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# The Emerging Significance of Sarcopenic Obesity in Older Adults with Type 2 Diabetes

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***Abstract***

*Communities worldwide are witnessing a rise in type 2 diabetes and obesity in older adults. Both nutritional factors and sedentary behavior lead to progressive age-related loss of muscle mass, termed sarcopenia. "Sacropenic Obesity" refers to the coexistence of decreased muscle mass in the setting of a high body mass index. Older persons with type 2 diabetes are particularly prone to adverse sequelae with sarcopenic obesity. Heightened endovascular inflammation and a high level of insulin resistance add to the elevated risk. Both basic and clinical research is necessary to evaluate the multidirectional impact of insulin, proinflammatory cytokines, muscle function, and vascular complications. For effective breakthroughs, improved daily habits in concert with novel drug interventions to combat sarcopenia older persons with type 2 diabetes are showing promise. The impact of both obesity and sarcopenia on the health status of patients with type 2 diabetes is an emerging topic of interest. The concept of sarcopenic obesity and the glucometabolic disease conditions are intimately connected with age-related musculoskeletal dysfunction and provide ripe avenues for future study.*

**Keywords:** Diabetes, Muscle Mass, Obesity, Older Adults, Sarcopenia.

## Introduction

Obesity is a rapidly worsening global epidemic due to an increase in sedentary lifestyle and dietary changes. A vast majority of the adult population in the United States will fall in the overweight or obese category by the end of this decade a statistic that is applicable in the older adults [1,2]. Aging is linked with an increased risk of acquiring type 2 diabetes (T2DM) and developing the metabolic syndrome (MetS) [3]. A generalized loss of muscle mass and a progressive decline in muscle strength are hallmarks of sarcopenia [4]. "Sarcopenic obesity" (SO) refers to the coexistence of obesity and sarcopenia in the same individual which manifests at a high rate in individuals with T2DM [5-7]. Thus, obesity is a risk-promoting variable in sarcopenia related to the aging process (8). SO elevates the risk of being diagnosed with hypertension, cardiovascular disease (CVD), cerebrovascular disorders, T2DM, and cognitive dysfunction, ultimately leading to increased all-cause mortality [9]. The economic burden of SO is being recognized [10, 11]. Increased insulin resistance (IR) is at the core of the heightened burden of CVD [12,13]. The emerging concept of "sarcopenic obesity" and its potential impact on the health of older patients with T2DM is the focus of this brief narrative review.

## Definition and Assessment of Sarcopenia

### Definition and Assessment

As defined by Santilli et al. in 2014, sarcopenia is a condition characterized by the progressive and generalized loss of skeletal muscle mass and function, primarily affecting the elderly [4]. However, they noted that its development may be associated with conditions that are not exclusively observed in older individuals. This condition is often multifactorial in origin, with contributing factors including chronic systemic diseases, prolonged physical inactivity, malnutrition, and inflammatory processes. The approach to quantifying sarcopenia has evolved significantly over the last 20 years. The European Working Group on Sarcopenia in Older People (EWGSOP2) established diagnostic

cut-off points stratified by age and gender and proposed an algorithm for detecting sarcopenia cases in older persons based on objective measures such as grip strength, gait speed, and skeletal muscle mass [14]. Robust diagnostic criteria for the quantification of muscle mass and strength, as well as physical capacity, were used to facilitate the development of a variety of tools to assess the presence and degree of sarcopenia. Subsequently, the EWGSOP2 introduced an updated diagnostic algorithm which also outlined the sequential steps for case-finding and grading the severity of muscle loss in clinical practice.

