JOURNAL OF EDUCATION, HEALTH AND SPORT
eISSN 2391-8306 · Open Access · Peer-reviewed
apcz.umk.pl/JEHS · Nicolaus Copernicus University in Toruń

Cite as: ŻEŻAWSKA, Karolina, PAL, Adrian, CEGIEŁKA, Patryk, CIENKOWSKI, Krzysztof, ADAMCZYK, Aleksandra, SICIŃSKA, Maria, ŚLOT, Marcin, GŁOWACKA, Izabela, KATRA, Małgorzata and SZCZĘSNY, Mikołaj. Impact of Supplements on Health, Sport Performance and Well-being of Climbers: A Narrative Review. The therapeutic potential of the ketogenic diet in selected neurodegenerative diseases and psychiatric disorders. Journal of Education, Health and Sport. 2026;94:72996. https://doi.org/10.12775/JEHS.2026.94.72996

ARTICLE TIMELINE
Received: 02.06.2026 Revised: 10.07.2026
Accepted: 10.07.2026 Published: 17.07.2026

INDEXING & EVALUATION
MEiN points: 40 Unique ID: 201159
Disciplines: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).

The journal has been awarded 40 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32318). Unique Journal Identifier: 201159. Scientific disciplines: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).

Punkty Ministerialne z 2019 – aktualny rok 40 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).

Impact of Supplements on Health, Sport Performance and Well-being of Climbers: A Narrative Review

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Abstract

Background. Sport climbing is becoming increasingly popular, especially after being added to the Olympic program. Both amateur and professional climbers are preparing through training programs, developing general strength, power, endurance and specific skills. Other factors related to sports results include nutrition, proper recovery, and the use of supplements, which are widely discussed in this article.

Aim. The aim of this study is to evaluate and summarize the impact of different supplements on sport performance, health, and overall wellbeing of climbers, considering many factors influencing the effectiveness of supplementation (including competitive and recreational levels of athletes and different genders).

Research materials and methods. A narrative review of the literature was conducted using PubMed and Google Scholar. Attention was devoted to meta-analysis and systematic reviews focused on the impact of supplements on sport performance, especially among climbers.

Summary and Conclusions. Supplements intake can have a significant impact on climbing performance. It can not only enhance physical parameters, like upper-body strength or forearm endurance, but also increase alertness, improve cognitive functions and wellbeing of athletes, although more research should be provided to understand and evaluate all potential risks and benefits.

Key words: climbing, bouldering, sport performance, supplements, caffeine, creatine, beta-alanine, beetroot juice, New Zealand blackcurrant.

1. Introduction

Sport climbing is a relatively new sport discipline, that was included in the Olympics in 2021 at Tokyo [1, 2]. It was firstly introduced as a triathlon consisting of three disciplines: bouldering, lead climbing and speed climbing. At the 2024 Olympics in Paris, this concept changed to two separate competitions – Speed and Boulder & Lead combined [3]. All these disciplines differ from each other in rules and have specific athletic demands for competitors [4]. Bouldering is practiced on smaller walls or rocks (up to 4-5 m) and protection from falls is provided by crashpads and spotters. The boulder 'problems' usually consist of few powerful and highly physically demanding moves. During competitions, the outcome is usually based on the number of solved 'problems' in the minimal possible attempts. Lead climbing is performed on higher objects (ranging from a few to approximately 60m). It demands a partner who can belay the climber by using ropes clipped to quickdraws attached to fixed points on an artificial wall or rock. During sports events, climbers try to 'send' (complete the whole route) in a limited time without seeing it beforehand. Climbers are obligated to overcome short or long sequences of moves, sometimes divided by easier terrain, where they have the possibility to recover. Speed climbing stands out, as the aim is not to climb at a particular difficulty level, but to complete a known route in the fastest possible way. Each discipline requires different preparation and specific skills from athletes. In general, sport climbing demands aerobic and nonaerobic energy systems [5], although lead climbing, as a long-term effort, is associated with greater emphasis on endurance, whereas bouldering and speed climbing rely more on power and strength [6]. The highest explosive strength is required in speed climbing. In general, there are many variables that affect the difficulty of a climbing route or problem, for example: the kind and size of holds, footholds and the angle of the wall. Usually, more overhang walls require more athletic moves, whereas smaller holds are associated with higher finger and grip strength [7]. Also, the mental aspect can affect the outcome, as not overcoming the difficulties may be associated with falling onto the crashpads in bouldering or a few meters of freefall in lead climbing, which can be potentially harmful. In competitions, this danger is reduced and the falls are rather safe [5].

