The correlation of psoas muscle index with bone mineral density and vertebral fractures in postmenopausal women

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Article

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Abstract

Purpose

To investigate the correlation of psoas muscle index (PMI) with bone mineral density (BMD) and vertebral fractures in postmenopausal women

Methods

A total of 184 postmenopausal female patients who were admitted to our hospital from January 2021 to December 2021 were included in the study. We measured the cross-sectional area of the psoas major on both sides (at the level of the lower border of the Lumbar (L)3 vertebrae) by computed tomography (CT), and then calculated the PMI. We measured the BMD of the study subjects’ lumbar spine and hip joint by dual-energy X-ray absorptiometry (DXA). According to the T value, the subjects were divided into the osteoporosis group (T value ≤ -2.5) and the non-osteoporosis group (T value > -2.5). Then, they were further grouped according to whether they had vertebral fractures. The data was collected and then statistically analyzed.

Results

Height, weight, body mass index (BMI), bilateral psoas major area, and PMI of the non-osteoporosis group were higher than those of the osteoporosis group (P < 0.05). There was no significant difference in age, age of amenorrhea, and incidence of spinal fractures between the two groups (P > 0.05). BMD of the L1-3 vertebrae, femoral neck, and femoral trochanter was positively correlated with the PMI (P < 0.05). For non-osteoporosis subjects, the PMI of the vertebral fracture group was lower than that of the non-vertebral fracture group (P < 0.05). There was no significant difference in the PMI for patients with osteoporosis between the vertebral fracture and non-vertebral fracture groups (P > 0.05).

Conclusions

Postmenopausal women with osteoporosis have lower skeletal muscle mass than those without osteoporosis. Decreased lumbar spine and hip BMD are associated with decreased skeletal muscle mass in postmenopausal women. Sarcopenia may be an independent risk factor for spinal fractures in postmenopausal women without osteoporosis.

Introduction

Menopause is a physiological condition related to age. It is related to the natural decline in estrogen levels. It can lead to a gradual decrease in muscle mass, strength, and bone mineral density (BMD), which can eventually cause osteoporosis and sarcopenia [1].
Osteoporosis seriously affects the elderly, especially older women. It can lead to decreased BMD and bone quality, bone microstructure destruction, bone fragility, and fracture incidence [2]. Vertebral fracture, considered a sign of osteoporosis, is the most common fragility fracture. It seriously affects the daily life of older women.

Sarcopenia is a progressive decrease in body muscle mass and/or decrease in muscle strength/muscle physiological function associated with age [3]. It is considered one of the main causes of functional limitation and exercise dependence in the elderly. The psoas muscle index (PMI) evaluates skeletal muscle mass and diagnoses sarcopenia through computed tomography (CT). The PMI is positively correlated with the total skeletal muscle volume and can be used to diagnose sarcopenia [4, 5]. A recent study showed that skeletal muscle mass measured by CT in patients with spinal degeneration was positively correlated with BMD. The PMI was considered a useful tool for diagnosing osteoporosis and assessing fracture risk [6]. Zanchetta et al. found that sarcopenia was associated with increased falls, osteoporosis, and vertebral fractures in postmenopausal women [7]. We investigated the correlation between PMI and BMD in postmenopausal women. We hypothesized that decreased skeletal muscle mass might impact the incidence of spinal fractures in postmenopausal women. The study explores the effect of skeletal muscle mass on BMD and spinal fractures in postmenopausal women.

**Materials And Methods**

**Subject**

Our study excluded patients who had taken drugs that could affect bone metabolism, severe degeneration of the lumbar spine, hip replacement, severe hip osteoarthritis, rheumatoid arthritis, a history of hysterectomy, oophorectomy, and history of thyroidectomy. Subjects with lumbar spine CT and BMD examinations with an interval of more than three months were also excluded. A total of 184 postmenopausal women who visited our hospital from January 2021 to December 2021 with 55 to 90 years were enrolled in the study.

We collected clinical data of the subjects, including age, menopausal age, height (m), weight (kg), and history of vertebral fractures, through electronic medical records and imaging diagnostic reports. Body mass index (BMI) was calculated by dividing weight by height squared (kg/m²).

**Measurement of psoas index**

Thoracic 12 (T12)/lumbar 3 (L3) to sacral 1 (S1) vertebral bodies of subjects were scanned by a 128-slice dual-source CT scanner (Siemens, Germany). CT scanning parameters: tube voltage 110kV, tube current 100mA, layer thickness 1mm. Two radiologists selected the cross-sectional CT images of the middle of the L3 vertebrae through localization images on the image post-processing workstation (Heart Shadow International) and manually delineated the border of the bilateral psoas primary muscles. They were blinded to the BMD of the subjects and how they were grouped. The software automatically calculated
the bilateral psoas major muscle's cross-sectional area (mm²) (Figure 1). The formula for calculating the PMI: divide the total area of the bilateral psoas by the square of height (mm²/m²).

