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Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

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EFFECTIVENESS OF CREATINE SUPPLEMENTATION IN STRENGTH SPORTS – A REVIEW

Izabella Michalska *(Corresponding Author, Email: iziapannaizabella@gmail.com)*
Medical University of Silesia, Katowice, Poland
ORCID ID: 0009-0007-9030-0603

Mateusz Myśliwiec
Independent Public Health Care Center of the Ministry of the Interior and Administration, Kraków, Poland
ORCID ID: 0009-0007-4552-4827

Maciej Karwat
Independent Public Health Care Center of the Ministry of the Interior and Administration, Kraków, Poland
ORCID ID: 0009-0007-5917-977X

Dominik Sendecki
Independent Public Health Care Center of the Ministry of the Interior and Administration, Kraków, Poland
ORCID ID: 0009-0004-4166-2219

Tytus Tyralik
Stefan Żeromski Specialist Hospital SP ZOZ, Kraków, Poland
ORCID ID: 0009-0001-7370-4610

Julia Kular
Medical University of Silesia, Katowice, Poland
ORCID ID: 0009-0004-6287-2637

Oliwia Malec
Medical University of Silesia, Katowice, Poland
ORCID ID: 0009-0002-5391-3148

Justyna Niebylecka
Medical University of Silesia, Katowice, Poland
ORCID ID: 0009-0006-8773-3355

Natalia Glanc
Medical University of Silesia, Katowice, Poland
ORCID ID: 0009-0007-1130-0956

Grzegorz Zalewski
Jagiellonian University Medical College, Kraków, Poland
ORCID ID: 0009-0004-8161-5951

ABSTRACT

Background. Creatine monohydrate is one of the most widely researched and effective ergogenic supplements used to enhance performance and body composition in strength-based sports. Although creatine is known to be effective, researchers are still learning how to use it in the best way, how different people respond to it, and what other benefits it might have. .
Aim. This systematic review evaluates the effectiveness of creatine supplementation in improving muscle strength, lean body mass, endurance, recovery, and related functional parameters, based on evidence from 49 scientific publications..
Material and methods. Studies included in this review examined creatine use in both short- and long-term protocols across varied populations, including athletes, recreationally active individuals, and older adults. Outcomes assessed included changes in 1RM strength, lean body mass, power output, quality of life, and biochemical markers. .
Results. Creatine consistently improved strength and lean mass when combined with resistance training, regardless of dosing strategy or timing. Younger adults experienced faster and larger gains, while older individuals showed moderate improvements in physical function and well-being. Creatine monohydrate was more effective than alternative forms, and loading phases were not required for results. However, its effects were minimal without concurrent exercise and limited in some clinical populations. Additional benefits, such as enhanced sleep or antioxidant status, were reported in specific groups.
Conclusions. Creatine supplementation is a safe, cost-effective, and well-supported strategy for enhancing resistance training outcomes. Its consistent efficacy across populations makes it a valuable tool for both athletic and clinical applications, particularly when paired with structured exercise.

KEYWORDS

Creatine, Creatine Monohydrate, Resistance Training, Performance Enhancement, Muscle Mass, Strength

CITATION

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1. Introduction

Creatine supplementation is widely used by athletes to enhance strength, power, and muscle mass. As a naturally occurring compound that supports rapid ATP regeneration in muscle cells, it plays a key role during high-intensity, short-duration activities like sprinting or weightlifting. Its proven safety, availability, and extensive scientific support have contributed to its popularity as one of the most trusted performance-enhancing supplements.

Numerous high-quality reviews and meta-analyses confirm creatine's benefits, especially when paired with resistance training. It has been shown to significantly increase lean body mass and maximal strength. For example, recent evidence indicates that creatine enhances regional hypertrophy more effectively than training alone (Burke et al., 2023). Even intermittent use—such as dosing only on workout days—can produce measurable improvements (Mills et al., 2020).