The typical body composition of elite athletes can be characterized as short, lean, low weight, with a low percentage of body fat [8]. This appearance has an explanation in the sport's specification. Some of the parameters, assessed as crucial for elite climbers, are the maximum finger and wrist flexor contraction, overall hand strength and strength-to-weight ratio [9]. This ratio can be improved either by improving strength or reducing body weight, which is a strategy

used by all-level climbers. Activities focused on weight and body fat reduction, when provided irresponsibly or inadequately, can lead to worsening of sports performance and serious health consequences. Inadequate nutrition and insufficient caloric intake are directly related to proper energy availability (EA), defined as the energy left for the body to function properly after energy is consumed during exercise. Inappropriate nutrition can result in low energy availability (LEA) [10], which is an inappropriate energy intake in relation to body requirements to maintain optimal health and sport performance [11]. The LEA definition was extended, firstly in 2014 [12] and later updated in 2018 [13] and 2023 [11] by International Olympic Committee's (IOC) as Relative Energy Deficiency in Sport (REDs). The new definition of REDs describes physiological malfunction (including low energy level, bone, immunological and cardiovascular health, metabolic and reproductive function) caused by exposure to LEA. It affects male and female athletes and can lead to a worse quality of life, poorer sports performance, and a higher risk of injury [11]. Nutritional restrictions and an inappropriate lifestyle can also lead to deficiencies in micronutrients and vitamins. In this context, proper nutrition and energy intake are highly important to maintain optimal condition and athletes' performance. Apart from diet, another factor affecting nutrition is dietary supplements. They are widely used by all-level athletes to benefit from reported advantages, including preventing and correcting deficiencies, increasing energy levels and performance during training sessions, and achieving health and sport-related benefits [14]. Despite many supplements being widely examined among athletes from different disciplines, not many studies are focused on climbers. The aim of this study is to investigate the impact of supplement use among climbers. The study considered the impact of supplements on athletes' health and general well-being, with a main emphasis on sports performance.

2. Research materials and methods

This study is based on two large, scientific databases – PubMed and Google Scholar to provide relevant and reliable literature on supplementation in sport climbing. The publication date was not limited, although the latest research, especially meta-analyses and literature reviews, was prioritized. The keywords used during the search process are presented in

Table 1. Articles were selected by authors in accordance with topic compliance, research quality and language of study.

Table 1. Databases and Keywords

DATABASES	PubMed, Google Scholar
KEYWORDS	„supplementation “, „climbing “, bouldering ““, „caffeine “, „creatine “, „beta alanine “, „beetroot “, „New Zealand blackcurrant “

3. Prevalence of supplement intake among climbers

The frequency of supplement use varies among athletes, ranging from 40 to 100% depending on sex, age, type of sport, method of study and definition of supplement [14, 15]. Among senior competitor climbers 65% declare intake of one or more supplement and 44% reported using more than one supplement during last 6 months. Another study that includes mostly advanced and intermittent climbers reported even higher prevalence of supplements intake (67.5% of women and 84.3% of male participants) [16]. The cross-section of supplements used by climbers is wide and differs between studies. Protein powder and creatine are the most popular supplements in most studies [16-18]. Prevalence of other supplements used varies and the most frequently mentioned are magnesium, vitamin C, B group vitamins and beta-alanine.

4. Supplements enhancing climbing performance

From the many available and often mentioned supplements, a few were selected for further investigation. Attention was focused on this, which has previously been reported in other sports as the most effective or was researched among climbers. Consequently, we described four supplements (caffeine, beta-alanine, beetroot juice and New Zealand blackcurrant extract), whose influence on climbing performance has already been studied. Besides, the impact of creatine intake was described, since it is one of the most researched supplements influencing athletes’ health and performance.

4.1. Caffeine

Among other supplements, caffeine is among the most common and well-studied substances. It is used by athletes of all kinds, regardless of whether they focus on strength or endurance. The main way in which caffeine works is by acting as an antagonist of adenosine receptors. Adenosine and its receptors participate in the regulation of neurotransmitter release

(acetylcholine, dopamine, norepinephrine, serotonin) [19]. Blockade of receptors results in increased concentrations of neurotransmitters, influencing cognitive functions, feelings of fatigue and mood (16). Other described mechanisms include impact on mobilization of intercellular calcium and inhibition of phosphodiesterases (resulting in cAMP accumulation) [20]. ll these actions, which occur at the biochemical level, affect the organism's function and sports performance. In a large umbrella review in 2019, Grgic et al. [21] reported the ergogenic effect of caffeine across the following aspects: aerobic endurance, strength, muscle endurance, power, jump height, and exercise speed. Most of the findings were observed among young male participants and the investigated benefits were associated with ingestion of a determined dose of caffeine (mainly 6mg/kg) around 1 hour before exercise.

Among climbers at all levels, caffeine is the most frequently reported supplement, believed to enhance performance, with a higher prevalence among elite athletes (51% of study participants) than among advanced and intermediate athletes (40% and 33% of study participants, respectively) [22]. In contrast, among Polish climbers, no one reported using caffeine, although it applies only to supplements (like pills or shots), excluding consumption with tea, coffee and other foods and drinks, so accurate daily intake is hard to evaluate [16]. Research among climbers is not fully consistent with the benefits reported in other types of training and exercise. Ruiz-López et al. [23] reported that participants receiving a low dose of caffeine (3mg/kg) noticed psychophysical improvements, although these did not transfer to objective measures. None of the physical indicators (strength, power, endurance) has improved. Surprisingly, a slight but statistically nonsignificant decrease in grip endurance was reported. The fact that the study does not include female and elite climbers is worth noting. However, another study that analyzed energy drink intake (containing 3mg/kg caffeine) reported increased maximal pull-up repetitions and prevented a decrease in isometric strength during performance, although it had no influence on maximal pull-up speed [22].

Sport climbing is regarded as an activity that demands both physical and psychological skills. It was reported that cognitive and psychological factors can affect not only climbing performance but also the preparation process (e.g., previewing boulder problems) [22] and in this context, caffeine intake may also confer benefits. It was previously mentioned that caffeine can improve the level of energy, alertness, mood and indicators such as simple reaction time, choice reaction time, memory and fatigue level [24], which is significant advantage during exercise and performance.

