

THE USE OF NUTRITION SUPPLEMENTS IN COMBAT SPORT: A SYSTEMATIC REVIEW

CĂTĂLIN PĂUNESCU^{1#*}, CRENGUȚA SORINA SERBOIU^{1#}, ADRIAN PRICOP^{2#}, MARIA LILIANA MIRCICĂ¹, ADELA CARAMOCI¹

Davila" University of Medicine and Pharmacy, Faculty of Pharmacy, Physical and Colloidal Department, 6 Traian Vuia Street, 020956, Bucharest, Romania

*corresponding author: catalin.paunescu@umfcd.ro

#Authors with equal contribution.

Manuscript received: December 2024

Abstract

This study is a systematic review of the use of dietary supplements by athletes and their effects in combat sports. Dietary supplements are not automatically considered prohibited substances in competitive sports. They are intended to supplement nutrition and are not classified as doping. The aim of this systematic review is to gather evidence on the use of dietary supplements in combat sports and to provide a clear perspective on their effectiveness and safety. Thus, we will analyse the most relevant scientific studies on the issue addressed, delivered in the last 10 years and published in academic databases such as PubMed, Google Scholar and Cochrane Library. Dietary supplements can play an important role in supporting the performance and recovery of performance athletes, but their use must be well-informed and supervised. The risks associated with supplements, such as contamination or abuse, emphasize the need for a cautious and well-documented approach. In essence, supplements cannot substitute a balanced diet and an adequate training plan, but they can contribute to maximizing results in performance sports when used correctly.

Rezumat

Acest studiu reprezintă o analiză sistematică a utilizării suplimentelor alimentare de către sportivii de performanță și a efectelor acestora în sporturile de contact. Suplimentele alimentare nu sunt considerate automat substanțe interzise în sportul de performanță. Acestea au rolul de a completa alimentația și nu sunt clasificate drept substanțe dopante sau interzise. Astfel, au fost analizate cele mai relevante studii științifice publicate în ultimii 10 ani în baze de date academice precum PubMed, Google Scholar și Cochrane Library. Suplimentele alimentare pot juca un rol important în susținerea performanței și a recuperării sportivilor de performanță, însă utilizarea lor trebuie să fie bine informată și atent monitorizată. Riscurile asociate cu suplimentele, precum contaminarea sau abuzul, subliniază necesitatea unei abordări prudente și bine documentate. Suplimentele nu pot înlocui o alimentație echilibrată și un plan de antrenament adecvat, dar, atunci când sunt utilizate corect, pot contribui la îmbunătățirea performanțelor sportive.

Keywords: food supplements, sports performance, martial arts, combat

Introduction

Combat sports are divided into two essential categories, namely: non-Olympic and Olympic, the latter being guided by the regulations imposed by the International Olympic Committee. Depending on the direct contact with the opponent, combat sports are classified as full-contact or semi-contact, all involving high dynamic activity, which increases the risk of injuries and creates a significant need for recovery. In direct combat with the opponent, a high capacity for effort is required, and to cope with the rhythm imposed by the opponent, with his actions, but especially to trigger vigorous actions throughout the match, physical training is considered the vital element in the training process [59]. Technical actions, attack/counterattack or defence/parrying are executed in one or more rounds, with the main objective of accumulating points or ending the fight quickly through technical superiority, all

depending on the specifics of the branch and its regulations [16]. The effort can take on any tone (aerobic or anaerobic) depending on the predominance of the type of effort for the sporting event. The type of strength also differs between combat sports, those with predominant actions of hitting or parrying with different segments of the body have a greater need for explosive strength (strength in speed regime) and on the other hand, those with grappling actions the emphasis is placed on isometric and concentric muscular strength [71]. It is important to note that competitions in these disciplines are held in weight categories, which are established in such a way as to ensure a minimum of fair play for combatants with similar physical characteristics. Athletes are often forced to adopt inadequate weight loss strategies that can negatively affect performance [48]. Many studies highlight how an adequate diet before,

during and after training or competition can improve performance, more than an evolution of lifestyles have led to a significant increase in the consumption of supplements [5]. Products that fall under the banner of “Sports Foods” or “Dietary Supplements” can be used to support effort during training or competitions but also in adapting the body to intense efforts or recovery [60]. Many athletes carry out their activity as a recreation but also the performance athletes use nutritional supplements in the hope of improving human performance [53]. Usually, food supplements are used regularly by athletes to support both performance and for faster recovery after intense or high efforts. In these situations, it is accepted that the athlete should also consider the use of food supplements through a dedicated and implemented programme, established by a specialist in the field, to provide minimal risk [15]. The use of food supplements is widespread among high-performance athletes but also at the university level for students participating in international competitions (Krumbach *et al.*, [41]; Froiland *et al.*, [33]), but in recovery, they should not replace physiotherapy [8, 9]. Often the real differences between well-trained competitors are insignificant and this promotes the use of food supplements, because a small improvement could be relevant in a higher classification [4]. In obtaining information about dietary supplements used by athletes, the most common sources of knowledge are the Internet and the coach, especially at the amateur level, where there is only one person in charge of training, technique and nutrition [11]. There are also proven situations where some seemingly legitimate dietary supplements on sale contain ingredients that are not declared on the label, but are prohibited by the doping regulations of the International Olympic Committee and the World Anti-Doping Agency [10]. In the European Union, there is the Food Supplements Directive 46/EC of 2002 which requires that they have proof that they are safe both in terms of quantity and quality, and only these can be marketed [17]. A large number of athletes use food supplements as part of their routine in training or competition, and they include vitamins, minerals, proteins, creatine and various growth compounds, being very often used without consulting a professional in sports nutrition [49]. Thus, the use of food supplements is increasing, among professional athletes, as is the market for them [61]. According to recent business analyses, the sports supplements industry contributes a substantial market share of 45.24 billion dollars in 2023 an expected annual growth rate of 7.5% from 2024 to 2030 [46]. These include vitamins, minerals, proteins, amino acids, and herbal extracts. There is a wide range of supplements on the market, but research supports a limited number focused on those that improve energy availability (sports drinks, carbohydrates, creatine, caffeine, β -alanine, etc.) and/or those for

