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Original article

Does Spine-Specific Sarcopenia Increase the Risk of Osteoporotic Vertebral Compression Fracture? A Retrospective MRI-Based Study

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Abstract

This study aimed to investigate the association between spine-specific sarcopenia, assessed using magnetic resonance imaging measurements of the multifidus muscle, and the risk of osteoporotic vertebral compression fractures in older adults.
This retrospective study included 85 patients aged 60 years or older who underwent both lumbar spine magnetic resonance imaging and bone mineral density measurement between January 2020 and 2025. Patients were assigned to fracture (n=43) or control (n=42) groups according to the presence of osteoporotic vertebral compression fractures. Spine-specific sarcopenia was evaluated using the cross-sectional area and fat infiltration of the multifidus and psoas muscles. The percentage of muscle fibers was calculated by subtracting the fat area from the total cross-sectional area. Statistical analyses compared demographic, radiological, and clinical parameters between groups.
There were no significant differences between groups regarding age, sex, Body mass index, or psoas index. However, spinal T-scores were significantly lower in the fracture group. The cross-sectional area of the multifidus muscle at L4–5 and L5–S1 levels was significantly higher in the fracture group. Notably, the percentage of muscle fibers of the multifidus muscle was significantly lower in the fracture group at both levels, indicating increased fat infiltration. Multivariate analysis demonstrated that reduced percentage of muscle fibers was independently associated with an increased risk of osteoporotic vertebral compression fractures, regardless of bone mineral density.
Reduced muscle fiber percentage and increased fat infiltration in the multifidus muscle are significant risk factors for osteoporotic vertebral compression fractures independent of bone mineral density. These findings highlight the importance of assessing paraspinal muscle quality for the evaluation and management of osteoporotic fracture risk in the elderly.

Keywords: spine-specific sarcopenia, osteoporotic vertebral fracture, bone mineral density, magnetic resonance imaging, paraspinal muscle.

1. Introduction

Sarcopenia, first described by Irwin Rosenberg in 1980, is a musculoskeletal disorder characterized by progressive loss of muscle mass and muscle function [1,2]. Its prevalence ranges from 24% to 56% among

individuals over 60 years of age, and sarcopenia is detected in approximately 44% of elderly patients undergoing orthopedic surgery [3]. The identification of sarcopenia is of major clinical importance, as it is associated with increased risk of falls, fractures, loss of mobility, hospitalization, postoperative morbidity, and mortality [1,2,4]. Sarcopenia can develop not only due to aging but also as a consequence of factors such as physical inactivity, malnutrition, neuromuscular disorders, insulin resistance, and chronic inflammation [1, 5-7]. Immobility related to severe spinal pathologies, particularly lumbar spinal stenosis, is also an important cause of sarcopenia [8].

The European Working Group on Sarcopenia in Older People (EWGSOP2) has recently defined sarcopenia as a "progressive and generalized skeletal muscle disorder associated with increased likelihood of adverse outcomes" [3]. According to EWGSOP2, diagnosis is based on low muscle strength, reduced muscle quantity, and poor physical performance. In spinal surgery, sarcopenia is frequently discussed in the context of paraspinal muscle atrophy. This so-called "spine-specific sarcopenia" is a unique entity, referring to muscle loss predominantly in stabilizing muscles such as the multifidus and psoas [9].

Both generalized sarcopenia and localized paraspinal muscle atrophy are characterized by decreased muscle quality, although their relationship remains unclear. In patients undergoing spinal surgery, conditions such as degenerative disc disease and spinal stenosis may result in localized muscle atrophy, affecting clinical outcomes [9,10]. Therefore, we hypothesized that age-related sarcopenia results in both quantitative and qualitative loss in paraspinal muscles, which may be associated with the incidence of osteoporotic vertebral compression fractures (OVCFs).

2. Materials and methods

This retrospective study included patients aged 60 years or older who underwent both lumbar spine magnetic resonance imaging (MRI) and bone mineral density (BMD) measurement between January 2020 and 2025. Institutional ethics committee approval and written informed consent were obtained. Exclusion criteria were a history of lumbar spine surgery, malignancy, spinal infection, severe scoliosis, and systemic diseases affecting bone density.

Sample size was calculated using G*Power software, with 80% power, an effect size of 0.5, and an allocation ratio of 0.5, resulting in a total of 85 participants (43 in the fracture group and 42 in the control group). Patients were classified into OVCF (+) and OVCF (−) groups according to BMD and MRI findings.

