutrient intake maintain normal levels across different age groups or physiological states and address deficiencies or pathological conditions [1].

Depending on their purpose and the subjects they target, supplements aim to improve general health and physical well-being, correct nutritional deficiencies, and support fitness and sports activities. Individuals who engage in physical exercise, especially athletes, have specific nutritional supplementation needs to maintain good health under increased demands, prevent deficiencies, and enhance physical and sports performance.

Supplements are used to address the specific needs of certain groups, including the variety, dosage, and balance of supplements required, as well as the appropriate timing and context for their use [2, 3]. In these individuals, supplementation in the context of physical and sports performance helps enhance muscle strength and power, improve endurance, promote muscle growth, and support more efficient fat breakdown, along with other benefits [4-6].

In athletes, supplementation is crucial not only in terms of quantity, quality, and specific ratios of different supplements but also in relation to the timing of their intake concerning athletic or competitive activities. This is particularly important for elite or competitive athletes [7]. In such cases, where maintaining sports performance and competitive capacity is increasingly demanding, nutritional supplementation has become a standard and routine practice. Consequently, a wide range of supplements is now produced and marketed for fitness and sports purposes [8].

Although supplements are generally considered safe, their use, by both the general population and physically active individuals, should be based on tests confirming a deficiency or need. They should only be taken upon the recommendation of physicians or nutrition specialists following a professional assessment. In the context of fitness and sports, supplements should be used under the guidance of sports physicians or nutritionists, particularly for elite-level athletes. The type of sport, training cycles, competitive seasons, and medical supervision are essential considerations for their proper use [9].

2. Objectives

The present study aims to address issues related to the use and main types of supplements most widely used within the sports community, including those at elite, competitive, and recreational levels.

3. Methods

To support our investigation on the use of supplements in the context of physical activity and sports, a scoping review was conducted, combining a broad literature review with critical analysis of data from well-recognized and high-impact scientific sources. This methodological approach allows for a comprehensive mapping of existing literature, identifying key concepts, types of evidence, and gaps in the current understanding of dietary supplements in athletic contexts.

Academic databases such as PubMed, Google Scholar, Web of Science, and the websites of World Health Organization (WHO) and World Anti Doping Agency (WADA) were used to search for scientific publications and relevant articles related to the topic.

The keywords and search phrases included were Dietary Supplements, Physical Activity, Sport, Athletes, Side Effects of Supplements, Proteins, Amino Acids, Vitamins, Caffeine, Creatine.

To ensure the quality, reliability, and relevance of the data sourced from the literature, priority was given to publications in peer-reviewed journals indexed in Scopus, Web of Science, Elsevier, and PubMed. The articles that met the objectives of our study were selected from the period between 2016 to 2024, including publications up to the present date.

The review methodology used in this investigation followed a five-stage framework, which included identifying the research questions, selecting relevant studies, charting the data, collating, summarizing, and reporting the results. This structured approach not only facilitates a comprehensive understanding of the existing literature but also highlights areas where further research is required, particularly regarding the efficacy and safety of various dietary supplements used by athletes [10].

After collection, the data were organized into thematic sections based on the objectives of our study, within which the studies were grouped according to their focus and key findings.

4. Results and Discussion

A total of 90 articles were initially selected for review, 10 were excluded due to limited access, as they were only available as abstracts and not in full text. Furthermore, 39 pubblications were excluded because they did not closely align with the specific focus or objectives of the research, thereby failing to meet the established inclusion criteria for the study. This rigorous selection process ensured that only the most relevant and accessible literature was considered for the final analysis. From the 41 studies analyzed, it is evident that dietary supplements are widely used by individuals engaged in organized physical activity and those involved in sports [11,12].

Currently, there is a considerable debate regarding the precise definition and classification of substances considered to be natural and healthy supplements. Various health authorities provide differing definitions of dietary supplements, which can contribute to confusion in the field. For instance, according to the Food and Drug Administration (FDA) a dietary supplement is"*a product intended for ingestion that, among other requirements, contains a "dietary ingredient" intended to supplement the diet*'' [13]. National Institutes of Health (NIH) defines a dietary supplement as, "*A product that is intended to supplement the diet; A dietary supplement contains one or more dietary ingredients (including vitamins, minerals, herbs or other botanicals, amino acids, and other substances) or their components; is intended to be taken by mouth as a pill, capsule, tablet, or liquid; and is identified on the front label of the product as being a dietary supplement*" [14]. While according to the International Olympic Committee (IOC) Consensus Statement as, "*A food, food component, nutrient, or non-food compound that is purposefully ingested in addition to the habitually consumed diet with the aim of achieving a specific health and/or performance benefit*" [15]. Despite the challenges and limitations posed by these varying definitions, the body of evidence concerning the use of dietary supplements is still extensive.