recovery (carbohydrates, proteins, essential amino acids, etc.) [38]. When supplemented with vitamin D, learning capacities and mechanisms are enhanced and can have significant influences on stress and psychological resilience [7]. Additionally, a 12-month administration of vitamin C contributes to the normal functioning of the nervous system, the maintenance of mental health, and the protection of cells against oxidative stress [27].

In contemporary society, the health and physical performance have become important objectives for international forums dealing with the management of high-performance sports. In this context, the emergence of substances and supplements that promise to improve and increase sports performance has become a widely discussed topic. However, there is an essential distinction between prohibited substances and dietary supplements, and knowledge of this difference is crucial for the health and ethics of the athlete.

Materials and Methods

Search and selection strategy

The conduct and reporting of the current systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline. This review aimed to improve the transparency and quality of systematic reviews and included three main stages, namely: identification, screening and inclusion. A systematic search was conducted in the following databases: PubMed, PubMed Central, Elsevier/ScienceDirect, Scopus, ResearchGate, ProQuest, MDPI, Google Scholar, and the American Chemical Society (CAS), using terms such as “sports supplements”, “martial arts/combat sports dietary supplements” and “performance supplements”. The search was limited to English-language articles published in the last ten years, between 2013 and 2023.

Inclusion and exclusion criteria

Inclusion criteria: studies that evaluated dietary supplements used in combat sports (mixed martial arts – MMA, Brazilian Jiu Jitsu – BJJ, judo, taekwondo – TKD, karate, jiu jitsu), only randomised studies.

Exclusion criteria: studies conducted on animals or outside combat sports as well as systematic review or meta-analysis studies; unpublished articles or those that do not present sufficient data.

Selection process

After eliminating duplicates, articles were examined based on title and abstract. Studies that met the inclusion criteria were evaluated in full.

Results and Discussion

The extensive research process was summarized in 7786 identified articles. After eliminating duplicates, books and book chapters, 1099 articles went to screening and several 486 articles entered the eligibility process.

The PRISMA diagram illustrates the step-by-step evaluation activities, with 51 articles ultimately included in the full evaluation (Figure 1). All included studies are randomised, of which 90% are placebo-controlled. The studies focused on increasing exercise capacity,

faster physical recovery, or reducing the risk of injury. The duration of the interventions ranged from one day to 8 weeks with a mode of administration ranging from 30 to 120 minutes before the specific exercise (Table I, Table II and Table III).

