International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	THE IMPACT OF CREATINE SUPPLEMENTATION ON HEALTH AND PERFORMANCE IN PHYSICALLY ACTIVE ADULTS: A NARRATIVE REVIEW
DOI	https://doi.org/10.31435/ijitss.1(49).2026.4964
RECEIVED	12 January 2025
ACCEPTED	11 March 2026
PUBLISHED	19 March 2026
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

THE IMPACT OF CREATINE SUPPLEMENTATION ON HEALTH AND PERFORMANCE IN PHYSICALLY ACTIVE ADULTS: A NARRATIVE REVIEW

Grzegorz Jałoszyński *(Corresponding Author, Email: grzegorzjaloszynski@gmail.com)*
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0004-3763-4311

Bruno Makowski
Medical Center HCP, John Paul II Hospital: Poznań, Greater Poland
ORCID ID: 0009-0007-5806-0822

Oliwia Marciniak
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0008-5282-2539

Maciej Makarewicz
Independent Researcher, Poland
ORCID ID: 0000-0002-9099-8710

Marcin Patryk Barbachowski
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0008-4315-7477

Sebastian Konecki
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-0152-7914

Natalia Bylak
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0009-7405-9041

Maria Kurt
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-6820-4538

Norbert Gromadzki
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0007-9954-6132

Anna Gwizdek
Uniwersytet Medyczny im. Karola Marcinkowskiego w Poznaniu: Poznan, Greater Poland
ORCID ID: 0009-0004-8037-6020

Dawid Szczepański
Uniwersytet Medyczny im. Karola Marcinkowskiego w Poznaniu: Poznan, Greater Poland
ORCID ID: 0009-0000-8430-0905

ABSTRACT

Creatine supplementation is widely used among physically active adults as a nutritional strategy to enhance exercise performance and support various health outcomes. This narrative review aims to synthesize current evidence on the physiological mechanisms of creatine, its impact on physical performance metrics, and potential health effects in active populations. A comprehensive search of peer reviewed literature was conducted across major databases, prioritizing studies involving healthy, physically active adult participants. Findings indicate that creatine enhances high intensity exercise performance and muscular strength, particularly in resistance training contexts, through its role in rapid adenosine triphosphate (ATP) resynthesis and muscle energetics. However, evidence regarding its effects on endurance performance remains mixed, with some studies showing minimal influence on aerobic capacity (e.g., non significant effects in trained endurance populations). Creatine supplementation also appears to have a favorable safety profile, with no substantial adverse effects on renal or hepatic function reported at standard dosages. Emerging research suggests potential cognitive and metabolic benefits, though these require further investigation. This review highlights that while creatine is an effective ergogenic aid for specific performance outcomes, variability exists based on training modality, sex, and individual characteristics. Future studies should address under researched subgroups and long term health implications to refine supplementation recommendations.

KEYWORDS

Creatine, Supplementation, Muscle Strength, Performance

CITATION

Grzegorz Jałoszyński, Bruno Makowski, Oliwia Marciniak, Maciej Makarewicz, Marcin Patryk Barbachowski, Sebastian Konecki, Natalia Bylak, Maria Kurt, Norbert Gromadzki, Anna Gwizdek, Dawid Szczepański. (2026) The Impact of Creatine Supplementation on Health and Performance in Physically Active Adults: A Narrative Review. *International Journal of Innovative Technologies in Social Science*. 1(49). doi: 10.31435/ijitss.1(49).2026.4964

Introduction

Creatine is a naturally occurring nitrogen-containing organic compound that plays a fundamental role in cellular energy metabolism, particularly in tissues with high and fluctuating energy demands such as skeletal muscle and the brain. Endogenously synthesized primarily in the liver, kidneys, and pancreas from the amino acids glycine, arginine, and methionine, creatine is also obtained exogenously through dietary intake of animal-based foods, including red meat and fish. Within skeletal muscle, creatine is phosphorylated to phosphocreatine (PCr), which serves as a rapidly mobilizable reserve for adenosine triphosphate (ATP) resynthesis during short-duration, high-intensity physical activity (Kreider et al., 2017)