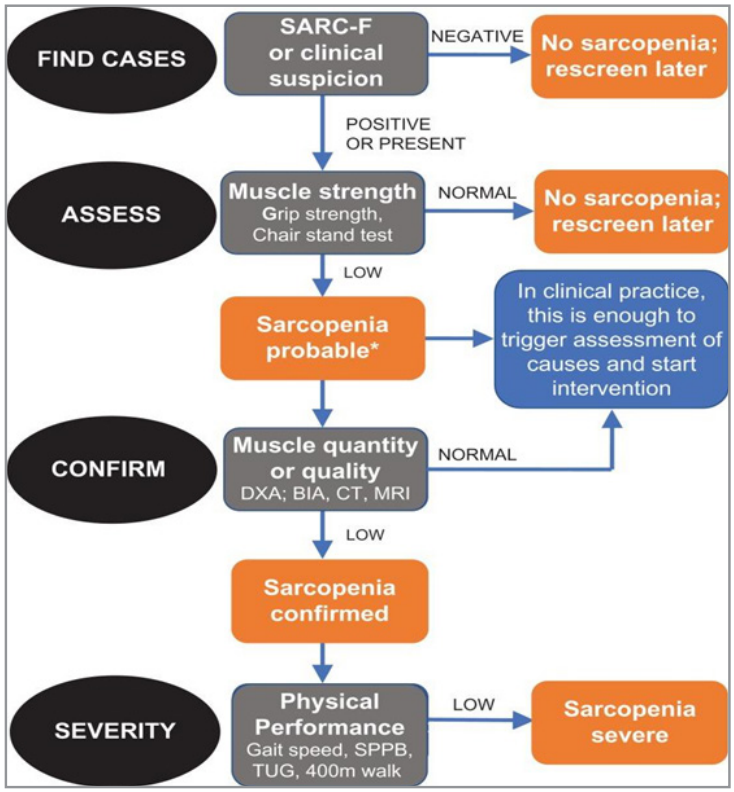


**Figure 1:** The EWGSOP2 algorithm for diagnosing, case-finding, and measuring the degree of severity of sarcopenia. The steps of the pathway are represented as Find-Assess-Confirm-Severity or F-A-C-S. (from: Cruz-Jentoft et al. 2019, available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6322506/, accessed on 9 June 2025).

This revised algorithm integrates contemporary evidence and provides a systematic framework for clinicians to identify and manage sarcopenia effectively. This clinical tool also included specific diagnostic thresholds for sarcopenia based on assessments of muscle strength, muscle mass, and physical performance.

| Test | Men | Women |
|---|---|---|
| Grip Strength with handheld dynamometer | <27 kg | <16 kg |
| Chair Stand to measure leg muscle strength | >15 seconds for five rises | |
| Appendicular Skeletal Muscle Mass | | |
| Quantified with MRI, CT, or DEXA | <20 kg | <15 kg |
| ASM/height2 (to adjust for body size) | <7.0 kg/m2 | <5.5 kg/m2 |
| Walking Speed | ≤0.8 meters/second | |
| Short Physical Performance Battery | Less than/equal to: 8-point score | |

**Figure 2:** EWGSOP2 Sarcopenia Cut-Off Points (modified from: Cruz-Jentoft et al. 2019, available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6322506/, accessed on 9 June 2025).

The presence of sarcopenia is categorized as "probable", "confirmed", or "severe" [15,16]. In addition, quick and simple questionnaires such as SARC-F can also aid in identifying older adults at risk for sarcopenia. SARC-F focuses on Strength, Assistance in walking, rising from a chair, climbing stairs, and Falls, providing a rapid screening option before proceeding to more detailed assessments like grip strength and imaging [15]. These categorizations enable tailored therapeutic interventions, with severe sarcopenia often necessitating comprehensive approaches, such as resistance training programs, protein supplementation, and management of underlying comorbidities.

**Muscle Quality**

Although the extent of sarcopenia has traditionally been estimated by measurement of muscle mass, emerging data suggests that muscle quality is equally important. Abnormal intramuscular fat deposition, also known as "myosteatosis," alterations in muscle architecture, and other molecular changes may impair contractile function and worsen insulin resistance in addition to simple muscle loss. These factors highlight the complexity of assessing sarcopenic obesity and further support the need for multidimensional diagnostic criteria [16].

