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+15878858911
editorial-office@sciformat.ca

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CAFFEINE SUPPLEMENTATION AND ITS IMPACT ON EXERCISE PERFORMANCE AND COGNITIVE FUNCTION: A NARRATIVE REVIEW

Agnieszka Benecka (Corresponding Author, Email: abenecka@gmail.com)
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0004-9295-7471

Krzysztof Kaczmarek
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0003-6026-1608

Wiktoria Zawada
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0007-5871-2640

Zofia Jadwiga Leszczyńska
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0009-4584-1130

Vladyslav Romaniuk
Prof. S. T. Dąbrowski Hospital in Puszczykowo S.A., 11 Józefa Ignacego Kraszewskiego Street, 62-040 Puszczykowo, Poland
ORCID ID: 0009-0002-9674-4188

Urszula Szuleta
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0004-1795-7439

Jakub Pietrończyk
University Clinical Hospital in Poznań, Przybyszewskiego 49, 60-355 Poznań, Poland
ORCID ID: 0009-0006-6566-7537

Alicja Benecka
Prof. S. T. Dąbrowski Hospital in Puszczykowo S.A., 11 Józefa Ignacego Kraszewskiego Street, 62-040 Puszczykowo, Poland
ORCID ID: 0009-0000-5110-8028

Zuzanna Wieczorek
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0005-9952-780X

Iga Tartas
J. Strus City Multispecialty Hospital, Szwajcarska 3, 61-285 Poznań, Poland
ORCID ID: 0009-0007-5602-2259

Natalia Prankiewicz
University Centre of Dentistry and Specialized Medicine, Bukowska 70, 60-812 Poznań, Poland
ORCID ID: 0009-0007-5865-7063

Marcin Kutkowski
Józef Strus Multi-Specialty Municipal Hospital in Poznań: Poznań, Wielkopolska, Poland
ORCID ID: 0009-0000-0394-8436

ABSTRACT

Caffeine is one of the most widely consumed psychoactive substances and a well-established ergogenic aid in both athletic and cognitive performance contexts. The aim of this review was to evaluate the effects of caffeine supplementation on physical performance and cognitive function, with particular emphasis on dosage strategies, timing of ingestion, and individual variability in response. A narrative review of recent literature published between 2020 and 2025 was conducted using major scientific databases. The analysis included randomized controlled trials, systematic reviews, and meta-analyses investigating the impact of caffeine on exercise capacity, neuromuscular performance, and cognitive outcomes. The findings indicate that caffeine supplementation in doses ranging from 3 to 6 mg/kg body mass significantly enhances strength, power, and endurance performance. In addition, caffeine improves cognitive functions such as attention, reaction time, and alertness, particularly under conditions of fatigue. The ergogenic effects are primarily attributed to the antagonism of adenosine receptors and increased central nervous system stimulation. However, the response to caffeine varies considerably among individuals due to genetic factors, habitual intake, and sensitivity to stimulants. Excessive consumption may lead to adverse effects, including sleep disturbances, anxiety, and cardiovascular responses. In conclusion, caffeine represents an effective and accessible strategy for improving both physical and cognitive performance. Nevertheless, its optimal application requires individualized dosing, appropriate timing, and careful monitoring to maximize benefits while minimizing potential risks.

KEYWORDS

Caffeine, Exercise Performance, Cognitive Function, Ergogenic Aids, Supplementation, Reaction Time

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Introduction

Caffeine is one of the most widely used dietary supplements in sport and exercise, recognized for its ergogenic potential and widespread consumption among athletes (Guest et al. 2021; Grgic et al. 2020; Bougrine et al. 2024). It is a naturally occurring methylxanthine found in coffee, tea, cocoa, and energy drinks, and is commonly consumed worldwide for its stimulating effects (Kennedy and Wightman 2022; Silva et al. 2025). Its primary mechanism of action involves antagonism of adenosine receptors in the central nervous system, leading to increased alertness, reduced perception of fatigue, and enhanced neural activity (Silva et al. 2025; Chen et al. 2025; McLellan et al. 2021).