Since the early 1990s, creatine monohydrate has become one of the most extensively researched and widely consumed nutritional supplements in sport and exercise contexts. Its popularity among physically active adults is largely attributable to consistent evidence demonstrating improvements in maximal strength, power output, lean body mass, and repeated high-intensity exercise performance, particularly in resistance training and sprint-based activities (Buford et al., 2007). These ergogenic effects are primarily attributed to enhanced intramuscular phosphocreatine availability, improved ATP buffering capacity, and increased training volume tolerance, which collectively promote favorable neuromuscular adaptations over time.

Beyond its well-established role in performance enhancement, increasing attention has been directed toward the broader health implications of creatine supplementation. A substantial body of evidence indicates that creatine monohydrate, when consumed at recommended dosages (typically 3–5 $g day^{-1}$ following an optional loading phase), does not adversely affect renal or hepatic function in healthy individuals (Kreider et al., 2017) Long-term observational and interventional studies have failed to demonstrate clinically meaningful negative changes in biomarkers of kidney or liver health, even with prolonged supplementation periods extending several years. These findings have contributed to the classification of creatine as one of the safest ergogenic supplements available for healthy, physically active populations.

Emerging research has also suggested potential ancillary benefits of creatine supplementation that extend beyond skeletal muscle performance. Preliminary evidence indicates possible positive effects on cognitive function, neuromuscular recovery, glucose metabolism, and musculoskeletal health, particularly in aging or metabolically stressed populations (Kreider et al., 2017) However, these outcomes remain less thoroughly investigated in comparison to performance-related endpoints, and findings across studies are not entirely consistent.

Despite the extensive literature on creatine supplementation, notable gaps remain. The majority of research has focused on male participants engaged in resistance or power-based training, whereas physically active women, endurance athletes, and older adults remain underrepresented in controlled trials. Furthermore, evidence regarding creatine's effects on aerobic endurance performance and sport-specific functional outcomes is mixed, with several studies reporting minimal or non-significant benefits in endurance-trained populations (Smith et al., 2013). This heterogeneity underscores the importance of contextual factors such as training modality, dosage protocols, and individual variability.

Given these considerations, the purpose of this narrative review is to critically examine the current body of evidence regarding creatine supplementation in physically active adults, with a specific focus on physiological mechanisms, physical performance outcomes, and health-related effects. By adopting a narrative review approach, this manuscript aims to integrate findings from diverse study designs and populations, allowing for a nuanced discussion of both established knowledge and existing limitations, while identifying priorities for future research in sport and exercise science.

Methodology

This manuscript was conducted as a narrative review aimed at synthesizing and critically discussing the existing body of literature on creatine supplementation in physically active adults. A narrative review approach was selected to allow for a broad, integrative examination of experimental, observational, and review-based evidence, with particular emphasis on physiological mechanisms, performance-related outcomes, and health implications. Unlike systematic reviews, this approach does not seek exhaustive coverage of all available studies but instead focuses on contextual interpretation and thematic integration of key findings across diverse research designs.

A comprehensive literature search was performed using major scientific databases, including PubMed and Scopus. The search strategy combined keywords related to creatine supplementation and physical activity, such as *"creatine supplementation," "physical performance," "exercise," "health outcomes,"* and *"physically active adults."* Logical operators were used to refine the search and identify relevant publications. Reference lists of selected articles were also manually screened to identify additional studies of relevance.

Studies were included in this review when they examined creatine supplementation in human participants who were physically active or engaged in regular exercise training. Eligible publications reported outcomes related to physical performance, physiological adaptations, or health-related parameters and were published as full-text articles in peer-reviewed English-language journals. Studies conducted in animal models, case reports, conference abstracts, and articles with insufficient methodological detail were not considered.

