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The Impact of Creatine Supplementation on Physical Function and Brain Health in the Aging Population: A Review Article

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ABSTRACT

Introduction. Rising global longevity is leading to a significant increase in the proportion of older adults worldwide. Inherent to this aging process are physiological and neurological declines, such as reduced muscle mass, diminished strength, and impaired cognitive functions. As a key driver of cellular energy production, creatine supplementation may represent a promising strategy to mitigate these deficits and preserve functional independence in older adults.

Aim of the study. The aim of this review is to synthesize current evidence on the effects of creatine supplementation on physical performance and cognitive function in older adults.

Materials and methods. A systematic review was executed across the PubMed and Google Scholar platforms. The following keywords were used: creatine, aging, geriatrics, sarcopenia, muscle strength, bone density, rehabilitation, cognitive function, memory, fall prevention, resistance training.

Results. Creatine supplementation improves both physical and mental health in older adults. It aids in the prevention of sarcopenia, the maintenance of muscle mass and strength, may positively influence bone health, and reduces the risk of falls. Additionally, it has a positive impact on cognitive functions, specifically improving memory and mental processing.

Conclusions. Creatine should be considered a key part of nutrition for the geriatric population to support healthy aging. Because it helps both the body and the brain, it is an important tool for improving quality of life. Future research should focus on determining the most effective doses for long-term health.

Keywords: creatine, aging, geriatrics, sarcopenia, muscle strength, bone density, rehabilitation, cognitive function, memory, fall prevention, resistance training

INTRODUCTION

Global life expectancy is increasing, resulting in most individuals worldwide reaching their sixties and beyond. Concurrently, every nation is observing a significant rise in both the overall number and the relative share of older citizens within its demographic structure.

The World Health Organisation (WHO) estimates that by 2030, one in every six of the world's population will be 60 years of age or older [1].

Aging is a continuous process marked by varied transformations across biological, functional, psychological, and social domains. These differences are modulated by genetic predispositions, susceptibility related to age, and unique capacities and reserves within the body's organs [2]. Consequently, this systemic biological degradation is clinically manifested as major geriatric syndromes, most notably sarcopenia [3], which leads to the frailty syndrome [4], and cognitive decline [5]. These pathological entities severely diminish functional autonomy and negatively impact the overall well-being of the aging population.

Therefore, in light of these challenges, assisting in the sustained maintenance of both cognitive and physical function, which underlies life quality for older individuals, must be recognized as an essential priority for public health policy and clinical practice in the forthcoming years. Attaining this goal requires a focus on complex therapeutic strategies, with an approach prioritizing physical activity [6, 7, 8] and optimized nutritional support [9, 10, 11] proving highly promising. In this context, creatine has emerged as one of the most widely studied nutritional supplements in recent years [11].

CREATINE

General information

Creatine is a naturally occurring non-protein organic amino acid, which is synthesized endogenously mainly in the kidneys, pancreas, and liver from arginine, glycine, and methionine. It can also be supplied exogenously through the consumption of fish, red meat, and via supplementation. Creatine is stored across a broad range of bodily tissues, including the three types of muscle (skeletal - approximately 95%, cardiac, and smooth), sperm, and the various components of the nervous system, such as the brain, eyes, and peripheral nerves. It is excreted from the body by the kidneys as creatinine [12,13].

Creatine's primary role is to facilitate the rapid production of energy in cells experiencing increased demand, which is achieved through the action of the phosphocreatine (PCr) / creatine kinase (CK) system. PCr is creatine to which a high-energy phosphate group has been attached upon reaching the target cell. CK is the enzyme that catalyzes the reversal of this reaction, instantaneously detaching the phosphate group from PCr and enabling its attachment to adenosine diphosphate (ADP). This process leads to the immediate resynthesis of adenosine triphosphate (ATP), thereby providing the cell with essential energy [11,12,14]. CK can also catalyze the attachment of a phosphate group to creatine, forming PCr. PCr, being a smaller and more mobile molecule than ATP, is transported more efficiently to sites within the cell with high energy demand (phosphorylcreatine energy shuttle system). Furthermore, creatine compounds are pleiotropic, influencing numerous cellular processes. They are involved in the modification of protein kinetics and the metabolism of both glycogen and calcium. Creatine additionally interacts with growth factors, such as Insulin-like Growth Factor-1 (IGF-1), and stimulates myogenic regulatory factors and satellite cells. Significantly, it possesses properties that modulate inflammation and reduce oxidative stress [15,16,17].