Diagnosis of sarcopenia was based on the criteria recommended by the EWGSOP2, including handgrip strength, psoas muscle index (PMI), gait speed, and the five-times-sit-to-stand test 3. Spine-specific sarcopenia was assessed using MRI-based measurements of the cross-sectional area (CSA) and fat infiltration of the psoas and multifidus muscles [9,11]. On axial T2-weighted MRI, bilateral psoas muscle CSA was manually measured at the L3 vertebral level, and PMI (cm^2/m^2) was calculated by dividing the sum of both sides' CSA by height squared. The CSA of the multifidus muscle was measured at the L4–5 and L5–S1 levels. Fat infiltration was determined using threshold analysis. The percentage of muscle fibers (PMF) was calculated by subtracting the fat area from the total CSA and multiplying the result by 100] (Figure 1) [11].

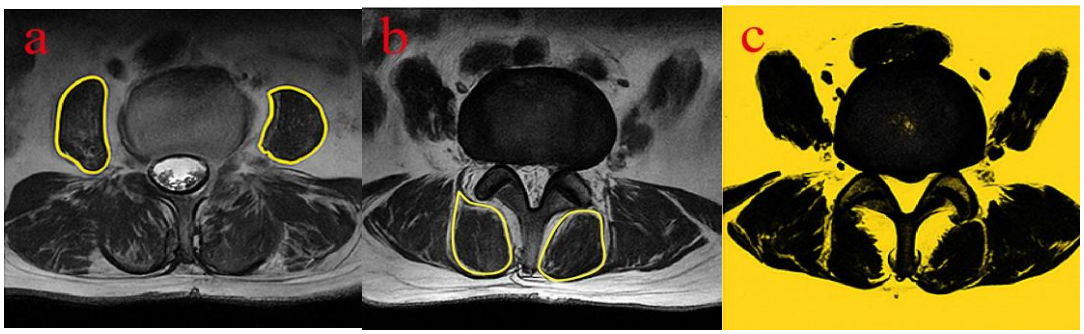

Figure 1 – Measurement of psoas and multifidus muscles on lumbar spine MRI. a) CSA of the psoas muscle was manually traced at the upper endplate of the L3 vertebra on axial T2-weighted MRI. b) The CSA of the multifidus muscle was measured at the L4–5 and L5–S1 levels. c) Fat area within the multifidus muscle was visualized using a threshold-based pseudocoloring technique. PMF was calculated by subtracting the fat area from the total CSA and multiplying by 100 [11]

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Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Normally distributed data were presented as mean ± standard deviation (SD), whereas non-normally distributed variables were expressed as median (minimum–maximum). For comparisons between two independent groups, the independent samples t-test was used for parametric data, and the Mann–Whitney U test for nonparametric data. Categorical variables were analyzed using the chi-square test. Differences between groups in terms of age, gender, body mass index (BMI), BMD, psoas index, CSA, PMF of the multifidus muscle were evaluated. A p-value < 0.05 was considered statistically significant in all analyses.

3. Results

A total of 85 patients were included in the study: 43 in the control group and 42 in the osteoporotic vertebral compression fracture (OVCF) group. The median ages in the control and fracture groups were 72.58 (60–85) and 73.44 (61–88) years, respectively, with no statistically significant difference between the groups (p > 0.05, Table 1). The gender distribution was similar in both groups (control: 53% female, 47% male; fracture: 52% female, 48% male; p = 1.00).

The spinal T-score was significantly lower in the fracture group compared to the control group (−2.51 ± 2.13 vs. −0.85 ± 1.21; p < 0.05). No statistically significant difference was found between the groups in terms of BMI and psoas index (p >0.05 and p = 0.18, respectively).

The cross-sectional area (CSA) of the multifidus muscle at both the L4–5 and L5–S1 levels was significantly greater in the fracture group compared to the control group (L4–5: 1269.89±15.27 vs. 1179.12±24.75; L5–S1: 1381.46 ± 87.31 vs. 1324.09 ± 92.07; both p < 0.05; Table 1). In contrast, PMF in the multifidus muscle was significantly lower in the fracture group than in the control group at both levels (L4–5: 53.87 ± 24.75 vs. 74.89 ± 12.23; L5–S1: 56.89 ± 14.31 vs. 69.97 ± 13.25; both p < 0.05).

Table 1 – Demographic and Clinical Characteristics of the Study Groups

	Control Group (n=43)	**Fracture Group (n=42)**	**p value**
Age	72.58 (60-85)	73.44 (61-88)	0.17
Gender (F/M), n (%)	23 (53%) / 20 (47%)	23 (53%) / 20 (47%)	1.00
BMI (kg/m²)	24.53 ± 3.44	22.87 ± 3.28	0.10
Spinal T-score	-0.85 ± 1.21	-2.51 ± 2.13	<0.05*
Psoas index (cm²/m²),	5.21 ± 1.13	4.72 ± 1.23	0.18
Multifidus at L4–5 CSA (cm²)	1179.12 ± 24.75	1269.89 ± 15.27	<0.05*
Multifidus at L4–5 PMF (%)	74.89 ± 12.23	53.87 ± 24.75	<0.05*
Multifidus at L5–S1 CSA (cm²)	1324.09 ± 92.07	1381.46 ± 87.31	<0.05*
Multifidus at L5–S1 PMF (%)	69.97 ± 13.25	56.89 ± 14.31	<0.05*