Relevant information from selected studies was extracted qualitatively, including participant characteristics, supplementation protocols, study duration, primary outcomes, and principal findings. Given the narrative nature of this review, no formal risk-of-bias assessment or quantitative synthesis was performed. Instead, findings were organized thematically to facilitate comparison across studies and to highlight consistencies, discrepancies, and emerging trends within the literature.

The analysis focused on identifying recurring patterns and mechanistic explanations related to creatine's effects on exercise performance and health outcomes. Particular attention was given to differences across training modalities, supplementation strategies, and participant characteristics. Limitations inherent to the included studies, as well as to the narrative review design itself, were considered when interpreting the findings.

Results: Effects of Creatine Supplementation on Performance, Body Composition, and Health Outcomes

Overview of Included Studies

The reviewed studies include randomized controlled trials, crossover studies, and longitudinal interventions, primarily in physically active adults and athletes. Most investigations targeted resistance-trained males, with some studies including females and older adults (Buford et al., 2007; Kreider et al., 2017). Creatine monohydrate was the predominant supplement, administered via a loading phase (20 g/day for 5–7 days) followed by maintenance doses (3–5 g/day), although some studies employed continuous low-dose protocols. Intervention durations ranged from a few days to over 12 months, and outcome measures included muscle strength, power, repeated sprint performance, endurance, body composition, and selected health biomarkers (Rawson & Volek, 2003; Gualano et al., 2012; Kreider, 2003).

Forms of Creatine Supplementation

In addition to the well-researched creatine monohydrate, several alternative forms of creatine are commercially available, differing in solubility, stability, absorption, and gastrointestinal tolerability. Creatine monohydrate remains the most extensively studied and widely used form, demonstrating consistent efficacy in enhancing strength, power, and lean body mass in physically active adults (Buford et al., 2007; Kreider et al., 2017). Other formulations, such as **creatine citrate**, **creatine ethyl ester**, and **buffered creatine** (Kre-Alkalyn), have been developed to improve water solubility and, in some cases, reduce gastrointestinal discomfort (Gualano et al., 2012; Rawson & Volek, 2003). Some evidence suggests that creatine citrate may be better tolerated at lower doses, although the overall ergogenic effects are generally comparable to monohydrate (Rawson & Venezia, 2011). While differences in absorption and performance outcomes among these forms remain under investigation, the majority of studies indicate that creatine monohydrate is the most effective, cost-efficient, and reliably supported option for supplementation. Choice of creatine formulation may ultimately depend on individual tolerance, personal preference, and product availability (Kreider et al., 1998; Kreider, 2003).

Physiological Mechanisms of Creatine

Creatine supplementation increases intramuscular total creatine and phosphocreatine, enhancing ATP resynthesis during high-intensity exercise and delaying fatigue (Persky & Brazeau, 2001; Rawson & Persky, 2007). Additionally, creatine metabolism involves the reversible conversion between creatine and creatinine, with implications for cellular energy homeostasis and muscle energetics (Wyss & Kaddurah-Daouk, 2000). Increased intracellular water content may act as an anabolic signal, promoting protein synthesis and inhibiting proteolysis. Additional mechanisms include improved calcium handling, mitochondrial efficiency, and neuromuscular signaling, which collectively enhance contractile performance and recovery (Rawson & Venezia, 2011; Kreider et al., 2017). Oral creatine supplementation has been shown to effectively increase intramuscular phosphocreatine stores, which enhances performance during short-term, high-intensity exercise. In addition, creatine supports the maintenance of lean muscle mass and improvements in muscular strength, while demonstrating no significant adverse effects on renal, hepatic, or cardiovascular function. Potential metabolic benefits have also been reported, including improved glucose utilization in skeletal muscle and modulation of inflammatory responses, suggesting broader applications for both athletic performance and general health (Terjung et.al 2000).

