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THE EFFICACY OF CREATINE MONOHYDRATE IN REDUCING MENTAL FATIGUE AND IMPROVING MEMORY IN INTELLECTUAL WORKERS: A REVIEW

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ABSTRACT

Background: Modern knowledge work is associated with a high risk of accumulating cognitive fatigue and occupational burnout. The primary objective of this review was to systematize the current knowledge regarding the efficacy of creatine monohydrate in mitigating mental fatigue and enhancing cognitive function among intellectual workers.

Methods: A comprehensive review of the scientific literature was conducted using the PubMed, Google Scholar, and ScienceDirect databases. The final analysis included 22 key publications evaluating the impact of supplementation on brain bioenergetics under both optimal physiological conditions and severe stress.

Results: The analysis demonstrates that creatine effectively crosses the blood-brain barrier, significantly increasing the intracellular phosphocreatine pool. While cognitive benefits in healthy and well-rested individuals remain marginal, the full neuroprotective potential of this intervention becomes evident under conditions of energetic deficit (sleep deprivation, hypoxia, extreme mental exertion), where it substantially reduces fatigue. Furthermore, unlike classic stimulants such as caffeine, creatine sustains psychomotor performance without triggering a rapid cortisol spike.

Conclusion: Creatine monohydrate represents a highly safe and effective strategy for preventing nervous system exhaustion. However, to maximize its cognitive benefits, it is imperative to develop standardized dosing protocols specifically tailored to the distinct uptake dynamics of creatine in neural tissue.

KEYWORDS

Creatine Monohydrate, Mental Fatigue, Cognitive Functions, Working Memory, Knowledge Workers, Biohacking

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1. Introduction

The modern model of intellectual work forces us to operate at maximum capacity. Sensory overload, the constant need for divided attention, and working under time pressure mean that the employee's nervous system is perpetually burdened. A direct consequence of this phenomenon is an epidemic of mental fatigue and occupational burnout. To prevent these issues, the scientific community is increasingly exploring innovative methods of performance optimization. Amidst this search, the "biohacking" trend has emerged, focusing on targeted brain support through proven, safe nutrients to maintain concentration and mental clarity even under the most demanding conditions.

Until recently, creatine monohydrate existed in the public consciousness almost exclusively as an athletic supplement used to enhance physical performance. However, contemporary scientific research has significantly revised this perspective. Today, there is growing discourse regarding the application of creatine far beyond the gym, highlighting its tangible impact on brain energetics as well as its support for memory and concentration [1,2]. Recent analyses clearly demonstrate that it is a safe and effective way to improve nervous system function, providing benefits even for those who are not athletes [3].

Because the brain consumes massive amounts of energy, it is exceptionally sensitive to overload and stress. Research shows, however, that appropriate supplementation can mitigate these effects. Landmark analyses have proven that creatine monohydrate favorably influences mental performance in healthy individuals who do not train competitively on a daily basis [4]. Furthermore, the latest studies provide strong evidence that this supplementation effectively improves working memory [5] and exhibits neuroprotective properties, significantly reducing the perception of mental fatigue [6].

Given the increasing cognitive demands placed on workers in the information age, it is reasonable to shift the focus of creatine research from sports laboratories to corporate and educational settings. The primary objective of this review is to systematize current knowledge regarding the efficacy of creatine monohydrate in reducing mental fatigue and improving memory among intellectual workers. This paper discusses the physiological mechanisms of creatine action in the brain, its effectiveness under conditions of acute stress and sleep deprivation, and the influence of dietary habits on supplementation outcomes in the knowledge-worker population.

2. Methodology

Information Sources

To ensure the literature review was reliable and objective, it was based on a structured search and selection plan. Materials for analysis were collected by searching established scientific and medical databases—primarily PubMed, Google Scholar, and ScienceDirect.

Search Strategies

To identify the most relevant publications, combinations of specific keywords and Boolean operators (AND/OR) were utilized. Search engines were filtered using terms such as: "creatine supplementation," "mental fatigue," "cognitive function," "working memory," "brain energetics," and "sleep deprivation." Additionally, to capture the influence of daily diet on the supplement's effects, the word "creatine" was combined with the terms "vegetarians" or "plant-based diet."

Inclusion and Exclusion Criteria

The scientific literature on creatine is extensive; therefore, it was necessary to adopt strict selection criteria. The review qualified studies involving healthy adults—particularly those exposed to specific stressors, such as time pressure or sleep deprivation.

To provide a comprehensive overview, the bibliography includes both recent meta-analyses published after 2015 and classic, pioneering experiments from 1999–2010, which form the foundation of current knowledge regarding brain bioenergetics.