**Sarcopenic Obesity in Older Adults**

**The Twin Global Epidemics**

Obesity and sarcopenia are a major threat to the health of older adults. Their pathologic interaction has not been fully examined, even though a substantial body of evidence has shed light on their prevalence and natural history. Emerging evidence suggests that SO exacerbates IR, and vice versa, leaving older persons at risk for CVD [12]. There is a link between increased body weight (BMI), waist-to-hip circumference ratio (WHR), and MetS [17].

**The Aging Process**

Aging contributes to a redistribution of adipose tissue and alterations in adipogenesis, leading to heightened inflammatory responses and dysregulated adipokine secretion. These changes exacerbate lipo-toxicity and insulin resistance [18]. These age-dependent mechanisms are critical contributors to IR and the emergence of T2DM [19]. Simultaneously, sarcopenia, a near-universal consequence of advancing age, disrupts the production of neuroactive chemicals and myokine agents that enhance insulin sensitivity [20]. The progression of sarcopenia involves significant impairments in muscle physiology and reduced responsiveness to anabolic sources [21]. Moreover, neural adaptations and changes in excitability of neurons further contribute to functional decline [22]. The deleterious effects of sarcopenia include increased frailty and reduced physical function, with profound implications for individuals with diabetes and public health systems [23,24]. Frailty in older adults is a clinical syndrome often characterized by reduced physiological reserve, increased vulnerability to musculoskeletal deterioration, and a greater risk of adverse outcomes such as falls and hospitalization. In those with SO, the overlap of excess fat mass and diminished muscle function can further accelerate the onset and progression of frailty, highlighting the importance of early detection and intervention to preserve independence [23,24].

**A Confluence of Factors**

The development of sarcopenia is influenced by a combination of coexistent chronic illnesses, poor nutrition, and relative immobility, all of which are common accompaniments of aging [25]. Comorbidities such as CVD), chronic kidney disease (CKD), and neoplastic conditions have the potential to further exacerbate the degree of sarcopenia [11]. Obesity is an undermining factor in the overall health of older adults [8]. The progression of sarcopenia is associated with accelerated cardiovascular disease (CVD) development, contributing to a higher risk of mortality in this population [26]. A vicious cycle of chronic disease and musculoskeletal issues is thus perpetuated in the older population and requires proactive strategies that target these risk factors and implement lifestyle modification. An accurate quantification of SO necessitates key parameters for objective assessments of cognitive function and quality of life [27,28]. MetS and low-grade inflammation have also been implicated in increasing SO risk concomitant with high-calorie diets and physical inactivity in the elderly [18,29]. Conversely, SO may amplify the risk of these adverse factors in a compounded manner and more than sarcopenia or obesity alone, potentially increasing morbidity. Thus, comprehensive management strategies are necessary when obesity and sarcopenia coexist to interrupt the vicious cycle of muscle dysfunction and metabolic derangement.

**Gaps and Pitfalls**

Despite the increasing recognition of SO, knowledge gaps remain about its pathophysiology and prevalence in the elderly. The integrated impact of obesity and sarcopenia on all-cause mortality was the subject of a pooled analysis of several large datasets [30]. The results showed that when compared to non-obese, non-sarcopenic individuals, the risk of death increased for individuals who had probable sarcopenia alone (hazard ratio [HR]: 1.61, 95% confidence interval [CI]: 1.39-1.85) or probable sarcopenia along with obesity (HR: 1.36, 95% CI: 1.13-1.64); however, the obese-only group revealed no difference (HR: 0.92, 95% CI: 0.85-1.01). The investigators concluded that pinpointing older adults who are at risk of developing sarcopenia and making efforts to maintain muscle strength appeared to be important steps towards reducing early mortality. Pérez-Zepeda et al. estimated sarcopenia prevalence in older persons in the Mexican Health and Aging Study using tailored cutoffs based on the EWGSOP algorithm [31]. The mean BMI was elevated at 28.4 kg/m2. Gait speed, handgrip strength, and muscle mass were assessed in over 1200 seniors. The prevalence of sarcopenia was 11% (n = 137); 39.1% (n = 484) showed pre-sarcopenia, 8.3% (n = 103) revealed moderate sarcopenia, and 2.75% (n = 34) were suffering from severe sarcopenia. A study of 1,416 community-dwelling adults using EWGSOP2 guidelines found that 9.6% of men met the sarcopenia definition, with low muscle strength being more prevalent in obese older men [32]. The authors concluded that the prevalence of sarcopenia might result in an underestimation if EWGSOP2 criteria are used in older populations.