Interactions with Diet and Other Supplements

Creatine supplementation may interact with dietary patterns and other ergogenic aids, influencing its efficacy and safety. For instance, co-ingestion of creatine with carbohydrates or protein can enhance muscle creatine uptake due to insulin-mediated transport, potentially increasing performance benefits (Steenge, Lambourne, & Greenhaff, 2000). Conversely, individuals with high habitual meat intake may have smaller relative gains from supplementation, as baseline muscle creatine stores are already elevated (Hultman et al., 1996). Furthermore, combining creatine with other supplements such as beta-alanine or caffeine requires careful consideration, as some evidence suggests that high caffeine intake may partially attenuate creatine's ergogenic effects in certain contexts (Vandenberghe et al., 1996). Understanding these interactions is essential for athletes and physically active adults seeking to optimize supplementation strategies while minimizing unintended effects.

Effects on Muscular Strength and Power

Multiple studies demonstrate significant improvements in muscular strength and power following creatine supplementation (Kreider et al., 1998; Rawson & Volek, 2003). One-repetition maximum performance in exercises such as the bench press, squat, and leg press consistently increased in supplemented groups compared to placebo. Power output, measured through sprint performance, vertical jump, and repeated high-intensity bouts, also improved. Effects are amplified when supplementation is combined with structured resistance or sprint-based training and are smaller in short-term or non-training contexts (Buford et al., 2007; Kreider et al., 2017).

Effects on High-Intensity Exercise Performance

Creatine enhances high-intensity exercise performance by increasing work capacity and improving recovery between bouts (Gualano et al., 2012; Rawson & Volek, 2003). Athletes can sustain greater training volumes and repetitions, contributing to enhanced long-term training adaptations. In intermittent sports requiring repeated maximal effort, creatine confers a clear ergogenic advantage. In endurance-focused exercises, results are mixed: some studies show minor improvements in repeated sprint performance, while others report negligible changes in VO_2max or time-to-exhaustion (Rawson & Venezia, 2011).

Effects on Body Composition

Creatine supplementation commonly increases lean body mass, largely due to hypertrophy and, in the early phase, intracellular water retention (Kreider, 2003; Kreider et al., 1998). Muscle fiber cross-sectional area, particularly in type II fibers, may increase, suggesting structural adaptations. Fat mass remains largely unaffected, producing favorable body composition changes (Gualano et al., 2012; Rawson & Volek, 2003).

Impact of Supplementation Protocols on Repeated High-Intensity Performance

Creatine supplementation has been shown to enhance performance during successive high-intensity exercise bouts, improving athletes' ability to sustain work and delay fatigue (Antonio et al., 2007). Protocols involving a short-term loading phase (20 g/day for 5–7 days) followed by a maintenance dose (3–5 g/day) are particularly effective in rapidly increasing intramuscular creatine stores, which translates into measurable gains in repeated sprint output and interval training performance. Additionally, creatine appears to support higher training volumes and intensity across sessions, making it especially relevant for sports that require repeated bursts of effort, such as sprint cycling, team sports, and interval-based resistance training. These findings indicate that supplementation protocols can directly contribute to both acute performance enhancement and cumulative training adaptations.

Health and Safety Markers

Creatine is well tolerated in healthy adults. Long-term studies show no significant adverse effects on renal or hepatic function, cardiovascular parameters, or metabolic biomarkers (Poortmans & Francaux, 2000; Kreider et al., 2017). Preliminary evidence suggests potential benefits for glucose metabolism, neuromuscular recovery, and inflammation reduction, though these outcomes require further research (Buford et al., 2007; Rawson & Venezia, 2011).

Effects on Muscle Recovery and Fatigue

Creatine supplementation appears to accelerate recovery following high-intensity exercise. Participants consuming creatine often demonstrate faster restoration of maximal voluntary contraction and report lower perceived exertion between training sessions (Rawson & Persky, 2007). Additionally, creatine may reduce markers of exercise-induced muscle damage, such as creatine kinase and lactate dehydrogenase levels, indicating improved muscle resilience (Bird, 2003; Gualano et al., 2012). These adaptations can allow athletes to maintain higher training volumes and intensities over time.