The data collected from numerous studies indicate that the results obtained regarding the efficacy and safety of these supplements are sufficiently reliable. This underscores the importance of a nuanced understanding of dietary supplements in the context of physical activity and sports, as well as the need for clear communication regarding their use among athletes and active individuals [3, 5].

4.1. Prevalence of supplements use for fitness and sport purposes

The selected studies covered a wide range of individuals, athletes, various age groups, both sexes and various sport categories. The analysis of the data reveals that the majority of publications confirm a significant rate of supplement use among these subjects, although this rate varies widely (from 14% to 97%), depending on factors such as the physical activity /sport type performed, age group, gender, sport type, and other geographical and social variables. Physically active men generally exhibit a higher prevalence of supplement use compared to women, particularly among athletes, with the highest usage observed in elite athletes [2, 16-18].

The use of supplements by individuals engaged in sports, fitness, and recreational physical activities has garnered significant attention in recent years, driven by the potential benefits these substances may

offer in enhancing performance, aiding post-exercise recovery, accelerating recovery from the inflammatory consequences of over or underexercise, and promoting overall health.

The use of supplements and nutraceuticals is widespread among individuals involved in sports and physical activity, with consumption rates varying significantly based on the type of sport and level of competition.

Studies suggest that, depending on the sport and level of competition, between 40% and 100% of athletes use at least one form of nutritional supplementation, thus indicating a high prevalence and variance of supplement use among athletes [10, 19]. For instance, the increasing consumption of protein supplements by athletes reflects a growing trend toward adopting functional foods that provide nutritional and health benefits [8, 20].

The use of supplements is a common practice not only among elite athletes but also among non-professional athletes and fitness exercisers, who use them to enhance training and support recovery.

According to a large international study, two-thirds of 3,887 elite adult, adolescent track and field athletes competing in world championships reported using one or more nutritional supplements, including, vitamins, minerals, creatine, caffeine, and amino acids [21]. In the years following this study, the use of these substances has rapidly increased, surpassing 70% among physically active individuals and exceeding 90% among athletes [22-24].

4.2. Categories of most used supplements for fitness and sports

The most used supplement categories among adults include vitamins, minerals, proteins, herbal supplements (both whole and processed), amino acids, while extracts, metabolites, and concentrates being used to a lesser extent [25,26]. Among these, supplements from the protein, vitamin, and mineral groups are the most prevalent and are used in higher quantities by both men and women (adults) [27,28].

Some studies indicate that 40% to 100% of athletes use a various range of supplements, including vitamins, minerals, proteins, and amino acids [19, 20]. At the World Championships, about two-thirds of 3,887 elite athletes reported using supplements, including creatine and caffeine [21]. Among male athletes, the prevalence of whey protein and creatine use is higher, while female athletes are more likely to use iron supplements and multivitamins [28]. Furthermore, among elite groups, about 71% of women and 69% of men reported using supplements compared to their non-elite counterparts, where use was about 48% for men and 42% for women [41]. These findings raise concerns about the appropriate use of supplements in terms of variety and quantity, awareness of potential adverse effects, appropriateness for specific subjects or context, and the need for awareness campaigns among the entire sports community and beyond.

In terms of age categories, the use of protein supplements and energy drinks was almost equally distributed among athletes. Athletes in the younger age group (15-16 years) tended to use more carbohydrates, beta-alanine, glutamine, and vitamin and mineral complexes, while those in the 17-18 age group commonly used more creatine, caffeine, and amino acids [18,35,36].

At the same time, gender differences are observed among the most used supplement categories. For instance, women tend to use more vitamin and mineral supplements, while men tipically prefer protein, amino acids, and mineral supplements [28,29]. Probiotics and omega-3 fatty acids are also highly favored by physically active individuals, as they have been associated with enhancing the immune system, reducing inflammation, and accelerating the recovery process [30,31].

