Body composition and bone mineral density in patients with chronic obstructive pulmonary diseases

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Abstract

The aim of this study was to assess the indices of the bone mineral density (BMD) and body composition of patients with chronic obstructive pulmonary disease (COPD).

Methods. For achievement of the stated objective we performed a comprehensive examination of 30 patients with COPD of different age, sex and COPD stage. The BMD and the body composition (Lean Total and Fat Total, Tissue % Fat) was determined by dual-energy X-ray absorptiometry (DXA) “Prodigy”. The statistical analysis was performed using the program STATISTICA 6.1.

Results. Assessment of the bone tissue condition in the patients with COPD showed a statistically significant reduction of BMD, T-score and Z-score L1–L4, Wards, Radius and Total in the patients with the 3rd stage of COPD that continued to increase and obtained the lowest values in the 4th stage of COPD. In this case sensitive areas in which structural and functional changes of the bone tissue manifest earlier than in the other areas are represented by the lumbar spine that evidences the highest sensitivity of the trabecular bone to systemic metabolic disorders in case of COPD. Direct correlation relationships between the BMD Legs and Lean Legs (r = 0.67, p < 0.05); between the BMD Pelvis and Spine with Lean Total (r = 0.52, p < 0.05), and between the BMD Total and Lean Total (r = 0.51, p < 0.05), Lean Arms (r = 0.62, p < 0.05) and Lean Gynoid (r = 0.51, p < 0.05) were established.

Conclusions. The results of the performed tests confirm the interrelation of a human somatotype and development of osteodeficient conditions evidencing that with reduction of the lean body mass mostly due to the muscular tissue the BMD reduces.

Key words:
bone mineral density, the body composition, chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is characterized by progressive limiting of the airflow speed caused both by bronchial tubes affection and pulmonary parenchyma destruction [9]. Under conditions of broncho-obstruction the apparatus of external respiration, including breathing muscles, performs an increased volume of work that contributes to occurrence of functional impairments [4]. COPD is often accompanied by other diseases [5, 7, 12, 15, 16] and the risk of their development increases due to COPD consequences, decrease of physical activity in particular [9]. Sedentary life of such patients disturbs the pulmonary mechanics, contributes
to hypercapnia, hypoxia, pathological changes of breathing muscles with loss of the lean body mass and bone mineral density developing parallel to each other [1, 6, 10, 11, 14].

The work objective was to assess the indices of the bone mineral density (BMD) and body composition of patients with COPD.

**Materials and methods**

For achievement of the stated objective we performed a comprehensive examination of 30 patients with COPD of different age and sex. There were 4 men (13.33%) and 26 women (86.67%) among the examined. The patients’ age ranged from 19 up to 70 years and the average age was (56.67 ± 10.28) years.

All the examined were divided into groups depending on COPD stage determined according to GOLD [9].

Anthropometric measurements: height (m), body weight (kg) was determined. The body-weight index (BWI) was calculated according to the formula:

\[ \text{BWI} = \frac{\text{body weight, kg}}{\text{height, m}^2}. \]

The BMD was determined by dual-energy X-ray absorptiometry (DXA) “Prodigy” (GE Medical systems, Lunar, model 8743, 2005, USA). The total bone mineral content (BMC, g) in the examined area, projection bone mineral density (BMD, g/cm²), T and Z-scores were measured. We analyzed DXA results of the lumbar spine (BMD L1–L4), proximal part of the thigh bone and Ward’s triangle (BMD Wards), forearm (BMD Radius), BMD Total and mineral content (BMC Total) of the whole skeleton. The advantage of this method is the possibility not only to make the quantitative assessment of BMD in the skeleton regions surrounded by large and uneven soft tissue masses but also of the body composition indices (Lean Total and Fat Total, Tissue % Fat). DXA software assesses the distribution of the body fat tissue in the regions that allows to determine the central and peripheral obesity types. Android (A) – abdominal and gynoid (G) – gluteofemoral types are distinguished [13]. Accumulation of the fat mass in the android-type areas is associated with the visceral type of obesity [2].

The statistical analysis was performed using the program STATISTICA 6.1.

**Results and discussion**

While comparing the patients with COPD divided according to the disease stage the significant reduction of BMD, T-score and Z-score in the examined areas was revealed. No statistically significant changes were revealed while comparing the groups with COPD in the 1st stage and COPD in the 2nd stage as to the level of the BMD Total, Wards and Radius according to all the indices as well as on comparison of the groups with COPD in the 1st stage and COPD of the 3rd stage as to the BMD Total according to Z-score and BMC Total (Table 1).