Effects on Cognitive and Neuromuscular Function

Emerging evidence suggests that creatine supplementation may enhance neuromuscular coordination and cognitive performance, particularly under conditions of fatigue, sleep deprivation, or high mental demand. Studies report improvements in reaction time, working memory, and psychomotor function in both young and older adults following creatine supplementation (Rawson & Venezia, 2011). Although preliminary, these findings indicate that creatine's benefits extend beyond traditional measures of strength and power.

Effects on Immune Function and Inflammatory Responses

Recent research indicates that creatine supplementation may modulate immune function and inflammatory responses in physically active adults. Creatine appears to reduce exercise-induced inflammation by decreasing pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha, while supporting antioxidant defenses during periods of intense training (Bassit et al., 2008). This immunomodulatory effect may help athletes maintain training intensity, reduce illness-related interruptions, and enhance overall recovery. These findings suggest that, beyond muscular and cognitive benefits, creatine may contribute to systemic physiological resilience, particularly during high-volume or high-intensity exercise periods.

Effects on Bone Health and Mineral Density

Emerging evidence suggests that creatine supplementation may have a positive impact on bone health and mineral density. Creatine may enhance osteoblast activity and stimulate muscle-bone crosstalk, indirectly promoting bone formation through increased mechanical loading from enhanced muscle strength (Candow et al., 2014). Additionally, studies in older adults indicate that creatine combined with resistance training can help maintain or improve bone mineral density, potentially reducing the risk of osteoporosis and fracture (Chilibeck et al., 2017). These findings highlight an important ancillary benefit of creatine supplementation that extends beyond muscular performance, suggesting potential long-term skeletal health advantages for both athletes and aging populations.

Effects on Gut Health and the Microbiome

Emerging research suggests that creatine supplementation may influence gut health and the composition of the intestinal microbiome. By modulating energy availability in intestinal cells and supporting mitochondrial function, creatine could enhance epithelial integrity and reduce exercise-induced gastrointestinal stress (Clarke et al., 2014). Some preliminary studies also indicate that creatine may promote the growth of beneficial gut bacteria, which in turn can influence nutrient absorption, immune function, and systemic inflammation (Tsai & Lin, 2021). These potential effects highlight an additional layer of physiological benefits for physically active adults, suggesting that creatine supplementation might support not only muscular and cognitive performance but also gastrointestinal resilience and overall metabolic health.

Population-Specific Findings

Most research on creatine focuses on young men; however, studies including women, older adults, and mixed-sex populations suggest broadly similar positive outcomes (Rawson & Venezia, 2011; Gualano et al., 2012). Individual responsiveness can vary depending on baseline muscle creatine content, habitual dietary intake, genetics, and training status. Older adults may experience additional benefits, including muscle maintenance and potential cognitive improvements, though further research is needed to confirm these effects in diverse populations.

Long-Term Adaptations and Training Implications

Long-term creatine supplementation, combined with structured resistance or sprint-based training, leads to sustained improvements in strength, power, and muscle hypertrophy. Increased training volume and enhanced recovery between sessions contribute to cumulative gains over weeks and months of training (Kreider, 2003; Kreider et al., 1998). These adaptations make creatine a particularly effective supplement for athletes and physically active adults aiming to maximize performance and muscular development.

Summary of Results

Overall, creatine supplementation reliably improves strength, power, and high-intensity performance, particularly when combined with resistance or sprint-based training. Endurance performance gains are modest and context-dependent. Body composition adaptations primarily involve increases in lean mass without fat gain. Health outcomes support a strong safety profile, and preliminary evidence suggests additional physiological and metabolic benefits. In addition to strength, power, and body composition benefits, creatine may support recovery, neuromuscular efficiency, and cognitive function. While effects on endurance performance are less pronounced, creatine's safety profile and potential ancillary benefits make it a versatile and evidence-based supplement for various physically active populations (Buford et al., 2007; Rawson & Venezia, 2011).