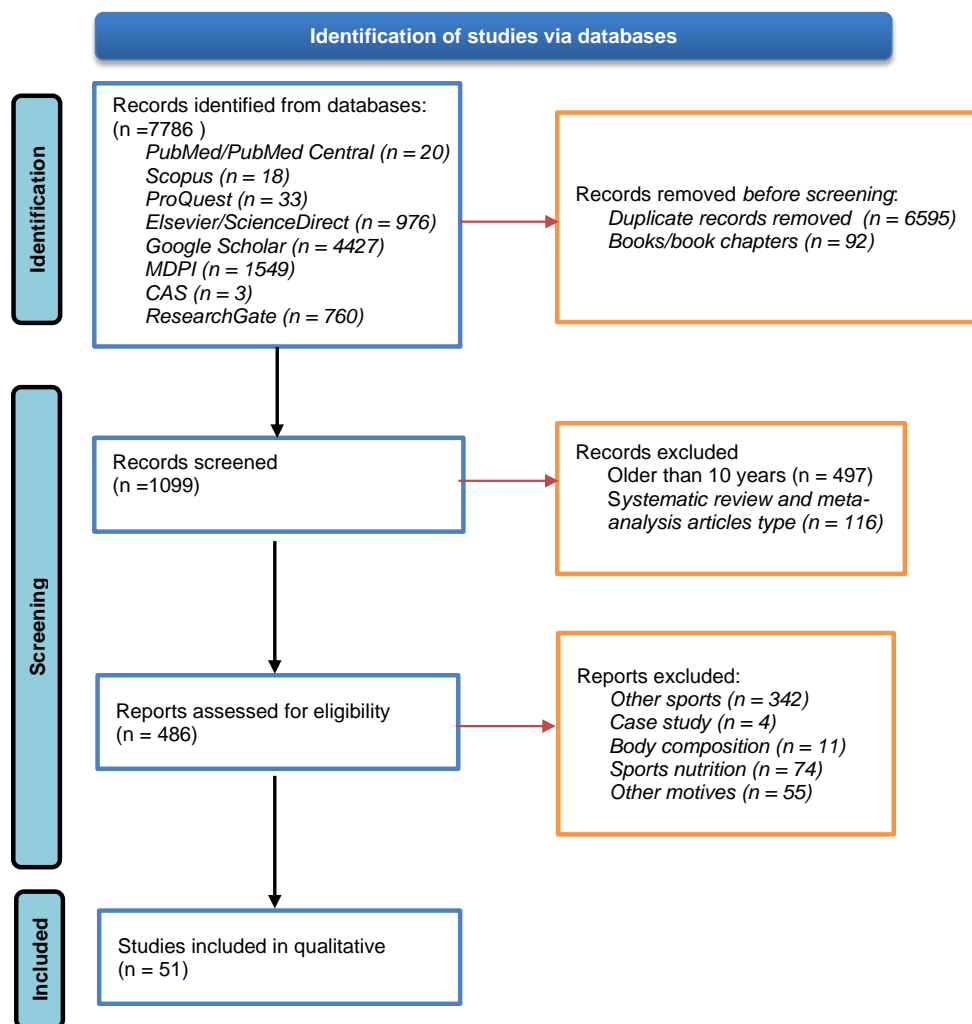


Figure 1.
PRISMA flowchart for the study selection process

Table I
Included studies analysing caffeine supplementation for enhancing sports performance

Type of research dosage and route of administration	Country/ Sport	Conclusions/Effect on the body	Authors, Year
Randomised, double-blind, counterbalanced, crossover, placebo-controlled; 14 male athletes, with a mean age of 25.3 years; 5 mg/kg of caffeine 30 minutes before the test.	Estonia/ BJJ	Heart rate and the increased blood lactate levels observed between matches suggest that it may impair recovery between consecutive maximal efforts.	Aedma <i>et al.</i> , [2], 2013
Randomised, double-blind, counterbalanced, crossover, placebo-controlled study conducted on 6 male athletes, with an average age of 25 years; all athletes received 6 mg/kg of caffeine or placebo with cellulose, both 60 minutes before the test.	Brazil/ Judo	Caffeine administration, after a 5-day weight loss period, did not improve performance during the specific test but reduced perceived exertion and increased plasma lactate.	Lopes-Silva <i>et al.</i> , [42], 2014
Randomised research was conducted on 10 male athletes, with an average age of 24.9 years, for 6 months; having a double-blind design, with repeated measures, caffeine (5 mg/kg) or placebo (cellulose) was administered 50 minutes before the test.	Brazil/ TKD	Caffeine ingestion reduced reaction time during a specific task and the intensity was higher, suggesting that caffeine may delay fatigue during successive taekwondo bouts	Santos <i>et al.</i> , [68], 2014

Type of research dosage and route of administration	Country/ Sport	Conclusions/Effect on the body	Authors, Year
Combat simulation in a double-blind, randomised, repeated-measures crossover design, conducted on 10 male athletes with an average age of 21 years, they received either a capsule containing caffeine (5 mg/kg) or placebo (cellulose), 60 minutes before the test.	Brazil/ TKD	Caffeine supplementation increased the estimated contribution of glycolytic metabolism during simulated taekwondo fighting.	Lopes-Silva <i>et al.</i> , [45], 2015
Randomised, double-blind, crossover, placebo-controlled study conducted on 14 male athletes, with an average age of 29 years; all athletes received either 3 mg/kg of caffeine or a placebo with cellulose, both 60 minutes before the test.	Spain/ BJJ	Caffeine administration helped maintain muscle strength and grip strength during the two simulated fights.	Diaz-Lara <i>et al.</i> , [25], 2016
Randomised, double-blind, crossover, placebo-controlled study was conducted on 14 male athletes with an average age of 29 years; all athletes received either 3 mg/kg of caffeine or placebo with cellulose, both 60 minutes before the test.	Spain/ BJJ	Caffeine administration before specific physical activity increased dynamic and isometric muscle strength, power, and endurance.	Diaz-Lara <i>et al.</i> , [26], 2016
Randomised, double-blind research conducted on 18 male athletes, with an average age of 16 years, divided into two equal groups; the first received 4 mg/kg caffeine and the second group received a placebo, both 60 minutes before exercise.	Brazil/ Judo	Caffeine administration improved specific performance in young athletes and reduced the assessment of perceived exertion.	Astley <i>et al.</i> , [6], 2017
Randomised, double-blind, crossover, placebo-controlled study conducted on 14 male athletes, with a mean age of 22.5 years; all athletes received a dose of 5 mg/kg caffeine and a cellulose placebo 60 minutes before the test.	Brazil/ Judo	This study supports evidence of caffeine's effect on fatigue tolerance and improvement of anaerobic capacity.	da Silva Athayde <i>et al.</i> , [20], 2018
Randomised, double-blind, crossover, placebo-controlled study conducted on 11 male athletes, with a mean age of 27.6 years; all athletes received 5 mg/kg of caffeine or placebo, both 60 minutes before the test.	Brazil/ MMA	Supplementation had no effect on impact force.	de Azevedo <i>et al.</i> , [22], 2019
Randomised, double-blind, placebo-controlled study conducted on 22 male athletes, with an average age of 21.7 years; all athletes received doses of 3, 6 and 9 mg/kg of caffeine and placebo, respectively, both 60 minutes before the test.	Poland/ Judo	Acute supplementation before specific exercise with 6 and 9 mg/kg of caffeine improved specific performance while 9 mg/kg also increased running (struggling) activity; the 3 mg/kg dose had no positive effect.	Durkaleo-Michalski <i>et al.</i> , [29], 2019
Randomised, double-blind, placebo-controlled study conducted on 12 male athletes, with an average age of 23.1 years; all athletes received a dose of 5 mg/kg caffeine and placebo, both 60 minutes before the test.	Brazil/ Judo	Match-derived technical variables were not sensitive for detecting small or medium effects of caffeine, but perceived exertion may detect at least medium effect after caffeine ingestion	Saldanha da Silva <i>et al.</i> , [67], 2019
Randomised research conducted on 27 athletes (18 male and 9 female) with an average age of 17 years; 6mg/kg was administered for 4 weeks.	Turkiye/ TKD	Exercise capacity increased significantly following caffeine use compared to placebo glucose use during the first 3 weeks of Ramadan (caffeine: $38.3 \pm 6.8\%$, glucose: $36.4 \pm 6.9\%$, placebo: $36.0 \pm 6.5\%$)	Park, I.E., <i>et al.</i> , [56], 2020
Randomised, double-blind, crossover, placebo-controlled study conducted on 8 male athletes, with an average age of 21.4 years; all athletes received a capsule with 5 mg/kg of caffeine and placebo 60 minutes before the test.	Brazil/ Judo	Caffeine administration led to an increase in plasma fatty acids and lactate, lower serum uric acid concentration, lower fatigue index, and higher specific workload.	Carmo <i>et al.</i> , [12], 2021
A double-blind, placebo-controlled, crossover design was used in this investigation, conducted on 16 athletes (8 male and 8 female), with an average age of 21 years; 60 minutes before the test, the athletes ingested 3 mg/kg of caffeine or placebo.	Spain/ Jiu Jitsu	It is an ergogenic aid that increases performance in both bilateral and unilateral vertical jumps; these increases were also accompanied by modified jump execution during the different phases of the countermovement before take-off.	Merino Fernandez <i>et al.</i> , [51], 2021
Randomised, double-blind, crossover, placebo-controlled study conducted on 9 male athletes, with an average age of 23.7 years; 15 minutes before the specific test, 2.7 mg/kg, 5.4 mg/kg and placebo were ingested by chewing gum at intervals of 7 days.	Poland/ Judo	Current investigations have shown that caffeine ingestion through chewing gum was ineffective in increasing the number of throws performed in this judo-specific event.	Filip-Stachnik <i>et al.</i> , [32], 2021