Articles were required to assess the impact of creatine on specific cognitive functions, including working memory, reaction time, and fluid intelligence, or to measure levels of neural oxygenation and fatigue. Conversely, articles were excluded if their sole end point was the assessment of muscle mass gain, physical strength in elite athletes, or performance in strength sports, as these did not align with the primary research objective of this paper. Studies focusing exclusively on severe neurological pathologies were also rejected to maintain the context of functioning within standard professional and educational environments.

Data Selection

As a result of this selection process, 22 key publications were identified. These were ultimately categorized into specific thematic areas, allowing for a logical narrative structure in the subsequent chapters of the work.

3. Results

3.1. Mechanism of Creatine Action in Neural Tissue

To understand why a supplement known for increasing muscle strength works so effectively in intellectual work, we must examine brain bioenergetics. Although the human brain accounts for only about 2% of total body mass, it is responsible for approximately 20% of the body's total energy consumption. The primary carrier of this energy is the ATP molecule. During intense mental effort, such as solving complex analytical problems, ATP resources in neural cells begin to drop rapidly.

In this context, creatine plays a critical role as it is converted into phosphocreatine within neural tissue, serving as the brain's primary energy buffer. This compound donates its phosphate group to rebuild ATP molecules, allowing neurons to function without interruption. Using modern imaging techniques, such as magnetic resonance spectroscopy, researchers have provided conclusive evidence that orally ingested creatine effectively crosses the blood-brain barrier [7].

Imaging results clearly indicate that creatine supplementation leads to a significant increase in the pool of high-energy phosphates within neural tissue [8,9]. Consequently, supplementation provides the brain with a more stable energy reserve, protecting the nervous system from rapid exhaustion during intensive mental work.

3.2. Impact on Working Memory and Fluid Intelligence

Increased energy availability in the brain translates into tangible, measurable cognitive benefits that can be utilized by software developers, financial analysts, and students alike. This is particularly evident in the area of working memory, which is responsible for holding and processing information over short periods.

In a landmark double-blind study, six weeks of supplementation significantly improved participants' scores in digit span tests. A marked increase was also observed in tests of fluid intelligence (Raven's Advanced

Progressive Matrices), which reflects the mind's ability to solve entirely new, unfamiliar problems [10]. However, one must maintain scientific objectivity, as more recent publications suggest a need to verify these highly optimistic assumptions. Modern, rigorous analyses show that in very young, well-rested individuals who are not under mental stress, the effect of creatine supplementation may be negligible or even unnoticeable [11]. For instance, recent clinical trials demonstrated that this intervention brought no significant improvement in fluid intelligence tests or additional cognitive tasks, and its impact on operational memory was only borderline statistically significant [12]. Creatine does not act like a classic stimulant; rather, it functions as a protective shield that activates its true potential only when the brain begins to experience an energy deficit.

3.3. Reduction of Mental Fatigue Under Stressful Conditions

The true potential of this supplementation is revealed in crisis situations, such as chronic stress, working under time pressure, or sleep deprivation. Contemporary corporate environments and project-based work necessitate maintaining maximum cognitive performance, which inevitably leads to the rapid accumulation of mental fatigue.

The direct impact of creatine on reducing this type of fatigue has been documented in studies utilizing mathematical tests. It was shown that supplementation not only decreased participants' subjective sense of mental exhaustion but also translated into a measurable improvement in the oxygenation of the brain's frontal cortex [13]. Particular attention should be paid to analyses regarding sleep deficiency, which is a growing challenge in developed populations. It was found that individuals functioning under sleep deprivation who took creatine achieved better results in demanding psychomotor tests. Furthermore, they exhibited limited secretion of stress hormones, such as cortisol [14]. Similar protective effects on cognitive abilities were observed under conditions of severe physiological stress, such as hypoxia [15]. Animal model studies suggest a mechanism where increased creatine resources reduce the amount of sleep necessary to restore homeostasis in brain tissue [16]. Notably, comparative studies have shown that creatine sustains psychomotor performance under sleep deprivation as effectively as caffeine [17].

3.4. Diet and Supplementation Efficacy

In reviewing the literature, it is difficult to overlook a key factor influencing biohacking success: the daily diet. The natural sources of creatine are primarily meat and fish. However, plant-based diets are gaining popularity in modern office environments. Consequently, researchers have begun to analyze whether dietary habits influence how strongly the brain responds to creatine supplementation.

Answers to this question come from studies comparing the impact of both diet and creatine supplementation on various body tissues. Analysis of available research clearly shows that the influence of diet and supplementation varies by tissue type. On one hand, it has been demonstrated that despite significantly lower dietary intake of creatine, vegetarians do not differ from omnivores regarding brain creatine concentrations. This suggests that under physiological conditions, the central nervous system relies primarily on its own endogenous synthesis of this compound. On the other hand, creatine supplementation in vegetarians leads to a marked increase in muscle creatine levels and improved exercise and cognitive parameters, yet without a significant impact on brain phosphocreatine levels. This indicates tissue-specific regulation of creatine metabolism, where muscles remain more susceptible to changes in exogenous supply, while the brain maintains relatively stable concentrations regardless of diet or supplementation [18,19].