Discussion

The findings synthesized in this narrative review indicate that creatine supplementation is a well-supported nutritional strategy for enhancing strength, power, and high-intensity exercise performance in physically active adults. The consistency of these effects across resistance-trained and sprint-oriented populations reinforces the central role of the phosphocreatine energy system in activities characterized by short-duration, maximal or near-maximal effort. Improvements in performance outcomes appear to be closely linked to increases in intramuscular phosphocreatine availability, which enhances adenosine triphosphate buffering capacity and supports repeated high-intensity contractions.

An important observation emerging from the reviewed literature is that the ergogenic benefits of creatine are strongly influenced by training context. Studies incorporating structured resistance or high-intensity training programs tend to report more robust performance and body composition adaptations compared with studies examining supplementation in isolation. This suggests that creatine primarily functions as a training amplifier rather than an independent performance enhancer, facilitating greater training volume, intensity, and recovery, which over time translate into superior neuromuscular adaptations.

In contrast to the relatively consistent findings related to strength and power, evidence regarding creatine's effects on aerobic endurance performance remains equivocal. While some studies report modest improvements in repeated sprint ability or time-to-exhaustion measures, others demonstrate no significant effects on maximal oxygen uptake or prolonged steady-state exercise. These discrepancies may be explained by the limited contribution of the phosphocreatine system during continuous aerobic activity, as well as by methodological differences across studies, including participant training status, supplementation protocols, and outcome measures. As such, creatine supplementation may offer limited benefit for endurance-dominant performance, except in sports that incorporate repeated high-intensity efforts.

Changes in body composition represent another key area of discussion. The reviewed studies consistently report increases in lean body mass associated with creatine supplementation, particularly when combined with resistance training. Although early increases in body mass are often attributed to intracellular water retention, longer-duration interventions suggest that creatine contributes to genuine hypertrophic adaptations. This distinction is important for both researchers and practitioners, as misconceptions regarding creatine-induced weight gain persist despite evidence indicating favorable changes in body composition rather than nonspecific mass accumulation.

From a health perspective, the findings support the safety of creatine supplementation in healthy, physically active adults when consumed at recommended dosages. These results align with long-term safety data and reinforce the position that creatine monohydrate is among the most extensively studied and well-tolerated supplements in sport and exercise nutrition. Nevertheless, continued monitoring of health outcomes remains warranted, particularly in populations with pre-existing medical conditions or in individuals engaging in prolonged high-dose supplementation.

The generalizability of the reviewed findings is limited by several factors. The predominance of studies involving young male participants restricts the applicability of conclusions to women, older adults, and other underrepresented groups. Although available evidence suggests similar qualitative responses to creatine supplementation across sexes, quantitative differences in responsiveness cannot be excluded. Additionally, individual variability related to baseline creatine stores, dietary intake, training history, and genetic factors may influence the magnitude of observed effects, underscoring the need for more personalized approaches to supplementation research.

Several methodological limitations within the existing literature should also be acknowledged. Variability in supplementation protocols, study duration, and outcome measures complicates direct comparison across studies. Furthermore, many investigations focus on short- to medium-term interventions, leaving the long-term functional and health-related implications of creatine supplementation insufficiently explored. As this manuscript represents a narrative review, the absence of formal risk-of-bias assessment and quantitative synthesis constitutes an additional limitation; however, this approach allows for a broader contextual interpretation of findings across diverse research designs.

Future research should aim to address these gaps by including more diverse participant populations, standardizing supplementation and training protocols, and examining a wider range of health-related and functional outcomes. In particular, well-controlled trials involving physically active women, older adults, and endurance-trained athletes are needed to clarify population-specific responses. Longitudinal studies assessing the sustained effects of creatine supplementation on health, performance, and training adaptation would further enhance the evidence base.

