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Evaluation of the relationship between the severity of sarcopenia and osteoporosis: A magnetic resonance imaging and dual-energy X-ray absorptiometry study

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Abstract

This study aimed to investigate the presence of sarcopenia which was graded according to Magnetic Resonance (MR) imaging in paraspinal muscles and explore the degree of osteoporosis by bone mineral density. Lumber MR images of 69 female patients complaining of back pain and Dual-Energy X-ray absorptiometry (DXA) examinations were evaluated retrospectively. On MR imaging, the degree of sarcopenia in the paraspinal muscles of these patients was graded as normal, moderate and severe according to the simplified 3-Tier classification which is considered a Modified Goutallier classification by two radiologists. DXA examinations were categorized based on the t-score, with scores above -2.5 denoting osteopenia and scores below -2.5 indicating osteoporosis. Grades of atrophy in paraspinal muscles were found to be normal (n=15, 21.7%), moderate (n=43, 62.3%) and severe (n=11, 15.9%). The degree of paraspinal muscle atrophy was found to be lower in patients with osteopenia compared to patients with osteoporosis by both observers. (Radiologist 1 p: 0.284, radiologist 2 p: 0.047). As the degree of atrophy in the paraspinal muscles increases, the DXA t score decreases in some osteoporotic patients. Paraspinal muscle atrophy detected on lumbar MRI and DXA T scores are correlated in patients with low back pain. Identifying pathways affecting both bone and muscle units will facilitate developmental entities aiming to treat both conditions.

Keywords: Sarcopenia, magnetic resonance, dual-energy X-ray absorptiometry, osteoporosis, osteopenia

Introduction

Sarcopenia is a condition marked by the gradual and progressive decline in muscle mass and strength. It primarily impacts the elderly population, resulting in decreased mobility and a lower overall quality of life [1]. The rate of muscle loss in sarcopenia is dependent on exercise levels, comorbidities, aging, nutrition, and other accompanying clinical conditions [2,3]. Sarcopenia is characterized by the replacement of muscle fibers with fibrotic tissues, which ultimately leads to the impairment of muscle function [4]. Magnetic Resonance (MR) imaging has been reported to be effective in the evaluation of muscle mass in sarcopenia by revealing atrophy and fat infiltration in lumbar paraspinal muscles. Diminished grip strength and a slow gait speed are additional functional indicators that can be employed in the assessment of sarcopenia [5,6]. Osteoporosis is characterized by a reduction in bone mineral density, which compromises bone strength and elevates the risk of fractures, even with minor trauma. The gold standard for assessing bone mass is dual-energy X-ray absorptiometry (DXA).

Osteoporosis and sarcopenia represent significant health challenges, contributing to heightened morbidity and mortality rates within the elderly. [7]. People with these comorbidities have an increased risk of falls, fractures, and frailty, with consequences for both quality of life and morality. Thus, it is vital that these comorbidities are promptly diagnosed to prevent their clinical onset.

The aim of this study was to investigate the relationship between the grade of sarcopenia and the degree of osteoporosis in patients with low back pain based on lumbar MR imaging of the paraspinal muscles and DXA t scores.

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Material and Methods

Study population

The research protocol received approval from the Ethics Committee at our university, as per the established procedures. Lumbar MR images of 69 female patients complaining of back pain and DXA examinations were evaluated retrospectively between December 2015 and December 2016. Patients with history of lumbar surgery, tumor, myopathy, muscular dystrophy, vertebral fractures, spinal deformity and scoliosis were excluded from the study. All MR images of sixty-nine patients (69 women; mean age 61.4±9.7 years; range, 44-84 years) were evaluated by two radiologist.

MR imaging

MR imaging used two 1.5 T superconducting magnets (GE Signa Excite HD; GE Medical Systems, USA, Ingenia; Philips Medical Systems, Best, Netherlands). Axial T2W TSE sequence parameters: TR/TE, 2873/100 ms; matrix, 288×231; field of view, 20 cm; slice thickness, 6 mm; slice spacing, 0.3 mm.