4.3. Prevalence of supplement use by gender and sport disciplines

As discussed in the previous subsection, gender differences in the prevalence of supplement use have been observed, with male athletes often reporting higher levels of supplement consumption compared to female athletes. According to Aguilar-Navarro *et al*., a higher percentage of male athletes (65.3%) reported using dietary supplements compared to female athletes (56.5%, $p<0.05$). However, the average amount of dietary supplements consumed by male and female athletes was similar (3.2 ± 2.1 vs. 3.4 ± 2.3 supplements per season, $p = 0.45$). Protein supplements were the most commonly used by male athletes (49.8%), with a significantly higher frequency compared to female athletes (29.3%, $p < 0.01$). On the other hand, iron supplements were more commonly used by women than men (22.2% vs.10.2%, $p = 0.01$). The most commonly used supplement categories among both genders were multivitamins (39.4%) and Branched-Chain Amino Acids (BCAA) (39.4%). Male athletes were more likely to independently plan their supplement intake (48.0%), while female athletes (34.0%, $p < 0.01$) tended to rely more on a physician's recommendation [46].

In a study by Jovanov *et al*. conducted across Germany, Serbia, Japan, and Croatia, 82.2% of athletes in the 15-16 and 17-18 age groups reported using sports supplements, with a higher percentage of male athletes (60.6%) compared to female athletes. Among this group, the simultaneous use of multiple supplement types was common: 82.2% of athletes used one to two types, 62.1% used three to five supplements, and 35.9% used four to six supplements, while 14.7% reported consuming five or more supplements. Among the most commonly used supplements, whey protein was consumed by 54.5% of female athletes. The study also found high usage of ten other sports supplements. Male athletes showed a higher percentage of using whey protein, creatine, amino acids, and caffeine, while female athletes preferred vitamin and mineral complexes. These findings are also consistent with studies conducted in other countries involving physically active individuals and athletes [28, 32-34].

Additionally, in a systematic literature review of 159 studies on sports populations, Knapik *et al*. examined the prevalence of dietary supplement use according to the classification defined in the US Food and Drug Administration's Dietary Supplement Health and Education Program [37]. This review analyzed the use of supplement by sport, gender, and other factors (e.g., sports nutrition, iron, vitamins) as well as athlete classification (elite vs. non-elite). The study found significant variation in supplement use across different sports groups, with prevalence ranging from 4% to 62% depending on the type of supplement. The results indicated that elite athletes showed higher levels of supplement use compared to their non-elite counterparts, with approximately 71% of female elite athletes and 69% of male elite athletes using supplements, compared to approximately 48% of male and 42% of female non-elite athletes. Moreover, gender differences were evident in the types of supplements used: female athletes reported higher use of supplemental iron, while male athletes more frequently used products such as protein, creatine, and vitamin E. These findings are supported by subsequent studies with similar results [39-41]. Although measuring supplement consumption across different athlete groups can be challenging, these results suggest that professionals, such as nutritionists and sports physicians should consider variations in supplement consumption based on factors like gender and performance level.

4.4. Impact of supplements on hematological and biochemical parameters in athletes

The use of nutritional supplements and nutraceuticals can significantly impact hematological and biochemical parameters in athletes, including hepatic enzymes such as Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) and others [3, 42] . These enzymes are commonly used as markers of liver health, and elevated levels are often associated to metabolic stress caused by certain supplements or intense physical exercise. For instance, creatine supplementation is frequently linked to increased blood creatinine levels, which typically indicate higher muscle mass and intense physical activity. However, in some cases, elevated creatinine levels may also indicate potential stress on the kidneys [42, 43]. Other supplements can affect the body’s electrolyte balance and antioxidant capacity,

enhancing the concentration of protective enzymes and increasing white blood cell and platelet levels. For regular supplement users, monitoring biochemical analyses is essential to prevent hormonal and oxidative imbalances that certain supplements may cause over time, potentially affecting liver and kidney health [3,].

5. Conclusions and recommendations

Comparing results from different surveys on nutritional supplement uses complex due to variations in supplements definition and the lack of standardization of measurement instruments. Supplement use varies by sport, performance level, and demographic factors, such as age and gender, reflecting cultural influences and perceived standards. The benefits and risks of supplements need to be carefully balanced to support safe and informed decisions, in particular to minimize potential anti-doping rule violations and health complications.

