EVALUATION OF PARAVERTEBRAL MUSCLE ATROPHY AND FATTY DEGENERATION IN PATIENTS WITH AXIAL SPONDYLOARTHRITIS

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Abstract. Sarcopenia or muscle atrophy is a common feature of many chronic diseases of the musculoskeletal system including those accompanied by chronic low back pain (LBP). The aim of the study was to evaluate the morphological changes of the muscles in the lumbosacral region in patients with axial spondyloarthritis (AxSpA) who underwent magnetic resonance imaging and to compare those changes with a group of patients with chronic low back pain of other etiology. A total of 82 patients with chronic LBP were studied, divided into three groups of interest – first group – controls with low back pain, the second group – patients with ankylosing spondylitis, and the third group – with non-radiographic AxSpA (nr-AxSpA). All patients underwent radiography and magnetic resonance imaging of the sacroiliac joints. The area of the following three paravertebral muscles was measured: lumbar multifidus muscle, erector spinae muscle, and psoas muscle. The available fatty infiltration of those muscles was graded (0-4). The area of the investigated paraspinal muscles did not differ significantly among the three study groups (p > .05). Multiple linear regression analysis determined that C-reactive protein was a predictor of the measured area of multifidus muscle (p < .001). The study groups differ significantly in their fatty infiltration of multifidus muscle (p = .02), with 15/23 (65%) of patients with ankylosing spondylitis having a high degree of fatty degeneration (score ≥ 3) in comparison with 27.5% and 21% in the control and nr-AxSpA group, respectively. The imaging characteristics of multifidus muscle may be a useful marker for assessing muscle atrophy in patients with axial spondyloarthritis. Inflammation can play a certain role in multifidus sarcopenia in patients with low back pain. Its fatty infiltration is associated with radiographic changes and may distinguish patients with AS from those with nr-AxSpA and lumbosacral pain of another origin.

Key words: ankylosing spondylitis, sarcopenia, muscle atrophy, paravertebral muscles, ankylosing spondylitis, spondyloarthritis, non-radiographic spondyloarthritis

INTRODUCTION

Seronegative spondyloarthritides (SpA) are a group of inflammatory musculoskeletal syndromes linked by common clinical features and immunopathologic mechanisms [1]. The term axial SpA (AxSpA) encompasses ankylosing spondylitis (AS) and non-radiographic axial SpA (nr-AxSpA). The modern concept presents both conditions as a single disease with two subgroups: present or absent radiographic changes in the sacroiliac joints, respectively [2]. In the conditions of modern imaging diagnostics, the criteria for classification of AxSpA have undergone significant development, as magnetic resonance imaging (MRI) has become an integral part of the algorithm for early diagnosis [3, 4].

Sarcopenia or muscle wasting is a common feature in several chronic diseases, including those with chronic low back pain (LBP). In recent years, various studies have shown that atrophy and weakening of the paraspinal muscles accompany degenerative disc disease, leading to an acceleration of intervertebral disc damage and causing additional pain and instability of the spine [5, 6]. Paravertebral muscle atrophy and muscle fatty infiltration can additionally contribute to pain and disability in AxSpA. However, there are still very few studies focused on sarcopenia of the paravertebral muscles. Immobilization in combination with systemic and local inflammation could lead not only to muscle atrophy, but also to fatty infiltration of the latter.

The study aimed at evaluating morphological changes in the muscles in the lumbosacral region in patients with AxSpA who underwent MRI and comparing them with a group of patients with chronic low back pain in the absence of AxSpA. Subsequently, we proposed the hypothesis that the inflammation in AxSpA further affects in a negative direction the sarcopenia of the paravertebral muscles with atrophy and fatty infiltration.
**Materials and Methods**

**Study design**

For the purpose of our study, retrospective monocentric observational study was conducted.