Several studies have suggested a smaller ergogenic response to caffeine among females [25], whereas a recent study including well-trained men and women showed no differences in the positive influence on strength, power and endurance between the sexes [26]. Despite that, no research regarding sex differences among climbers was conducted. To evaluate the cognitive and physical benefits for all-level climbers, more studies should be conducted, taking into account elite climbers, females, and different caffeine dosages, as most previously reported benefits were observed after consuming 6 mg/kg caffeine. Nevertheless, it is highly probable that caffeine supplementation can improve climbing performance by increasing alertness and focus, as well as strength, power, and endurance, and it cannot be ruled out that it influences all of them.

4.2. Creatine

Creatine is an amino acid belonging to the guanidine phosphagens family and is naturally occurring in the human body, mostly in muscles (95%) and the remaining in the heart, brain, and testes. It comes from two sources: dietary intake (mostly red meat and fish) (26, 27), or endogenous synthesis. In the human body, creatine is formed from two amino acids through several processes. Firstly, arginine and glycine are combined to form guanidinoacetate (GAA) by arginine glycine amidinotransferase (AGAT). This process continues with GAA methylatization by the enzyme guanidinoacetate N-methyltransferase (GAMT) using S-adenosyl methionine (SAMe) to obtain the final form of creatine (28). Normally, during the elimination process, creatine is converted to creatinine and excreted with the urine at approximately 2g/day [27]**.** Average daily, unsupplemented intake of creatine is 1-2g/d, although the provided type of diet (depending on daily meat and fish consumption) and other health conditions must be considered to determine optimal intake [28].

In muscles creatine occurs in two forms: 2/3 as phosphocreatine (PCr) and 1/3 as free particle (Cr) [27, 29]. PCr is a high-energy product and participates in energy production by providing phosphagens for the regeneration of adenosine triphosphate (ATP) from adenosine diphosphate (ADP) during exercise. It participates in energy metabolism mainly during short-term exercise, as the PCr stores are depleted within 10-15 seconds [27].

Best of our knowledge, no studies investigating the influence of creatine on climbing training or performance have been conducted. There are, however, many papers describing the benefits and ergogenic effects of creatine supplementation among different types of athletes. Typically, two supplementation protocols are suggested: 1) ingesting 20g/day (divided into four

portions) for 5 to 7 days, followed by dose 5g/day, which is suggested the most effective way or 2) ingesting 3g creatine/day for 28 days, but the ergogenic effects on trainings and performance are delayed in time, compared to the first protocol [28]. reatine influences many aspects of sport performance, including body recomposition, increased high-intensity exercise capacity [30] muscle mass and strength adaptation, enhanced recovery [28, 31] and improved glycogen restoration [32]. It affects body mass by increasing lean body mass and reducing body fat percentage [33]. Regardless of the type of exercise or training performed,, creatine supplementation may help prevent and rehabilitate from injuries, which is significant, especially in competitive sport [28]. Moreover, cognitive functions (such as memory, attention time improvement, and processing speed time) are reported to improve after regular supplementation [34]. All these benefits clearly indicate that climbers should also theoretically benefit from creatine supplementation. Greater muscle mass and strength shall be advantageous, especially in bouldering or speed climbing, due to more athletic strength and power demands. The only side effect, although relevant for climbers, might be weight gain. It may worsen climbing performance by impairing the strength-to-weight ratio, although no studies on this topic have been conducted, so it is impossible to provide a final evaluation [28, 30]. Nevertheless, despite the lack of data from climbing athletes, it is highly probable that all previously mentioned benefits may outweigh potential weight gain.

4.3. Beta-alanine

Beata-alanine (BA) supplementation is currently popular among elite athletes due to its ability to improve sports performance. BA, classified as a nonproteinogenic amino-acid, along with histidine, is a substrate necessary for carnosine synthesis (β-alanyl-L-histidine), a substance responsible for maintaining acid-base homeostasis in skeletal muscles. High-intensity, short-term training is associated with anaerobic metabolism and an increase in the concentration of lactic acid, which is later decomposed to lactate and H+ ions, leading to changes in acid-base balance [35]. Physiologically, homeostasis of pH is ensured by intra- and extracellular buffers (e. g., beta-alanine (intracellular) and bicarbonate (extracellular)) [36]. As the effort continues, buffering capacity lowers and pH decreases, resulting in less efficient muscle contraction and increased fatigue, consequently impairing athletic performance [37]. Carnosine acts like an intracellular buffer, reducing acidosis in muscles and thereby delaying the onset of exhaustion [38]. Supplementation of BA can significantly improve the efficiency of the buffering process, as its low concentration in muscles is considered a limiting factor for

carnosine synthesis [39]. A small amount of BA is delivered to muscles from the liver and the other way to increase the concentration is through dietary intake or additional supplementation [40]. Besides its buffering features, other health benefits of carnosine are highlighted in the literature (antioxidant, anti-aging function and Ca2+ sensitization of the contractile system leading to enhanced force production) [36, 41]. As mentioned before, bicarbonate also provides acid-base regulation, with the difference that they work extracellularly. Theoretically, providing its supplementation should increase buffering capacity and act additively with BA. It is worth noting that some studies suggested additional benefit from co-supplementation of BA with sodium bicarbonate [42, 43].