Creatine and physical function

Aging is accompanied by a progressive loss of muscle strength and mass, alongside a reduction in physical performance, a condition collectively known as sarcopenia. Sarcopenia affects approximately 10% of the population aged 60 and older. Its prevalence is also linked to the deterioration of the skeletal system (osteoporosis), an increased risk of falls, and overall higher mortality [18, 19]. Therefore, promoting gains in muscle strength and mass is crucial for maintaining better mobility in older adults. Creatine can be instrumental in achieving this goal. Furthermore, muscle creatine concentration declines with age, and because the natural dietary supply of creatine decreases in older individuals, often due to reduced consumption of red meat, creatine supplementation can prove to be a valuable aid [18, 20].

Creatine's therapeutic potential against the morphological and metabolic parameters of sarcopenia is mediated by several distinct mechanisms. One primary pathway involves increasing intramuscular PCr reserves, which accelerates ATP regeneration. This effect augments the muscle's adaptive response to training stimuli, by both enabling higher intensity exercise and enhancing post-exercise recovery. Another key mechanism is the positive influence on the differentiation and activity, and—when combined with resistance training—on the proliferation of satellite cells, which are crucial for muscle adaptation and regeneration. Furthermore, creatine supplementation increases glycogen storage capacity, stimulates mitochondrial oxidative phosphorylation (through elevating mitochondrial ADP concentration), and maintains force generation capacity by preventing calcium ion leakage from the sarcoplasmic reticulum. Overall, combining creatine supplementation with resistance training is shown to be an effective intervention to augment age-related muscle mass, strength, and functional physical performance [17, 21, 22, 23, 24].

In vitro studies have shown that creatine exerts beneficial effects on bone-forming cells (osteoblasts)—enhancing their metabolic activity, differentiation, and mineralization—and on bone-resorbing cells (osteoclasts) by reducing their activity, which results in decreased bone resorption [20,24,25]. However, results from studies on aging humans and animals involving creatine supplementation combined with resistance training and assessing bone mineral density

(BMD) remain equivocal [24,26]. Conversely, one study demonstrated a beneficial impact on the geometry of the proximal femur, which may have positive implications for preventing osteoporotic hip fractures [27]. It is also suggested that the increase in muscle strength and mass resulting from creatine supplementation and resistance training may lead to increased mechanical loading on the bone, thereby exerting a beneficial stimulating effect [23].

With advancing age, the risk of falls increases, leading to serious consequences for older adults and a significant deterioration in quality of life. It has been proven that greater muscle strength and mass improve balance and reduce this risk [28]. A recognized predictor of fall risk in the aging population is the sit-to-stand test. This assessment was utilized to compare older adults performing resistance training and supplementing with creatine against a placebo group. The results demonstrated significantly better performance in the intervention group compared to the control group, suggesting that creatine supplementation combined with training is effective in reducing the risk of falls [24].

In older adults, rehabilitation is often necessary due to coexisting comorbidities, and this process can be supported by creatine monohydrate supplementation. Its efficacy has been proven in enhancing physiotherapy outcomes—specifically by increasing muscle strength recovery and attenuating symptoms of delayed onset muscle soreness (DOMS). It has also been shown to potentially benefit the rehabilitation of individuals with arthritic diseases, spinal cord injury, chronic obstructive pulmonary disease (COPD), heart failure, and during periods of immobilization; however, these results remain equivocal due to the limited number of studies, and further research is needed to substantiate these findings [29,30].