The nutritional supplement and nutraceutical industry operates under less stringent regulations than the pharmaceutical industry, allowing products to be marketed without mandatory evidence of their efficacy and safety. This leads to quality product variations and increases the risk of contamination with banned substances, causing athletes to unknowingly violate anti-doping regulations [44]. Furthermore, many athletes lack sufficient knowledge about ergogenic aids, increasing the likelihood of improper use and adverse side effects [45,46]. These factors emphasize the importance of athletes being well-informed and consulting with specialists to ensure the safe and effective use of supplements.

In summary, the inconsistencies in the definitions of dietary supplements, along with variations in reporting periods and data collection methods across different studies, pose significant challenges for comparing findings. Therefore, the insights from this review can contribute in shaping future educational initiatives focused on enhancing users' comprehension of dietary supplements, particularly regarding their potential advantages and drawbacks, as well as the importance of professional guidance in their use. Given the elevated rates of supplement consumption among athletes, there is a pressing need for additional research and more targeted and properly tailored programs.

Ensuring proper nutrition is vital not only for sustaining a high quality of life but also for maximizing athletic performance. Consequently, addressing these knowledge gaps and promoting safe supplement practices among athletes is essential for their overall health and success in their respective sports.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Tirla, A., Islam, F., Islam, M. R., Vicas, S. I. & Cavalu, S. (2022). New Insight and Future Perspectives on Nutraceuticals for Improving Sports Performance of Combat Players: Focus on Natural Supplements, Importance and Advantages over Synthetic Ones. Applied Sciences, 12(17), 8611. https://doi.org/10.3390/app12178611

[2] Peeling, P., Castell, L. M., Derave, W., De Hon, O., & Burke, L. M. (2019). Sports Foods and Dietary Supplements for Optimal Function and Performance Enhancement in Track-and-Field Athletes. International Journal of Sport Nutrition and Exercise Metabolism, 29(2), 198–209. https://doi.org/10.1123/ijsnem.2018-0271

[3] Jahan, S., Fatima, A., Alam, I., Ullah, A., Rehman, H., Afsar, T., Almajwal, A., & Razak, S. (2018). Effects of dietary supplements on selected hematological and biochemical parameters of Pakistani athletes. BMC Nutrition, 4(1). https://doi.org/10.1186/s40795-018-0250-y

[4] West, D. W. D., Sawan, S. A., Mazzulla, M., Williamson, E., & Moore, D. R. (2017). Whey Protein Supplementation Enhances Whole Body Protein Metabolism and Performance Recovery after Resistance Exercise: A Double-Blind Crossover Study. Nutrients, 9(7). 735. https://doi.org/10.3390/nu9070735

[5] Shcheglevatyh, A. N., & Ovechkin, S. A. (2021). Endurance product for sprinters. Proceedings of the Voronezh State University of Engineering Technologies, 83(1), 253–257. https://doi.org/10.20914/2310-1202-2021-1-253-257

[6] Supplements. (n.d.-a). Australian Sports Commission (AIS). https://www.ais.gov.au/nutrition/supplements

[7] Naderi, A., de Oliveira, E. P., Ziegenfuss, T. N., & Willems, M. T. (2016). Timing, Optimal Dose and Intake Duration of Dietary Supplements with Evidence-Based Use in Sports Nutrition. Journal of exercise nutrition & biochemistry, 20(4), 1–12. https://doi.org/10.20463/jenb.2016.0031

[8] Office of Dietary Supplements - Dietary Supplements for Exercise and Athletic Performance.https://ods.od.nih.gov/factsheets/ExerciseAndAthleticPerformance-HealthProfessional/

[9] Jeukendrup, A. E. (2017). Periodized Nutrition for Athletes. Sports Medicine, 47(S1), 51–63.https://doi.org/10.1007/s40279-017-0694-2

[10] De Meo, C., de Waure, C., De Meo, C., Terracciano, E., Di Nardo, F., & Ricciardi, W. (2022). Does the use of dietary supplements enhance athletes' sport performances? A systematic review and a meta-analysis. Epidemiology, Biostatistics, and Public Health, 12(4). https://doi.org/10.2427/11593

