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Review Article

The Impact of Resistance Training, Whey Protein, and Creatine Supplementation on Diabetes-Induced Sarcopenia

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Abstract
Diabetes mellitus is a global disorder affecting blood glucose regulation, with a steadily increasing prevalence. Predominantly, type 2 diabetes accounts for the majority of cases, and if left undiagnosed or inadequately managed, it may lead to several complications, including sarcopenia, kidney failure, visual impairment, and cardiovascular diseases. In patients with diabetes-induced sarcopenia, the simultaneous reduction in muscle mass and strength further complicates glycemic management. This systematic review explored the impact of resistance training and the supplementation of whey protein and creatine on muscle strength, muscle mass, and glycemic indices in these individuals. A thorough search of English-language articles in Google Scholar and PubMed was conducted using relevant keywords. The evidence indicated that resistance training enhances muscle strength and mass while improving glycemic control, as observed in reductions in hemoglobin *A1c* levels. Similarly, whey protein and creatine supplementation were associated with beneficial effects on postprandial glycemia and the preservation of muscle integrity. Overall, these interventions, when applied following appropriate guidelines, offer promising strategies for the prevention and management of both diabetes and sarcopenia.
Keywords: Diabetes, Sarcopenia, Resistance training, Whey protein, Creatine

Introduction
Diabetes mellitus is a chronic disorder characterized by significant disturbances in the regulation of blood glucose levels.[1] The International Diabetes Federation (2019) reported that approximately 463 million individuals are affected by this condition worldwide. Projections suggest that this number will rise to 578 million by 2030 and reach 700 million by 2045. Global statistics further reveal that the prevalence of diabetes has nearly tripled over the past two decades.[2] With this rapid increase, the economic burden associated with the prevention and management of diabetes has escalated on a global scale.[3] Currently, about 11% of the adult population is globally diagnosed with diabetes, and in the United States, the prevalence reaches up to 25% among individuals over 65 years of age.[4]

Diabetes is broadly classified into three main categories. The first category, type 1 diabetes (T1D), is primarily attributed to an absolute deficiency in insulin secretion. In contrast, T2D results from insulin resistance and is responsible for approximately 90% of all diabetes cases, while gestational diabetes—typically resolving after childbirth—accounts for about 2% of cases, with the remainder (around 8%) being T1D.[1,5] Additionally, available data indicate that nearly half of those with T2D are older than 65, making this group particularly vulnerable to the adverse complications associated with the disease.[6] These complications can include, but are not limited to, renal failure, visual disturbances, and, notably, sarcopenia.[4]

Sarcopenia is defined as a progressive reduction in both muscle mass and muscle function.[7] Although it is a common consequence of aging, several factors exacerbate its onset in diabetic populations. These factors include a decline in physical activity, reduced caloric and nutrient intake, vitamin deficiencies, dysfunctions in endocrine glands, and disturbances in the secretion of growth hormones and testosterone. Furthermore, elevated levels of inflammatory markers, such as interleukin-6 and C-reactive protein, have been implicated in the development of sarcopenia.[8] Importantly, diabetic individuals are at a substantially higher risk—up to three times more likely—of developing sarcopenia compared to non-diabetic individuals.[9,10]

In the context of diabetes-induced sarcopenia, the loss of muscle mass and strength is particularly problematic because it contributes to decreased overall physical activity levels.[11] Empirical studies suggest a direct correlation between increased physical activity and a reduced risk of concurrently developing T2D and sarcopenia.[12] Although aerobic exercise has been shown to be more effective for acute blood glucose regulation, resistance training offers additional benefits by specifically enhancing muscle mass and strength.[13,14] It is important to note that while the metabolic improvements following an exercise session can be substantial, these benefits tend to diminish within 96 hours unless regular exercise is maintained. Therefore, adherence to a consistent exercise regimen is critical. The American College of Sports Medicine recommends that diabetic individuals, particularly those with sarcopenia, engage in a combined regimen of 150 minutes of aerobic exercise and resistance training distributed over two to three sessions per week.[3]

Nutritional factors also play a critical role in the etiology of T2D. Research indicates that dietary habits significantly contribute to the onset of the condition.[15] One effective strategy for managing blood glucose levels in diabetic individuals involves dietary modulation, particularly the regulation of postprandial glycemia—a hallmark of T2D.[16] Recent investigations have demonstrated that the ingestion of a specific amount of protein before main meals can lead to a reduction in post-meal blood glucose levels, primarily through the stimulation of insulin secretion and the deceleration of gastric emptying.[17,18]

Methods

This systematic review was performed by searching English-language literature in Google Scholar and PubMed using several keywords, such as “Diabetes,” “Sarcopenia,” “Resistance Training,” “Whey Protein,” and “Creatine.” The screening process involved the removal of non-English articles, followed by an evaluation of titles, abstracts, and full texts to select studies that specifically examined the effects of resistance training and nutritional supplementation on diabetic individuals with sarcopenia. Only those studies that met these inclusion criteria were considered for detailed analysis.