**Patients**

A total of 82 patients aged between 18 and 50 years for the period from May 2013 to May 2020 were included. All of the participants attended the Clinic of Rheumatology and the Clinic of Imaging Diagnostics of the University Hospital „St. Marina“ – Varna and experienced chronic pain (> 3 mo) in the lumbosacral region. Forty-two of them were classified as patients with axial spondyloarthritis, meeting the ASAS [7] classification criteria, and were the focus of the study for sarcopenia with fatty infiltration in sacroiliitis. Patients with axial spondyloarthritis are divided into two groups according to the imaging data – patients with non-radiographic AxSpA (nr-AxSpA) and patients with radiographic SpA or ankylosing spondylitis (AS), meeting the 1984 modified New York (mNY) classification criteria from [8].

Forty of the patients fell into the control group. They suffer from LBP, but at the time of the imaging examination, they did not meet the criteria for AxSpA [5].

Excluding criteria for both groups are age below 18 years and over 50 years, the presence of another rheumatic disease, prior treatment with biological agents, body mass index (BMI) over 40, sacroiliitis of infectious origin. Disc degeneration such as bulging, hernia, or Modic changes was not taken into account.

**Imaging interpretation**

All participants underwent Ferguson-centered pelvic radiography and magnetic resonance imaging (MRI) of the sacroiliac joints. The radiographs were interpreted by an experienced radiologist and/or rheumatologist using mNY classification criteria (Fig. 1). In bilateral sacroiliitis ≥ 2 or unilateral sacroiliitis ≥ 3 and clinical correlation, the diagnosis of AS was set.

The magnetic resonance images were obtained at the Clinic of Imaging Diagnostics at University Hospital „Sv. Marina“ – Varna, on a Siemens Magnetom Verio MR machine with a field intensity of 3T using a protocol for sacroiliac joints through the plane of the joints – axial T1, axial T2, and axial short tau inversion recovery (STIR).

A trained radiologist performs the evaluation of all magnetic resonance images according to the presence or absence of typical characteristics of active inflammation according to the definitions of ASAS MRI working group [9]. They are based entirely on the presence or absence of bone marrow oedema (BMO) – 0 – no oedema (picture on the left), 1 – oedema (picture on the right); used sequence is STIR – a fat suppression technique with an inversion time $TI = \ln(2)$ (Fig. 2).

**Area measurement of paravertebral muscles – m.psoas, m.erector spinae et m.multifidus**

Necessary measurements of the paravertebral muscles were made for each participant in the three groups (n = 82 in total). We calculated the area of psoas muscle at the level of L3-4, lumbar erector spinae, and multifidus muscles at the level of L4-5 (Fig. 3). Siemens Syngo work postprocessing console was used, as T1 sequences are pre-selected, in which the muscle tissue is better distinguished. The ROI (region of interest) for each individual muscle on a given slice is determined manually and the average area was calculated. The hypointense signal from the muscle fibers only without fat content of each of the muscles is included in the measurement (Fig. 3).
Evaluation of fat infiltration of lumbar erector spinae and multifidus muscles

Subsequently, fat infiltration between the muscle fibers of the T1 sequence was evaluated, where both the muscle tissue, which is hypointense, and the adipose tissue, which is hyperintense, were easily distinguished, and alternatively, images in the T2 sequence were used. For muscle infiltration, a scale modified by Ranson [10] from 1 to 4 is used, as 0 is no infiltration (observed only in young athletes), and 1-2-3-4 as described in the Fig. 4.

Statistical analysis

Statistical analysis was performed using the software product SPSS 21. The data distribution was calculated using the Shapiro-Wilk test. Descriptive statistics, nonparametric tests, and multiple linear regression analysis were used. The Spearman rank analysis was performed to examine the correlations between the variables with an abnormal distribution. Fisher’s exact test was used to analyze the presence of a linear relationship between category values. Multiple linear regression analysis determined the prognostic factors for the area of the studied muscles.