Type of research dosage and route of administration	Country/ Sport	Conclusions/Effect on the body	Authors, Year
In a double-blind, crossover, randomised placebo-controlled trial, conducted on 20 athletes (10 male and 10 female), with an average age of 17.5 years; the experimental group was administered 3 mg/kg of caffeine 60 minutes before the warm-up/test.	Tunisia/ TKD	The synergistic effects of caffeine and conditioning activity could be an effective strategy to prepare athletes to cope with physical and psychological stress during training, pre-competitive preparation, or competitions.	Quergui <i>et al.</i> , [55], 2022
Randomised, double-blind, counterbalanced, crossover study; 22 athletes (11 male and 11 female), with a mean age of 22.4 years; 3 mg/kg of caffeine anhydrous powder or placebo with cellulose, both administered 60 minutes before the test.	Spain/ Jiu Jitsu	After administration, there was an increase in performance on the gold standard test specific to judo grip skills by decreasing the perception of fatigue and increasing the perception of power and endurance	Merino-Fernandez <i>et al.</i> , [50], 2022
Randomised, double-blind, placebo-controlled study conducted on 10 athletes (6 males and 4 females), with an average age of 24 years; all athletes received 3 mg/kg of caffeine, 6mg/kg of caffeine and placebo in turn 60 minutes before the test.	Poland/ Judo	Ingestion of 3 or 6 mg/kg of caffeine before a specific exercise resulted in significant improvements in several aspects associated with judo performance.	Krawczyk <i>et al.</i> , [40], 2022
Randomised, double-blind, crossover, placebo-controlled research, conducted on 10 athletes (2 judo and 8 jiu jitsu), with an average age of 25 years; 60 minutes before the test, the athletes ingested 5 mg/kg caffeine or placebo with cellulose.	Brazil/ Judo, Jiu Jitsu	Caffeine ingestion improved upper body resistance strength and maximal isometric strength in combat.	Lopez-Silva <i>et al.</i> , [44], 2022

Table II

Included studies analysing dietary supplements (excluding caffeine) for enhancing sports performance

