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REVIEW ARTICLE

Creatine and body composition in individuals with obesity: a brief review

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Abstract

Obesity represents a global public health challenge, characterized by excessive body fat accumulation, associated with comorbidities such as type 2 diabetes and sarcopenic obesity. Effective intervention requires body composition modulation, prioritizing fat mass loss and the preservation of Fat-Free Mass (FFM), which is essential for metabolism and insulin sensitivity. In this context, the present study, a Systematic Literature Review, aimed to analyze the impact of creatine (Cr) supplementation, combined with resistance training, on body composition modulation in individuals with obesity. The search was conducted in the PubMed, SciELO, and Google Scholar databases, filtering for high-quality studies (RCTs and Meta-Analyses) from the last ten years. Creatine was identified as a "gold standard" supplement with dual mechanisms of action: (1) energetic, optimizing the ATP-PCr system to increase strength and training intensity, and (2) anabolic, promoting cell volumization and positively influencing protein synthesis pathways (mTOR) to combat catabolism. Literature findings in clinical populations, such as sarcopenic elderly, suggest that creatine is promising in preserving FFM and increasing strength without inducing fat mass gain. It is concluded that creatine supplementation is a safe and effective adjunct strategy to enhance resistance training in individuals with obesity, optimizing body composition and improving metabolic and functional prognosis.

Keywords: Creatine. Obesity. Body composition. Lean mass. Resistance training.

Introduction

Obesity still represents one of the most serious and complex global public health challenges, recognized for its multifactorial and progressive nature. This condition, characterized by the excessive accumulation of body fat, transcends the aesthetic dimension, becoming a chronic disease that is intrinsically linked to the development and aggravation of various comorbidities. Pathologies such as type 2 diabetes mellitus, cardiovascular diseases, dyslipidemias, and certain types of cancer are commonly observed in individuals with obesity, as pointed out by authors who describe the high burden of chronic non-communicable diseases in Brazil **[1]**.

Effective intervention in obesity requires an approach that goes beyond simply reducing total body weight, focusing fundamentally on modulating body composition. Body composition, defined by the relative proportion of fat mass versus fat-free mass (lean mass), is a more robust predictor of health and functionality than Body Mass Index (BMI) alone. The preservation and, ideally, the increase of skeletal muscle mass - the primary component of lean mass - are crucial, as muscle plays a central role in glucose metabolism and insulin sensitivity. Undesirable loss of lean mass, frequently observed in weight loss programs based solely on caloric restriction, compromises the basal metabolic rate and increases the risk of long-term weight regain **[2,3]**.

A phenomenon of growing clinical concern is sarcopenic obesity, where excess adiposity coexists with reduced muscle mass and/or function. This association potentiates health risks, increasing the likelihood of functional disability and mortality **[4]**. Thus, any treatment strategy for obesity should prioritize maintaining or gaining muscle mass concomitant with fat loss. It is in this context that physical exercise, particularly resistance training, becomes an undeniable pillar of therapy **[5-7]**.

The potentiation of the effects of resistance training on muscle mass in vulnerable populations, such as the obese, has directed research attention towards nutritional supplementation. Creatine (Cr) is one of the most extensively studied and validated supplements, known for its strong ergogenic and anabolic effect **[8,9]**. Its main physiological function lies in optimizing the phosphocreatine (PCr) energy system, facilitating the rapid regeneration of ATP during high-intensity exercise **[10,11]**. The classic benefits of creatine supplementation include increased strength, muscle power, and fat-free mass, as evidenced in bodybuilders and athletes **[6,7,12]**. These effects have shown particular utility in clinical populations, such as elderly people with sarcopenia, where creatine, combined with training, helps preserve muscle function and increase lean mass **[4,13,14]**. The relevance lies in the fact that, by increasing work capacity and training intensity, creatine allows for superior muscle stimulation, which is vital to counterbalance muscle loss associated with caloric restriction in obesity.