The optimal BA supplementation protocol assumes consumption of 4-5.6g to 6.4g per day for 4 weeks, preferably divided into smaller portions [44, 45]. Beyond that, it is significant to understand that the benefits of BA supplementation depend on the type and length of training. It can improve power, strength, performance time and total sets performed when the work duration is up to 10 minutes. It is not conclusive whether the minimal duration time is 4 minutes [44] or 0.5 minutes [46], although it is certain that it has no influence on effort under 0.5 minutes. It is important to understand that not every athlete may benefit from the supplementation in the same way.

To our knowledge, the influence of isolated BA supplementation on climbing performance has been studied twice. The first study revealed no improvement in climbing performance among amateur boulderers, except for later fatigue onset [47]. Conversely, the results reported by Sas-Nowosielski et al. [48] matched those of research conducted among athletes from other fields. The supplementation enhances power endurance, in this case understood as the ability to repeat high-intensity, intermittent upper-body training. Athletes were also tested on two kinds of traverses (previously designed routes), divided into easy and difficult ones. No benefit was observed on “hard” traverse (where climbers performed below 1 minute due to its’ intensity), although time to failure and the number of moves performed before failure on “easy” (and longer lasting) traverse increased by 59% and 51% respectively. Moreover, another study showed improvement in the number of moves made and time of climbing on both „hard” and “easy” planned circuits, after four weeks of co-supplementation of BA and sodium citrate (CarnoRushTM) [49] indicating enhancement in short-term, climbing endurance. Due to limited data among climbers, it is impossible to decide unequivocally whether BA supplementation improves climbing performance. However, given the mentioned research, it is probable and warrants further studies.

4.4. Beetroot Juice

Beetroot juice (BJ) is considered **a** supplement that enhances sports performance due to its high nitrate (NO3-) concentration [50]. It can be broken down to nitrite (NO2-) in oral cavity [51] and later in stomach, where it is converted to nitrite oxide [52]. NO compound, which acts as a vasodilator, may have positive impact on blood flow, increasing muscle oxygenation [53] and improving force of contraction in fast-twitch (type II) muscle fibres [54], which can result in more effective muscle contractions and lower consumption of ATP during performance [55]. Some studies have shown a positive effect of BJ on brain perfusion and cognitive function. The impact on neuromuscular performance is still inconclusive. Some improvements were reported [56, 57], as well as few researches without noticeable results [58, 59]. To provide the best possible outcome, the following supplementation parameters were established: 5-25 mmol·d−1, provided 2–3.5 h before exercise [60].

In a 2020 systematic review, it was reported that BJ can improve sports performance in some competitors [60]. The visible ergogenic effect of NO3- supplementation was observed in healthy, amateur athletes. It probably does not depend on FiO2 during workout (hypoxia vs normoxia) [60]. There was no improvement in studies that included only women or elite athletes. Acute BJ supplementation may also improve cardiorespiratory endurance, whether chronic supplementation can enhance time-to exhaustion during submaximal effort) [61]. The newest umbrella review, focused on nitrate supplementation and sport performance, reaffirms a beneficial effect on time-to-exhaustion [TTE], total distance covered, muscular endurance, peak power output [PPO] and time to reach PPO, although it denies other effects (including muscular strength) [62]. In total, nitrate consumption can lead to improvements of up to approximately 3% [60], which is an objectively low value, although in professional sports, differences around 1% are considered significant [63].

Like other supplements, the influence of BJ has been very little examined among climbers. Berlanga et al. [64] in their research, they reported no effect of acute BJ supplementation (70 mL, 6.4 mmol NO3-) on neuromuscular performance in amateur climbers, measured by jump height, isometric handgrip strength, the pull-up until failure test, and the maximal isometric half crimp test. No changes in isometric strength have been reported in other athletes [65]. However, a positive impact on lower-body strength, power and endurance among high-mountain climbers was also reported, indicating that it probably reduces muscle fatigue and pain [66]. This small amount of data does not allow for a reliable and unambiguous evaluation of the influence of BJ consumption on climbing performance. Although based on

the above-mentioned studies, it is advisable to conduct further research in this group of athletes, considering optimal supplementation parameters and including different criteria (biological sex, training level).

4.5. New Zealand Blackcurrant

Berries are fruits, considered health-improving superfoods due to yheir content of anthocyanins [67], specific class of flavonoids capable of decreasing oxidative stress, inflammation and mitochondrial depletion [68]. Blackcurrant contains a higher concentration of anthocyanins, mainly delphinidin glycoside, than other berries (130-460 mg/100 g fruit weight of total anthocyanins compared to 62–300 mg/100 g fruit weight of total anthocyanins in blueberries) [69]. It was found that New Zealand Blackcurrant (NZ BC), which grows in New Zealand, has the highest concentration of anthocyanins, probably due to exposure to intense UV radiation and long insulation [70]. Besides reducing oxidative stress, anthocyanins can also induce vasodilatation and improve peripheral blood flow, potentially enhancing athletes' performance [71]. The standard dosing protocol used in studies involves taking 600 mg/day NZ BC extract for 7 days.