**Type 2 Diabetes and Sarcopenic Obesity in Older Adults**

**Operative Factors**

Obesity, physical inactivity, vascular factors, suboptimal nutrition, and glucose perturbations are key risk factors for cognitive decline and proneness to frailty in older adults who suffer from diabetes [7- 19]. Insulin resistance, arteriosclerosis, chronic inflammation, oxidative stress, and mitochondrial dysfunction may be common mechanisms shared by frailty and cognitive impairment. However, it is unclear if a unique syndrome of "diabetic sarcopenic obesity" exists that exacerbates the age-related health decline seen in clinical practice [33]. Currently there is not a consensus regarding the method to identify sarcopenic obesity, with BMI calculations having lower accuracy compared to general population [33].

**Underlying Mechanisms**

The mechanisms predisposing older obese adults to sarcopenia, and the impact of T2DM on this association, are not completely understood. The issue is further complicated by the complex interaction between insulin and protein metabolism among different individuals and in various muscle groups. The relation-

ship of SO with glucometabolic and cardiovascular risk has not yet been fully studied, especially in the 65 to 85-year subgroup [34]. It is unclear if plasma glucose, insulin, and hemoglobin A1c are higher in sarcopenic obese elderly who are glucose intolerant. Similarly, there is a dire need to explore the association of SO with inflammatory markers like C-reactive protein (CRP), interleukin 6 (IL-6), homocysteine, leptin, and adiponectin. In addition, levels of myokines that promote muscle growth and function are an emerging avenue of further research [32-35].

**Insulin Resistance**

Advancing age is a significant and non-modifiable risk factor for worsening IR. Insulin effectiveness gradually and inexorably declines with age and is a major metabolic abnormality underlying T2DM and MetS [36]. Adiposity, muscle mass, physical conditioning, chronic illnesses, and the use of medications may impact the association between aging and reduced insulin sensitivity [37,38]. Sarcopenia is associated with IR in both non-obese (HOMA-IR ratio 1.39) and obese individuals (HOMA-IR ratio 1.16), as well as with glycemia in the obese group; these findings were revealed in a cross-sectional analysis of the National Health and Nutrition Examination Survey III (NHANES III) [39]. IR disrupts key physiological processes implicated in both metabolic and anabolic defects in skeletal muscle [34]. Regardless of the presence of obesity or sarcopenia, functional activities of daily living seemed to be affected equally in older individuals [40]. It is possible that these associations are influenced by differences in IR among distinct phenotypes with varying body composition. In community-dwelling older persons, SO did not appear to confer greater risk for incident MS or IR than obesity alone when examined in the Concord Health and Ageing in Men Project [41]. Nevertheless, an older study suggested that the actions of insulin in healthy, non-obese postmenopausal women did not play an important role in the development and progression of sarcopenic states [42].

**Muscle Mass and Function**

Population-based, epidemiologic data has indicated an inverse association between relative muscle mass, insulin resistance, and prediabetes [39]. The interplay between muscle mass decline, obesity, and T2DM has been highlighted before [43]. A venue for the synthesis and secretion of cytokines and peptides, the skeletal muscle is now considered a part of the endocrine system [44]. Produced and released in response to muscular activity, these "myokines" facilitate an autocrine, paracrine, and endocrine hormonal crosstalk with other organs [45]. Importantly, a sedentary lifestyle impairs the secretion of myokines and thus predispose to a multitude of chronic illnesses.