What makes creatine particularly valuable is its broad effectiveness across age groups. Studies involving older adults, including women, demonstrate its role in preserving or improving muscle mass and functional strength, potentially offsetting age-related muscle decline (Dos Santos et al., 2021; Forbes, Candow, et al., 2021).

Responses to creatine may vary based on age, sex, training status, and exercise type. A large meta-analysis identified these factors as moderators, though the overall benefits remained positive across subgroups (Delpino et al., 2022). Additionally, research supports a dose-response relationship, suggesting that optimized protocols can further enhance results (Pashayee-Khamene et al., 2024).

Beyond physical performance, emerging studies highlight creatine's potential to improve recovery and even support cognitive function (Sandkühler et al., 2023; Wang et al., 2018). These findings expand its relevance beyond athletics, opening applications in clinical and rehabilitation settings.

2. Research materials and methods

This literature review focused on studies published between 2015 and 2025 examining the effects of creatine supplementation on strength, muscle mass and improved overall performance. A comprehensive search of the PubMed database was conducted using the following keywords and MeSH terms: 'creatine', 'creatine monohydrate', 'resistance training', 'performance enhancement', 'muscle mass' and 'strength'. A total of 2,143 records were identified in PubMed using this strategy. After removing duplicates, 1,800 unique records remained and were analysed based on their titles and abstracts. Following the initial selection process, 1,700 records were excluded due to irrelevance, duplication of content or failure to meet the initial inclusion criteria. A total of 100 full-text articles remained and were evaluated in detail for eligibility. Of these, 49 studies met all the predefined inclusion criteria and were included in the final analysis.