Among climbers, only a few studies on NZ BC intake have been conducted, although they have suggested potential benefits for sport performance. It increases muscle oxidative capacity, a value assessed as the amount of oxygen in the middle of recovery; however, it does not affect isolated forearm muscle performance [72]. Improvement in time to half recovery was confirmed in another study, although without influence on forearm endurance performance or arterial blood flow. Among potential advantages, it significantly improved total climbing time (TCT) comparing to placebo (+23% vs -11%) over three climbs to exhaustion, which which were separated by 20-minute rests [73]. Also, higher hang time was noticeable, although influence on pull-ups was not observed. Measuring parameters (heart rate, blood lactate, forearm girth, and hand grip strength) allow to define that 20 minutes was not enough time to obtain full recovery. This fact confirms the statement that NZBC enhance recovery and improves climbing performance by increasing TCT.

5. Risk associated with supplementation

Every supplement, even this recognised as safe, may cause adverse effects, especially when the optimal supplementation protocol is not followed or many substances are consumed,

as they can interact with each other [14]. The most common side effects of supplements mentioned in this study are:

1) Caffeine: muscle soreness, increased urine output, tachycardia and heart palpitations, anxiety or nervousness, headache, gastrointestinal problems, insomnia [74, 75]
2) Creatine: weight gain [28]
3) Beta-alanine: paresthesia [76]
4) Beetroot juice: Not reported
5) New Zealand blackcurrant extract: Not studied

All side effects of caffeine intake were reported significantly more frequently with high-dose supplementation (9mg/kg) than with lower doses (3mg/kg and 6mg/kg). Kreider et al. [28] reported that low-dose creatine supplementation does not cause any other side effects. No side effects after consumption of beetroot juice were reported, although it can be potentially harmful due to its high nitrate concentration, which may promote NOCs formation. NOCs can have potentially carcinogenic effects, although the correlation between cancer risk and beetroot juice supplementation was not studied [77]**.** To our knowledge, the side effects of New Zealand blackcurrant extract have not been studied.

Another negative aspect of using supplements is the possibility of contamination. Even though the previously described substances are legal and safe, they may contain prohibited substances (as undeclared ingredients or contaminants). It is hard to estimate the probability of supplement contamination, though even a small addition of substances could lead to positive anti-doping test results [14]. In this regard, the selection of the type and source of the supplement, as well as the supplementation protocol, should be preceded by proper research and comparison of potential risks and benefits.

6. Conclusions

Sport climbing is becoming more popular and an increasing number of people are beginning to train and compete. While properly structured training plans and suitable nutrition remain the most significant factors in progress, athletes will always seek additional ways to enhance their performance. It is important to identify means to develop it in an optimal and safe way. The aim of this study was to summarise current knowledge about the influence of

supplements on climbing performance. They can enhance physical factors such as strength, endurance, power and specific climbing skills, as well as cognitive functions, concentration, alertness, feelings of fatigue and recovery time. Multiple studies reported significant ergogenic effects and promising improvements, although it is important to note that only a few included climbers. To determine potential benefits with greater certainty, more future studies should be conducted. Also, potential risks, including negative health effects and contamination with prohibited substances, should be considered before deciding to consume supplements.

Disclossure

Author's Contributions

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

Supplementary Materials

Not applicable.

Funding

The study did not receive special funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Acknowledgements

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process.

In preparing this work, the authors used Grammarly for the purpose of spelling, grammar, punctuation and style check and enhance the readability and clarity of the article. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication

References

1. IOC. IOC approves five new sports for Olympic Games Tokyo 2020 - Olympic News 2016 [Available from: https://www.olympics.com/ioc/news/ioc-approves-five-new-sports-for-olympic-games-tokyo-2020.
2. Lutter C, Tischer T, Schöffl VR. Olympic competition climbing: the beginning of a new era-a narrative review. Br J Sports Med. 2021;55(15):857–64.
3. IOC. History of Sport Climbing [Available from: https://www.olympics.com/en/sports/sport-climbing/.
4. Chmielewska A, Regulska-Ilow B. The Evaluation of Energy Availability and Dietary Nutrient Intake of Sport Climbers at Different Climbing Levels. Int J Environ Res Public Health. 2023;20(6).
5. Sheel AW. Physiology of sport rock climbing. Br J Sports Med. 2004;38(3):355–9.
6. Strand M. Attitudes towards disordered eating in the rock climbing community: a digital ethnography. J Eat Disord. 2022;10(1):96.
7. Amca AM, Vigouroux L, Aritan S, Berton E. Effect of hold depth and grip technique on maximal finger forces in rock climbing. J Sports Sci. 2012;30(7):669–77.
8. Booth J, Marino F, Hill C, Gwinn T. Energy cost of sport rock climbing in elite performers. Br J Sports Med. 1999;33(1):14–8.
9. Saul D, Steinmetz G, Lehmann W, Schilling AF. Determinants for success in climbing: A systematic review. Journal of Exercise Science & Fitness. 2019;17(3):91–100.
10. Monedero J, Duff C, Egan B. Dietary Intakes and the Risk of Low Energy Availability in Male and Female Advanced and Elite Rock Climbers. The Journal of Strength & Conditioning Research. 2023;37(3):e8–e15.
11. Mountjoy M, Ackerman KE, Bailey DM, Burke LM, Constantini N, Hackney AC, et al. 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). British Journal of Sports Medicine. 2023;57(17):1073–98.