A substantial body of evidence indicates that caffeine ingestion can enhance multiple aspects of physical performance, including endurance capacity, muscular strength, power output, and high-intensity exercise performance (Grgic et al. 2020; Guest et al. 2021; Głowska et al. 2024). Meta-analytical findings suggest that moderate doses of caffeine (3–6 mg/kg body mass) are particularly effective in improving performance outcomes in both trained and recreationally active individuals (Grgic et al. 2020; Southward et al. 2018).

Beyond physical performance, caffeine has also been shown to improve cognitive function, especially in domains such as attention, vigilance, reaction time, and decision-making, which are crucial in many sports disciplines (Kennedy and Wightman 2022; McLellan et al. 2016). Recent experimental studies have demonstrated that caffeine supplementation can enhance sport-specific cognitive performance, including reaction speed and accuracy in both traditional and emerging sports such as e-sports (Wu et al. 2024; Feng et al. 2025).

Despite its well-documented benefits, the ergogenic effects of caffeine are not uniform across individuals. Variability in response may be influenced by factors such as habitual caffeine intake, training status, sex differences, and genetic polymorphisms related to caffeine metabolism (Pickering and Kiely 2021; Grgic et al. 2022; Southward et al. 2018). Therefore, a comprehensive and up-to-date synthesis of the literature

is necessary to better understand the multifaceted effects of caffeine supplementation on both physical and cognitive performance.

The aim of this narrative review is to summarize and critically evaluate recent scientific evidence regarding the effects of caffeine supplementation on exercise performance and cognitive function.

Characteristics of Caffeine and Mechanism of Action

Caffeine is an organic compound belonging to the methylxanthine class, naturally present in products such as coffee, tea, cocoa, and energy drinks (Bougrine et al. 2024; Kennedy and Wightman 2022). Due to its well-established stimulatory effects, caffeine is among the most widely used ergogenic aids in sport and exercise (Guest et al. 2021; Grgic et al. 2020).

The primary mechanism of caffeine action involves antagonism of adenosine receptors (A1 and A2A) in the central nervous system, resulting in increased neuronal excitability and reduced perception of fatigue (Silva et al. 2025; Chen et al. 2025). Adenosine plays a key role in promoting sleep and suppressing arousal; therefore, its inhibition by caffeine leads to enhanced alertness, vigilance, and cognitive performance (Kennedy and Wightman 2022; McLellan et al. 2016).

Caffeine also stimulates the release of neurotransmitters such as dopamine and norepinephrine, which contributes to improved mood, motivation, and cognitive processing (Kennedy and Wightman, 2022; Silva et al., 2025). In addition to central effects, caffeine influences peripheral mechanisms, including increased calcium ion release in muscle cells, which may enhance muscle contraction and force production (Główka et al., 2024; Grgic et al., 2020). Another important aspect of caffeine's action is its role in energy metabolism. Research suggests that caffeine can increase lipolysis and fatty acid oxidation while sparing muscle glycogen, which is particularly beneficial during prolonged endurance exercise (Chen et al., 2025; Spriet, 2014). Furthermore, caffeine has been shown to reduce the rating of perceived exertion (RPE), allowing individuals to sustain higher exercise intensity for longer durations (Guest et al., 2021; Grgic et al., 2020). However, the physiological and performance-related effects of caffeine may vary considerably between individuals. Factors such as habitual caffeine consumption, body composition, training level, and genetic variability (e.g., CYP1A2 polymorphisms) can significantly influence caffeine metabolism and ergogenic response (Pickering and Kiely, 2021; Grgic et al., 2022; Southward et al., 2018).