Creatine and brain health

To keep up cellular processes - including neurotransmitter release and synapse function—the brain needs a large energy supply. Creatine is a critical molecule for cerebral energy metabolism, playing a key role in ATP resynthesis, especially during periods of high metabolic requirement (including sleep deprivation, mental health issues, or neurological impairment) [31]. In a fast, reversible process, CK converts PCr and ADP into creatine and ATP. This ATP production is quicker than the energy made by oxidative phosphorylation and glycolysis [32].

Similar to skeletal muscle, cerebral creatine stores are observed to decline with advancing age, potentially resulting in diminished brain activity and increased susceptibility to disease. Signs of cognitive impairment in older adults often include poor executive control (e.g., decision-making and working memory), attentional difficulties, and a slowing of response time. These deficits follow a continuum, extending from slight, subthreshold findings to advanced neurodegenerative conditions, and are consistently associated with a reduction in the quality of life and an increased risk of developing dementia, and consequently, mortality [20, 33].

Supplementation with creatine not only increases cerebral creatine stores and the PCr:ATP ratio but also provides antioxidant defense [34]. Although this increase is approximately half as pronounced as that seen in skeletal muscle [35], these bioenergetic and protective mechanisms offer a compelling rationale. Given that cognitive function - particularly memory recall - deteriorates with age and is a process highly dependent on ATP resynthesis, it was hypothesized that creatine supplementation in the older population would have a beneficial effect on cognitive abilities [34, 36].

Research has confirmed that supplementation aided cognitive performance in seniors, showing significant improvement in simpler memory tasks, such as forward number recall and all spatial recall. Crucially, the benefit was not observed in highly demanding executive tasks like random number generation or backward number recall, suggesting the effect is dependent on the level of cerebral resource recruitment [36]. A pioneering meta-analysis further supports this, demonstrating that creatine improves memory performance in healthy individuals, with the most pronounced effects observed in older adults aged 66–76 years. However, the results should be treated with caution due to the high variability between studies and a potential risk of bias [34]. Evidence also points to a threshold effect, where a daily creatine intake exceeding 0.95 g is associated with significantly higher cognitive test scores compared to lower-intake groups ($P < 0.05$) [37]. Similarly, a positive correlation exists between dietary creatine consumption and visuospatial short-term memory. Data indicate that individuals with a daily intake above the 0.382 g median perform significantly better in both forward and backward Corsi assessments compared to those with lower intake [38]. Furthermore, evidence from a 16-week pilot intervention suggests that daily creatine supplementation (5 g/day) combined with resistance training enhances cognitive performance. However, the small sample size and lack of isolated control groups make it difficult to determine the independent effects of creatine [39].

While most studies support the cognitive benefits of creatine, some evidence indicates that these effects may not be universal. For instance, research conducted on healthy older women (aged 60 to 80) found no significant improvements in cognitive or emotional parameters following supplementation. Furthermore, strength training alone improved emotional state and strength, with no additive effects from creatine [40].

CONCLUSIONS

Evidence synthesis indicates that creatine supplementation is an effective strategy for supporting healthy aging by simultaneously targeting physical and cognitive health. Regarding physical function, it contributes to the prevention of sarcopenia, the maintenance of muscle mass and strength, may favorably affect bone health, and reduces the risk of falls. It is worth noting, however, that in the majority of studies, the inclusion of resistance training was necessary to elicit positive physical health outcomes. Furthermore, creatine supplementation facilitates rehabilitative processes by accelerating functional recovery and mitigating the clinical symptoms of delayed onset muscle soreness (DOMS). Simultaneously, creatine significantly benefits brain health by enhancing cognitive performance. Research confirms its positive impact on memory, information recall, and overall mental processing.

Based on the evidence presented in this review, creatine warrants consideration as a clinically relevant component of geriatric nutritional strategies. Future studies should prioritize the identification of optimal dosing protocols to maximize the long-term benefits in the aging organism.

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While preparing this manuscript, the authors used the Gemini tool to enhance language quality and readability. After using this tool, the authors thoroughly reviewed and edited the text as necessary and accept full responsibility for the scientific content of the publication.

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