12. Mountjoy M, Sundgot-Borgen J, Burke L, Carter S, Constantini N, Lebrun C, et al. The IOC consensus statement: beyond the Female Athlete Triad—Relative Energy Deficiency in Sport (RED-S). British Journal of Sports Medicine. 2014;48(7):491–7.
13. Mountjoy M, Sundgot-Borgen JK, Burke LM, Ackerman KE, Blauwet C, Constantini N, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. British Journal of Sports Medicine. 2018;52(11):687–97.
14. Maughan RJ, Burke LM, Dvorak J, Larson-Meyer DE, Peeling P, Phillips SM, et al. IOC consensus statement: dietary supplements and the high-performance athlete. Br J Sports Med. 2018;52(7):439–55.
15. Garthe I, Maughan RJ. Athletes and Supplements: Prevalence and Perspectives. Int J Sport Nutr Exerc Metab. 2018;28(2):126–38.
16. Chmielewska A, Regulska-Ilow B. Evaluation of Supplement Use in Sport Climbers at Different Climbing Levels. Nutrients. 2022;15(1).
17. Mora-Fernandez A, Argüello-Arbe A, Tojeiro-Iglesias A, Latorre JA, Conde-Pipó J, Mariscal-Arcas M. Nutritional Assessment, Body Composition, and Low Energy Availability in Sport Climbing Athletes of Different Genders and Categories: A Cross-Sectional Study. Nutrients. 2024;16(17).
18. Gibson-Smith E, Storey R, Michael M, Ranchordas M. Corrigendum: Nutrition knowledge, weight loss practices, and supplement use in senior competition climbers. Front Nutr. 2024;11:1452189.
19. Gan SH, Ramli NA, Mukiar N. Dual Effects of Low and High Dose Caffeine. Latin American Journal of Pharmacy. 2009.
20. Fiani B, Zhu L, Musch BL, Briceno S, Andel R, Sadeq N, et al. The Neurophysiology of Caffeine as a Central Nervous System Stimulant and the Resultant Effects on Cognitive Function. Cureus. 2021;13(5):e15032.
21. Grgic J, Grgic I, Pickering C, Schoenfeld BJ, Bishop DJ, Pedisic Z. Wake up and smell the coffee: caffeine supplementation and exercise performance—an umbrella review of 21 published meta-analyses. British Journal of Sports Medicine. 2020;54(11):681–8.
22. Peoples G, Parker S, Anthony R, Craddock J. Rock climbers' self-reported dietary practices and supplement use in the context of supporting climbing performance. The Journal of Sport and Exercise Science. 2021;5:130–8.
23. Ruiz-López A, Montalvo-Alonso JJ, Martín-Rivas I, Del Val-Manzano M, Ferragut C, Valadés D, et al. Effects of Acute and Moderate Caffeine Doses on Sport Climbing Performance: A Randomized Controlled Trial. Nutrients. 2026;18(2).
24. Calvo JL, Fei X, Domínguez R, Pareja-Galeano H. Caffeine and Cognitive Functions in Sports: A Systematic Review and Meta-Analysis. Nutrients. 2021;13(3).
25. Mielgo-Ayuso J, Marques-Jiménez D, Refoyo I, Del Coso J, León-Guereño P, Calleja-González J. Effect of Caffeine Supplementation on Sports Performance Based on Differences Between Sexes: A Systematic Review. Nutrients. 2019;11(10).
26. Montalvo-Alonso JJ, Ferragut C, Del Val-Manzano M, Valadés D, Roberts J, Pérez-López A. Sex Differences in the Ergogenic Response of Acute Caffeine Intake on Muscular Strength, Power and Endurance Performance in Resistance-Trained Individuals: A Randomized Controlled Trial. Nutrients. 2024;16(11).
27. Paddon-Jones D, Børsheim E, Wolfe RR. Potential ergogenic effects of arginine and creatine supplementation. J Nutr. 2004;134(10 Suppl):2888S–94S; discussion 95S.
28. Kreider RB, Kalman DS, Antonio J, Ziegenfuss TN, Wildman R, Collins R, et al. International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine. J Int Soc Sports Nutr. 2017;14:18.
29. Kreider RB, Stout JR. Creatine in Health and Disease. Nutrients. 2021;13(2).