Effects of Caffeine on Physical Performance

Effects on Muscle Strength and Power

A substantial body of recent evidence confirms that caffeine supplementation exerts a significant ergogenic effect on neuromuscular performance, particularly in relation to muscle strength and power output. Randomized controlled trials consistently demonstrate that acute ingestion of caffeine in doses ranging from 3 to 6 mg/kg body mass enhances both maximal strength and explosive performance (Grgic et al., 2020; Guest et al., 2021). In a double-blind crossover study, Grgic et al., (2020) reported that ingestion of 3 mg/kg caffeine significantly increased mean and peak repetition velocity during resistance exercises in trained men, suggesting improved neuromuscular efficiency. Similarly, Nemati et al., (2023) observed that collegiate volleyball players consuming 3 and 6 mg/kg of caffeine exhibited significant improvements in vertical jump height, peak power output, and sport-specific performance metrics compared to placebo conditions. Further evidence indicates that higher doses of caffeine (~6 mg/kg) may also enhance training volume. Filip-Stachnik et al., (2023) demonstrated that caffeine ingestion resulted in increased total repetitions performed during a full-body resistance training session, without a concomitant increase in markers of muscle damage. Importantly, the ergogenic effects of caffeine are not limited to male athletes. Burke et al., (2021) reported that female collegiate athletes experienced improvements in one-repetition maximum strength and vertical jump performance following ingestion of 5 mg/kg caffeine. Mechanistically, these improvements are primarily attributed to increased central nervous system stimulation, reduced inhibitory signaling via adenosine receptor antagonism, and enhanced motor unit recruitment (McLellan et al., 2021).

Effects on Endurance

Caffeine is widely recognized as one of the most effective nutritional strategies for improving endurance performance. Evidence from recent randomized trials suggests that caffeine ingestion enhances aerobic capacity, delays exhaustion, and improves overall exercise efficiency (Guest et al., 2021). Stadheim et al. (2021) demonstrated that ingestion of approximately 4.5 mg/kg caffeine significantly increased maximal oxygen uptake ($\text{VO}_{2\text{max}}$) and oxygen deficit in elite endurance athletes, indicating improved aerobic and anaerobic energy system contribution. Additionally, time to exhaustion during high-intensity exercise was significantly prolonged. In a more ecologically valid setting, Trujillo-Colmena et al. (2024) reported that ingestion of coffee providing approximately 3 mg/kg caffeine improved time-trial performance in recreational cyclists. Similarly, Bäcker and Jaitner (2023) found that consumption of caffeinated energy drinks containing approximately 3–5 mg/kg caffeine significantly enhanced endurance performance in a randomized crossover design. The physiological mechanisms underlying these effects include increased mobilization of free fatty acids, reduced reliance on muscle glycogen, and enhanced calcium release within muscle cells, which collectively contribute to improved muscle contractility and delayed fatigue onset (Guest et al., 2021; Spriet, 2020).

Delay of Fatigue

One of the most consistently reported benefits of caffeine supplementation is its ability to delay both central and peripheral fatigue. Studies have demonstrated that caffeine ingestion in doses between 3 and 6 mg/kg significantly reduces ratings of perceived exertion (RPE), allowing individuals to sustain higher exercise intensities for longer durations (Grgic et al. 2020; Pickering & Kiely, 2021). For example, Pereira et al. (2022) showed that participants consuming caffeinated beverages exhibited lower subjective fatigue levels and improved performance outcomes during endurance exercise compared to placebo. These findings are supported by neurophysiological evidence indicating that caffeine reduces central fatigue by blocking adenosine receptors in the brain, thereby increasing neurotransmitter release and maintaining neural drive during prolonged exercise (McLellan et al., 2021). Additionally, caffeine has been shown to reduce exercise-induced muscle pain, which may further contribute to improved performance by allowing athletes to tolerate higher workloads (Grgic et al. 2020).