The images of all patients were evaluated on the "GE Advantage Windows Workstation 4.2" and "Philips Ingenia 1.5 T version 4.1.1, Eindhoven, Netherlands" workstation.

Image analysis

Axial T2W TSE sequences were used to evaluate degree of sarcopenia in paraspinal muscles were used in the MR imaging. All patients was graded as mild, moderate and severe according to the simplified 3 -Tier classification which is considered a Modified Goutallier classification. Simplified 3 -Tier classification method was used to grade the atrophy in paraspinal muscles (psoas major, multifidus, quadratus lumborum, and erector spinae) at L3-L4 level by MR imaging. Normal/Mild: <10% fat, Slight/Moderate: <50% fat, Severe: >50% fat (Figures 1,2 and 3).

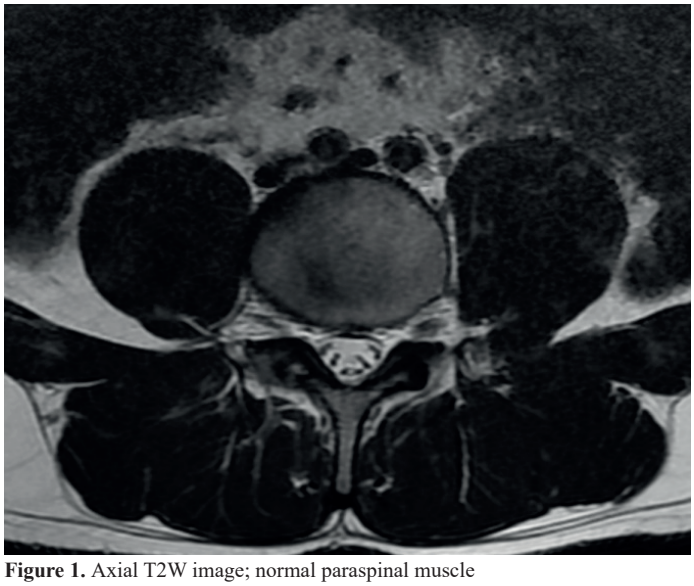

Figure 1. Axial T2W image; normal paraspinal muscle

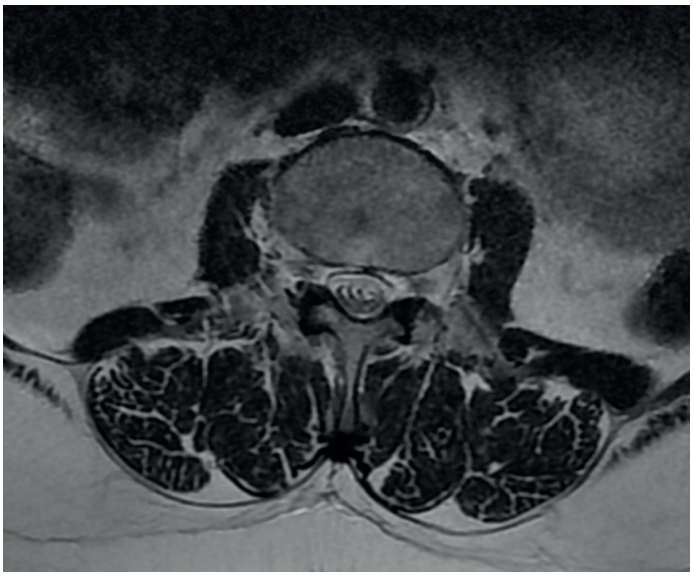

Figure 2. Axial T2W image; moderate athrophy of paraspinal muscle

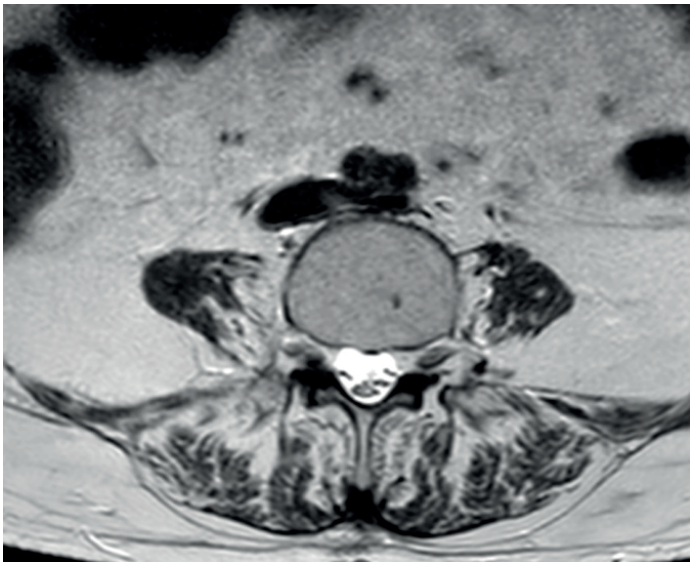

Figure 3. Axial T2W image; severe athrophy of paraspinal muscle

DXA are recommended for the evaluation of bone burden. DXA examinations were classified based on the t-score, with scores above -2.5 categorized as osteopenia and scores below -2.5 classified as osteoporosis. [8]. The relationship between sarcopenia degrees in lumbar MR images of the study group patients and their DXA t scores was investigated. Body mass indexes (BMI) and Subcutaneous fat tissue thicknesses of the patients in the study group were measured. These values were compared with the degrees of sarcopenia.

Statistical analysis

Data analysis was carried out utilizing statistical software, specifically SPSS 21 for Windows, based in Chicago, IL. Descriptive statistics were presented as mean values with standard deviations for continuous variables, while categorical variables were expressed as percentages. Categorical variables

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were assessed using the chi-square test, and inter-observer reliability analysis was conducted using the kappa statistic. A significance level of $p<0.05$ was adopted to determine statistical significance.

Results