Supplement	Type of research dosage and route of administration	Country/ Sport	Conclusions/ Effect on the body	Authors, Year
Proteins	Randomised, placebo-controlled research; 16 athletes, male, with an average age of 21 years; 1.6 - 2.2 g/kg/day whey protein, depending on the volume and intensity of training.	USA/ MMA	Post-exercise protein supplementation led to a significant reduction in muscle soreness and muscle damage markers and to faster muscle recovery and increased muscle mass.	Kersick <i>et al.</i> [38], 2018
Branched-chain amino acids (BCAA)	Randomised, double-blind, crossover, placebo-controlled research was conducted on 12 male athletes, with an average age of 20 years; in the first part the subjects ingested 0.17 g/kg BCAA, 0.05 g/kg arginine and 0.05 g/kg citrulline and later placebo effect.	Taiwan/ TKD	Combined supplementation could alleviate central fatigue induced by three simulated matches.	Chen <i>et al.</i> [13], 2016
Creatine	Randomised, placebo-controlled research was conducted on 12 male athletes, with an average age of 20; all athletes were divided into two groups, one of which received a supplement with 50 mg/kg/day creatine and the other a placebo, both for 6 weeks.	Mexico/ TKD	Creatine supplementation may increase fat mass and serum triglyceride concentration without improvement in anaerobic power output.	de Oca <i>et al.</i> [23], 2013
Creatine	Randomised, placebo-controlled research was conducted on 20 male athletes (in two groups), with an average age of 25 years; 0.3 g/kg/day of creatine for 5 days.	Estonia/ BJJ	Creatine monohydrate supplementation for 5 days failed to increase upper body anaerobic power performed in the match-mimicking form.	Aedma <i>et al.</i> , [1], 2015
Creatine	Randomised research, conducted on 31 male athletes, received a 20 g/day creatinine supplement for 6 days, with an increase in muscle saturation of 20%, subsequently maintaining this concentration for 30 days by administering 2 g/day.	SUA and Canada/ MMA	Creatine improves short-term high-intensity exercise performance, has positive effects on cognitive performance, and may protect or improve recovery from mild traumatic brain injury.	Ricci <i>et al.</i> , [66], 2020
Creatine	Double-blind, randomised, placebo-controlled study, 40 elite males, with an average age of 21.4 years who were divided into 5 groups; they received: creatine monohydrate + sodium bicarbonate (0.5 g/kg each), creatine monohydrate (0.5 g/kg), sodium bicarbonate (0.5 gr/kg), placebo (cellulose 0.5 g/kg) and the last control group.	Iran and Brazil/ TKD	A concomitant ingestion of creatine with sodium bicarbonate further improved average power and maximum power.	Koozehchian <i>et al.</i> , [39], 2020

Supplement	Type of research dosage and route of administration	Country/ Sport	Conclusions/ Effect on the body	Authors, Year
Creatine	Randomised research, conducted on 40 national-level athletes, with an average age of 21 years, male; creatine 5 g/day for 5 days.	Iran/ TKD	Creatine and sodium bicarbonate supplements improve anaerobic performance.	Sarshin, <i>et al.</i> , [69], 2021
Sodium bicarbonate	In a double-blind, crossover, randomised placebo-controlled trial, conducted on 9 male athletes, with an average age of 19.4 years; they were administered 300 mg/kg of NaHCO ₃ or placebo calcium bicarbonate 90 minutes before the test.	Brazil/ TKD	An increase in glycolytic metabolism and attack efficiency was observed throughout the fight.	Lopes-Silva <i>et al.</i> , [43], 2018
Sodium bicarbonate	Randomised, double-blind, counter-balanced, crossover, placebo-controlled study conducted on 10 male athletes with a mean age of 22.2 years; all athletes received a dose of 0.3 g/kg sodium bicarbonate and placebo 80, 70 and 60 min before the test.	Brazil/ Jiu Jitsu	Sodium bicarbonate supplementation does not generate adverse responses leading to gastrointestinal discomfort and does not benefit performance, but provides a state of metabolic alkalosis.	Ragone <i>et al.</i> , [63], 2020
Sodium bicarbonate	Randomised, placebo-controlled study conducted on 16 male athletes, average age 24 years; athletes received either 5000 mg x 2/day of sodium bicarbonate 90 minutes before exercise or placebo for 21 days.	Poland/ Judo	This study suggests that low lactate levels are a dominant mechanism for improving working memory.	Chycki <i>et al.</i> , [14], 2020
Sodium bicarbonate	Randomised, placebo-controlled research, conducted on 10 male athletes, with an average age of 20 years, divided into two equal groups; one group received 0.3 g/kg of NaHCO ₃ and the other received placebo with Ringer's solution, both 120 minutes before the specific effort.	Serbia/ Judo	Sodium bicarbonate supplementation improved recovery after exercise	Dankovic <i>et al.</i> , [19], 2023
Beetroot-based	Randomised, double-blind, crossover, placebo-controlled study conducted on 12 male athletes, with a mean age of 29 years; athletes received 12.2 ± 0.2 mmol nitrate or placebo 02.2 ± 0.02 mmol nitrate, 7 consecutive days.	Brazil/ BJJ	Improving O ₂ saturation for upper limb muscles and preventing strength decline.	de Oliveira <i>et al.</i> , [24], 2018
Beetroot-based gel	Randomised, double-blind, crossover, placebo-controlled study conducted on 14 male athletes, mean age 29.9 years; athletes received a gel with 12.2 ± 0.2 mmol nitrate or placebo 02.2 ± 0.02 mmol nitrate, both 120 minutes before the test.	Brazil/ BJJ	A single dose of high-nitrate beetroot-based gel accelerated maximal forearm muscle isometric strength recovery 20 min after exhaustive handgrip exercise in recreational combat athletes.	de Oliveira <i>et al.</i> , [18], 2020
Beetroot juice	A pilot study was conducted on 8 male athletes, with an average age of 20 years, during the pre-competitive period for 4 weeks; a randomised, double-blind, placebo-controlled design was used (using two acute doses of 400 mg and 800 mg of nitrate-rich beetroot juice -NO ₃ , placebo and control).	Iran/ TKD	Ingestion of two acute doses of beetroot juice containing 400 and 800 mg NO ₃ provided moderate and large effect sizes on anaerobic and aerobic capacity, but no statistical differences in taekwondo-specific performance.	Miraftabi <i>et al.</i> , [52], 2021
Beetroot extract	Randomised research, conducted on 12 male athletes, with an average age of 26.8 years; all athletes performed a maximum aerobic exercise protocol, using bandal chagi, under conditions of supplementation with 1 g beetroot extract and placebo.	Mexico/ TKD	Supplementation with beetroot extract has an ergogenic effect on aerobic capacity and specific performance in the test used specifically for taekwondo.	Antonietto <i>et al.</i> , [65], 2021
Sodium citrate	Randomised, double-blind, crossover, counterbalanced, placebo-controlled study on 11 male athletes, mean age 25.9 years; 30 minutes before the test the athletes ingested 900 mg/kg sodium citrate and wheat flour placebo.	Estonia/ BJJ	4 consecutive simulated matches induce metabolic alkalosis, counteracts reduction in plasma volume, increases post-exercise blood lactate concentration and reduces the perceived effort.	Aedma <i>et al.</i> , [3], 2015