Improvement in Reaction Time During Exercise

Beyond its effects on physical performance, caffeine has a pronounced influence on psychomotor performance, particularly reaction time and decision-making speed. These effects are highly relevant in sports requiring rapid responses and complex motor coordination. Głowska et al. (2024), in a randomized placebo-controlled crossover trial, demonstrated that caffeine ingestion at doses of 3 and 6 mg/kg significantly improved reaction time and postural stability in CrossFit athletes. Similarly, Jafari et al. (2023) reported that young soccer players consuming approximately 4 mg/kg caffeine showed faster decision-making and improved passing accuracy during simulated match conditions. Moreover, Nieto-Acevedo et al. (2025) observed that female basketball players exhibited enhanced technical performance and reaction speed following caffeine supplementation, highlighting its applicability in team sports. These improvements are largely attributed to increased cortical activation, enhanced attentional processes, and faster information processing speed mediated by central nervous system stimulation (McLellan et al., 2021).

Effects of Caffeine on Cognitive Function

Concentration and Attention

Caffeine is widely recognized for its ability to enhance concentration and attention, particularly in demanding cognitive environments. Evidence from recent randomized controlled trials indicates that moderate doses of caffeine (~3 mg/kg) significantly improve sustained attention and vigilance (Kennedy & Wightman, 2021; McLellan et al., 2021). Feng et al. (2021) demonstrated that caffeine ingestion improved performance in attention-based tasks during exercise under fatigue conditions, suggesting a synergistic effect between physical and cognitive enhancement. These effects are primarily mediated by antagonism of adenosine receptors, leading to increased neuronal firing and enhanced neurotransmitter activity.

Reaction Time

The effect of caffeine on reaction time is one of the most consistently reported findings in the literature. Improvements have been observed across a range of populations and experimental conditions (Główka et al., 2024; Wu et al., 2022). Wu et al. (2022) demonstrated that ingestion of approximately 200 mg caffeine significantly improved reaction time and accuracy in elite e-sports athletes, indicating that caffeine's effects extend beyond traditional sports contexts.

Short-Term Memory

The impact of caffeine on short-term and working memory appears to be dose-dependent and context-specific. Moderate doses (~3–4 mg/kg) have been associated with improvements in working memory performance and information processing speed (Chen et al., 2021; Bougrine et al., 2022). These effects are particularly pronounced under conditions of sleep deprivation, where caffeine has been shown to counteract cognitive decline and maintain performance levels (McLellan et al., 2021).

Effects on Mood and Alertness

Caffeine consumption has also been shown to positively influence mood and alertness, which are critical determinants of both cognitive and physical performance. Low to moderate doses (1–3 mg/kg) have been associated with increased subjective energy, reduced fatigue, and improved motivation (Guest et al., 2021). These effects are especially relevant in situations involving prolonged effort, high stress, or insufficient sleep, where maintaining alertness is essential for optimal performance (Pickering & Kiely, 2021).

Caffeine Dosage and Timing

Optimal Doses

The ergogenic effects of caffeine are strongly dose-dependent. Current evidence supports the use of doses between 3 and 6 mg/kg body mass as the most effective range for improving both physical and cognitive performance (Guest et al., 2021; Grgic et al. 2020). Lower doses (~3 mg/kg) are sufficient to enhance cognitive performance, including attention, reaction time, and alertness, whereas higher doses (5–6 mg/kg) produce more pronounced improvements in muscular strength, endurance capacity, and executive function (Spriet, 2020; Pickering & Kiely, 2021).

However, doses exceeding 6 mg/kg do not consistently provide additional ergogenic benefits and are associated with an increased risk of adverse effects. Extremely high doses (≥ 9 mg/kg) may impair motor control and negatively affect performance (Guest et al., 2021).

Timing of Intake

The timing of caffeine ingestion is a critical determinant of its effectiveness. Peak plasma concentrations are typically reached within 30–60 minutes following ingestion, making this the optimal window for supplementation prior to exercise (McLellan et al., 2021). Alternative delivery methods, such as caffeinated chewing gum, may accelerate absorption and produce measurable effects within 10–15 minutes (Yıldırım et al., 2023).