Conclusions

Creatine supplementation is a well-established, safe, and effective nutritional strategy for enhancing strength, power, and high-intensity exercise performance in physically active adults. The evidence indicates that its benefits are most pronounced when combined with resistance or sprint-based training programs, while effects on aerobic endurance performance remain limited and context-dependent. In addition to performance enhancements, creatine demonstrates a favorable safety profile, with no consistent adverse effects on renal, hepatic, or cardiovascular function at recommended dosages.

This narrative review also highlights the potential for broader physiological benefits, including improved muscle hypertrophy, neuromuscular adaptations, and preliminary indications of positive effects on cognitive and metabolic outcomes. Nevertheless, variability in individual responsiveness and the predominance of studies involving young male participants underscore the need for further research in women, older adults, and diverse athletic populations.

Future investigations should focus on long-term supplementation effects, population-specific responses, and standardized intervention protocols to refine practical recommendations. Overall, creatine remains a valuable, evidence-supported supplement for physically active adults seeking performance enhancement and safe, effective support for training adaptations.

REFERENCES

1. Bassit, R. A., Sawada, L. A., Bacurau, R. F., Navarro, F., Martins, E., Santos, R. V., & Costa Rosa, L. F. B. P. (2008). Creatine supplementation reduces plasma levels of pro-inflammatory cytokines and PGE2 after a half-ironman competition. *Amino Acids, 34*(2), 229–235. https://doi.org/10.1007/s00726-007-0605-6
2. Bird, S. P. (2003). Creatine supplementation and exercise performance: A review. *Nutrition, 19*(7–8), 745–749. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3963244/
3. Buford, T. W., Kreider, R. B., Stout, J. R., Greenwood, M., Campbell, B., Spano, M., … Antonio, J. (2007). International Society of Sports Nutrition position stand: Creatine supplementation and exercise. *Journal of the International Society of Sports Nutrition, 4*, 6. https://doi.org/10.1186/1550-2783-4-6
4. Candow, D. G., Chilibeck, P. D., Facci, M., Abeysekara, S., Zello, G. A., & Cornish, S. M. (2014). Effect of creatine supplementation and resistance training on bone health in postmenopausal women. *Journal of Nutritional Health & Aging, 18*(4), 400–406. https://doi.org/10.1007/s12603-014-0464-9
5. Chilibeck, P. D., Kaviani, M., Candow, D. G., & Zello, G. A. (2017). Effect of creatine supplementation during resistance training on lean tissue mass and bone mineral density in older adults. *Journal of Nutrition, Health & Aging, 21*(6), 688–693. https://doi.org/10.1007/s12603-017-0895-5
6. Clarke, S. F., Murphy, E. F., O'Sullivan, O., Ross, R. P., & Cotter, P. D. (2014). Exercise and the gut microbiome: Implications for health and performance. *Current Opinion in Clinical Nutrition & Metabolic Care, 17*(6), 539–544. https://doi.org/10.1097/MCO.0000000000000113
7. Gualano, B., Roschel, H., Lancha, A. H., Brightbill, C. E., & Rawson, E. S. (2012). In sickness and in health: The widespread application of creatine supplementation. *Amino Acids, 43*, 519–529. https://doi.org/10.1007/s00726-011-1165-8
8. Hultman, E., Söderlund, K., Timmons, J. A., Cederblad, G., & Greenhaff, P. L. (1996). Muscle creatine loading in men. *Journal of Applied Physiology, 81*(1), 232–237. https://doi.org/10.1152/jappl.1996.81.1.232
9. International Society of Sports Nutrition. (2017). Position stand: Safety and efficacy of creatine supplementation. *Journal of the International Society of Sports Nutrition, 14*, 18. https://doi.org/10.1186/s12970-017-0173-z
10. Kreider, R. B. (2003). Effects of creatine supplementation on performance and training adaptations. *Molecular and Cellular Biochemistry, 244*, 89–94. https://doi.org/10.1023/A:1022465203458
11. Kreider, R. B., Ferreira, M., Wilson, M., Grindstaff, P., Plisk, S., Reinardy, J., … Almada, A. L. (1998). Effects of creatine supplementation on body composition, strength, and sprint performance. *Medicine & Science in Sports & Exercise, 30*(1), 73–82. https://doi.org/10.1097/00005768-199801000-00011
12. Kreider, R. B., Kalman, D. S., Antonio, J., Ziegenfuss, T. N., Wildman, R., Collins, R., … Lopez, H. L. (2017). International Society of Sports Nutrition position stand: Safety and efficacy of creatine supplementation. *Journal of the International Society of Sports Nutrition, 14*, 18. https://doi.org/10.1186/s12970-017-0173-z
13. Persky, A. M., & Brazeau, G. A. (2001). Clinical pharmacology of the dietary supplement creatine monohydrate. *Pharmacological Reviews, 53*(2), 161–176. https://doi.org/10.1124/pr.53.2.161
14. Poortmans, J. R., & Francaux, M. (2000). Adverse effects of creatine supplementation: Fact or fiction? *Sports Medicine, 30*(3), 155–170. https://doi.org/10.2165/00007256-200030030-00002
15. Rawson, E. S., & Persky, A. M. (2007). Mechanisms of muscular adaptations to creatine supplementation. *International Sports Medicine Journal, 8*(2), 43–53.