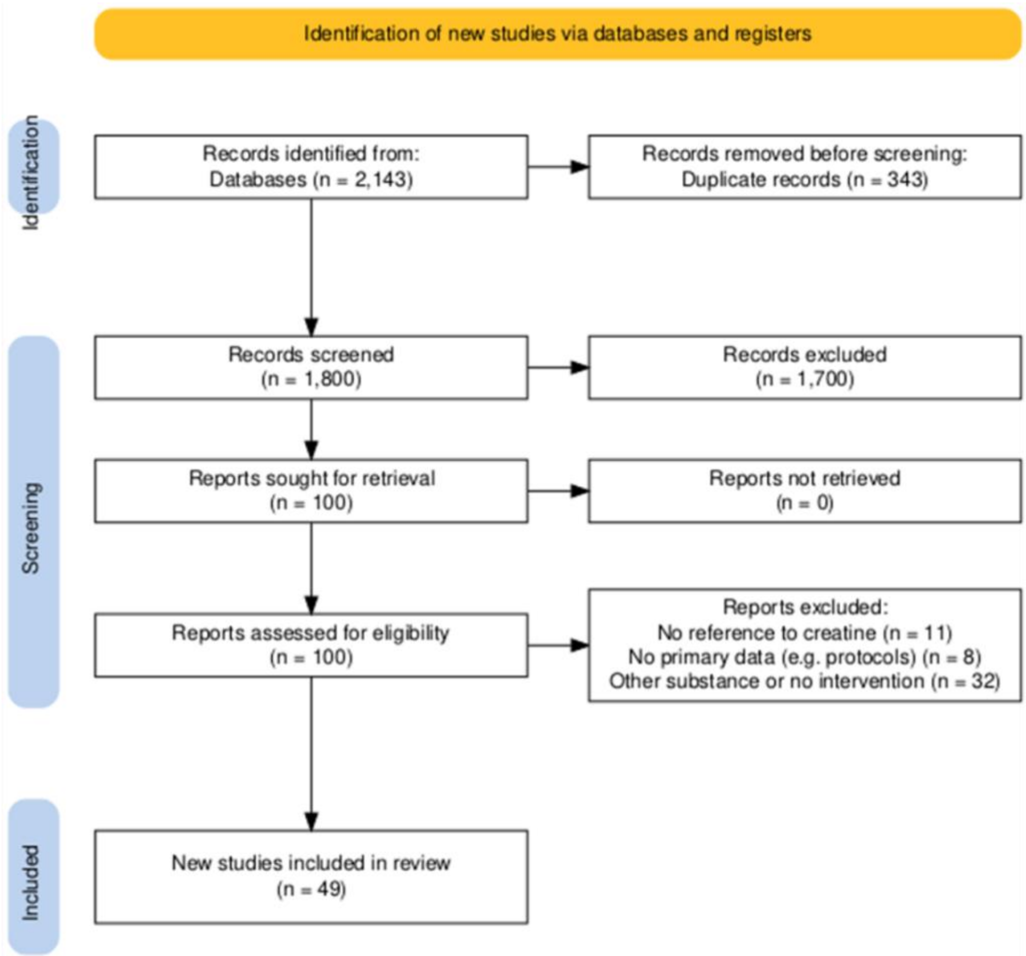

Fig. 1. *PRISMA 2020 flow diagram for systematic review*

3. Research results

Creatine monohydrate is among the most studied and widely used ergogenic aids in strength sports. Its primary benefits include increases in maximal strength, LBM (LBM; *lean body mass*), anaerobic power, and muscular endurance. Numerous RCTs (RCTs; *randomized controlled trials)* confirm that creatine, especially when combined with resistance training, leads to significant improvements in body composition and performance across various populations.

3.1.1. General Strength and Mass Gains

Several trials show that creatine produces greater strength and muscle mass gains compared to resistance training alone. For example, Mills et al. found that young adults taking 0.1 g/kg of creatine post-exercise gained +2.4 ± 0.7 kg of LBM and improved bench press 1RM (1RM; *one-repetition maximum*) by +8.3 ± 3.5 kg, versus +1.2 ± 0.6 kg and +4.7 ± 2.9 kg in the placebo group ($p < 0.05$) (Mills et al., 2020). Similarly, in a

12 - month trial, Candow et al. reported that older men using creatine increased LBM by +1.4 kg ($p = 0.01$), 1RM strength by 15.1%, and femoral bone mineral density by +2.3% ($p = 0.03$) (Candow et al., 2021).

3.1.2. Timing of Adaptations and Short-Term Effectiveness

Creatine can be effective even in short durations. Kaviani et al. noted a 14% increase in leg press strength within two weeks of daily supplementation (0.1 g/kg), with gains sustained over eight weeks ($p < 0.05$) (Kaviani et al., 2019). Yáñez-Silva et al. showed that a 7-day, low-dose loading phase (3 g/day) improved peak Wingate power by +6.2% and reduced 10 m sprint time by 0.08 s in elite youth soccer players ($p < 0.05$) (Yáñez-Silva et al., 2017).

3.1.3. Effectiveness Across Training Levels and Modalities

Creatine is beneficial across various training styles. Bonilla et al. demonstrated that in a cluster-set protocol, creatine increased leg strength by 17.6% vs. 10.3% in placebo, and leg muscle mass by +1.7 kg vs. +0.9 kg ($p < 0.05$) (Bonilla et al., 2021). Feuerbacher et al. found that five days of loading (20 g/day) led to an 11% increase in bench press repetitions and a 9% improvement in total work ($p = 0.03–0.04$) (Feuerbacher et al., 2021). Additionally, Candow et al. observed strength and hypertrophy gains in postmenopausal women, despite age-related anabolic resistance (Almeida et al., 2020).

3.1.4 Role of Formulation and Bioavailability

While various creatine forms exist, monohydrate remains the most effective. Askow et al. found that only creatine monohydrate significantly increased intramuscular creatine content ($p < 0.001$), whereas creatyl-L-leucine did not (Askow et al., 2022). This confirms monohydrate as the gold standard for both clinical and athletic use.