**Measurement of bone mineral density**

BMD of the lumbar spine and one side of the hip joint was measured by dual-energy X-ray absorptiometry (DXA) (GE Lunar Prodigy). Measurement process: The subjects lay supine in the middle of the examination table with their hands flat on both sides of the body. The posterior-anterior program scanned the spine and hip joints. After scanning, the system will automatically display the data. The collected data included T values and BMD of the L1-4 vertebrae, femoral neck, and femoral trochanter. We divided the subjects into two groups according to T-value, the osteoporosis group (T value ≤ -2.5) and the non-osteoporosis group (T value > -2.5).

**Statistical analysis**

We use Statistical Product and Service Solutions 19.0 software package for statistical analysis. Measurement data were expressed as mean±standard deviation. Enumeration data were expressed as numbers (percentages). The Kolmogorov-Smirnov test was used to test whether the data conformed to a normal distribution. The measurement data of the two groups were compared using the independent sample t-test. Pearson correlation analysis was used for data subject to normal distribution. Spearman correlation analysis was used for data that did not obey the normal distribution. The comparison of sample rates between the two groups was performed using the chi-square test or Fisher's exact test. P<0.05 was considered statistically significant.

**Results**

**Demographic characteristics in the osteoporosis group and the non-osteoporotic group**

A total of 184 postmenopausal women were included in this study. There were 89 patients in the osteoporosis group, with 71 years (range 56-86 years). There were 95 patients in the non-osteoporotic group, including 62 patients with osteopenia (-2.5 < T value ≤ -1) and 33 patients with normal bone mass (T value > -1), and the mean age was 70 years (range 55-90 years).

Height, weight, BMI, bilateral psoas area, PMI, BMD of the L1-4 vertebral body, BMD of the femoral neck, and femoral trochanter in the non-osteoporosis group were higher than those in the osteoporosis group, and the difference was statistically significant (P<0.05). There were no significant differences in age, age of menopause, and incidence of spinal fractures between the two groups (P>0.05). (Table 1)

**Correlation between psoas index and bone mineral density**

The PMI was positively correlated with BMD of the L1-3 vertebrae, femoral neck, and femoral trochanter (P<0.05). There was no significant correlation between the PMI and L4 BMD (P>0.05) (Table 2 and...
Figure2). In other words, the BMD of the lumbar 1-3 vertebral body, the femoral neck, and the femoral trochanter decreased with a decrease in the PMI.

**Correlation between psoas index and spinal fractures**

There were 57 osteoporotic postmenopausal women with spinal fractures. There were 50 non-osteoporotic postmenopausal women with spinal fractures, including 37 with low bone mass and 13 with normal bone mass, as shown in Table 3.

There were 57 osteoporotic patients with spinal fractures and 32 osteoporotic patients without spinal fractures, and there was no significant difference in their PMI (t value = 0.846, P>0.05). Among the non-osteoporotic patients, 50 had vertebral fractures, and 45 had no vertebral fractures. For non-osteoporotic patients, the PMI in the vertebral fracture group was lower than that in the non-vertebral fracture group, and the difference was statistically significant (t value = -2.155, P<0.05)(figure 3).

**Discussion**

Our study showed that the height, weight, and BMI of the non-osteoporotic group were higher than those of the osteoporotic group. It suggests that the protective effect of high body weight is probably due to the greater loading on bones. Other studies suggest that body weight and BMI may be protective factors for BMD [8, 9]. The mechanism may be that the decreased level of sex hormone-binding globulin and the increase of free sex hormones positively affect bone mineral density in obese patients [10]. In addition, BMI can positively affect on BMD by increasing muscle and fat.