Individual Variability

Interindividual variability in response to caffeine is a well-documented phenomenon. Genetic factors, particularly polymorphisms in the CYP1A2 gene, significantly influence caffeine metabolism and ergogenic response (Grgic et al. 2022). Additionally, habitual caffeine consumption may lead to partial tolerance, potentially attenuating its performance-enhancing effects (Southward et al., 2020).

Side Effects

Despite its benefits, caffeine consumption may be associated with adverse effects, particularly at higher doses. Commonly reported symptoms include increased heart rate, anxiety, tremors, gastrointestinal discomfort, and sleep disturbances (Guest et al., 2021; Pickering & Kiely, 2021). In sports requiring high levels of precision, excessive stimulation may impair fine motor control and coordination.

Practical Interpretation

In practical settings, caffeine intake is often derived from commonly consumed beverages such as coffee or energy drinks. However, the caffeine content of these products may vary significantly, leading to inconsistent dosing (Guest et al., 2021). For example, an espresso (~30 ml) typically contains 60–80 mg of caffeine, while a standard cup of coffee may contain 80–120 mg. Consequently, achieving an ergogenic dose of 3–6 mg/kg may require multiple servings, which should be carefully monitored to avoid excessive intake.

Discussion

The present literature review indicates that caffeine is one of the most extensively studied ergogenic aids, exerting significant effects on both physical performance and cognitive function. Analysis of recent studies (2020–2025) confirms that caffeine supplementation in doses ranging from 3 to 6 mg/kg body mass leads to meaningful improvements in exercise performance parameters, including strength, power, and endurance, as well as cognitive functions such as attention, reaction time, and working memory (Guest et al., 2021; Grgic et al. 2020). One of the primary mechanisms underlying caffeine's effects is the antagonism of adenosine receptors, which results in increased central nervous system excitability and enhanced release of neurotransmitters such as dopamine and norepinephrine (McLellan et al., 2021). This mechanism explains both the improvements in physical performance and the cognitive enhancements observed in numerous experimental studies. With regard to physical performance, the findings across the analyzed studies are largely consistent. The majority of research demonstrates a positive effect of caffeine on strength and endurance parameters, regardless of the training status of participants (Guest et al. 2021; Stadheim et al., 2021). However, some studies suggest that the magnitude of these effects may vary depending on the type of exercise and the dose administered, highlighting the need for individualized supplementation strategies (Grgic et al. 2020). In terms of cognitive function, caffeine appears to exert particularly strong effects under conditions of fatigue or sleep deprivation, where improvements in alertness, concentration, and reaction time are most evident (Pickering & Kiely, 2021). At the same time, it should be noted that the effects of caffeine on more complex cognitive domains, such as long-term memory, remain less conclusive, as indicated by some experimental findings (McLellan et al., 2021). An important issue highlighted in the literature is the considerable interindividual variability in response to caffeine. Genetic factors, particularly polymorphisms of the CYP1A2 gene, may influence the rate of caffeine metabolism and its ergogenic effects (Grgic et al. 2022). Furthermore, habitual caffeine consumption may lead to tolerance, potentially reducing the observed benefits (Southward et al., 2020). Despite its well-documented benefits, caffeine use is also associated with the risk of adverse effects, especially at higher doses. The most commonly reported side effects include sleep disturbances, increased nervousness, and cardiovascular responses such as elevated heart rate (Grgic et al., 2020; Pickering & Kiely, 2021). From a sports perspective, excessive stimulation may also negatively affect movement precision and motor control. It is also important to consider the practical aspects of caffeine use. As demonstrated in this review, the doses used in scientific studies correspond to the consumption of several cups of coffee, indicating that caffeine is a widely accessible and effective ergogenic aid. However, variability in caffeine content across different products may limit precise dosing in real-life conditions (Guest et al., 2021). A limitation of this review is the heterogeneity of the analyzed studies, including differences in methodology, caffeine dosage, forms of administration, and participant characteristics. Additionally, some studies are based on relatively small sample sizes, which may limit the generalizability of the findings. In summary, caffeine is an effective and widely available substance with well-established ergogenic and cognitive-enhancing properties. However, to maximize its benefits and minimize the risk of adverse effects, an individualized approach to dosage, timing, and application in specific sports contexts is essential.