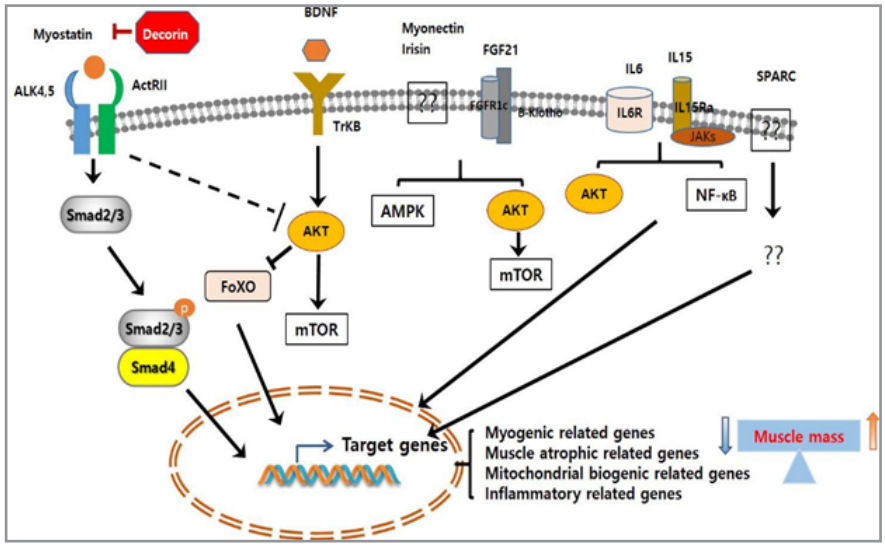


**Figure 3:** The Production and Function of Exercise-Induced Myokines BDNF, brain-derived neurotrophic factor; FGF21, fibroblast growth factor 21; SPARC, secreted protein acidic and rich in cysteine; IL, interleukin. (From: Lee et al. 2019, available at https://www.frontiersin.org/journals/physiology/articles/10.3389/fphys.2019.00042/full, accessed on 9 June 2025).

Some of the functional and metabolic defects found in the frail, sarcopenic elderly might be explained on the basis of fat accumulation in the muscle, whether accompanied by obesity or not [46]. Interestingly, the loss of muscle mass is often seen in conjunction with reduction of bone mass and strength, a phenomenon sometimes termed "osteo-sarcopenia" [47]. This condition can dramatically increase fall risk, fracture risk, and morbidity. The exact underlying pathophysiologic changes in this condition are unclear; however, similar biomechanical, endocrine, and nutritional abnormalities in muscle-bone interactions may contribute to the pathophysiologic underpinnings of this process, emphasizing the need for comprehensive assessment and intervention. [48].

**Long-term Changes**

Chronic disorders, such as T2DM, have been implicated in accelerating the progression of the sarcopenic condition. It is being increasingly recognized that the proinflammatory milieu in T2DM mediates this risk by increased IR and the production of well-documented advanced glycation end-products [19]. As a downstream process, oxidative stress negatively affects the parameters of muscle function by impacting protein metabolism and vascular and mitochondrial aspects of cellular health. In a converse manner, the development of T2DM is accelerated through loss of muscle mass which likely plays a role through the decreased production of myokines and metabolic dysfunction with time [49].

**Metabolic Syndrome**

The cardiometabolic interconnection between SO and MetS,

even in the absence of glucose intolerance, is being increasingly noted. SO was associated with MetS and low-grade inflammation in Caucasian adults when studied in a cross-sectional analysis [50]. Retrospective data from the Framingham cohort also showed that about 10% of the subjects had SO when observed at 10, 20, and 30 year intervals of time [51]. They exhibited a higher prevalence of CVD risk factors such as hypertension and T2DM when compared to the other three categories ($p < 0.03$). The investigators concluded that, from a clinical standpoint, early recognition of sarcopenia provided an opportunity for interventions to reverse or delay the progression of musculoskeletal conditions and could also reduce adverse cardiovascular outcomes. It has been clearly demonstrated that sarcopenia in older adults is associated with a more rapid progression of a variety of CVD endpoints [23-29]. This is coupled with a higher risk of mortality and falls and a reduced quality of life.