[11] Knapik, J. J., Steelman, R. A., Hoedebecke, S. S., Austin, K. G., Farina, E. K., & Lieberman, H. R. (2016). Prevalence of Dietary Supplement Use by Athletes: Systematic Review and Meta-Analysis. Sports medicine (Auckland, N.Z.), 46(1), 103–123. https://doi.org/10.1007/s40279-015-0387-7

[12] Moradi, F., Yazdani, A., Nematolahi, F., Hosseini-Roknabadi, S. M., & Sharifi, N. (2024). Prevalence of supplement usage and related attitudes and reasons among fitness athletes in the gyms of Kashan and its relationship with feeding behavior: a cross-sectional study. BMC sports science, medicine & rehabilitation, 16(1), 150. https://doi.org/10.1186/s13102-024-00940-3

[13] Food Code. Food and Drug Administration (FDA). (2017). https://www.fda.gov/media/133749/download

[14] National Institutes of Health. (2022) Available online: https://ods.od.nih.gov/factsheets/ËYNTK-Consumer/

[15] Maughan, R. J., Burke, L. M., Dvorak, J., Larson-Meyer, D. E., Peeling, P., Phillips, S. M., Rawson, E. S., Walsh, N. P., Garthe, I., Geyer, H., Meeusen, R., van Loon, L., Shirreffs, S. M., Spriet, L. L., Stuart, M., Vernec, A., Currell, K., Ali, V. M., Budgett, R. G. M., Ljungqvist, A., …

Engebretsen, L. (2018). IOC Consensus Statement: Dietary Supplements and the High-Performance Athlete. International journal of sport nutrition and exercise metabolism, 28(2), 104–125. https://doi.org/10.1123/ijsnem.2018-0020

[16] Barrack, M., Fredericson, M., Dizon, F., Tenforde, A., Kim, B., Kraus, E., Kussman, A., Singh, S., & Nattiv, A. (2021). Dietary Supplement Use According to Sex and Triad Risk Factors in Collegiate Endurance Runners. Journal of strength and conditioning research, 35(2), 404–410. https://doi.org/10.1519/JSC.0000000000003848

[17] Barrack, M. T., Muster, M., Nguyen, J., Rafferty, A., & Lisagor, T. (2020). An Investigation of Habitual Dietary Supplement Use Among 557 NCAA Division I Athletes. Journal of the American College of Nutrition, 39(7), 619–627. https://doi.org/10.1080/07315724.2020.1713247

[18] Jovanov, P., Đorđić, V., Obradović, B., Barak, O., Pezo, L., Marić, A., & Sakač, M. (2019). Prevalence, knowledge and attitudes towards using sports supplements among young athletes. Journal of the International Society of Sports Nutrition, 16(1), 27. https://doi.org/10.1186/s12970-019-0294-7

[19] Garthe, I., & Maughan, R. J. (2018). Athletes and Supplements: Prevalence and Perspectives. International Journal of Sport Nutrition and Exercise Metabolism, 28(2), 126–138. https://doi.org/10.1123/ijsnem.2017-0429

[20] Gupta, C., Prakash, D., & Gupta, S.
(2016). Nutraceuticals for Athletes. Advanced in Food Technology and Nutritional Sciences - Open Journal, 2(2), 73–82. https://doi.org/10.17140/aftnsoj-2-132

[21] Tscholl, P., Alonso, J. M., DolPeelilé, G., Junge, A., & Dvorak, J. (2019). The Use of Drugs and Nutritional Supplements in Top-Level Track and Field Athletes. The American Journal of Sports Medicine, 38(1), 133–140. https://doi.org/10.1177/0363546509344071

[22] Southward, K., Rutherfurd-Markwick, K. J., & Ali, A. (2018). The Effect of Acute Caffeine Ingestion on Endurance Performance: A Systematic Review and Meta-Analysis. Sports medicine (Auckland, N.Z.), 48(8), 1913–1928. https://doi.org/10.1007/s40279-018-0939-8

[23] Roschel, H., Gualano, B., Ostojic, S. M., & Rawson, E. S. (2021). Creatine Supplementation and Brain Health. *Nutrients*, *13*(2), 586. https://doi.org/10.3390/nu13020586