Note: Data are presented as mean ± standard deviation (SD) or n (%), as appropriate. Statistically significant difference (p < 0.05)

4. Discussion

The most significant finding of this study is that the reduction in the PMF and the increase in fat infiltration in the multifidus muscle are significantly associated with an increased risk of OVCF. Furthermore, the CSA of the multifidus muscle was found to be significantly higher in the fracture group compared to the control group. However, despite this increase in CSA, the decrease in the percentage of muscle fibers emerged as the main determinant. Our analysis indicates that the combined assessment of traditional parameters, such as bone mineral density (BMD), with muscle quality (PMF) provides a more sensitive approach for

predicting spinal fracture risk. In particular, our results showed that increased fatty infiltration in the multifidus muscle elevated the risk of vertebral fracture even when BMD was in the osteopenic range [11]. These findings highlight that muscle quality is a critical determinant for the development of OVCF, independent of conventional approaches based solely on BMD measurements.

In clinical practice, BMD measurement is widely used to diagnose osteopenia and osteoporosis and to estimate fracture risk [3]. However, as observed in our study, vertebral fractures may still occur in some patients whose BMD is within or above the osteopenic threshold. This suggests that relying exclusively on BMD for fracture risk assessment may be insufficient. The literature similarly emphasizes the necessity of considering additional risk factors such as muscle quality, muscle strength, and fat infiltration [1,3]. In our study, a reduced PMF and increased fat infiltration in the multifidus muscle were shown to significantly increase OVCF risk, independent of BMD [3,9]. This finding further underscores the importance of objectively evaluating muscle quality in clinical management, with a focus not only on bone density but also on muscle structure and function.

Muscle quality and, in particular, intramuscular fat infiltration (myosteatosis) are recognized as key biomarkers of aging and frailty [1,12]. Increased fat content and decreased muscle fiber percentage in the multifidus muscle may impair spinal stability and negatively affect bone–muscle interaction [7,9,11]. Previous studies have demonstrated that increased fat infiltration in the back extensor muscles is strongly associated with increased risk of falls, impaired balance, and ultimately fractures [6,8,12]. In our study, high fat infiltration and a low muscle fiber percentage in the multifidus muscle were also found to significantly increase the risk of OVCF independently of BMD values. This suggests that myosteatosis and muscle quality should be considered more comprehensively—beyond conventional approaches based solely on BMD measurements—when assessing the risk of osteoporotic fractures.

BMD is a commonly used quantitative marker for determining osteoporotic fracture risk [3]. However, the accuracy of BMD measurements may be compromised in elderly individuals due to degenerative spinal changes, calcified ligaments, and other technical limitations [1]. Therefore, fracture risk assessment based only on BMD can be inadequate, especially in older adults and those with degenerative spinal disease. In our study, the percentage of muscle fibers (PMF) in the multifidus muscle was shown to play a significant role in the development of OVCF, independent of BMD. This finding indicates that the objective evaluation of muscle quality can make a significant contribution to the identification of fracture risk and the development of preventive strategies [11,12].

This study has several limitations. First, the evaluation of the multifidus muscle was limited to the L4–5 and L5–S1 levels, and other paraspinal muscle groups were not analyzed. Additionally, due to the retrospective design, potential confounding factors such as physical activity level, comorbidities, and treatment history could not be fully controlled. In the future, larger and prospective cohort studies are needed to more comprehensively evaluate the effects of multifidus muscle quality and fat infiltration on the risk of OVCF. Furthermore, multivariate regression analysis was not performed, and therefore, the independent effects of potential confounders could not be fully evaluated.

6. Conclusions

Spinal sarcopenia and fat infiltration may affect OVCFs in elderly patients independently of BMD. Therefore, clinicians should consider the condition of paraspinal muscles, in addition to BMD, when assessing fracture risk and planning preventive strategies in the elderly.

Conflicts of Interest. The authors declare no conflicts of interest.

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Омыртқаға тән саркопения остеопороздық компрессиялық омыртқа сынуының қаупін арттырады ма? МРТ негізіндегі ретроспективті зерттеу

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Түйіндеме

Зерттеудің мақсаты: егде жастағы адамдарда омыртқаның көпбөлікті бұлшықетінің МРТ арқылы өлшенген көрсеткіштері негізінде бағаланған омыртқаға тән саркопения мен остеопороздық омыртқа сынуының даму қаупі арасындағы байланысты зерттеу.