30. Kerksick CM, Wilborn CD, Roberts MD, Smith-Ryan A, Kleiner SM, Jäger R, et al. ISSN exercise & sports nutrition review update: research & recommendations. J Int Soc Sports Nutr. 2018;15(1):38.
31. Cooke MB, Rybalka E, Williams AD, Cribb PJ, Hayes A. Creatine supplementation enhances muscle force recovery after eccentrically-induced muscle damage in healthy individuals. J Int Soc Sports Nutr. 2009;6:13.
32. Nelson AG, Arnall DA, Kokkonen J, Day R, Evans J. Muscle glycogen supercompensation is enhanced by prior creatine supplementation. Med Sci Sports Exerc. 2001;33(7):1096–100.
33. Desai I, Wewege MA, Jones MD, Clifford BK, Pandit A, Kaakoush NO, et al. The Effect of Creatine Supplementation on Resistance Training-Based Changes to Body Composition: A Systematic Review and Meta-analysis. J Strength Cond Res. 2024;38(10):1813–21.
34. Xu C, Bi S, Zhang W, Luo L. The effects of creatine supplementation on cognitive function in adults: a systematic review and meta-analysis. Front Nutr. 2024;11:1424972.
35. Scott CB. Contribution of anaerobic energy expenditure to whole body thermogenesis. Nutr Metab (Lond). 2005;2(1):14.
36. Sale C, Saunders B, Harris RC. Effect of beta-alanine supplementation on muscle carnosine concentrations and exercise performance. Amino Acids. 2010;39(2):321–33.
37. Debold EP, Beck SE, Warshaw DM. Effect of low pH on single skeletal muscle myosin mechanics and kinetics. Am J Physiol Cell Physiol. 2008;295(1):C173–9.
38. Hobson RM, Saunders B, Ball G, Harris RC, Sale C. Effects of β-alanine supplementation on exercise performance: a meta-analysis. Amino Acids. 2012;43(1):25–37.
39. Perim P, Marticorena FM, Ribeiro F, Barreto G, Gobbi N, Kerksick C, et al. Can the Skeletal Muscle Carnosine Response to Beta-Alanine Supplementation Be Optimized? Front Nutr. 2019;6:135.
40. Harris RC, Tallon MJ, Dunnett M, Boobis L, Coakley J, Kim HJ, et al. The absorption of orally supplied beta-alanine and its effect on muscle carnosine synthesis in human vastus lateralis. Amino Acids. 2006;30(3):279–89.
41. Artioli G, Gualano B, Smith-Ryan A, Stout J, Lancha Jr A. The Role of β-alanine Supplementation on Muscle Carnosine and Exercise Performance. Medicine and science in sports and exercise. 2010;42:1162–73.
42. Curran-Bowen T, Guedes da Silva A, Barreto G, Buckley J, Saunders B. Sodium bicarbonate and beta-alanine supplementation: Is combining both better than either alone? A systematic review and meta-analysis. Biol Sport. 2024;41(3):79–87.
43. Gilsanz L, López-Seoane J, Jiménez SL, Pareja-Galeano H. Effect of β-alanine and sodium bicarbonate co-supplementation on the body's buffering capacity and sports performance: A systematic review. Crit Rev Food Sci Nutr. 2023;63(21):5080–93.
44. Georgiou GD, Antoniou K, Antoniou S, Michelekaki EA, Zare R, Ali Redha A, et al. Effect of Beta-Alanine Supplementation on Maximal Intensity Exercise in Trained Young Male Individuals: A Systematic Review and Meta-Analysis. International Journal of Sport Nutrition and Exercise Metabolism. 2024;34(6):397–412.
45. Ong SW, Chen WL, Chien KY, Hsu CW. Dosing strategies for β-alanine supplementation in strength and power performance: a systematic review. J Int Soc Sports Nutr. 2025;22(1):2566368.
46. Saunders B, Elliott-Sale K, Artioli GG, Swinton PA, Dolan E, Roschel H, et al. β-alanine supplementation to improve exercise capacity and performance: a systematic review and meta-analysis. British Journal of Sports Medicine. 2017;51(8):658–69.

47. Wood DT, editor THE EFFECTS OF BETA-ALANINE ON INDOOR BOULDERING PERFORMANCE2018.
48. Sas-Nowosielski K, Wyciślik J, Kaczka P. Beta-Alanine Supplementation and Sport Climbing Performance. Int J Environ Res Public Health. 2021;18(10).
49. Sas-Nowosielski K, Kaczka P. A pilot study to examine the effects of beta-alanine and sodium citrate (CarnoRushTM, Olimp®) supplementation on climbing-specific performance. Baltic Journal of Health and Physical Activity. 2021;14:Article–4.
50. Jones AM, Thompson C, Wylie LJ, Vanhatalo A. Dietary Nitrate and Physical Performance. Annual Review of Nutrition. 2018;38(Volume 38, 2018):303–28.
51. Duncan C, Dougall H, Johnston P, Green S, Brogan R, Leifert C, et al. Chemical generation of nitric oxide in the mouth from the enterosalivary circulation of dietary nitrate. Nature Medicine. 1995;1(6):546–51.
52. Lundberg JO, Govoni M. Inorganic nitrate is a possible source for systemic generation of nitric oxide. Free Radic Biol Med. 2004;37(3):395–400.
53. Joyner MJ, Dietz NM. Nitric oxide and vasodilation in human limbs. J Appl Physiol (1985). 1997;83(6):1785–96.
54. Hernández A, Schiffer TA, Ivarsson N, Cheng AJ, Bruton JD, Lundberg JO, et al. Dietary nitrate increases tetanic [Ca2+]i and contractile force in mouse fast-twitch muscle. J Physiol. 2012;590(15):3575–83.
55. Bailey SJ, Fulford J, Vanhatalo A, Winyard PG, Blackwell JR, DiMenna FJ, et al. Dietary nitrate supplementation enhances muscle contractile efficiency during knee-extensor exercise in humans. J Appl Physiol (1985). 2010;109(1):135–48.
56. Gilchrist M, Winyard PG, Fulford J, Anning C, Shore AC, Benjamin N. Dietary nitrate supplementation improves reaction time in type 2 diabetes: development and application of a novel nitrate-depleted beetroot juice placebo. Nitric Oxide. 2014;40:67–74.
57. Thompson C, Wylie LJ, Fulford J, Kelly J, Black MI, McDonagh ST, et al. Dietary nitrate improves sprint performance and cognitive function during prolonged intermittent exercise. Eur J Appl Physiol. 2015;115(9):1825–34.
58. Thompson KG, Turner L, Prichard J, Dodd F, Kennedy DO, Haskell C, et al. Influence of dietary nitrate supplementation on physiological and cognitive responses to incremental cycle exercise. Respiratory Physiology & Neurobiology. 2014;193:11–20.
59. Shannon OM, Duckworth L, Barlow MJ, Deighton K, Matu J, Williams EL, et al. Effects of Dietary Nitrate Supplementation on Physiological Responses, Cognitive Function, and Exercise Performance at Moderate and Very-High Simulated Altitude. Front Physiol. 2017;8:401.
60. Senefeld JW, Wiggins CC, Regimbal RJ, Dominelli PB, Baker SE, Joyner MJ. Ergogenic Effect of Nitrate Supplementation: A Systematic Review and Meta-analysis. Med Sci Sports Exerc. 2020;52(10):2250–61.
61. Domínguez R, Cuenca E, Maté-Muñoz JL, García-Fernández P, Serra-Paya N, Estevan MC, et al. Effects of Beetroot Juice Supplementation on Cardiorespiratory Endurance in Athletes. A Systematic Review. Nutrients. 2017;9(1).
62. Poon ET, Iu JC, Sum WM, Wong PS, Lo KK, Ali A, et al. Dietary Nitrate Supplementation and Exercise Performance: An Umbrella Review of 20 Published Systematic Reviews with Meta-analyses. Sports Med. 2025;55(5):1213–31.
63. Paton CDH, W. G. Performance enhancement at the Fifth IOC Congress on Sport Sciences. In Sportscience. 1999;Dec 1999; v.3 n.3/4
64. Berlanga LA, Lopez-Samanes A, Martin-Lopez J, de la Cruz RM, Garces-Rimon M, Roberts J, et al. Dietary Nitrate Ingestion Does Not Improve Neuromuscular Performance in Male Sport Climbers. J Hum Kinet. 2023;87:47–57.