Supplement	Type of research dosage and route of administration	Country/ Sport	Conclusions/ Effect on the body	Authors, Year
Beta-alanine	Randomised, placebo-controlled research, conducted on 5 athletes (2 male and 3 female), with an average age of 24.2 years, divided into two groups; the first group of 2 athletes received 6 g/day of beta-alanine and the second group received a placebo with maltodextrins, both administered for 35 days.	Spain/ Judo	Beta-alanine supplementation appears to improve physical performance and accelerate recovery after exercise.	Grueso <i>et al.</i> , [34], 2014
Beta-alanine	Randomised, double-blind, placebo-controlled study was conducted on 23 male athletes, with an average age of 23 years, who were randomly divided into two groups; the first group (12 athletes) received 6.4 g/ day and the second group (11 athletes) received placebo, both for 4 weeks.	Brazil/ Judo	Supplementation effectively improved athletic performance suggesting it may also benefit from ergogenic effects.	de Andrade Kratz <i>et al.</i> , [21], 2017
Beta-alanine	Randomised, placebo-controlled study conducted on 16 male athletes (two groups of 8), with an average age of 21.8 years; the two groups received either 4 g/day of beta-alanine for the first 2 weeks and then 6 g/day for the next 2 weeks or placebo for 4 weeks.	Poland/ Judo	Chronic supplementation of beta-alanine effectively enhances high-intensity intermittent upper and lower-body performance.	Halz <i>et al.</i> , [35], 2022
Vitamin D ₃	Randomised, double-blind, crossover, placebo-controlled study; 27 male athletes, with an average age of 24.4 years; placebo with 300 mg of maltodextrin with 300 mL of Jersey full fat milk for 6 weeks, and another 6 weeks they consumed either 50000 IU's (D1), 80000 IU's (D2) or 110000 IU's (D3) of vitamin D ₃ with 300 mL of Jersey full fat milk.	United Kingdom/ MMA, Jiu Jitsu	There was a large effect size for D1 compared to D3 for all variables (d > 0.8). Therefore, there is no additional benefit to increasing dose above 50,000 IU vitamin D <i>per week</i>	Marley <i>et al.</i> , [47], 2021
Vitamin D ₃	Randomised, double-blind, placebo-controlled study conducted on 23 male athletes, with an average age of 23 years, were divided into two groups; for 4 weeks, the two groups received either vitamin D ₃ (n = 12) or probiotics + vitamin D3 (n = 11).	Poland/ MMA	Four weeks of combined probiotic and vitamin D ₃ supplementation enhanced lactate utilization and beneficially affected anaerobic performance.	Przewlocka <i>et al.</i> , [62], 2023
L-arginine	Randomised, placebo-controlled study conducted on 28 male athletes, with an average age of 21 years, divided into two groups of 14 athletes each; the first group received 3 g of L-arginine (three times a day) and the second group received placebo with maltodextrin, for 8 weeks.	Korea/ TKD	For kyorugi athletes, can play a positive role in the rapid synthesis of nitric oxide in the blood vessels and the rapid elimination of substances that cause fatigue in the body.	Park, K.H., <i>et al.</i> , [57], 2023
Citrulline-malate	Randomised, double-blind, crossover, placebo-controlled study conducted on 12 athletes (7 male and 5 female), with a mean age of 28.2 years; 8 g maltodextrin + 250 mg/kg citrulline-malate and the placebo 8 g maltodextrin.	Malaysia/ Judo	Acute citrulline-malate supplementation can increase maximal strength and grip strength, as well as anaerobic performance.	Naimah <i>et al.</i> , [54], 2022

Table III

Included studies analysing compound dietary supplements for enhancing sports performance

Supplement	Type of research dosage and route of administration	Country/ Sport	Conclusions/ Effect on the body	Authors, Year
Intracellular buffering supplementation with: Beta-alanine, Alkagen, sodium	Randomised crossover double-blind trial, conducted on 9 athletes (5 male and 4 female), aged between 18 and 35 years; for eight weeks a multi-ingredient intra-cellular buffering supplement (5 g day ⁻¹ of β-alanine) was	Poland/ TKD	The supplementation solely resulted in a modest reduction in total blood ammonia concentration at the exercise intensity corresponding to	Durkalec-Michalski <i>et al.</i> , [28], 2021