According to a qualitative evaluation of paraspinal muscle atrophy by two observers, the degree of atrophy in osteopenia patients was lower than that in osteoporosis patients (radiologist 1: p=0.284; radiologist 2: p=0.047) (Table 1). As the degree of paraspinal muscle atrophy increased, the DXA t score decreased in some osteoporotic patients (radiologist 1: 50%, radiologist 2: 55%). Normal paraspinal muscles were seen more in osteopenia than osteoporosis.

In terms of subcutaneous fat tissue thicknesses, there were no statistically significant difference between the observers' measurements according to the simplified three-tier classification used in this study (radiologist 1: p=0.728; radiologist 2: p=0.624). Interobserver agreement was 85.5% (kappa value: 0.738; p=0.001).

When examining the correlation between patients' BMI values and sarcopenia grades, it was observed that individuals in the severe group had significantly higher BMI values compared to those in the other groups (p=0.042). The results revealed no significant correlation between subcutaneous fat tissue thickness and the degree of sarcopenia (p>0.05).

Table 1. The relationship between simplified 3-Tier classification and t score

Simplified 3-Tier classification	t score<-2.5 (osteoporosis)		t score>-2.5 (osteopenia)	
Observers	**R1**	**R2**	**R1**	**R2**
Normal	13.3% (n: 4)	6.7% (n: 2)	28.2% (n: 11)	30.8% (n: 12)
Moderete	66.7% (n: 20)	70% (n: 21)	59% (n: 23)	%51.3 (n: 20)
Severe	20% (n: 6)	23.3% (n: 7)	12.8% (n: 5)	%17.9 (n: 7)

*R1: radiologist 1, R2: radiologist 2, n: number patients, R1 p: 0.284, R2 p: 0.047

Discussion

The European Working Group on Sarcopenia in Older People has defined sarcopenia as a condition characterized by both diminished muscle mass and reduced muscle strength or performance [9]. A gradual decline in muscle mass is observed with advancing age, with documented reports indicating a 6% reduction occurring approximately every 10 years starting from middle age and beyond [10]. Primary sarcopenia refers to aging-related loss of muscle mass, and secondary sarcopenia refers to disease-related loss of muscle mass (e.g., organ failure, malignancy, and neurodegenerative diseases) and immobility [9].