[24] Guest, N. S., VanDusseldorp, T. A., Nelson, M. T., Grgic, J., Schoenfeld, B. J., Jenkins, N. D. M., Arent, S. M., Antonio, J., Stout, J. R., Trexler, E. T., Smith-Ryan, A. E., Goldstein, E. R., Kalman, D. S., & Campbell, B. I. (2021). International society of sports nutrition position stand: caffeine and exercise performance. Journal of the International Society of Sports Nutrition, 18(1), 1. https://doi.org/10.1186/s12970-020-00383-4

[25] Diehl, K., Thiel, A., Zipfel, S., Mayer, J., Schnell, A., & Schneider, S. (2012). Elite adolescent athletes' use of dietary supplements: characteristics, opinions, and sources of supply and information. International journal of sport nutrition and exercise metabolism, 22(3), 165–174. https://doi.org/10.1123/ijsnem.22.3.165

[26] Close, G. L., Kasper, A. M., Walsh, N. P., & Maughan, R. J. (2022). "Food First but Not Always Food Only": Recommendations for Using Dietary Supplements in Sport. International journal of sport nutrition and exercise metabolism, 32(5), 371–386. https://doi.org/10.1123/ijsnem.2021-0335

[27] Cintineo, H. P., Arent, M. A., Antonio, J., & Arent, S. M. (2018). Effects of Protein Supplementation on Performance and Recovery in Resistance and Endurance Training. Frontiers in nutrition, 5, 83. https://doi.org/10.3389/fnut.2018.00083

[28] Aguilar-Navarro, M., Baltazar-Martins, G., Brito de Souza, D., Muñoz-Guerra, J., Del Mar Plata, M., & Del Coso, J. (2021). Gender Differences in Prevalence and Patterns of Dietary Supplement Use in Elite Athletes. Research quarterly for exercise and sport, 92(4), 659–668. https://doi.org/10.1080/02701367.2020.1764469

[29] Mata, F., Domínguez, R., López-Samanes, Á., Sánchez-Gómez, Á., Jodra, P., & Sánchez-Oliver, A. J. (2021). Analysis of the consumption of sports supplements in elite fencers according to sex and competitive level. BMC sports science, medicine & rehabilitation, 13(1), 50. https://doi.org/10.1186/s13102-021-00278-0

[30] D'Angelo, S. (2019). Omega 3 fatty acids as nutraceuticals in sporting performances. International Journal of Engineering and Advanced Research Technology (IJEART), 5(6). https://doi.org/10.31873/ijeart.5.6.2019.01

[31] Díaz-Jiménez, J., Sánchez-Sánchez, E., Ordoñez, F. J., Rosety, I., Díaz, A. J., Rosety-Rodriguez, M., Rosety, M. Á., & Brenes, F. (2021). Impact of Probiotics on the Performance of Endurance Athletes: A Systematic Review. International Journal of Environmental Research and Public Health, 18(21), 11576. https://doi.org/10.3390/ijerph182111576

[32] Baltazar-Martins, G., De Souza, D. B., Aguilar-Navarro, M., Muñoz-Guerra, J., Del Mar Plata, M., & Del Coso, J. (2019). Prevalence and patterns of dietary supplement use in elite Spanish athletes. Journal of the International Society of Sports Nutrition, 16(1). https://doi.org/10.1186/s12970-019-0296-5

[33] Cava, E., Padua, E., Campaci, D., Bernardi, M., Muthanna, F. M. S., Caprio, M., & Lombardo, M. (2024). Investigating the Health Implications of Whey Protein Consumption: A Narrative Review of Risks, Adverse Effects, and Associated Health Issues. Healthcare, 12 (2), 246. https://doi.org/10.3390/healthcare12020246

[34] De Souza, J. G., Del Coso, J., De Souza Fonseca, F., Silva, B. V. C., De Souza, D. B., Da Silva Gianoni, R. L., Filip-Stachnik, A., Serrão, J. C., & Claudino, J. G. (2022). Risk or benefit? Side effects of caffeine supplementation in sport: a systematic review. European Journal of Nutrition, 61(8), 3823–3834. https://doi.org/10.1007/s00394-022-02874-3