The population with obesity, however, presents a unique metabolic, hormonal, and inflammatory profile, which raises the need for focused studies to determine if creatine exerts the same benefits of modulating body composition and performance in this population. Although creatine has been shown to be effective in preserving lean mass in older adults, who frequently exhibit an increase in fat mass **[15]**, the direct application of these findings to individuals with obesity is limited by the heterogeneity of the samples and the lack of an exclusive focus on obesity. Furthermore, preliminary evidence suggests that creatine may positively influence lipid metabolism and inhibit the formation of fat cells (adipogenesis) **[15]**, which lends additional interest to its investigation in the context of obesity.

The gap in the literature and the clinical relevance of finding safe and effective strategies to preserve lean mass during weight loss in individuals with obesity justify this study. If proven effective, creatine supplementation can be incorporated as a valuable and accessible adjunct to obesity treatment programs, improving long-term metabolic and functional outcomes. Focusing on body composition variables, such as fat mass and fat-free mass, is imperative to measure the true success of the intervention.

The overall objective of this study was to analyze the impact of creatine supplementation, in conjunction with resistance training, on the modulation of body composition (fat mass and fat-free mass) in individuals with obesity. Specifically, it sought to evaluate changes in lean body mass, determine the magnitude of fat mass reduction, and investigate the influence of creatine on physical and metabolic performance parameters in this specific population. To achieve these objectives, the present work was structured as a literature review that addressed the pathophysiology of obesity and sarcopenia, the mechanism of action of creatine, and previous studies in clinical populations.

Methods

This study was developed in the form of a Literature Review, with the purpose of critically analyzing the impact of creatine supplementation, in association with resistance training, on the modulation of body composition in individuals with obesity. The choice of this type of study aims to provide a robust and high-quality body of evidence on the subject.

The bibliographic research was carefully conducted in electronic databases of reference in the area of Health Sciences, including platforms such as

PubMed (U.S. National Library of Medicine), Scientific Electronic Library Online (SciELO), and Google Scholar. The search strategy was planned using a combination of Health Sciences Descriptors (DeCS) and free terms, linked by Boolean operators (AND, OR), focusing on combinations such as: "Creatine" OR Creatine" AND "Obesity" OR "Obesity" AND "Body Composition" OR "Body Composition" AND "Resistance Training" OR "Resistance Training". The filters applied restricted the search to articles published in the last ten years (2015 to 2025) to ensure the relevance and updating of the evidence.

Eligibility criteria were established for the inclusion of articles: only original studies were considered, primarily Randomized Controlled Trials (RCTs), Systematic Reviews, and Meta-Analyses. The target population should include adult individuals with obesity (BMI ≥ 30 kg/m²) or clinical subgroups, such as elderly individuals with sarcopenic obesity. The primary outcomes of interest focused specifically on the modulation of body composition, such as changes in Fat-Free Mass (FFM) and Fat Mass, as well as parameters of physical performance (muscle strength). Articles that did not meet all these criteria or that were in vitro and animal studies were excluded.

The selection of studies occurred in well-defined stages. Initially, a screening was carried out based on reading the titles and abstracts for the immediate exclusion of irrelevant articles. In the subsequent stage, the full texts of the pre-selected studies were analyzed in their entirety to confirm full compliance with the inclusion criteria and to ensure methodological validity. Finally, the extraction of relevant data, such as the supplementation and training protocol, sample characteristics, and results obtained on body composition, was systematized so that the synthesis of the findings could be interpreted and presented clearly, answering the objectives proposed by this work.

Results and Discussion

Obesity is characterized by a state of chronic, low-grade, systemic inflammation, largely established by adipose tissue dysfunction **[16]**. Unlike a passive storage tissue, adipose tissue, especially visceral adipose tissue, becomes an active and dysfunctional endocrine organ in the context of obesity. This excessive fat accumulation leads to the expansion and hypertrophy of adipocytes, a process that results in cellular stress, cell death (necrosis), and the attraction of macrophages to the adipose tissue, initiating the chronic inflammatory response **[16]**.