**Is There a COVID-19-Related Sarcopenia?**

Acute sarcopenia is an often an under-recognized condition in the context of the COVID-19 pandemic. It is manifested by a rapid decline in both muscle mass and functionality within six months of a moderate to severe COVID-19 episode [52]. However, because of its global and devastating impact on societies, the SARS CoV-2 virus and the COVID pandemic warrants special attention regarding their effects on older persons who are already or are at risk of developing sarcopenia. Numerous studies have reported an increased risk of severe sarcopenia in COVID-19 patients during and after recovery. The factors predisposing to this include reduced physical activity, relative isolation, immobility and homebound status, and slow recovery from an acute illness that abruptly impacts health. In a study by Lopez-Sampalo et al. that prospectively examined various parameters (body composition, muscle strength, sarcopenia, and functional status) in approximately 100 older individuals with COVID-19, there was a 80% prevalence of sarcopenia at 3 months after infection, which was more pronounced in women and in those requiring hospital stay [53]. Interestingly, at 12 months after the infection, the prevalence dropped considerably to 55%, coincident with functional improvement, symptomatic recovery, and the normalization of inflammatory markers. The investigators concluded that older survivors with acute COVID-19 could make a favorable clinical recovery and regain muscle function if careful attention was given to nutrition and early rehabilitation. A large review examining the association between sarcopenia and mortality risk in critically ill COVID-19 patients revealed interesting findings [54]. The majority uncovered a significant association, while 5 studies did not show such findings [17]. Of note, both preexisting T2DM and new-onset hyperglycemia were aggravating factors. The investigators emphasized the bedside assessment of lean muscle mass in patients with severe COVID-19 for prognostic purposes.

**Management of Sarcopenic Obesity in Older Patients with Type 2 Diabetes**

**Lifestyle Interventions**

Management strategies for SO are focused on calorie restriction and increased physical activity and are the cornerstone of therapy [55,56]. However, due to physical limitations and the concomitant presence of chronic comorbid conditions, the effectiveness of lifestyle modifications is often limited in diabetic patients who have SO. The goal is to reduce IR, metabolic complications, and progression of disabilities in without exacerbating further reductions in lean mass or bone mineral density. Thus, an individualized diet with moderate caloric restriction that is otherwise nutritious, together with regular aerobic and isometric exercise promises to reduce weight and improve hyperglycemia [57]. A large meta-analysis demonstrated that a diet low in calorie content but relatively high in protein, when combined with "cardio" exercise was successful in reducing body weight and amount of fat but failed to improve physical performance measures [58]. Maintaining adequate protein intake can be challenging for older adults, especially those with T2DM and other comorbidities. A daily protein intake of 1.0-1.2 grams per kilogram of body weight for older individuals has been recommended [55, 56]. In addition, exercise improves β-cell dysfunction in T2DM and promotes an anabolic shift in muscle protein the older individuals [59]. It is to be kept in mind that the prevention of muscle atrophy and effective amelioration of musculoskeletal inflammation usually requires initiating and maintaining resistance exercise of sufficient frequency and intensity [60]. The importance of preserving skeletal muscle mass and reducing fat is reflected by the findings that weight-based exercise improved body composition, grip strength, and physical capacity in both diabetic and non-diabetic persons with SO [61, 62].