Sarcopenia and osteoporosis are age-related declines in the quantity and quality of muscles and bones. Both of them share the same pathophysiological basis and have a similar adverse effect on the health of older adults. Our results showed that the bilateral psoas area and PMI of postmenopausal women without osteoporosis were higher than those in the osteoporosis group (P < 0.05). Except for BMD of the L4 vertebrae, the PMI was positively correlated with BMD of the L1-3 vertebral body, femoral neck, and femoral tuberosity (P < 0.05). These results indicate that reduction in skeletal muscle volume and mass as the main pathological feature of sarcopenia is associated with decreased lumbar spine and hip BMD in postmenopausal women. There is a close relationship between sarcopenia and osteoporosis. The mechanism is relatively complex, mainly including the influence of the mechanical load of muscle contraction on the mechanical force of bone and the complex and precise endocrine regulation mechanism between muscle and bone [11–13]. The mechano-regulatory system hypothesis states that muscle contraction directly provides mechanical bone stimulation, promoting osteogenesis [14]. Both muscles and bones have endocrine functions and are regulated by a variety of factors, including some endocrine hormones (growth hormone, insulin-like growth factor-1, glucocorticoids), growth factors (fibroblast growth factor-2, myogenesis Inhibin), extracellular matrix molecules (metalloproteinase-2), inflammatory cytokines (interleukin-6, interleukin-7), vitamin D [15].
Several studies have reported the association between sarcopenia and osteoporotic vertebral compression fracture. A survey by Wang et al. showed that sarcopenia was an independent risk predictor of refracture in patients with osteoporotic vertebral compression fractures [16]. Iolascon et al. showed that the incidence of sarcopenia increased with the number of fractured vertebral bodies in women with osteoporosis [17]. Tetsuro et al. showed that sarcopenia and decreased calf muscle mass were more common in patients with acute osteoporotic vertebral compression fractures than in patients without osteoporotic vertebral compression fractures [18]. There are few studies on the association of sarcopenia with non-osteoporotic vertebral fractures in older women. Our study found that the PMI of the vertebral fracture group in the non-osteoporotic patients was lower than that of the non-vertebral fracture group (P < 0.05), in contrast, the difference in the PMI between the two groups in the osteoporotic patients was not significant (P > 0.05). This suggests that sarcopenia may be a risk factor for vertebral fractures in postmenopausal women without osteoporosis. Therefore, we hypothesize that delaying sarcopenia progression and improving skeletal muscle function, which would reduce the risk of vertebral fractures in postmenopausal women with osteopenia and normal bone mass, may not help prevent vertebral fractures in postmenopausal women with osteoporosis.

The study also has some limitations. The sample included in this study was small, and the proportion of postmenopausal women with osteoporosis, osteopenia, and normal bone mass was not balanced. We combined osteopenia and normal bone mass into the non-osteoporotic group. Therefore, this study cannot more strictly interpret the association of psoas index alone with normal bone mass or osteopenic spine fractures. Some subjects had mild lumbar degeneration or spondylolisthesis, which may affect the accuracy of vertebral BMD.

**Conclusions**

Postmenopausal women with osteoporosis have lower skeletal muscle mass than those without osteoporosis. Decreased lumbar spine and hip BMD are associated with reduced skeletal muscle mass in postmenopausal women. In postmenopausal women without osteoporosis, sarcopenia may be an independent risk factor for spinal fractures.

**Abbreviations**

PMI  Psoas muscle index
CT    Computed tomography
DXA   Dual-energy X-ray absorptiometry
BMI   Body mass index
BMD   Bone mineral density
Declarations

Ethics approval and consent to participate

This study was performed by the principles of the declaration of Helsinki. Ethical approval for the study was obtained from the ethical review committee for the sixth affiliated hospital of Xinjiang medical university (approval number: LFYLLSC20210820-01). All participants provided written informed consent.

Consent for publication

All authors and All participants declare consent to publication.

Availability of data and material

Our data and images support the usability of our articles.

Funding

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Authors' contributions

H.G. and Y.Z. conceived the idea. H.G. and Y.Z. wrote the main manuscript text. Y.Z. and Y.D. and X.C. collected the data. H.G. and Y.Z. and Y.D. and X.C. performed the literature search. All authors reviewed the manuscript. All authors approved the final version for submission.

Acknowledgments

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Competing interests

Yihui Zhang, Yilihamu Dilixiati, Xiufeng Cao and Hui Guo declare that they have no conflict of interest.

Availability of data and materials

The data sets cannot be made publicly available, and restrictions apply to the availability of these data. Data can be requested from the authors and require permission from Xinjiang Medical University.
affiliated Six Hospital.

References


Tables
Table 1. Demographic characteristics in the osteoporosis group and the non-osteoporotic group.