RESULTS

Demographic and clinical data

Patients in the three groups of interest (controls, nr-AxSpA, and AS) did not differ significantly in their gender, age, and body mass index (BMI). The most important demographic, laboratory, and clinical data are presented in Table 1.
Fig. 4. Degrees of sarcopenia (muscle degeneration with fatty infiltration), modified by Ranson. I degree – norm or minimum fatty infiltration; II degree – fatty infiltration up to 25% of muscle; III degree – fatty infiltration 25-50% of muscle; IV degree – over 50% fatty infiltration

Table 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Patients with non-AxSpA low back pain N = 40</th>
<th>Patients with AxSpA</th>
<th>Patients with nr-AxSpA N = 19</th>
<th>Patients with AS N = 23</th>
<th>P</th>
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<td>Demographics</td>
<td></td>
<td></td>
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<tr>
<td>Age (years)</td>
<td>36.5 (20; 50)</td>
<td>30 (22; 49)</td>
<td>36 (22; 49)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>23.7 (18.8; 38.1)</td>
<td>27.5 (19.5; 37)</td>
<td>26.1 (22.3; 37.5)</td>
<td>NS</td>
<td></td>
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<tr>
<td>Female (%)</td>
<td>72.5 %</td>
<td>56.5 %</td>
<td>42.1 %</td>
<td>NS</td>
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<td>Clinical and laboratory characteristics</td>
<td></td>
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<tr>
<td>Pain duration (mo)</td>
<td>12 (2; 36)</td>
<td>9 (2; 48)</td>
<td>18 (3; 60)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>CRP (mg/dL)</td>
<td>1.35 (.13; 69.1)</td>
<td>5.3 (.1; 68.4)</td>
<td>11.06 (0; 51.7)</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>HLA-B27+ (%)</td>
<td>12.5 %</td>
<td>52.6 %</td>
<td>82.6 %</td>
<td>&lt; .001</td>
<td></td>
</tr>
</tbody>
</table>

BMI = Body Mass Index; CRP – c-reactive protein; AxSpA – axial spondyloarthritis; AS – ankylosing spondylitis; nr – non-radiographic
The presented data non-normally distriubed and presented as median (min; max)

Correlations between the area of the studied paraspinal muscles and the other parameters

The area of m. multifidus correlates positively with that of the other examined paraspinal muscles: psoas muscle (r = .289, p = .009) and erector spinae muscle (r = .652; p < .001). It showed a negative relationship with age (r = -.477; p < .001), body mass index (r = -.255; p = .021), and C-reactive protein (CRP) levels (r = -.287; p = .009) in patients with lumbosacral pain. Interestingly, men and women did not have a significant difference in the area of lumbar multifidus muscle (p > .05). Multiple linear regression was calculated to predict the area of multifidus muscle based on age, gender, BMI, and CRP levels. Both age and CRP (both p values <.001) were significant predictors of multifidus muscle area according to our model where a significant regression equation was found (F(2, 79) = 24.39, p < .001), with an R² of .382.

The area of m. psoas correlated only with age among all studied parameters (r = -.228, p = .041).
Erector spinae muscle correlates negatively with age, body mass index ($r = -0.477$, $p < 0.001$; $r = -0.255$, $p = 0.021$; $r = -0.297$, $p = 0.009$), but this relationship does not maintain after controlling for age and sex. Women have a smaller area of m. psoas and m. erector compared to men (respectively $p < 0.001$ and $p = 0.001$).

**Comparisons of muscle area and fat infiltration among groups**

The area of the studied paraspinal muscle groups did not differ significantly among the three studied groups: patients with lumbosacral pain without a diagnosis of axial spondyloarthritis, patients with nr-AxSpA, and patients with AS ($p > 0.05$).

The groups differed significantly in the fatty infiltration of multifidus muscle ($p = 0.02$), with 15/23 (65%) of patients with ankylosing spondylitis having a score ≥ 3. This percentage for the AxSpA-free group and the AxSpA group was 27.5% and 21%, respectively, without a significant difference between them.

**Discussion**

In our study, we measured the average volume of the paravertebral muscles and fatty infiltration at a specific level using MRI. Correlation between the characteristics of lumbar muscles with parameters of patients with LBP and more specifically with axial spondyloarthritis was studied. The associations between those parameters and demographic and clinical data for patient groups such as age, BMI, gender, duration, and CRP (a marker of systemic inflammation) were explored. Of the studied group of axial (or paravertebral) muscles, the strongest affection from LBP demonstrates multifidus muscle, followed by the erector spinae muscle. Psoas muscle shows no significant difference in area or fat infiltration in the groups. Although poorly studied, the topic of sarcopenia in these muscles in patients with LBP has been addressed by other authors. There are few studies in the literature based on MRI technology in which these parameters are monitored, and comparison with previous sources is limited.