Baumgartner et al. defined sarcopenia as an appendicular muscle mass below 2 standard deviations (SDs) of the mean in young adults (muscle mass/m^2). This definition (appendicular muscle mass/height^2) was strongly associated with BMI values [11]. Jansen et al. used the skeletal muscle index (SMI) (SMI=skeletal muscle mass/body mass×100) to determine the prevalence of sarcopenia in an elderly American population [12]. In their study, they divided sarcopenia patients into two classes: class 1 and class 2. In their study, the SMI classified class 1 sarcopenia as below 1 SD-2 SD as average value and class 2 sarcopenia as below 2 SD as a mean value.

In our study, we classified sarcopenia into three categories (normal, moderate, and severe) based on lumbar MR imaging of the paraspinal muscles and a simplified three-tier classification. Our findings indicated that individuals classified in the severe group had notably higher BMI values compared to those in the normal and moderate groups.

Studies exist suggesting that higher BMI is protective against sarcopenia; however, these studies typically encompass patients with secondary sarcopenia [13,14]. Our study, in contrast, focuses on patients with primary sarcopenia.

Sarcopenic obesity is defined as a combination of sarcopenia and obesity [15]. Sarcopenic obesity is characterized as the coexistence of both sarcopenia and obesity. A study by Wagenaar et al. showed that the prevalence of sarcopenic obesity is higher in women and that it increases after the age of 50 [16]. Our study also comprises a female patient group with an average age of 61.4±9.7 years. We believe that the BMI values in patients with sarcopenic obesity are higher, especially in those with severe sarcopenia.

MR imaging distinguishes fat and muscle from other soft tissues. However, various reasons, such as the high cost and long shooting time, make it difficult for MR imaging to be used for sarcopenia research. Osteoporosis is defined by reduced bone mass, deterioration of bone tissue, and an elevated vulnerability to bone fractures. DXA is used to determine bone mineral density, although it has low radiation, and it is used to evaluate relative muscle mass [17-19]. In our study, we investigated whether there exists a correlation between osteopenia and osteoporosis and the severity of sarcopenia. The results revealed a negative correlation between the DXA t scores and degree of sarcopenia, with the severity of sarcopenia increasing in accordance with a decrease in the t score.

The association of osteoporosis and sarcopenia is defined 'osteosarcopenia' [20]. The etiopathogenesis of both conditions includes common related factors such as genetics, alcohol and cigarette use, physical activity, diet, age, gender and ethnicity. There are different studies in the literature regarding

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the prevalence of osteosarcopenia. In their study, Huo et al. reported the prevalence of osteosarcopenia as 50% [21]. Wang et al. reported the prevalence of osteosarcopenia in women as 15.1% [22]. Locquet et al. stated that sarcopenic individuals have a 4-fold higher risk of having accompanying osteoporosis [23]. Our findings similarly show that the presence and degree of sarcopenia is higher in osteoporotic patients and that the two conditions are related to each other.

Our study had some limitations. First, it was retrospective. Second, we graded sarcopenia visually using a simplified three-tier classification system according to the degree of paraspinal muscle atrophy. Finally, we did not calculate the skeletal mass index in the sarcopenia patients.

Conclusion

In patients with low back pain, paraspinal muscle atrophy detected on lumbar MR imaging was correlated with DXA t scores. Muscle strength is not exclusively contingent on muscle mass, and the association between strength and mass is not linear. Therefore, employing both criteria is a more rational approach for diagnosis. This study concludes that identification of pathways affecting both bone and muscle unit will facilitate the development entities aiming to treat both conditions.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Pamukkale University Faculty of Medicine Ethics Committee was approved for the study(Number:60116787-020/13247).

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