4. Discussion

A review of the available literature reveals a conflicting picture of the impact of creatine supplementation on cognitive functions. On one hand, it has been proven that in young, well-rested, and stress-free individuals, this intervention does not bring significant improvement in fluid intelligence or working memory tests [11,12]. On the other hand, clear cognitive benefits are observed in subjects subjected to severe stressors, such as sleep deprivation, hypoxia, or extreme intellectual exertion [14,15]. This demonstrates that creatine should not be viewed as a general stimulant. Rather, it serves as an intracellular energy buffer that reveals its true potential only in pathological and paraphysiological states [2]. Such a perspective also explains why earlier, less controlled experiments so often provided divergent results.

This protective effect of creatine in crisis situations stems directly from the metabolic processes of neural tissue. Under conditions of extreme load, such as oxygen deficiency or chronic sleep deprivation, natural ATP production undergoes a rapid collapse. This results in a decrease in the membrane potential of neurons and a marked deterioration in the performance of the prefrontal cortex [15]. However, increased phosphocreatine reserves in the brain allow for rapid, anaerobic ATP resynthesis, which effectively protects the nervous system and maintains energy homeostasis. Furthermore, as shown by preclinical studies on animal models, optimizing this pathway reduces homeostatic sleep pressure and limits the accumulation of extracellular adenosine, which directly translates into a lower sleep requirement and delayed symptoms of accumulating fatigue [16].

An exceptionally promising aspect observed in the literature is the safety profile of creatine concerning the endocrine system. Comparative studies show that under sleep deprivation, creatine maintains psychomotor performance and executive functions with an efficacy similar to caffeine [17]. However, a significant difference lies in the response of the hypothalamus-pituitary-adrenal (HPA) axis. While high doses of caffeine provoke a significant release of cortisol [17], the creatine intervention does not generate additional biochemical stress load and, according to some reports, may even mitigate the cortisol response to sleep loss [14]. This makes it a potentially safer stimulatory alternative, especially under conditions of chronic professional tension.

When evaluating the effectiveness of supplementation in crisis conditions, the weaknesses of previous studies must be taken into account. One of these is the influence of the participants' daily diet. We already know that the brain can protect itself against a drastic drop in creatine levels through its own endogenous synthesis. However, this makes the mechanism of its uptake from exogenous supplements much more difficult and complex in neural tissue than in skeletal muscle [18, 19]. A significant obstacle in formulating firm recommendations is also the lack of consistent dosing guidelines. Currently, there is no single "gold standard" defining the required dosages or the duration of the loading phase necessary to optimally support brain function. This necessitates further, standardized clinical trials.

Safety Profile and Regenerative Potential

When proposing the use of creatine in intellectual work, we must be absolutely certain of its systemic safety. Although groundless concerns regarding the alleged negative impact of this substance on kidney and liver function or hair loss still circulate in the public sphere, modern clinical data unequivocally debunk these myths [20]. According to the official position of the International Society of Sports Nutrition (ISSN), formulated based on hundreds of clinical trials, properly dosed creatine does not burden internal organs and remains completely safe even with long-term use [21]. In the context of brain function, it should also be emphasized that this supplement is not merely a tool for rapid fatigue relief. It supports broad, long-term regeneration of the nervous system in response to increasing environmental demands [22]. Thanks to such a high safety standard, creatine represents a promising element in the prevention of occupational burnout.

5. Conclusion

Based on the review of the current scientific literature, the following conclusions have been formulated:

- Targeted Cognitive Support: Creatine monohydrate is a safe, well-researched, and effective method for supporting brain bioenergetics, useful not only in sports but also in intellectual work and educational environments.
- Context-Dependent Efficacy: In well-rested, young, and stress-free individuals, the effects of supplementation on cognitive functions are negligible. The true neuroprotective potential of creatine emerges under conditions of energy deficit, significantly reducing mental fatigue during sleep deprivation, hypoxia, and time pressure.
- Alternative to Classic Stimulants: Creatine effectively sustains psychomotor abilities without activating the stress axis. Unlike caffeine, it does not cause a rapid cortisol spike, making it a more favorable alternative for managing chronic occupational load.
- Need for Dosing Optimization: Because the brain efficiently regulates its own creatine levels and is shielded by the blood-brain barrier, the uptake mechanism of this supplement in neural tissue differs from the processes occurring in muscles. To fully harness creatine's cognitive potential, new, precise dosing regimens must be developed, specifically designed for brain energetics rather than just physical performance.
- High Safety Profile: Creatine monohydrate is a substance with documented and rigorously verified clinical safety. Long-term supplementation in healthy individuals does not burden the kidneys or liver. This, combined with its proven neuroprotective potential, allows for its safe, daily use as an element of burnout prevention and nervous system regeneration support.

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