**Non-Pharmacological Approaches**

Interventions beyond traditional lifestyle modifications in managing SO have been studied [63]. These include, but are not limited to, dietary supplements, gut microbiome changes, and rehabilitative methods [63]. SO, in diabetic patients can be mitigated by consuming antioxidant-rich nutrients that are found mainly in vegetables and fruits, along with supplementation with specific ergogenic or branched-chain amino acids [64]. Although essential amino acids appear to be effective for enhancing muscle mass and strength in the elderly, their effectiveness in reducing fat mass is certain [65]. It is assumed that this uncertainty applies to patients with diabetes as well. Along these lines, a protective role of antioxidant flavonoids would appear promising, since oxidative stress is a prominent finding underlying SO [66]. The myostatin inhibition properties of flavones have the property of inhibiting myostatin and have been proposed as a novel therapeutic possibility. Indeed, certain flavones have been identified as lead molecules in drug discovery [67]. Mice data reveals that 5,7-Dimethoxyflavone improves protein turnover and mitochondrial function, thereby acting as a natural agent that would inhibit sarcopenia [68]. Epicatechin is another potential candidate in the management of SO and its related complications by showing myostatin inhibition activity in pre-clinical and clinical studies [69]. Brazilian green propolis is a product obtained from the honeybee industry and has been demonstrated to counteract SO. It is purported to achieve this by inducing "dysbiosis", thus offering new insights into the diet-microbiota milieu [70].

**Pharmacologic Therapies**

The possible influence of different medications on the extent and progression of SO in older individuals with T2DM represents an important area for further investigation. Zhang and colleagues reviewed the data on the impact of various antidiabetic therapies on muscle mass in patients with diabetes [71]. Table 1 summarizes some of the published findings in this field.

**Table 1:** Effects of Anti-Diabetic Pharmacologic Interventions on Body Weight, Muscle, and Adiposity
GLP-1, glucagon-like peptide-; DPP-4, dipeptidyl peptidase 4; SGLT2, sodium-glucose co-transporter 2; ATP, adenosine triphosphate; AMPKα2, AMP-activated protein kinase α2; PPAR-γ, peroxisome proliferator-activated receptor gamma.

| Medication | Actions on Skeletal Muscle | Impact on Muscle Mass and Function | Effect on Body Weight | Effect on Fat Mass |
|---|---|---|---|---|
| Insulin | Enhanced protein synthesis (anabolic) | Attenuates the decline of muscle strength; preserves muscle mass but not muscle function | Moderate to significant increase | Increase |
| Sulfonylureas | Inhibit ATP-sensitive K channel and increase caspase-3 activity | Non-significant decrease in muscle mass | Usually Increase | Unchanged |
| Metformin | Increasing AMPKα2 activity | Attenuates muscle loss and increases lean mass | Modest decrease | Significant reduction in total and percent fat |
| Thiazolidinediones | Activate PPAR-γ pathway | Increase muscle mass and reduced muscle lipid content | Mild to moderate increase; fluid retention | Redistribution of fat stores and reduced intraabdominal visceral content |
| GLP-1 Receptor Agonists | Slowing of protein loss | Reduced lean mass in some studies | Significant loss | Variable decrease |
| DPP-4 Inhibitors | Unclear | Slower age-related muscle loss | Neutral | Unclear |
| SGLT2 Inhibitors | Inhibit inflammatory cytokines and macrophage aggregation | increased muscle contractility with reduced lean mass | Loss | Decrease in total body fat mass |

Insulin is a potent stimulator of protein synthesis in the muscles through enhanced mRNA translation, recruitment of the microvasculature, increased blood flow, and retardation of protein degradation [72]. However, the presence of IR, endothelial dysfunction, and microvascular complications may blunt this anabolic effect in patients with T2DM. Interestingly, diminished insulin secretion appears to be an independent risk factor in males with sarcopenia [73]. Both fat and fat-free mass is responsible for the increase in insulin-induced weight gain [74,75].

Sulfonylurea drugs such as glibenclamide and glimepiride may exacerbate the risk of sarcopenia in patients with diabetes [76]. They work via inhibition of ATP-sensitive K+ (KATP) channel, which has been suggested as a mechanistic factor. Their use has witnessed a decline due to the more widespread use of newer glucose-lowering agents.