Бұл ретроспективті зерттеуге 2020–2025 жылдар аралығында бел омыртқасының МРТ зерттеуін және сүйек минералдық тығыздығын анықтаудан өткен 60 жастан асқан 85 науқас енгізілді. Науқастар остеопороздық омыртқа сынықтарының болуына қарай екі топқа бөлінді: сынуы бар тобы (n=43) және бақылау тобы (n=42). Омыртқаға тән саркопения көпбөлікті және бел бұлшықеттердің көлденең қимасының ауданы мен май инфильтрациясының деңгейі арқылы бағаланды. Бұлшықет талшықтарының пайыздық үлесі жалпы көлденең

қиманың ауданынан майлы тіннің ауданын алып тастау арқылы есептелді. Статистикалық талдау кезінде топтар арасындағы демографиялық, радиологиялық және клиникалық көрсеткіштер салыстырылды.

Топтар арасында жас, жыныс, дене салмағының индексі және бел бұлшықетінің индексі бойынша айтарлықтай айырмашылық анықталған жоқ. Алайда омыртқаның Т- көрсеткіштері сынуы бар тобында едәуір төмен болды. L4–5 және L5–S1 деңгейлерінде көпбөлікті бұлшықеттің көлденең қимасының ауданы сынуы бар тобында айтарлықтай жоғары болды. Атап айтқанда, осы деңгейлерде көпбөлікті бұлшықет талшықтарының пайыздық үлесі сынуы бар тобында едәуір төмен болып, май инфильтрациясының артқанын көрсетті. Көпфакторлы талдау нәтижесінде бұлшықет талшықтарының төмен пайыздық үлесі сүйек минералдық тығыздығынан тәуелсіз түрде остеопороздық омыртқа сынуының жоғары қаупімен байланысты екені анықталды.

Көпбөлікті бұлшықеттегі талшық үлесінің азаюы мен май инфильтрациясының артуы сүйек минералдық тығыздығына тәуелсіз остеопороздық омыртқа сынуының маңызды қауіп факторлары болып табылады. Бұл нәтижелер егде жастағы адамдарда остеопороздық сыну қаупін бағалау мен басқаруда параспинальды бұлшықет сапасын бағалаудың маңыздылығын айқындайды.

Түйін сөздер: омыртқаға тән саркопения, остеопороздық омыртқа сынуы, сүйек минералдық тығыздығы, МРТ, параспинальды бұлшықет.

Повышает ли специфическая для позвоночника саркопения риск остеопоротического компрессионного перелома позвонков? Ретроспективное исследование на основе данных МРТ

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Резюме

Целью данного исследования было изучение взаимосвязи между специфической для позвоночника саркопенией, оцененной по данным МРТ многораздельной мышцы, и риском остеопоротических компрессионных переломов позвонков у пожилых пациентов.

В ретроспективное исследование были включены 85 пациентов в возрасте 60 лет и старше, которым в период с января 2020 по 2025 год проводилась МРТ поясничного отдела позвоночника и измерение минеральной плотности кости. В зависимости от наличия остеопоротического компрессионного перелома позвонка пациенты были распределены на группу переломов (n=43) и контрольную группу (n=42). Специфическая для позвоночника саркопения оценивалась по площади поперечного сечения и степени жировой инфильтрации многораздельной и поясничной мышц. Процент мышечных волокон рассчитывали путем вычитания площади жира из общей площади поперечного сечения. В ходе статистического анализа сравнивались демографические, радиологические и клинические показатели между группами.

Значимых различий между группами по возрасту, полу, индексу массы тела или индексу поясничной мышцы не выявлено. Однако значения Т-критерия позвоночника были значительно ниже в группе переломов. Площадь поперечного сечения многораздельной мышцы на уровнях L4–5 и L5–S1 была значительно выше в группе переломов. При этом процент мышечных волокон многораздельной мышцы был достоверно ниже в группе переломов на обоих уровнях, что указывает на повышенную жировую инфильтрацию. Многофакторный анализ показал, что снижение процента мышечных волокон независимо связано с повышенным риском остеопоротических компрессионных переломов позвонков, независимо от минеральной плотности кости.

Снижение процента мышечных волокон и увеличение жировой инфильтрации в многораздельной мышце являются значимыми факторами риска остеопоротических компрессионных переломов позвонков, независимыми от минеральной плотности кости. Полученные результаты подчеркивают важность оценки качества паравертебральных мышц при диагностике и ведении пациентов с риском остеопоротических переломов в пожилом возрасте.

Ключевые слова: специфическая для позвоночника саркопения, остеопоротический перелом позвонка, минеральная плотность кости, магнитно-резонансная томография, паравертебральные мышцы.