Results

Resistance Training

The literature consistently demonstrates that resistance training not only increases muscle mass and strength in older adults with diabetes but also improves insulin sensitivity and reduces inflammatory markers, such as tumor necrosis factor-alpha.[19] In one 48-week trial involving diabetic patients aged 70–79 with sarcopenia, participants who engaged in 15 minutes of daily resistance training using elastic bands—either alone or with additional leucine-rich amino acid supplementation—showed increases in muscle strength and mass, although some differences did not reach statistical significance.[20] In another study, patients over 50 undergoing twice-weekly resistance exercises with sandbag attachments exhibited significant improvements in hemoglobin *A1c* (HbA1c) levels, muscle mass, and strength compared to controls.[9] A separate study from China involving resistance training at 70% of one-repetition maximum also represented significant improvements in fasting blood glucose, interleukin-6, and tumor necrosis factor-alpha levels.[21] Meta-analyses further support that resistance training—via gym machines, free weights, or elastic bands—effectively lowers HbA1c and boosts muscle strength.[22] Additional experimental studies, including an animal model combining resistance training with ginseng supplementation, corroborate these findings by revealing increased muscle mass and mitochondrial biogenesis.[23] Moreover, in a nine-month study, resistance training was the only intervention that significantly increased lean body mass compared to aerobic or combined exercise protocols.[24] Finally, during the coronavirus disease 19 pandemic, home-based resistance training preserved muscle mass among diabetic patients, even though HbA1c levels did not significantly differ from routine care alone.[25] The American College of Sports Medicine has endorsed resistance training for diabetes management, outlining guidelines that include two non-consecutive sessions per week with multiple exercises per session at 50%–70% of one-repetition maximum.

Whey Protein Supplementation

Research has shown that whey protein supplementation plays an essential role in glycemic management and muscle preservation. In one study with 22 obese diabetic patients, 21 g of whey protein taken before breakfast and dinner over two weeks resulted in improvements in insulin levels, blood glucose, and muscle mass.[26] Other review studies indicate that consuming 15–30 g of whey protein approximately 15–30 minutes before each major meal significantly reduces postprandial blood glucose levels and assists in maintaining lean muscle mass.[27] Furthermore, an average muscle mass increase of up to 10% has been reported, alongside enhancements in insulin sensitivity and glucose transporter type 4 expression.[28] A study involving 60 diabetic women demonstrated that a 14-day protocol with 20 g of whey protein daily led to notable reductions in postprandial blood glucose, insulin resistance, and cortisol levels while concurrently elevating insulin levels for up to two hours after ingestion.[29] In another trial, 18 diabetic individuals over 50 years old who received 15 g of whey protein before meals for three months experienced significant improvements in hyperglycemia and overall glycemic control.[30] Additionally, consumption of strawberry-flavored whey protein over three months resulted in an 8% reduction in hyperglycemia and an 11% increase in muscle mass, with improvements in lipid profiles.[31] A further review of 13 articles confirmed that whey protein supplementation decreases HbA1c and insulin resistance while maintaining or increasing muscle mass without significantly altering C-reactive protein levels.[32] Finally, in a study of 39 elderly type 2 diabetic individuals undergoing twice-weekly resistance training, the addition of 33 g of daily whey protein significantly improved the quality of life, with no significant renal effects.[33]

Creatine Supplementation

Creatine supplementation has been explored as an adjunct to exercise in diabetic patients. In one study, obese diabetic individuals over 45 years of age who consumed 5 g of creatine daily and participated in combined aerobic and resistance training showed improvements in muscle mass, strength, and phosphocreatine content without significant changes in blood creatinine levels compared to placebo.[34] Another investigation compared creatine monohydrate with creatine ethyl ester in diabetic individuals with potential sarcopenia; both formulations maintained muscle mass and enhanced strength, though creatine ethyl ester was associated with increased plasma and urinary creatinine levels.[28] A review further indicated that creatine supplementation, in doses ranging from 5 g to 20 g daily for 3–12 weeks, positively affects muscle strength and muscle mass and may contribute to improved glycemic control through several mechanisms.[35] A meta-analysis of five studies confirmed that creatine effectively increases muscle mass and strength, although its impact on fasting blood glucose and insulin resistance remains less pronounced.[36] Moreover, creatine has been shown to aid in the prevention and treatment of sarcopenia among elderly diabetic patients by enhancing muscular function.[37]

Discussion

The evidence reviewed herein suggests that resistance training and nutritional supplementation, specifically with whey protein and creatine, provide a multifaceted approach to managing diabetes-induced sarcopenia. Resistance training not only counteracts the decline in muscle mass and strength through improved insulin-like growth factor-1 signaling but also enhances glucose uptake via upregulation of glucose transporter type 4.[38] Whey protein supplementation contributes to glycemic control by stimulating incretin release, delaying gastric emptying, and promoting satiety, thereby reducing postprandial glucose excursions.[18,39-41] Additionally, the branched-chain amino acids in whey protein may stimulate pancreatic beta cells to secrete insulin, further aiding in glycemic management.[42] Creatine supplementation appears to support muscular energetics and enhance muscle strength, which in turn may improve overall glucose utilization and reduce the risk of hyperglycemia.[35] The synergistic effects of these interventions suggest that combining resistance training with nutritional strategies could offer a superior approach to managing both the metabolic and musculoskeletal complications of diabetes.

Conclusion

As the prevalence of diabetes and its associated complications, including sarcopenia, continues to rise, integrated interventions that combine resistance training with whey protein and creatine supplementation emerge as effective, cost-efficient strategies. These approaches appear to stabilize or enhance muscle mass and strength while improving glycemic control. Accordingly, future research should focus on refining these intervention protocols and conducting long-term randomized controlled trials to fully elucidate their synergistic potential and optimize clinical outcomes.

Authors' Contribution

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Competing Interests

None.

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