Supplement	Type of research dosage and route of administration	Country/ Sport	Conclusions/ Effect on the body	Authors, Year
bicarbonate, BCAA and creatine	administered, versus supplementation with alkagen (0.07 g/kg·day-1 of sodium bicarbonate) combined with branched-chain amino acids (0.2 g/kg day-1) and creatine malate (0.05 g/kg day-1) during a standard training period.		VO ₂ max, however, without significant changes in body mass and composition, aerobic capacity, and haematological indices.	
Creatine+ sodium bicarbonate	Randomised research was conducted on 16 athletes with an average age of 17.9 years, divided into two groups; for the experimental group, a combination of creatinine and sodium bicarbonate was administered 4 x 5 g/day for 6 days and 0.065 g/kg on the test day (seventh day) and for the placebo group was provided with maltodextrin 4 × 5 g <i>per</i> day for 6 days and 0.065 g <i>per</i> kg body weight on the test day.	Canada and Iran/ TKD	Supplementation with creatinine and sodium bicarbonate improved anaerobic power but had no significant effect on blood lactate.	Kazemi <i>et al.</i> , [37], 2013
Caffeine + sodium bicarbonate	Randomised, double-blind, counterbalanced, placebo-controlled study was conducted on 10 male athletes, with an average age of 23 years; all athletes received, one after the other, 3 mg/kg sodium bicarbonate, 6 mg/kg caffeine, 3 + 6 mg/kg sodium bicarbonate + caffeine and placebo with cellulose, administered 60 minutes before the test, with a one-week break.	Brazil/ Judo	Combined supplementation of sodium bicarbonate and caffeine resulted in a significant improvement in performance during the specific test compared to individual administration.	Felippe <i>et al.</i> , [31], 2016
Caffeine + sodium bicarbonate	In a double-blind, crossover, randomised placebo-controlled trial, conducted on 10 athletes with an average age of 20 years, divided into an experimental group and a placebo group for a duration of six weeks; capsules containing 6 mg/kg caffeine were consumed 50 min prior to a test whilst 0.3 g/kg NaHCO ₃ was consumed for 3 days leading to and 120, 90, and 60 min prior to a test.	Iran/ Karate	Administration of sodium bicarbonate and caffeine separately or combined could improve performance during a karate-specific aerobic test.	Razei <i>et al.</i> , [64], 2019
Sodium bicarbonate+ beta-alanine	Randomised, double-blind, placebo-controlled study was conducted on 37 male athletes (16 judo and 21 jiu jitsu), with an average age of 23 years, were divided into 4 groups; all athletes received, depending on the group, placebo (calcium carbonate), 6.4 g beta-alanine, 500 mg/kg sodium bicarbonate or both combined for 7 days in the fourth week of training.	Brazil/ Judo, Jiu Jitsu	Beta-alanine and sodium bicarbonate supplementation equally improved high-intensity upper body performance; combined the two supplements resulted in lower ratings of perceived effort.	Tobias <i>et al.</i> , [70], 2013
Beta-alanine and sodium bicarbonate	Randomised research, conducted on 20 male athletes, with an average age of 26.2 years, divided into two equal groups; one group received 3.2 g/day 3 hours before exercise and the second group 3 g/kg sodium bicarbonate one hour before exercise, both for 6 weeks.	Iran/ TKD	Beta-alanine supplementation compared to sodium bicarbonate results in both being effective in preventing fatigue and reducing muscle damage.	Yousef <i>et al.</i> , [72], 2015
Inosine	Randomised research, conducted on 30 athletes (20 male and 10 female), with an average age of 21 years; all athletes received 1000 mg of inosine 30 minutes before the specific test.	Romania/ TKD, Ashihara karate	24% on the competitive motor performances; the best results are found in taekwondo – speed-force.	Păunescu <i>et al.</i> , [58], 2021
Multicomplex “MDX”	Randomised research conducted on 70 male athletes, with an average age of 21 years; for five days they received 1 g/kg divided into two doses, one 30 minutes before training and one 30 minutes after training.	Russia/ Judo	After supplementation, it was found that the execution speed increased.	Kachenkova <i>et al.</i> , [36], 2023
Compound supplement: whey protein concentrate, L-arginine, Korean red ginseng root extract, cocoa powder	Randomised research conducted on 15 male athletes, with an average age of 20.29 years; all athletes received 40 g of whey protein concentrate, 2 g of L-arginine, 9 g of Korean red ginseng root extract and 9 g of cocoa powder for 4 weeks.	Egypt/ TKD	Can be used for a long time without health hazards, having the effect of eliminating anaerobic byproducts and helping combat muscle fatigue, decreasing recovery time and improves anaerobic endurance.	El-Shobaki <i>et al.</i> , [30], 2018

The present study was conducted on 891 athletes, martial arts practitioners, of which 827 were male and only 64 were female, aged between 16 and 35 years, which means that they included juniors and seniors, amateur and professional levels. As a procedure for verifying the experiments, the placebo effect was used in 90% of the cases presented. The studies analysed were generally conducted in countries with a tradition in the world and Olympic elite of martial arts such as: USA, Canada, Mexico, Taiwan, Brazil, Spain, Poland, Korea, Turkey, Russia, Iran, Estonia, Tunisia, Romania, England, Malaysia, Egypt and Serbia. The martial arts involved in studying the effect of food supplements on sports performance, in the last ten years, are Olympic (judo, taekwondo) and non-Olympic (MMA, BJJ, jiu jitsu, karate) as can be seen in Figure 2.