[35] Jäger, R., Kerksick, C. M., Campbell, B. I., Cribb, P. J., Wells, S. D., Skwiat, T. M., Purpura, M., Ziegenfuss, T. N., Ferrando, A. A., Arent, S. M., Smith-Ryan, A. E., Stout, J. R., Arciero, P. J., Ormsbee, M. J., Taylor, L. W., Wilborn, C. D., Kalman, D. S., Kreider, R. B., Willoughby, D. S., Hoffman, J. R., … Antonio, J. (2017). International Society of Sports Nutrition Position Stand: protein and exercise. Journal of the International Society of Sports Nutrition, 14, 20. https://doi.org/10.1186/s12970-017-0177-8

[36] Graybeal, A. J., Kreutzer, A., Willis, J. L., Moss, K., Braun-Trocchio, R., & Shah, M. (2023). Age Drives the Differences in Dietary Supplement Use in Endurance Athletes: A Cross-Sectional Analysis of Cyclists, Runners, and Triathletes. Journal of dietary supplements, 20(4), 602–620. https://doi.org/10.1080/19390211.2022.2056670

[37] FDA Staff Manual Guides, Volume I – Organizations and Functions. Office of Food Chemical Safety, Dietary Supplements, and Innovation (2024). https://www.fda.gov/media/181219/download?attachment

[38] Kreider, R. B., Kalman, D. S., Antonio, J., Ziegenfuss, T. N., Wildman, R., Collins, R., Candow, D. G., Kleiner, S. M., Almada, A. L., & Lopez, H. L. (2017). International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine. Journal of the International Society of Sports Nutrition, 14, 18. https://doi.org/10.1186/s12970-017-0173-z

[39] Kreutzer, A., Graybeal, A. J., Moss, K., Braun-Trocchio, R., & Shah, M. (2022). Caffeine Supplementation Strategies Among Endurance Athletes. Frontiers in sports and active living, 4, 821750. https://doi.org/10.3389/fspor.2022.821750

[40] Pickering, C., & Grgic, J. (2019). Caffeine and Exercise: What Next?. Sports medicine (Auckland, N.Z.), 49(7), 1007–1030. https://doi.org/10.1007/s40279-019-01101-0

[41] Li, M., &Liu, F. (2019). Effect of whey protein supplementation during resistance training sessions on body mass and muscular strength: a meta-analysis. Food & Function, 10(5), 2766–2773. https://doi.org/10.1039/c9fo00182d

[42] Nunes, R., Silva, P., Alves, J., Stefani, G., Petry, M., Rhoden, C., Lago, P. D., & Schneider, C. D. (2013). Effects of resistance training associated with whey protein supplementation on liver and kidney biomarkers in rats. Applied Physiology Nutrition and Metabolism, 38(11), 1166–1169. https://doi.org/10.1139/apnm-2013-0004

[43] Meamar, R., Maracy, M., Nematollahi, S., Yeroshalmi, S., Zamani-Moghaddam, A., & Ghazvini, M. A. (2015). Effect of taking dietary supplement on hematological and biochemical parameters in male bodybuilders an equation model. Iranian Journal of Nursing and Midwifery Research, 20(6), 681. https://doi.org/10.4103/1735-9066.170004

[44] Mallick, M., Camacho, C. B., Daher, J., & Khoury, D. E. (2023). Dietary Supplements: A Gateway to Doping? Nutrients, 15(4), 881. https://doi.org/10.3390/nu15040881

[45] Sak, D., Dayi, T., Günay, E., &ÖniZ, A. (2022). Nutritional Knowledge and Ergogenic Aid Using Status of Competitive and Recreational Cyclists. Pamukkale Journal of Sport Sciences, 13(3), 131–145. https://doi.org/10.54141/psbd.1143549

[46] Salem, A., Maaoui, K. B., Jahrami, H., AlMarzooqi, M. A., Boukhris, O., Messai, B., Clark, C. C. T., Glenn, J. M., Ghazzaoui, H. A., Bragazzi, N. L., Ammar, A., Trabelsi, K., &Chtourou, H. (2024). Attenuating Muscle Damage Biomarkers and Muscle Soreness After an Exercise-Induced Muscle Damage with Branched-Chain Amino Acid (BCAA) Supplementation: A Systematic Review and Meta-analysis with Meta-regression. Sports Medicine - Open, 10(1). https://doi.org/10.1186/s40798-024-00686-9