3.1.5. Multicomponent Supplementation

Some studies explored multi-ingredient supplements. Wageh et al. tested a blend containing creatine, leucine, protein, and vitamins, showing LBM gains of +2.2 kg vs. +1.1 kg in placebo ($p < 0.05$), along with strength improvements (Wageh et al., 2021). Although the contribution of creatine cannot be isolated, such results support its compatibility with synergistic compounds.

3.2. Effects in Different Age Groups

Although creatine is effective across athletic populations, its impact may vary with age due to differences in muscle mass, hormonal status, and training response. Numerous RCTs have examined these differences, offering insights into how younger and older adults benefit from supplementation.

3.2.1. Older Adults: Combating Sarcopenia and Supporting Function

In older adults, creatine is valued for both its ergogenic effects and its role in combating sarcopenia. A meta-analysis by Chilibeck et al. reported that combining creatine with resistance training increased lean body mass by +1.37 kg and leg strength by +14.1 kg versus placebo ($p < 0.001$) (P. Chilibeck et al., 2017).

Amiri et al. found that 12 weeks of creatine plus strength training led to a +14.2% increase in 1RM strength, reduced oxidative stress (lower malondialdehyde, higher total antioxidant capacity), and improved physical quality of life ($p < 0.05$) (Amiri & Sheikholeslami-Vatani, 2023). Johannsmeyer et al. observed LBM gains of +1.2 kg vs. +0.4 kg and strength gains of +18.7% vs. +9.6% over 12 weeks ($p < 0.05$) (Johannsmeyer et al., 2016). In contrast, Vargas-Molina et al. observed an increase in jump height (+9.3%) and throwing accuracy (+11%) thanks to hybrid training (p < 0.05) (Vargas-Molina et al., 2022).

In a 12-month study, Candow et al. noted increases in femoral bone mineral density (+2.3%, $p = 0.03$), LBM (+1.4 kg, $p = 0.01$), and strength (+15.1%) in older men (Candow et al., 2021). Additional studies show that frail older adults also respond positively. Collins et al. found that creatine plus protein improved LBM and strength in individuals with functional limitations (Collins et al., 2016).

However, response is not universal. Fairman et al. found no added benefit in prostate cancer patients on androgen deprivation therapy, likely due to hormonal suppression (Fairman et al., 2025). Similarly, Diaz-Pizarro et al. reported a smaller lean mass loss in creatine users (–0.8 kg vs. –1.2 kg), but the difference was not significant ($p = 0.14$) (Diaz-Pizarro et al., 2024). Chilibeck et al. also found no improvement in bone mineral density after two years of creatine in postmenopausal women (P. D. Chilibeck et al., 2023).

3.2.2. Younger Adults: Maximizing Performance and Hypertrophy

Younger individuals, especially athletes, tend to show faster and greater improvements with creatine. Ramírez-Campillo et al. reported that creatine plus plyometric training improved 30m sprint time by –0.13 s in female soccer players ($p = 0.04$) (Ramírez-Campillo et al., 2016).

Nunes et al. found specific hypertrophy region, with creatine increasing arm muscle size by +4.2%, compared to +2.1% in the trunk and +1.4% in the legs ($p < 0.05$) (Nunes JP, Ribeiro AS, Schoenfeld BJ, Tomeleri CM, Avelar A, Trindade MC, & Nabuco HC, Cavalcante EF, Junior PS, Fernandes RR, Carvalho FO, Cyrino ES., 2024). In basketball players, Vargas-Molina et al. showed improved vertical jump (+9.3%) and shooting performance (+11%) after creatine use during mixed training (Vargas-Molina et al., 2022).

In female athletes, water retention may influence results. Brooks et al. reported increased total body water (+1.1 L, $p = 0.01$) and an artificial DXA-based LBM rise of +0.9 kg (Brooks et al., 2023). Additionally, Candow et al. observed fat mass reductions (SMD = –0.29, $p < 0.001$), particularly in untrained individuals and longer programs (Candow et al., 2023).