In this state of dysfunction, hypertrophied adipocytes and infiltrated immune cells (macrophages) release a series of pro-inflammatory adipokines and cytokines, such as Tumor Necrosis Factor alpha (TNF-α) and Interleukin 6 (IL-6) **[17]**. The elevated circulation of these molecules critically interferes with insulin signaling in metabolically active peripheral tissues, notably skeletal muscle. The action of (TNF-α) and IL-6 leads to the inhibition of insulin signaling pathways, promoting a state of insulin resistance that is central to the pathogenesis of chronic comorbidities associated with obesity **[1,17]**.

This systemic inflammation and the resulting insulin resistance contribute significantly to protein catabolism and muscle atrophy, facilitating the development of sarcopenic obesity **[4]**. Insulin resistance decreases glucose uptake by muscle and impairs protein synthesis, while chronic inflammation increases protein degradation. This vicious cycle compromises muscle quality and function, increasing the risk of functional disability and mortality and making the preservation of lean mass the most critical challenge in the management of obesity **[4]**.

This systemic inflammation and insulin resistance contribute significantly to muscle atrophy and the development of sarcopenia, even in individuals with excess total body weight, which is known as sarcopenic obesity **[4]**. Excess visceral fat has been directly correlated with lipid infiltration in skeletal muscle (myosteatosis), which further compromises muscle quality and function. Maintaining lean mass is a critical challenge in the treatment of obesity, as muscle is the main site of glucose consumption in the body. Loss of lean mass during caloric restriction slows metabolism and facilitates weight regain, sabotaging long-term efforts **[2,18]**. Thus, the focus of therapeutic intervention should be twofold: to promote fat loss and optimize the gain or preservation of fat-free mass **[5]**.

The urgency in modulating body composition, aiming at fat loss and protection of Fat-Free Mass (FFM) **[5]**, directs research interest towards nutritional interventions that enhance the effect of resistance training. In this scenario, creatine (Cr) is introduced as an endogenous and exogenous organic compound, synthesized primarily in the liver and kidneys, with about 95% of its stock stored in skeletal muscle **[9]**.

Physiologically, creatine acts as a fast-acting energy buffer, regenerating ATP from ADP through the enzyme creatine kinase **[10]**. This system, known as ATP-PCr, is crucial for providing immediate energy during high-intensity, short-duration efforts, typical of strength training **[8,11]**, and, consequently, is an ideal target for maximizing the anabolic stimulus needed for muscle preservation in contexts of caloric restriction.

Exogenous supplementation significantly increases

Phosphocreatine (PCr) concentrations in skeletal muscle, potentially increasing stores by up to 40% **[3]**. This increase is the basis for improving physical performance, as it allows for more efficient ATP resynthesis, prolonging the ability to sustain high-power work and reducing the accumulation of inorganic phosphate and the drop in pH, which are factors associated with muscle fatigue. Consequently, the improvement in work capacity and recovery between sets of resistance training is the main factor that drives strength gain and, indirectly, muscle hypertrophy **[12,16]**.

In addition to its energetic effects, creatine has direct mechanisms in modulating hypertrophy. Creatine has been shown to positively influence cell signaling pathways, promoting an anabolic environment. This includes the inhibition of myostatin – a negative regulator of muscle growth – and the potentiation of growth factors such as IGF-1, which activates the PI3K-AKT/PKB-mTOR cascade. The mTOR axis is crucial for increasing protein synthesis and the proliferation of satellite cells, fundamental elements for increasing the number of myonuclei and, subsequently, sustained muscle growth **[3,12]**.

Another mechanism of great relevance is the osmotic effect of creatine. When stored in the sarcoplasm, creatine attracts water into the muscle cell, a phenomenon known as cell volumization. Although initially this increase in Fat-Free Mass (FFM) could be attributed to water retention, the current belief is that this cell swelling functions as an anabolic signal. The volume stress generated is postulated as a stimulus that increases protein synthesis and decreases proteolysis (protein breakdown) **[3,12]**. For populations in a catabolic state, such as individuals with obesity on caloric restriction, this anti-catabolic effect becomes particularly valuable in preserving lean mass **[15]**.