65. Fernández-Elías V, Courel-Ibáñez J, Pérez-López A, Jodra P, Moreno-Pérez V, Coso JD, et al. Acute Beetroot Juice Supplementation Does Not Improve Match-Play Activity in Professional Tennis Players. J Am Nutr Assoc. 2022;41(1):30–7.
66. Daneshparvar A, Hemmatinafar M, Salesi M, Rezaei R, Imanian B, Pirmohammadi S. The effect of acute beetroot juice consumption prior to climbing on lower-body isokinetic and isometric strength, aerobic power, and muscle soreness among mountain climbers. J Int Soc Sports Nutr. 2025;22(1):2502656.
67. Cook MD, Willems MET. Dietary Anthocyanins: A Review of the Exercise Performance Effects and Related Physiological Responses. International Journal of Sport Nutrition and Exercise Metabolism. 2019;29(3):322–30.
68. Tang X, Shen T, Jiang X, Xia M, Sun X, Guo H, et al. Purified anthocyanins from bilberry and black currant attenuate hepatic mitochondrial dysfunction and steatohepatitis in mice with methionine and choline deficiency. J Agric Food Chem. 2015;63(2):552–61.
69. de Pascual-Teresa S, Moreno DA, García-Viguera C. Flavanols and anthocyanins in cardiovascular health: a review of current evidence. Int J Mol Sci. 2010;11(4):1679–703.
70. Braakhuis AJ, Somerville VX, Hurst RD. The effect of New Zealand blackcurrant on sport performance and related biomarkers: a systematic review and meta-analysis. J Int Soc Sports Nutr. 2020;17(1):25.
71. Cook MD, Myers SD, Blacker SD, Willems ME. New Zealand blackcurrant extract improves cycling performance and fat oxidation in cyclists. Eur J Appl Physiol. 2015;115(11):2357–65.
72. Fryer S, Giles D, Bird E, Stone K, Paterson C, Baláš J, et al. New Zealand blackcurrant extract enhances muscle oxygenation during repeated intermittent forearm muscle contractions in advanced and elite rock climbers. Eur J Sport Sci. 2021;21(9):1290–8.
73. Potter JA, Hodgson CI, Broadhurst M, Howell L, Gilbert J, Willems MET, et al. Effects of New Zealand blackcurrant extract on sport climbing performance. European Journal of Applied Physiology. 2020;120(1):67–75.
74. de Souza JG, Del Coso J, Fonseca FdS, Silva BVC, de Souza DB, da Silva Gianoni RL, et al. Risk or benefit? Side effects of caffeine supplementation in sport: a systematic review. European Journal of Nutrition. 2022;61(8):3823–34.
75. Pallarés JG, Fernández-Elías VE, Ortega JF, Muñoz G, Muñoz-Guerra J, Mora-Rodríguez R. Neuromuscular responses to incremental caffeine doses: performance and side effects. Med Sci Sports Exerc. 2013;45(11):2184–92.
76. Dolan E, Swinton PA, Painelli VS, Stephens Hemingway B, Mazzolani B, Infante Smaira F, et al. A Systematic Risk Assessment and Meta-Analysis on the Use of Oral β-Alanine Supplementation. Adv Nutr. 2019;10(3):452–63.
77. Zamani H, de Joode M, Hossein IJ, Henckens NFT, Guggeis MA, Berends JE, et al. The benefits and risks of beetroot juice consumption: a systematic review. Crit Rev Food Sci Nutr. 2021;61(5):788–804.