Assessment of the bone tissue (BT) condition accord-

<table>
<thead>
<tr>
<th>Indices</th>
<th>1st stage n = 6</th>
<th>2nd stage n = 6</th>
<th>3rd stage n = 12</th>
<th>4th stage n = 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMD L1–L4, g/cm²</td>
<td>1.39 ± 0.05</td>
<td>1.19 ± 0.05*</td>
<td>1.05 ± 0.03*</td>
<td>0.93 ± 0.07*</td>
</tr>
<tr>
<td>T-score L1–L4, SD</td>
<td>1.90 ± 0.26</td>
<td>–0.17 ± 0.29*</td>
<td>–1.23 ± 0.16*</td>
<td>–2.13 ± 0.38*</td>
</tr>
<tr>
<td>Z-score L1–L4, SD</td>
<td>1.81 ± 0.44</td>
<td>0.33 ± 0.62</td>
<td>–0.36 ± 0.2*</td>
<td>–1.17 ± 0.37*</td>
</tr>
<tr>
<td>BMD Wards, g/cm²</td>
<td>0.96 ± 0.03</td>
<td>0.89 ± 0.05</td>
<td>0.67 ± 0.04*</td>
<td>0.64 ± 0.06*</td>
</tr>
<tr>
<td>T-score Wards, SD</td>
<td>0.38 ± 0.42</td>
<td>–0.23 ± 0.2</td>
<td>–1.93 ± 0.16*</td>
<td>–2.08 ± 0.27*</td>
</tr>
<tr>
<td>Z-score Wards, SD</td>
<td>1.1 ± 0.34</td>
<td>0.87 ± 0.33</td>
<td>–0.44 ± 0.19*</td>
<td>–0.57 ± 0.16*</td>
</tr>
<tr>
<td>BMD Radius, g/cm²</td>
<td>0.58 ± 0.02</td>
<td>0.55 ± 0.04</td>
<td>0.51 ± 0.03*</td>
<td>0.4 ± 0.03*</td>
</tr>
<tr>
<td>T-score Radius, SD</td>
<td>0.58 ± 0.43</td>
<td>–0.37 ± 0.17</td>
<td>–1.11 ± 0.25*</td>
<td>–3.1 ± 0.25*</td>
</tr>
<tr>
<td>Z-score Radius, SD</td>
<td>0.78 ± 0.31</td>
<td>–0.07 ± 0.23</td>
<td>–0.02 ± 0.18</td>
<td>–2.07 ± 0.28*</td>
</tr>
<tr>
<td>BMD Total, g/cm²</td>
<td>1.2 ± 0.04</td>
<td>1.18 ± 0.04</td>
<td>1.10 ± 0.02*</td>
<td>1.01 ± 0.03*</td>
</tr>
<tr>
<td>T-score Total, SD</td>
<td>1.36 ± 0.38</td>
<td>0.33 ± 0.68</td>
<td>–0.71 ± 0.23*</td>
<td>–1.45 ± 0.29*</td>
</tr>
<tr>
<td>Z-score Total, SD</td>
<td>0.92 ± 0.71</td>
<td>0.58 ± 0.44</td>
<td>–0.15 ± 0.15</td>
<td>–0.77 ± 0.2*</td>
</tr>
<tr>
<td>BMC Total, g</td>
<td>2 853.48 ± 2.54</td>
<td>2 843.33 ± 5.51</td>
<td>2 501.90 ± 1.99</td>
<td>2 214.83 ± 2.44*</td>
</tr>
</tbody>
</table>

*Note. The character * denotes a significant difference in the indices as compared to the 1st stage of COPD (p < 0.05).*
ing to the BMD L₁−L₄ and T-score L₁−L₄ showed a significant reduction from the 1st stage of COPD to the 2nd (p < 0.05), from the 1st to the 3rd and 4th (p < 0.001 for both values). Z-score L₁−L₄ reduced significantly in the 3rd and 4th stage of COPD (p < 0.01) as compared to the patients with the 1st stage of COPD. Determination of BMD Radius and T-score Radius revealed significant index differences on comparison of the 1st and 3rd and 4th stage of COPD (p < 0.001 for both values). Z-score L₁−L₄ reduced significantly in the 3rd and 4th stage as compared to the patients with the 1st stage of COPD (p < 0.01). Z-score value discrepancies in the comparison groups approached the significant ones (p = 0.05). BMC Total index changed insignificantly from the 1st stage to the 2nd stage (p = 0.98) and the 3rd (p = 0.05) and the degree of significance was high in the 4th stage of COPD (p < 0.01).