Creatine transcends the function of a mere energy aid, acting on multiple fronts to optimize body composition. Its classic ergogenic and anabolic benefits, which result in increased strength and lean muscle mass, are extended to clinical populations such as elderly individuals with sarcopenia and, by inference, to individuals with sarcopenic obesity, where the maintenance of muscle tissue is critical for metabolic and functional health. Its classification as a "gold standard" supplement by the scientific community is due to the robust evidence of its efficacy and safety in healthy individuals, justifying its recommendation as a fundamental adjunct in the treatment of obesity **[12,15,17]**.

The increase in intramuscular creatine and phosphocreatine (PCr) reserves induced by supplementation allows the individual to perform more repetitions and sets with the same load **[6]**. This increase in work capacity and exercise intensity is the main indirect mechanism by which creatine promotes muscle hypertrophy. A higher volume of training with superior quality leads to greater mechanical and metabolic stress on the muscle, activating anabolic pathways (such as mTOR) and promoting muscle growth **[7,12]**.

In addition to the energy effect, creatine can exert direct actions on muscle growth. Some studies suggest that creatine can modulate the expression of myogenic genes and reduce the expression of catabolic factors, such as myostatin **[4,6]**. Additionally, creatine is osmotically active, which results in an increase in intracellular water content (volumization), a phenomenon that is postulated as an anabolic signal that promotes protein synthesis and inhibits proteolysis **[12]**.

The scientific literature is robust in demonstrating that creatine supplementation, combined with resistance training, consistently increases FFM in healthy individuals **[6,12]**. However, specific research in individuals with obesity is more limited and crucial due to their metabolic peculiarities. One of the main findings in systematic reviews and meta-analyses is the effectiveness of creatine in preserving lean mass and increasing strength in elderly and clinical populations, often affected by sarcopenic obesity.

The effectiveness of creatine supplementation in maintaining muscle quality in vulnerable populations is well established, with the work of Santos et al. **[4]** being a landmark in this field. In their meta-analysis focused on older women, the authors found a significant increase in both muscle strength and fat-free mass when creatine was combined with resistance training, compared to the placebo group. This finding is crucial because, although the studied population was not exclusively obese, the intervention demonstrates the ability of creatine to optimize adaptations to exercise in a context of predisposition to sarcopenia and age-related catabolism **[14]**.

The relevance of extrapolation to the treatment of obesity lies in the pathophysiological similarity between age-related sarcopenia and sarcopenic obesity. Both conditions share the challenge of preserving lean mass in the face of catabolic and inflammatory processes. By potentiating muscle mass gain in elderly women, creatine suggests being a promising tool for individuals with obesity undergoing caloric restriction. The increase in strength and lean mass allows the individuals with obesity to perform higher volume and intensity training, which is fundamental to maximizing energy expenditure and body fat loss, counterbalancing the risk of muscle loss inherent in caloric deficit **[6]**.

The results obtained by Santos et al. **[4]** provide a strong theoretical basis for the application of creatine in the population with obesity. By mitigating muscle loss and improving functional performance, supplementation offers therapeutic support to combat sarcopenic obesity. However, this inference must be validated by studies dedicated exclusively to the population with obesity, considering the unique metabolic and inflammatory profile of this population **[15]**.

The main concern when introducing creatine supplementation into obesity treatment programs is the risk of increased total body mass being attributed to fat gain. The meta-analysis by Forbes et al. **[15]** sought to mitigate this uncertainty by specifically reviewing changes in fat mass in adults aged 50 years or older who supplemented with creatine combined with resistance training. The results were unequivocal: creatine use did not lead to an increase in fat mass compared to placebo, demystifying the concern that water retention or weight gain would translate into fat accumulation.