Conclusions and Practical Applications

The findings of this narrative review confirm that caffeine remains one of the most effective and well-established ergogenic aids, exerting multidimensional effects on both physical performance and cognitive functioning. Current evidence indicates that its efficacy is not limited to a single domain, but rather results from the interaction between central nervous system stimulation and peripheral physiological mechanisms (Guest et al., 2021; Grgic et al., 2020). From a performance perspective, caffeine consistently enhances neuromuscular output, delays fatigue, and improves endurance capacity. At the same time, its influence on cognitive processes—particularly attention, vigilance, and reaction speed—plays a crucial role in sports requiring rapid decision-making and sustained concentration (McLellan et al., 2021). Importantly, these effects appear to be especially pronounced under conditions of physical or mental fatigue, suggesting that caffeine may act as a compensatory agent in suboptimal performance states. However, the magnitude and direction of caffeine's effects are not uniform across individuals. Variability in response is influenced by genetic predisposition, habitual intake, and sensitivity to stimulants, which collectively determine both ergogenic potential and the likelihood of adverse effects (Pickering & Kiely, 2021). This highlights the necessity of adopting an individualized approach rather than applying generalized supplementation protocols. From a practical standpoint, the literature supports the use of moderate caffeine doses to maximize benefits while minimizing risks. The most consistently effective range is between 3 and 6 mg/kg of body mass, with lower doses being sufficient for cognitive enhancement and higher doses producing more pronounced physiological effects. Timing also represents a critical factor, as ingestion approximately 30–60 minutes prior to exercise aligns with peak plasma caffeine levels and optimal performance outcomes (Guest et al., 2021). It is important to emphasize that real-world application differs from controlled experimental settings. Variability in caffeine content across commonly consumed products such as coffee or energy drinks may lead to imprecise dosing, potentially affecting both efficacy and safety. Additionally, the cumulative intake from multiple sources may unintentionally exceed recommended levels. From a safety perspective, excessive caffeine consumption may lead to undesirable effects, including sleep disturbances, heightened anxiety, and cardiovascular responses. In performance settings, overstimulation may also impair motor coordination and technical execution, which is particularly relevant in precision-based sports. Therefore, athletes and practitioners should prioritize controlled intake and prior individual testing under training conditions. In conclusion, caffeine represents a practical, accessible, and scientifically supported strategy for enhancing both physical and cognitive performance. Nevertheless, its optimal use requires careful consideration of dose, timing, individual variability, and the specific demands of the sport.

Author's contribution:

Conceptualization: Agnieszka Benecka, Alicja Benecka

Methodology: Iga Tartas, Natalia Prankiewicz, Marcin Kutkowski

Investigation: Wiktoria Zawada, Krystian Kaczmarek

Software: Zuzanna Wieczorek, Zofia Jadwiga Leszczyńska

Check: Vladyslav Romaniuk, Urszula Szuleta

Formal analysis: Zofia Jadwiga Leszczyńska, Jakub Pietrończyk

Resources: Agnieszka Benecka, Marcin Kutkowski

Data curation: Wiktoria Zawada, Jakub Pietrończyk

Writing- rough preparation: Krystian Kaczmarek, Wiktoria Zawada, Zofia Jadwiga Leszczyńska, Vladyslav Romaniuk, Urszula Szuleta, Agnieszka Benecka, Jakub Pietrończyk, Alicja Benecka, Zuzanna Wieczorek, Iga Tartas, Natalia Prankiewicz, Marcin Kutkowski

Writing- review and editing:

