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Review

Osteosarcopenic obesity and fall prevention strategies

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ABSTRACT

Sarcopenia, obesity, and osteoporosis are three interrelated entities which may share common pathophysiological factors. In the last decades, overall survival has drastically increased. Postmenopausal women, due to their estrogen depletion, are at higher risk of developing any of these three conditions or the three, which is termed osteosarcopenic obesity. One of the most common health problems among these patients is the elevated risk of falls and fractures. Falls and fall-related injuries are one of the major causes of mortality and morbidity in older adults, and have a significant impact on social, economical and health-related costs. Several extrinsic and intrinsic risk factors have been described that play a role in the etiology of falls. A therapeutic approach to osteosarcopenic obesity aimed at the prevention of falls must include several factors, and act on those risk elements which can be effectively modified. An adequate weight-loss diet and a good nutritional intake, with an appropriate amount of vitamin D and the right protein/carbohydrates ratio, may contribute to the prevention of falls. The recommendation of physical exercise, both traditional (resistance or aerobic training) and more recent varieties (Tai Chi, Pilates, body vibration), can improve balance and positively contribute to fall prevention, whether by itself or in combination with other therapeutic strategies. Finally, a pharmacological approach, especially one focused on hormone therapy, has shown to have a positive effect on postmenopausal women's balance, leading to a decreased risk of falls.

Contents

Abbreviations: ASM, appendicular skeletal muscle mass; BMD, bone mineral density; BMI, body mass index; EWGSOP, European Working Group on Sarcopenia in Older People; DEXA, dual energy X-ray absorptiometry; MRI, magnetic resonance imaging.

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1. Introduction

During the twentieth century, global survival rates have increased radically, and it is predicted that, in the fifth decade of the twenty-first century, two billion people will be over 60 years old [1]. As the number of elderly people throughout the world increases, efforts to promote independence and decrease frailty in this demographic group will become major challenges [2].

Aging is accompanied by changes in body composition, including a decrease in both muscle and bone mass. After middle age fat mass gradually increases, while lean tissue mass decreases, thus contributing to muscle weakness in older adults [3]. One of the main risks related to such changes is the increase in the risk of falling, and therefore in the number of eventual fractures. Whether we separately consider increased fat mass (obesity), bone mass loss (osteoporosis) and muscle mass and function loss (sarcopenia) or if they appear combined as a single condition (osteosarcopenic obesity) there are risks of decreased quality of life, medical complications and reduced survival [4].

Therefore, the purpose of this document is to summarize the current literature regarding the definition, the pathophysiological factors, the diagnosis criteria, and the management of osteosarcopenic obesity, as well as its relationship with fall risk.

2. Sarcopenia

The European Working Group on Sarcopenia in Older People (EWGSOP) has defined sarcopenia as a progressive and generalized loss of skeletal muscle mass and strength, with a risk of adverse outcomes such as physical disability, reduction in physical function and poor quality of life [5]. Sarcopenia has a complex multifactorial etiology. At the molecular level, sarcopenia results from a disproportionate decrease in skeletal muscle protein synthesis and/or an increase of skeletal muscle protein breakdown [6].

Several biological markers have been described in relation to age-related muscle loss, but they are still highly unspecific [7,8]. Recently, some studies have explored the link between sarcopenia and some biomarkers such as myostatin [9], fast skeletal muscle specific troponin T [10], C-terminal agrin fragment [11] or procollagen type III *N*-terminal peptide [12]) and have looked into their relevance in the evaluation of skeletal muscle age-related modifications. At a histological level, and compared with type I myofibers, sarcopenia has been associated with overall age-related type II atrophy (fast twitch) and myofiber type conversions (type II to type I) [13].

3. Osteoporosis and sarco-osteoporosis

Osteoporosis is characterized by low bone mineral density (BMD) and the deterioration of bone tissue quality, resulting in an increased risk of fragility fractures [14]. It is well known that factors such as hormonal changes (especially a decrease in gonadal sex steroids, growth hormone and/or insulin growth factor-1, low physical activity, low dietary protein, vitamin D-deficiency, and catabolic states derived from chronic inflammatory conditions are all associated with low BMD and osteoporosis [15]. A common etiology has been advocated between osteoporosis and sarcopenia, with the intervention of genetic factors in linking muscle and bone mass [16].

Although the terms “sarco-osteopenia” or “sarco-osteoporosis” have been recently proposed [17], the link between muscle and bone mass loss, which may also be independent age-related conditions, has been extensively studied, and it has been shown that components of clinical sarcopenia, especially muscle strength (grip strength), are strongly associated with osteoporosis [18].

4. Obesity and sarcopenia

The coexistence of diminished muscle mass/strength and increased fat mass is referred to as ‘sarcopenic obesity’ [19]. With age, intramuscular and visceral fat increases, while subcutaneous fat declines leading to poor muscle quality. This contributes to muscle fatigue, fragility, and lifestyle-related diseases [20]. Excessive adiposity may be associated with a high risk of the metabolic syndrome, and evidence increasingly suggests that this risk may be elevated with the addition of low muscle mass [21]. As in sarco-osteoporosis, endocrine, vascular, immunological and lifestyle factors have been described to interplay in the multifactorial etiology of sarcopenic obesity [22].

5. Osteosarcopenic obesity

The study of osteosarcopenic obesity has become increasingly important from both a scientific and a general point of view. It has been hypothesized that the prevalence of osteosarcopenic obesity may rise in the case of chronic clinical conditions such as cancer or diabetes [4].

A link has been described between muscle, bone, and fat, and the processes that can lead to the deterioration of muscle and bone in the presence (or as a result) of excessive adiposity [23], although being underweight has been also associated with sarcopenia, osteoporosis and fractures [14,24]. It has been shown that low BMD and sarcopenia are not only conditions characterized by low BMD and low muscle mass, but that fat infiltration of both bone and muscle tissues can also occur [23]. Even though at this point the pathophysiological mechanisms related to osteosarcopenic obesity can only be based on hypotheses, the pro-inflammatory environment and the hormonal disturbances related to excessive adiposity may lead to the loss of both muscle and bone tissue through a variety of mechanisms, leading to an increase in the risk of falls and fractures and a decrease in physical activity. This situation increases adiposity in a vicious circle of progressive loss of muscle and bone accompanied by fat gain [4] (Fig. 1).

6. Diagnosis and diagnostic criteria

6.1. Sarcopenia

The diagnosis of sarcopenia requires the presence of low muscle mass in addition to low muscle strength or low physical