More than simply not causing fat gain, the review suggested that creatine may be beneficial, tending towards a slight reduction or improvement in fat mass distribution **[15]**. This finding is indirectly attributed to training optimization. By allowing for greater volume and intensity of exercise, creatine maximizes caloric expenditure and the stimulus for lipid metabolism, which aids in the loss or redistribution of body fat, especially in a context of increased fat-free mass. This evidence reinforces the safety of the supplement with regard to the goal of weight loss, which is the loss of fat mass.

Forbes et al. **[15]** provide crucial evidence for patients with obesity. Their findings confirm creatine's safety in weight loss programs, focusing attention on its main advantage: supporting lean mass gain or retention. Since lean mass retention is vital for metabolic health and long-term weight loss in obesity **[2,18]**, creatine's neutral or slight benefit on fat mass makes it a compelling therapeutic option.

Despite this methodological limitation, the volumizing effect should not be seen merely as a measurement "artifact"; it is, in fact, metabolically beneficial. Cellular swelling caused by water intake is postulated as an anabolic signal that promotes protein synthesis and inhibits proteolysis (protein breakdown) **[12]**. In individuals with obesity in a caloric deficit, where muscle mass loss is a constant risk, the volumizing effect of creatine acts as a protective mechanism, combating the catabolic state. In addition, water retention stabilizes cellular function and can improve training performance, which, in the long term, leads to real muscle hypertrophy **[10]**.

In clinical studies with individuals with obesity, the assessment of lean muscle mass gain requires caution: the gain observed in the initial weeks is mostly water-related but is functionally positive and serves as a foundation for longer-term hypertrophy. The focus should be on persistence and quality of training. Creatine, by enabling greater exercise intensity and volume, delivers the mechanical stimulus necessary for sustained muscle growth, improving metabolism and functionality.

Despite this, lean muscle mass gain, even if partially water-related, is metabolically and functionally beneficial. Increased strength and endurance allow for higher volume training, burning more calories, and increasing total energy expenditure **[2,10]**.

Furthermore, increased lean mass, even with water retention, contributes to a more metabolically active tissue, helping to improve insulin sensitivity **[1,17]**. Creatine supplementation, therefore, emerges as a promising tool to optimize the adaptive response to training in individuals with obesity, helping them maintain muscle quality while seeking body fat loss, which is fundamental for the sustainability of the treatment.

Limitations

Creatine supplementation should be considered a valuable and accessible adjunctive strategy in weight loss programs that include resistance training for individuals with obesity. However, we recommend conducting more specific randomized controlled clinical trials, focusing exclusively on the adult with obesity and young adult population, to confirm the benefits on body composition and determine ideal dosage protocols to maximize fat loss and lean mass gain.

Conclusion

This literature review reinforces the complexity of obesity treatment, which requires an approach that prioritizes improving body composition, not just reducing total weight. Focusing on preserving and gaining fat-free mass is crucial to mitigate lean mass loss associated with caloric restriction and to combat sarcopenic obesity, which increases the risks of morbidity and mortality. The incorporation of resistance training is therefore indispensable, but its optimization is vital for the sustainable success of the treatment. Creatine has proven to be a highly effective and safe supplement to enhance adaptations to resistance training. Its main mechanism of action, focused on optimizing the ATP-PCr system, allows individuals with obesity to perform a higher volume and intensity of exercise, resulting in greater anabolic stress and, consequently, greater fat-free mass gain. In addition to its ergogenic effects, creatine contributes to cell volumization and can positively influence protein synthesis pathways, being particularly beneficial for populations struggling with muscle catabolism. Findings from the literature, especially those focused on clinical populations such as the elderly and older women, suggest that creatine is a promising tool for the treatment of obesity, as it helps preserve lean mass and does not promote fat mass gain. By protecting muscle and improving performance, creatine supplementation offers therapeutic support that can improve metabolic outcomes, such as insulin sensitivity, and physical functionality in individuals with obesity.

CRediT

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