Spinal Sarcopenia

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Spinal sarcopenia is a complex and multifactorial disorder associated with loss of strength, increased frailty, and increased risk of fractures and falls. In addition, spinal sarcopenia has been associated with lumbar spine disorders and osteoporosis, which renders making decisions on treatment modalities difficult. Patients with spinal sarcopenia typically exhibit lower cumulative survival, a higher risk of in-hospital complications, prolonged hospital stays, higher postoperative costs, and higher rates of blood transfusion after thoracolumbar spine surgery. Several studies have focused on the relationships between spinal sarcopenia, appendicular muscle mass, and bone-related problems—such as osteoporotic fractures and low bone mineral density—and malnutrition and vitamin D deficiency. Although several techniques are available for measuring sarcopenia, each of them has its advantages and shortcomings. For treating spinal sarcopenia, nutrition, physical therapy, and medication have been proven to be effective; regenerative therapeutic options seem to be promising owing to their repair and regeneration potential. Therefore, in this narrative review, we summarize the characteristics, detection methodologies, and treatment options for spinal sarcopenia, as well as its role in spinal disorders.

image detection muscle myogenesis pathogenesis spinal sarcopenia

1. Introduction

Spinal sarcopenia—the loss of skeletal muscle mass and function—is of crucial concern, owing to its high rate of adverse outcomes among older adults [1]. Skeletal muscle strength declines by 40 years in both sexes [1]. Muscle power declines approximately 10% more than muscle strength in men, whereas no significant differences are observed in women [1]. In some articles, it has been reported that handgrip strength declines faster in older women compared with older men [2][3]. A study from Korea revealed that in addition to advanced age, crucial factors associated with sarcopenia in all age groups were physical activity, blood pressure, waist circumference, triglyceride and vitamin D levels [4]. Notably, overall energy intake was related to sarcopenia among young adults, whereas fasting glucose, suicidal ideation, and sex were factors related to sarcopenia among the elderly. In addition, Brzeszczyńska J. et al. found that increased cellular stress, with impaired oxidative stress and misfolded protein response, were associated with the development of sarcopenia based on the in vitro system of myogenesis [5].

Notably, the prevalence of spinal sarcopenia varies in different regions worldwide [6][7][8][9][10]. For one systemic review, a meta-analysis was conducted, and the overall prevalence was estimated to be 10% (95%, confidence interval (CI): 8–12%) in men and 10% in women (95%, CI: 8–13%) [11]. Moreover, the results demonstrated that the

prevalence was higher among non-Asian individuals than in Asian individuals of both sexes [12]. Other studies have indicated that estimates of sarcopenia prevalence vary widely because of the definitions used (e.g., those of the European Working Group on Sarcopenia, the Asian Working Group on Sarcopenia, the International Working Group on Sarcopenia) and appendicular lean mass or weight definitions [13]. Sarcopenia is often associated with various pathologic conditions, such as Alzheimer's disease and rheumatoid arthritis in women, both of which increase the need for institutional care as well as the mortality rate of hospitalized older adults [14][15][16][17][18]. A cohort study for estimating mortality risk revealed that muscle strength is a better marker of muscle quality than muscle quantity, and grip strength provides risk estimates similar to those of quadricep strength [19]. Furthermore, researchers from several studies have recognized sarcopenia as an independent predictor of overall survival among patients undergoing surgeries such as radical cystectomy for bladder cancer and the resection of pancreatic adenocarcinoma [20].

While the pathophysiology of spinal sarcopenia is complex, several studies have discussed the mechanism which leads to skeletal muscle atrophy, including insulin resistance, myostatin activation, mitochondrial function, and glucocorticoid response [21][22][23][24][25]. Regarding the relationship between sarcopenia and obesity, elevated insulin resistance—which results in obesity and metabolic syndrome—was found in patients with sarcopenia, probably because of their reduced available insulin-response muscle [8]. Besides this, increased fat mass accompanied with obesity provoked the production of tumor necrosis factor-α, interleukin-6, and other adipokines which further promote insulin resistance and have a catabolic effect on muscle [26]. In the end, a vicious cycle is created. Myostatin, which is growth differentiation factor 8, is considered to be another contributor to sarcopenia-related obesity in the transforming growth factor-β superfamily. It is found in abundance in skeletal muscle and less in adipose tissue as well as cardiac muscle [27][28]. In the study performed by Yarasheski KE et al., their results found that serum myostatin increased with aging, which suggested that human serum myostatin might be a biomarker of age-related sarcopenia [29]. The Baltimore Longitudinal Study suggested that skeletal muscle ex vivo mitochondrial respiration parallels decline in vivo oxidative capacity, cardiorespiratory fitness, and muscle strength [30]. This finding was consistent with many human studies, which have shown that mitochondrial function declines with age, perhaps due to the exaggerated apoptotic sensitivity found in the elderly that hence leads to age-related sarcopenia [31][32][33][34]. Glucocorticoids also provide an important influence on muscle atrophy. Glucocorticoid-induced muscle atrophy is based on the activation of the ubiquitin proteasome and the lysosomal systems, which leads to muscle proteolysis. In addition, these two systems were confirmed to be mediated by the increased expression of several atrophy-related genes, such as FOXO and Atrogin-1 [35].

2. Development

Studies have demonstrated the role of sex in spinal sarcopenia [36][37]. Sylvia Kirchengast et al. conducted a population-based study to analyze gender differences in the prevalence of sarcopenia among elderly [25]. The results showed that sarcopenia was found more frequently among women in the youngest age group (<70 years), while the opposite was true in the oldest age group (>80 years) [25]. L. Tay et al. also demonstrated sex-specific pathophysiological mechanisms for sarcopenia, which may be applied to clinical intervention in patients with

sarcopenia in both sexes [24]. The results showed that malnutrition and higher triglyceride levels appear to be risk factors for sarcopenia in women and men, respectively [24]. On the other hand, therapies that block myostatin signaling may be relevant in male elderly patients, while the role of IGF-1 agonists may hold greater promise in female elderly patients [24]. Despite numerous studies having confirmed the benefits of testosterone in treating sarcopenia, including increased muscle mass and grip strength, the potential risks cannot be neglected [38][39][40]. Risks of testosterone supplementing include sleep apnea, thrombotic complications, and prostate cancer [41]. Associated with a decline in estrogen levels, the menopause also leads to decreased muscle mass and muscle strength [42].

In recent years, several original articles have discussed how spinal sarcopenia influences spinal parameters in individuals, including cervical lordosis, thoracic kyphosis, and lumbar lordosis [43][44][45][46]. Notably, these spinal changes often lead to pathologic conditions such as degenerative scoliosis and compression fractures which are associated with poor quality of life compared to their normal counterpart [33]. However, only a few studies have examined spinal sarcopenia and its pathogenesis comprehensively.

Spinal alignment may be influenced by an imbalance between the extensor and flexor back muscles and provides an objective measurement to evaluate the severity of spinal sarcopenia. Image detection methodologies have evidenced that L3 is recognized as the most ideal site for CT-based sarcopenia measurements. Spinal sarcopenia patients usually have inferior outcomes after different surgeries. Although nutrition supplementing, physical therapy, and medications have been proven to be effective, regenerative therapeutic options seem to be promising owing to their repair and regeneration potentials. Therefore, further research should focus on providing a clear understanding of the pathogenic mechanism of spinal sarcopenia and its relationship with other spinal disorders to develop therapeutic modalities in conjunction with surgical and regenerative approaches.

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