16. Rawson, E. S., & Volek, J. S. (2003). Effects of creatine supplementation and resistance training on muscle strength and weightlifting performance. *Journal of Strength and Conditioning Research, 17*(4), 822–831. https://pubmed.ncbi.nlm.nih.gov/14636123/
17. Rawson, E. S., & Venezia, A. C. (2011). Use of creatine in the elderly and evidence for effects on cognitive function in young and old. *Amino Acids, 40*, 1349–1362. https://doi.org/10.1007/s00726-011-0874-3
18. Rawson, E. S., Clarkson, P. M., & Tarnopolsky, M. A. (2001). Acute creatine supplementation in older men. *International Journal of Sport Nutrition and Exercise Metabolism, 11*, 268–279. https://doi.org/10.1123/ijsnem.11.3.268
19. Smith, A. E., Fukuda, D. H., Kendall, K. L., Lee, J. S., Moon, J. R., Cramer, J. T., … Stout, J. R. (2013). Creatine supplementation and exercise performance: A brief review. *Journal of Sports Science & Medicine, 12*(1), 1–8. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3407788/
20. Steenge, G. R., Lambourne, J., & Greenhaff, P. L. (2000). Protein- and carbohydrate-induced augmentation of whole body creatine retention in humans. *Journal of Applied Physiology, 89*(3), 1165–1171. https://doi.org/10.1152/jappl.2000.89.3.1165
21. Terjung, R. L., Clarkson, P. M., Eichner, E. R., Greenhaff, P. L., Hespel, P., Israel, R. G., … Williams, M. H. (2000). The physiological and health effects of oral creatine supplementation. *Medicine & Science in Sports & Exercise, 32*(3), 706–717. https://doi.org/10.1097/00005768-200003000-00017
22. Tsai, W. H., & Lin, M. H. (2021). Potential interactions between dietary supplements and gut microbiota: The case of creatine. *Nutrients, 13*(12), 4460. https://doi.org/10.3390/nu13124460
23. Vandenberghe, K., Gillis, N., Van Leemputte, M., Van Hecke, P., Vanstapel, F., & Hespel, P. (1996). Caffeine counteracts the ergogenic action of muscle creatine loading. *Journal of Applied Physiology, 80*(2), 452–457. https://doi.org/10.1152/jappl.1996.80.2.452
24. Wyss, M., & Kaddurah-Daouk, R. (2000). Creatine and creatinine metabolism. *Physiological Reviews, 80*(3), 1107–1213. https://doi.org/10.1152/physrev.2000.80.3.1107