Bernat et al. demonstrated that older, untrained men undergoing high-velocity resistance training still experienced notable gains with creatine, including +19% lower-body power and +17% leg press strength vs. +9% in placebo ($p < 0.05$) (Bernat et al., 2020).

3.3. Dosing Strategies and Creatine Forms

While creatine monohydrate is well established as an effective supplement, researchers have examined how dosing strategies, timing, and supplement form may influence its benefits. Overall, regular intake combined with resistance training remains the most important factor for results.

3.3.1. Loading vs. Daily Dosing

A common method involves a short-term loading phase (20 g/day for 5–7 days) followed by a lower maintenance dose (3–5 g/day). However, studies show that loading is not essential. In older adults, Chami and Candow compared a loading protocol to constant daily dosing over eight weeks. Both groups experienced similar increases in lean mass (+1.3 kg) and strength (Chami & Candow, 2019). Likewise, Dos Santos et al. found that older women gained strength (SMD = 0.23) and LBM (SMD = 0.36) regardless of dosing style (Dos Santos et al., 2021). These findings support the use of steady daily doses without loading.

3.3.2. Timing Around Workouts

The timing of creatine consumption—before or after training—has also been studied. Forbes et al. found no significant differences in strength or hypertrophy between pre- and post-workout intake over six weeks (Forbes, Krentz, et al., 2021). In a year-long trial, Candow et al. observed similar improvements in muscle mass and bone strength, regardless of timing (Candow et al., 2019). A meta-analysis by Forbes et al. noted slightly better results with peri-exercise dosing (SMD = 0.40), but the difference was minimal (Forbes, Candow, et al., 2021). Overall, consistent daily use is more important than exact timing.

3.3.3. Different Forms of Creatine

Several forms of creatine are available, including creatine hydrochloride (HCl) and creatyl-L-leucine. However, creatine monohydrate remains the gold standard. Askow et al. demonstrated that only monohydrate significantly increased intramuscular creatine ($p < 0.001$), while creatyl-L-leucine did not (Askow et al., 2022). In another RCT, Eghbali et al. found similar improvements in leg press strength with both HCl (+21.4%) and monohydrate (+18.3%), compared to +10.6% in placebo. LBM gains were also similar, though HCl modestly increased testosterone ($p = 0.04$) (Eghbali et al., 2024). Given its effectiveness, safety, and affordability, monohydrate remains the preferred form.

3.3.4. With and Without Training

The role of resistance training is crucial. Desai et al. analyzed 72 trials comparing creatine with and without training. When used alone, creatine led to small increases in LBM (SMD = +0.14), while combining it with resistance exercise yielded much larger gains (SMD = +0.42) (Desai et al., 2025).

Burke et al. further showed that creatine produced the greatest hypertrophy in lower-body muscles, possibly due to higher loading and blood flow in the legs (Burke et al., 2023).

3.4. Combined Supplementation and Complex Protocols

While creatine on its own is effective, some studies have tested whether combining it with other supplements, like caffeine, protein, amino acids, or plant extracts, can make its effects stronger. These "multi-ingredient" protocols are popular in athletic settings, but it's important to know whether the added ingredients really help or not.

3.4.1. Creatine with Caffeine

There has been debate about whether caffeine weakens or improves creatine's effects. In a study by Pakulak et al., participants trained for eight weeks and were divided into four groups: creatine alone, caffeine alone, both together, and placebo. The group taking both creatine and caffeine had the best strength gains (+13.2%), followed by creatine alone (+10.2%), while placebo showed the smallest improvement (+7.5%, $p < 0.05$) (Pakulak et al., 2022). This study suggests that caffeine does not block creatine's effect, and the combination might even help, especially for strength training.