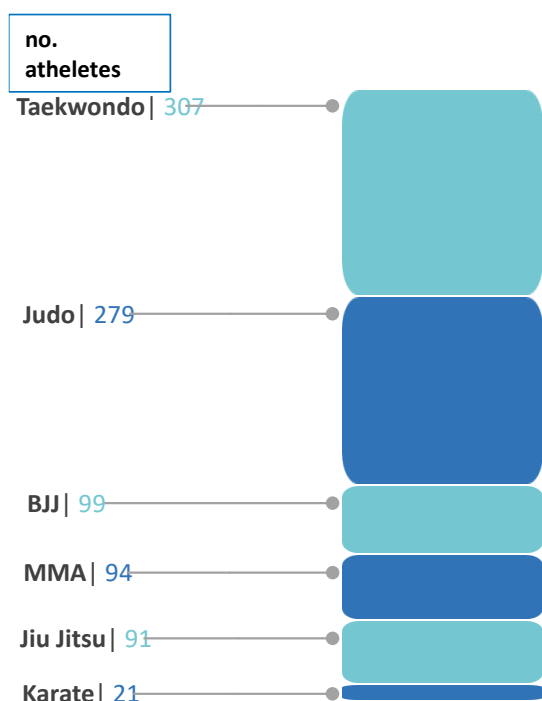


Figure 2.

Distribution of participating athletes by sport branch

As can be seen from the above analysis, in the last ten years, the most tested supplement for combat practitioners has been caffeine. This has been administered from 3 to 9 mg/kg body weight, 30 - 60 minutes before exercise. Caffeine supplementation for sports involving body combat has been reported to increase dynamic and isometric muscle strength and power, grip strength, improve anaerobic capacity, increase running (fighting) activity and decrease the perception of fatigue, this being also achieved by administering 900 mg/kg of sodium citrate. For sports where lower limb activity predominates, such as TKD, after caffeine administration, better reaction time, higher work intensity, overall increase in exercise capacity, delay fatigue and help reduce physical and

mental stress from training or competition have been observed. Another reduction in fatigue, after 3 simulated kyorugi matches, is also achieved by administering 0.17 g/kg of BCAA.

Caffeine in a proportion of 6 mg/kg of body weight combined with 3 mg/kg of sodium bicarbonate, administered in sports such as judo, significantly improves physical performance, while for karate the aerobic part is highlighted.

The studies presented above show that *sodium bicarbonate*, administered in a proportion of 0.3 g/kg body to 10 g/day, for judo athletes, maintains low lactate levels with faster recovery after exercise, while for a dynamic sport like TKD it ensures an increase in glycolytic metabolism and efficiency in the attack in kyorugi. If *sodium bicarbonate* is combined with *beta-alanine* (0.5 + 6.4 g/kg), for sports like judo and jiu jitsu, it considerably increases high-intensity performance in the upper body.

Beta-alanine administered between 3 and 6.4 g/day in sports like judo can improve physical performance and accelerate recovery and in TKD it brings results in preventing fatigue.

Creatine, the second most studied supplement, has been administered in amounts ranging from 5 - 20 g/day to 0.05 - 0.5g/kg body weight for a minimum of 5 days and a maximum of 6 weeks. In ground fighting sports such as MMA and BJJ, it increases upper body anaerobic power and improves high-intensity exercise performance. When *creatine* is combined with *sodium bicarbonate*, in sports such as TKD, it produces an improvement in average and maximum power as well as anaerobic power.

Whey protein administered in amounts of 1.6 - 2.2 g/kg of body weight, in ground fighting sports such as MMA, reduces muscle soreness after intense exercise, helps with faster muscle recovery and growth. A compound supplement based on 40 g of protein and 2 g of *L-arginine*, combats muscle fatigue, increases anaerobic endurance and significantly decreases recovery time for sports such as TKD. Administration of 1 g of *L-arginine* three times a day, for kyorugi athletes in TKD, plays an important role in the rapid synthesis of nitric oxide from the blood and the rapid elimination of substances that cause fatigue, directly helping to accelerate recovery.

Citrulline-malate administered in amounts of 250 mg/kg of body weight, in ground fighting sports, can increase maximum execution power and grip strength as well as anaerobic effort. Improvements in anaerobic performance, in sports involving hand-to-hand combat, are also obtained by administering vitamin D3 at 50,000 IU/day.IU's.

Beetroot administered in the form of gel (12.2 mmol), juice (400 - 800 mg) or extract (1 g), in sports such as BJJ can improve oxygen transport for the upper limb muscles and ensure a faster recovery of isometric

strength, while for TKD it acts on the aerobic and anaerobic capacities used specifically.

In complex sports such as TKD, the administration of 2 g of *inosine*, 30 minutes before the effort, considerably increases the speed-strength work capacity and implicitly the specific resistance. The administration of inosine in sports such as karate wkf and karate ashihara does not have such a considerable effect.

The “MDX” *multicomplex*, administered 1 g/kg body weight, in sports such as judo, increases the speed of execution.

Thus, food supplements can be chosen according to the needs of the athlete and the type of test in which he participates or the nutritional objectives [10].

In conclusion, this systematic review highlights that dietary supplements may contribute to improved strength, power, speed, endurance, aerobic and anaerobic capacity, reduced stress, and faster recovery in combat athletes. However, existing studies are questionable regarding their effects on performance in official competitions, and the limited number of long-term studies makes it difficult to assess long-term safety. We believe that further research is needed to further understand the role of supplements in combat sports as well as longitudinal research examining the safety and the effectiveness of dietary supplements used over extended periods.

Conclusions

Overall, the use of dietary supplements may provide benefits to combat athletes, particularly in terms of increasing some motor fitness characteristics and improving recovery after exercise. This is widespread and generally well documented, but athletes should be aware of the risks associated with contamination and overuse. In conclusion, supplements can be a valuable tool for combat athletes when used judiciously and under the supervision of a sports nutritionist. However, evidence regarding their effects on overall performance and safety is still limited. Future research should address these gaps and provide clearer guidance for athletes and coaches.

Conflict of interest

The authors declare no conflict of interest.

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