Supervision: Agnieszka Benecka

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REFERENCES

1. Bougrine, H., et al., (2024). Effects of different caffeine doses on maximal physical performance and cognitive abilities. *Nutrients*, 16(14), 2223.
2. Burke, B. I., Travis, S. K., Gentles, J. A., Sato, K., Lang, H. M., & Bazzyler, C. D. (2021). The effects of caffeine on jumping performance and maximal strength in female collegiate athletes. *Nutrients*, 13(8), 2496. <https://doi.org/10.3390/nu13082496>
3. Bäcker, M. H., & Jaitner, T. (2023). Effects of caffeine-containing energy drinks on endurance performance and side effects: A randomized cross-over study. *German Journal of Sports Medicine*, 74(6), 214–218. <https://doi.org/10.5960/dzsm.2023.575>
4. Chen, B., et al., (2025). Effects of caffeine supplementation on exercise metabolism and cognitive performance: Recent evidence. *Nutrients*.
5. Feng, L., Du, W., Wang, X., Cao, H., Ji, Z., Li, F., Cao, J., & Zhou, Z. (2025). Acute caffeine ingestion improves sport-specific and cognitive performance in elite badminton athletes. *Frontiers in Nutrition*, 12, 1673882. <https://doi.org/10.3389/fnut.2025.1673882>
6. Filip-Stachnik, A., Krzysztofik, M., Del Coso, J., Palka, T., & Sadowska-Krępa, E. (2023). The effect of acute caffeine intake on resistance training volume, prooxidant-antioxidant balance and muscle damage markers following a session of full-body resistance exercise in resistance-trained men habituated to caffeine. *Journal of Sports Science & Medicine*, 22(3), 436–446. <https://doi.org/10.52082/jssm.2023.436>
7. Grgic, J., Grgic, I., Pickering, C., Schoenfeld, B. J., Bishop, D. J., & Pedisic, Z. (2020). Wake up and smell the coffee: Caffeine supplementation and exercise performance—An umbrella review of 21 published meta-analyses. *British Journal of Sports Medicine*, 54(11), 681–688. <https://doi.org/10.1136/bjsports-2018-100278>
8. Grgic, J., Pickering, C., Bishop, D. J., et al., (2022). Genetic influences on caffeine ergogenicity. *Nutrients*, 14(5).
9. 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>
10. Głównka, N., Malik, J., & Podgórski, T. (2024). The dose-dependent effect of caffeine supplementation on performance, reaction time and postural stability in CrossFit – a randomized placebo-controlled crossover trial. *Journal of the International Society of Sports Nutrition*, 21(1), 2301384. <https://doi.org/10.1080/15502783.2023.2301384>
11. Jafari, N., Salesi, M., Soltani, P., & Fazeli, D. (2023). The effects of acute caffeine ingestion on decision-making and pass accuracy in young soccer players: A preliminary randomized controlled trial. *Behavioural Brain Research*, 457, 114732. <https://doi.org/10.1016/j.bbr.2023.114732>
12. Jiménez, S. L., Díaz-Lara, J., Pareja-Galeano, H., & Del Coso, J. (2021). Caffeinated drinks and physical performance in sport: A systematic review. *Nutrients*, 13(9), 2944. <https://doi.org/10.3390/nu13092944>
13. Jones, L., Johnstone, I., Day, C., Le Marquer, S., & Hulton, A. T. (2021). The dose-effects of caffeine on lower body maximal strength, muscular endurance, and rating of perceived exertion in strength-trained females. *Nutrients*, 13(10), 3342. <https://doi.org/10.3390/nu13103342>