3.4.2. Creatine in Multi-Ingredient Blends

Wageh et al. tested a supplement that included creatine, leucine, protein, and vitamins. After 12 weeks of training, participants who took the supplement gained +2.2 kg of lean mass compared to +1.1 kg in the placebo group ($p < 0.05$), along with greater strength improvements (Wageh et al., 2021). Another study by Wilborn et al. compared whey protein alone vs. whey protein plus creatine in resistance-trained women. After eight weeks, the group receiving both gained more LBM ($p = 0.04$) and improved 1RM strength by +14.2% versus +8.9% in the protein-only group (Wilborn et al., 2016). Together, these results show that adding creatine to a base of protein or amino acids improves training outcomes.

3.4.3. Creatine with Novel Compounds

Some studies have added less common compounds to creatine. Semeredi et al. combined creatine with guanidinoacetic acid (GAA) and found that this blend increased muscle creatine content more than creatine alone ($p = 0.01$) and improved anaerobic power output ($p = 0.02$) (Semeredi et al., 2019). In a newer study, Roberts et al. tested a blend of creatine, sodium citrate, leucine, and blueberry extract. After eight weeks of training, the blend group had significantly better results in leg extension strength (+18.2% vs. +10.7%, $p = 0.03$), endurance, and muscle thickness ($p = 0.04$) (Roberts et al., 2025). Although the effects cannot be linked to creatine alone, these studies show that multi-ingredient formulas can be effective, especially if they include proven compounds like creatine, leucine, and quality protein.

3.5. Recovery, Sleep, and Quality of Life

Although creatine is mostly known for improving strength and muscle mass, some studies have looked at other effects — like how it influences recovery, sleep, inflammation, and overall well-being. These outcomes are especially important for older adults and athletes who train hard and need time to recover.

3.5.1. Recovery and Sleep

One area of growing interest is whether creatine can help the body recover faster after training. A study by Aguiar Bonfim Cruz et al. tested this in active women. After a short creatine loading phase (20 g/day for 7 days, then 5 g/day), participants slept an average of 36 minutes longer on training days compared to the placebo group ($p = 0.01$) (Aguiar Bonfim Cruz et al., 2024). This suggests that creatine may improve sleep quality and recovery after workouts. In a study by Amiri et al., older adults supplemented with creatine for 12 weeks while doing strength training. Compared to placebo, the creatine group not only improved muscle strength (+14.2% vs. +6.7%, $p < 0.05$), but also showed better antioxidant status and higher scores in physical quality of life (SF-36 scale) (Amiri & Sheikholeslami-Vatani, 2023). These results suggest that creatine can help older adults feel better physically, in addition to gaining strength.

3.5.2. Inflammation and Metabolic Markers

However, creatine may not affect all health markers. Oliveira et al. studied older adults and found that creatine had no significant impact on inflammation markers like CRP or insulin sensitivity compared to placebo ($p > 0.05$) (Oliveira et al., 2020). Interestingly, Semeredi et al. found that a combination of creatine and guanidinoacetic acid (GAA) increased creatine levels and performance but also raised homocysteine — a marker that may be linked to cardiovascular risk ($p = 0.01$) (Semeredi et al., 2019). This suggests that complex blends should be used with caution, especially in clinical populations.

3.6. Limitations and Non-Responders

Although most people benefit from creatine supplementation, some groups show weaker or no response. This may be due to health conditions, training status, or lack of muscle stimulation.

3.6.1. Clinical Populations

In specific medical situations, creatine appears to be less effective. Fairman et al. studied prostate cancer patients undergoing androgen deprivation therapy (ADT) and found no extra gains in strength or muscle mass from creatine compared to placebo ($p > 0.05$) (Fairman et al., 2025). Similarly, Diaz-Pizarro et al. found that women who had bariatric surgery lost less lean mass when using creatine (–0.8 kg vs. –1.2 kg), but the difference was not statistically significant ($p = 0.14$) (Diaz-Pizarro et al., 2024). In a 2-year study, Chilibeck et al. tested creatine in postmenopausal women for bone health. Despite good compliance, there were no significant improvements in bone mineral density or strength (P. D. Chilibeck et al., 2023). This suggests that very long-term use may not help without strong resistance training.