<table>
<thead>
<tr>
<th></th>
<th>osteoporosis</th>
<th>non-osteoporotic</th>
<th>t/χ² value</th>
<th>P-value</th>
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</thead>
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<tr>
<td>n=89</td>
<td>n=95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age y</td>
<td>71.0±6.8</td>
<td>70.0±8.0</td>
<td>0.928</td>
<td>0.355</td>
</tr>
<tr>
<td>age of menopause y</td>
<td>49.3±3.3</td>
<td>48.5±4.2</td>
<td>1.330</td>
<td>0.185</td>
</tr>
<tr>
<td>height m</td>
<td>1.57±0.05</td>
<td>1.59±0.06</td>
<td>-2.520</td>
<td>0.013</td>
</tr>
<tr>
<td>weight kg</td>
<td>57.7±8.5</td>
<td>65.3±9.2</td>
<td>-5.802</td>
<td>0.001</td>
</tr>
<tr>
<td>body mass index kg/m²</td>
<td>23.3±3.3</td>
<td>25.7±3.8</td>
<td>-4.663</td>
<td>0.001</td>
</tr>
<tr>
<td>right psoas area mm²</td>
<td>446±140</td>
<td>501±142</td>
<td>-2.671</td>
<td>0.008</td>
</tr>
<tr>
<td>left psoas area mm²</td>
<td>444±114</td>
<td>520±146</td>
<td>-3.915</td>
<td>0.001</td>
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<tr>
<td>psoas index mm²/m²</td>
<td>360.0±98.5</td>
<td>403.0±111.0</td>
<td>-2.773</td>
<td>0.006</td>
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<tr>
<td>L1 BMD g/cm²</td>
<td>0.726±0.098</td>
<td>0.943±0.140</td>
<td>-12.085</td>
<td>0.001</td>
</tr>
<tr>
<td>L2 BMD g/cm²</td>
<td>0.745±0.107</td>
<td>1.014±0.142</td>
<td>-14.452</td>
<td>0.001</td>
</tr>
<tr>
<td>L3 BMD g/cm²</td>
<td>0.803±0.125</td>
<td>1.082±0.151</td>
<td>-13.592</td>
<td>0.001</td>
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<tr>
<td>L4 BMD g/cm²</td>
<td>0.836±0.154</td>
<td>1.109±0.141</td>
<td>-12.505</td>
<td>0.001</td>
</tr>
<tr>
<td>femoral neck BMD g/cm²</td>
<td>0.638±0.108</td>
<td>0.788±0.104</td>
<td>-9.573</td>
<td>0.001</td>
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<tr>
<td>femoral trochanter BMD g/cm²</td>
<td>0.534±0.097</td>
<td>0.664±0.097</td>
<td>-9.100</td>
<td>0.001</td>
</tr>
<tr>
<td>vertebral body fracture</td>
<td>57±64.0</td>
<td>50±52.6</td>
<td>2.460</td>
<td>0.117</td>
</tr>
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</table>
Table 2. Correlation of psoas index with BMD of lumbar 1-4 vertebrae, femoral neck nter variable

<table>
<thead>
<tr>
<th>variable</th>
<th>psoas index</th>
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<tr>
<td></td>
<td>R-value</td>
<td>P-value</td>
</tr>
<tr>
<td>L1 BMDg/cm²</td>
<td>0.250</td>
<td>0.001</td>
</tr>
<tr>
<td>L2 BMDg/cm²</td>
<td>0.308</td>
<td>0.001</td>
</tr>
<tr>
<td>L3 BMDg/cm²</td>
<td>0.213</td>
<td>0.004</td>
</tr>
<tr>
<td>L4 BMDg/cm²</td>
<td>0.128</td>
<td>0.084</td>
</tr>
<tr>
<td>femoral neck BMDg/cm²</td>
<td>0.238</td>
<td>0.001</td>
</tr>
<tr>
<td>femoral trochanter BMDg/cm²</td>
<td>0.215</td>
<td>0.003</td>
</tr>
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</table>

Table 3. Number and distribution of vertebral fractures(n(\%))

<table>
<thead>
<tr>
<th>Vertebral fractures in osteoporosis group</th>
<th>Vertebral fractures in the non-osteoporotic group</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>osteopenia</td>
</tr>
<tr>
<td>lumbar vertebral fracture</td>
<td>20 (10.9%)</td>
</tr>
<tr>
<td>thoracic vertebral fracture</td>
<td>10 (5.4%)</td>
</tr>
<tr>
<td>Combined thoracolumbar fractures</td>
<td>17 (9.2%)</td>
</tr>
<tr>
<td>total</td>
<td>57</td>
</tr>
</tbody>
</table>

**Figures**
Figure 1

1A. The localization image showed that the plane of line 28 was the middle level of the lumbar three vertebral body.

1B. We manually delineated the edges of the bilateral psoas major on the mid-level of the lumbar 3 vertebral body in the CT axial image. The cross-sectional area of the psoas major was calculated automatically by the software. The area of the right psoas major was 663 mm\(^2\). The left psoas muscle area was 662 mm\(^2\).
Figure 2

The six scatter plots showed a correlation of the psoas muscle index with BMD of the lumbar 1-4 vertebral body, femoral neck, and femoral trochanter.
Figure 3

Box plot showing the difference in PMI in postmenopausal women with vertebral fractures and nonvertebral fractures. Blue represents spinal fractures and red represents non-vertebral fractures. The top-to-bottom data next to each boxplot are the maximum, upper quartile, median, lower quartile, and minimum value of the PMI.