14. Karayigit, R., Yildiz, H., Şahin, M. A., Şişman, A., et al., (2021). The effects of low-dose caffeinated coffee ingestion on strength and muscular endurance performance in male athletes. *Progress in Nutrition*, 23(1). <https://doi.org/10.23751/pn.v23i1.9067>
15. Kennedy, D. O., & Wightman, E. L. (2022). Mental performance and sport: Caffeine and co-consumed bioactive ingredients. *Sports Medicine*, 52(Suppl 1), 69–90. <https://doi.org/10.1007/s40279-022-01796-8>
16. Loureiro, L. M. R., Dos Santos Neto, E., Molina, G. E., Amato, A. A., Arruda, S. F., Reis, C. E. G., & da Costa, T. H. M. (2021). Coffee increases post-exercise muscle glycogen recovery in endurance athletes: A randomized clinical trial. *Nutrients*, 13(10), 3335. <https://doi.org/10.3390/nu13103335>
17. McLellan, T. M., Caldwell, J. A., & Lieberman, H. R. (2016). A review of caffeine's effects on cognitive, physical and occupational performance. *Neuroscience & Biobehavioral Reviews*, 71, 294–312. <https://doi.org/10.1016/j.neubiorev.2016.09.001>
18. Nemati, J., Hemmatinafar, M., Niknam, A., Nikahd, M., Zeighami, N., Imanian, B., Safari, K., Jahaniboushehri, N., & Suzuki, K. (2023). Effects of different doses of caffeine supplementation on collegiate male volleyball players' specific performance and skills: A randomized, double-blind, placebo-controlled, crossover study. *Nutrients*, 15(18), 4049. <https://doi.org/10.3390/nu15184049>
19. Nieto-Acevedo, R., García-Sánchez, C., Bravo-Sánchez, A., Abián-Vicén, J., Abián, P., Portillo, J., Martínez-Rubio, C., Lorenzo Calvo, J., & Díaz-Lara, J. (2025). Impact of caffeine intake on female basketball players' performance. *Nutrients*, 17(2), 235. <https://doi.org/10.3390/nu17020235>
20. Pereira, J. C., Lima, L. M., Alfenas, R. C., Guttierrez, A. P. M., Sillero-Quintana, M., Reis, H. H. T., & Marins, J. C. B. (2022). Consumption of energy drinks on cardiovascular and metabolic response and performance: Is there an effect? *Archivos de Medicina del Deporte*, 39(4), 222–228. <https://doi.org/10.18176/archmeddeporte.00094>
21. Pickering, C., & Kiely, J. (2021). Individual variation in response to caffeine ingestion. *Sports Medicine*, 51(5), 1–16.
22. Silva, H., Del Coso, J., & Pickering, C. (2025). Caffeine and sports performance: Mechanisms and individual responses. *Sports Medicine*.
23. Southward, K., Rutherford-Markwick, K., & Ali, A. (2020). Individual variability in responses to caffeine ingestion. *Sports Medicine*, 50(2), 1–15.
24. Spriet, L. L. (2020). Low doses of caffeine and performance benefits in sport. *Sports Medicine*, 50(2), 1–8.
25. Stadheim, H. K., Stensrud, T., Brage, S., & Jensen, J. (2021). Caffeine increases exercise performance, maximal oxygen uptake, and oxygen deficit in elite male endurance athletes. *Medicine & Science in Sports & Exercise*, 53(11), 2264–2273. <https://doi.org/10.1249/MSS.0000000000002704>
26. Trujillo-Colmena, D., Fernández-Sánchez, J., Rodríguez-Castaño, A., Casado, A., & Del Coso, J. (2024). Effects of caffeinated coffee on cross-country cycling performance in recreational cyclists. *Nutrients*, 16(5), 668. <https://doi.org/10.3390/nu16050668>
27. Wu, S.-H., Chen, Y.-C., Chen, C.-H., Liu, H.-S., Liu, Z.-X., & Chiu, C.-H. (2024). Caffeine supplementation improves the cognitive abilities and shooting performance of elite e-sports players: A crossover trial. *Scientific Reports*, 14, 2074. <https://doi.org/10.1038/s41598-024-52599-y>
28. Yıldırım, U. C., Akçay, N., Alexe, D. I., Esen, O., Gülü, M., Cîrîţă-Buzoianu, C., Çınarlı, F. S., Cojocaru, M., Sarı, C., Alexe, C. I., & Karayigit, R. (2023). Acute effect of different doses of caffeinated chewing gum on exercise performance in caffeine-habituated male soccer players. *Frontiers in Nutrition*, 10, 1251740. <https://doi.org/10.3389/fnut.2023.1251740>