3.6.2. Special Cases and Inactivity

Roschel et al. used creatine in a complex supplement to improve function in frail older adults. While some gains were observed, the effect of creatine could not be isolated, limiting conclusions (Roschel et al., 2021). Finally, Backx et al. showed that creatine does not prevent muscle loss during leg immobilization. After 7 days without movement, both the creatine and placebo groups lost strength and mass equally (Backx et al., 2017).

4. Discussion

This review confirms that creatine supplementation, especially when combined with resistance training, is a highly effective strategy to enhance strength, lean body mass, and physical performance across various populations (Candow et al., 2013; Arazi et al., 2022; Forbes et al., 2021).

Gains in strength and hypertrophy were observed regardless of dosing method—whether through a loading phase or steady low-dose intake—suggesting that consistency matters more than specific timing strategies (Forbes et al., 2021; Candow et al., 2015). Likewise, pre- vs. post-exercise supplementation showed no significant difference in outcomes (Candow et al., 2013).

Creatine was particularly effective in younger and athletic individuals, promoting rapid improvements in strength and body composition (Arazi et al., 2022). In older adults, it led to moderate but meaningful improvements in muscle mass and functional outcomes (Amiri & Sheikholeslami-Vatani, 2023; Forbes et al., 2021). However, in clinical populations, such as post-bariatric women or individuals on androgen deprivation therapy, the effects were limited (Antonio et al., 2021; Gualano et al., 2021).

Among various forms, creatine monohydrate remains the gold standard, with superior evidence for increasing intramuscular creatine and improving performance (Kreider et al., 2022; Rawson et al., 2018). While some multi-ingredient blends show added benefits, creatine itself appears to be the primary active agent (Banerjee et al., 2021; Candow & Chilibeck, 2022).

5. Conclusions

Creatine supplementation has been shown to be safe and effective for improving muscle strength, lean body mass, and performance in both young and older adults. Across 49 scientific publications, creatine consistently enhanced training outcomes when used alongside resistance exercise. Daily use of creatine monohydrate — with or without a loading phase — is effective. Timing (before or after workouts) has little impact, and multi-ingredient blends may offer added benefits, though creatine remains the core active agent.

Older adults gain strength and function, while younger athletes may see faster, more noticeable improvements. However, creatine is not effective without training, and clinical groups (e.g. cancer or bariatric patients) may show limited response.

In practice, a low daily dose (3–5 g/day) of creatine monohydrate, combined with regular strength training, offers the best results across populations. Its versatility and strong evidence base make it one of the most reliable and.

Author Contributions:

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

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Conceptualization and methodology: Julia Kular, Oliwia Malec, Justyna Niebylecka, Izabella Michalska

Software: Natalia Glanc, Mateusz Myśliwiec, Dominik Sendecki, Maciej Karwat, Grzegorz Zalewski

Check: Justyna Niebylecka,

Formal analysis: Julia Kular, Oliwia Malec, Izabella Michalska, Mateusz Myśliwiec

Investigation: Justyna Niebylecka, Oliwia Malec, Maciej Karwat

Resources: Justyna Niebylecka, Natalia Glanc, Izabella Michalska, Mateusz Myśliwiec, Dominik Sendecki, Maciej Karwat

Writing-rough preparation: Julia Kular, Natalia Glanc, Grzegorz Zalewski

Writing-review and editing: Oliwia Malec, Izabella Michalska, Tytus Tyralik

Visualization: Natalia Glanc, Oliwia Malec, Dominik Sendecki, Grzegorz Zalewski, Tytus Tyralik

Supervision: Justyna Niebylecka, Julia Kular, Tytus Tyralik

Project administration: Natalia Glanc

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