MRI with protocol for sacroiliac joints makes it possible not only to measure bone marrow oedema BMO of the joint in active (inflammatory) sacroiliitis, but also to measure the volume or area of paravertebral muscles and their fatty infiltration. Patients with radiographic sacroiliitis, classified as AS, showed a higher rate of fatty infiltration (grade 3 or 4) than those with non-radiographic spondylitis. Parameters such as age, BMI, and CRP were also compared in these groups. In our and other studies, such as Danneels’ [11], it has been shown that paravertebral muscles are more severely affected with a smaller area and more pronounced fatty infiltration. This leads to the conclusion that active systemic inflammation could lead to restricted movement in this area, muscle atrophy and a significant deterioration in the quality of life of patients [11].

Danneels also demonstrated in his study the correlation between the progressive course of axSpA and high-grade sarcopenia in these patients. Another important finding from the same study was the significant fat degeneration at L3-4 levels in all patients with sacroiliitis. Similar results were shown by Resorlu et al. [12].

In our article, we emphasize the importance of measuring the area of the paravertebral muscles and especially to determine the degree of fatty infiltration of the latter, as a marker for inflammation or radiographic structural damage. Such fatty infiltration, a sign of muscle degeneration, was observed most prominently in the study group with AS; however, it was still observed in the other two groups. The results are logical, as patients are often referred for MRI of the sacroiliac joints in chronic and/or recurrent low back pain.

![Fig. 5. The area of the examined muscles did not differ significantly in the three groups of interest](image-url)
In case of a negative result for sacroiliitis – lack of active inflammation or other type of joint inflammation – the cause of this pain could come from degeneration of lumbar muscles multifidus and spinal erector. There is still no solid evidence whether those changes are permanent or reversible and whether it could be affected by physical activity or medication. Like in osteoarthritis [13] and other rheumatic diseases, physical inactivity and overweight/obesity could be modifiable risk factors in patients with LBP regardless of its etiology. Intervention on those factors could lead to major clinical improvement since reduced size and fatty degeneration of spinal muscles are associated with increased pain, depression, and decreased strength [14].

A 15-year longitudinal study by Fortin et al [15] on the morphological changes of erector spinae and multifidus muscles showed a decrease in size and muscle mass over time, as well as an increase in fat infiltration and asymmetry. Interestingly, the level of physical activity and LBP do not significantly affect these parameters. The correlation between the parameters and BMI is significant.

It is of importance that in our study the study groups were consisted of mostly young patients (up to 50 years of age) and all groups had less favorable indicators in terms of sarcopenia. This proves that this morphological criterion is important for the clinical onset in patients with LBP.

A large study by Sasaki et al. with 796 participants in the Japanese population demonstrated that fatty infiltration of the m.erector spinae group, as measured by MRI, was closely associated with chronic low back pain [16]. Other similar studies have also reported an association between paraspinal muscle size and fat content in LBP. Fortin et al evaluated the paraspinal muscles in patients with LBP. Compared to controls, the paraspinal muscles of the LBP group were significantly smaller [15]. Teichtahl et al. studied fatty infiltration by MRI in 72 individuals, proving that it was associated with LBP [17].

In our study, psoas area was also measured, but no significant difference in volume or fat infiltration was found, proving that it could not differentiate different causes of LBP such as degenerative disc disease and AxSpA. From all the measured demographic and clinical parameters, psoas muscle area showed association with age – a finding that is contradictory to what Lee et al reported. In their study, no significant change in characteristics of the muscle according to age was demonstrated. Fatty infiltration of psoas muscle was minimal in contrast to that of erector spinae and multifidus [18].

**Conclusion**

The imaging characteristics of multifidus muscle may be a useful marker for assessing muscle atrophy in patients with axial spondyloarthritis. Inflammation can play a certain role in multifidus sarcopenia in patients with low back pain. Its fatty infiltration is associated with radiographic changes and may distinguish patients with AS from those with nr-AxSpA and lumbosacral pain of another origin.

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**Библиография / References**