Metformin is a commonly used medication for hyperglycemia and improves insulin resistance and hyperinsulinemia through multiple mechanisms. Studies have consistently associated long-term metformin use with decreased fat mass [77, 78]. The impact of metformin on lean mass in T2DM patients, however, seems controversial. Metformin treatment ranging from 10 weeks to 6 months did not result in significant change in fat-free mass [79,80]. On the contrary, lean mass loss was higher in metformin users in a longitudinal cohort study compared to those with untreated diabetes, or diabetes treated without metformin [81]. Therefore, the clinical risk of sarcopenia with metformin therapy should be kept in mind, especially because of its appetite-suppressive effects.

Thiazolidinediones (TZDs) enhance insulin sensitivity in the target organs of skeletal muscle, liver, and adipose tissue via activation of peroxisome proliferator-activated receptor gamma (PPAR-γ). Their actions on muscle mass and function are not well characterized. Although pioglitazone significantly improves skeletal muscle fatty acid metabolism, its effect on muscle content and function is unknown [82].

Glucagon-like peptide-1 (GLP-1) agonists reduce glucose and induce potent weight loss in patients with T2DM. Both liraglutide and dulaglutide have been shown to primarily decrease fat mass, the former when used in obese T2DM patients in combination with metformin and the latter in patients on hemodialysis [83,84]. Exenatide therapy reduced body weight and fat without loss of muscle mass [85]. However, a meta-analysis indicated that semaglutide-induced weight loss was associated with reductions in both fat and fat-free mass [86].

The dipeptidyl peptidase 4 inhibitors appear to have no significant effect on body weight, and their influence on body composition and muscle mass remains inconsistent [87, 88].

In studies to date, all three commonly used members of the sodium-glucose co-transporter 2 (SGLT2) inhibitor class of drugs favorably impacted body composition and muscle mass in patients with T2DM including varying reductions in body weight, body mass index, waist circumference, visceral and subcutaneous fat, and percent body fat [89-91]. Although there are concerns that their long-term use could theoretically aggravate muscle and bone loss, most evidence has been reassuring [92, 93].

In summary, more data is required to establish a clear relationship between the array of pharmacologic interventions and

changes in muscle mass in patients with T2DM. When prescribing antihyperglycemic medications in the clinical setting, the possible aggravation of sarcopenia by glucose-lowering agents in susceptible individuals should be kept in mind.

**Metabolic Weight-loss Procedures**

Bariatric surgery targeting weight loss, demonstrated significant and sustained weight loss concomitant with reduction in comorbidities with a good safety profile and acceptably low complication rate in individuals with SO compared to those without sarcopenia [94]. These benefits extend to those with diabetes, where long-term disease remission is possible [95]. However, the role of surgical weight loss in improving functional autonomy and activities of daily living remains unproven. It seems reasonable to abstain from attempting significant or rapid weight loss in the very oldest and frail individuals (≥80 years), since this might come at great effort and lead to aggravation of sarcopenia. It was reassuring that early loss of fat-free mass was not accompanied by changes in protein turnover in patients with SO that underwent gastric bypass surgery [96].

## Conclusions

Sarcopenic obesity is an emerging pathophysiologic concept that appears to have an adverse impact in older individuals with T2DM. The implications for clinical practice based on accumulated knowledge are twofold. First, the determinants of age-related sarcopenia in older patients with T2DM, consisting of malnutrition and muscle deconditioning, should be addressed to improve general health and quality of life. Second, the amelioration of IR and reduction of cardiovascular and metabolic risk in this high-risk group is best achieved through weight loss, ideally with an increase in physical activity. Understanding the impact of both glucose-lowering pharmacologic therapies and concurrent medications on body composition in patients at risk of sarcopenia is paramount. Strategies aimed at preservation of muscle mass are poised to play a central role in formulating long-term approaches in health maintenance in the elderly population with diabetes. With the rapid increase in the older segment in societies worldwide, translating new research into clinical practice through utilization and improvement of clinical criteria and tools and clinical criteria is warranted.

## Disclaimer

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