Strong negative relation was established between the COPD stage and BMD Spine at the level of L₁−L₄ (r = –0.80, p < 0.05), BMD Wards (r = –0.75, p < 0.05), BMD Radius (r = –0.73, p < 0.05). Negative relations were also established between the same indices and COPD prescription: with BMD Spine L₁−L₄ (r = –0.39, p < 0.05); BMD Wards (r = –0.46, p < 0.05), BMD Radius (r = –0.41, p < 0.05).

So, assessment of the BT condition in the patients with COPD showed a statistically significant reduction of BMD, T-score and Z-score L₁−L₄, Wards, Radius and Total in the patients with the 3rd stage of COPD that continued to increase and obtained the lowest values in the 4th stage of COPD.

It should be noted that discrepancy of the densitometry results in certain skeleton segments of the same examined person does not allow to diagnose the systemacity and severity of the osteoporosis (OP) according to the examination results of some single skeleton area but reveals the most sensitive areas in which structural-functional changes of the BT manifest earlier than the other areas. In patients with COPD such area is represented by the lumbar spine that is evidenced by the most marked changes in the trabecular bone in this group of the examined patients.

Analyzing the received somatotype data of the patients with COPD of different disease stage it was revealed that the BWI value in all the groups of the examined corresponded to the overweight one, that is why it was reasonable to determine the percentage of the patients with normal body weight and obesity in each group. Normal BWI was revealed in 48.96% of patients with the 1st stage of COPD, 46.35% – with the 2nd stage, 50.31% with the 3rd stage and 40.74% with the 4th stage of COPD with no difference between the groups (p > 0.05). Obesity signs were revealed in 12.5% of patients with the 1st stage of COPD, in 23.18% with the 2nd stage of COPD, 19.63% with the 3rd stage of COPD and 25.93% with the 4th stage of COPD with a significant difference between the groups with the 1st and 2nd and 4th stages of COPD (p < 0.05). Thus, in the course of COPD progressing the tendency to BWI reduction with parallel increase of the number of patients with obesity could be observed.

In connection therewith the study of changes of the body composition depending on the disease severity is of scientific and practical interest. Determination of obesity types of the examined revealed the central type of fat tissue deposit in 16.67% of persons with the 1st and 2nd stage of COPD, in 50% – with the 3rd stage and in 33.33% with the 4th stage of COPD. Accumulation of the fat tissue in android areas with a relative decrease in the region of limbs was diagnosed in 16.67% with the 1st stage of COPD, 66.67% – with the 2nd and 3rd stage of COPD and in 33.33% – with the 4th stage of COPD. A direct correlation relationship between the COPD stage and obesity android type (r = 0.41, p < 0.05) was established.

Thus, a progressing increase of patients with the visceral obesity type in the 1st–3rd stage of COPD can predict the co morbid pathology development in these patients. Decrease of the number of patients with overweight signs in the 4th stage (up to 66.67%) confirms the systematic influence of the COPD with development of skeletal muscles dysfunction and loss of the muscle mass (Table 2).

Using the method of nonparametric statistics the significant discrepancies in indices on comparison of the 1st and 3rd, 1st and 4th COPD severity degrees were revealed according to Wilcoxon, Mann–Whitney, van der Waerden criteria (p < 0.05).

The analysis of the received data depending on the disease severity did not reveal a significant difference in the indices: Fat Total. Lean Total and Tissue % Fat
though there was a tendency to growth of the Fat Total and Tissue % Fat in the course of the disease progressing (Table 3).

So, the revealed overweight and obesity in the patients with COPD directly depending on the disease severity can be accompanied by the loss of the muscle mass and can be additional factors contributing to a negative clinical course of the COPD and causing undesired consequences, particularly deterioration of lung ventilation, development of cardiovascular pathology and others.

Weakness of the breathing muscles on obesity leads to reduction of chest compliance and/or reduction of physiologic lung volumes [3, 8]. Reduction of the lean body mass that occurs mostly due to the muscular tissue constitutes a considerable problem for the patients with COPD worsening the function of the external respiration and the life quality correspondingly.

Comparison of the body composition indices depending on the age of the patients with COPD by the method of parametric statistics revealed no significant differences in young, elderly and old patients. While comparing the groups of patients of different age using nonparametric statistics a significant difference was revealed in the tested parameters: Fat Total, Lean Total and Tissue % Fat between the groups of young, elderly and old people according to Smirnov criterion (p < 0.01).

Thus, with aging of the patients the Lean Total reduces and the Fat Total and Tissue % Fat – increases. This fact confirms the hypothesis that the BWI value does not represent in full the somatotype condition in the course of COPD progressing [2].

While establishing the correlation relationships it is important to search the most essential factors of BMD reduction, particularly the body composition, as exactly this factor may contribute to osteoporosis development. Thus, direct correlation relationships between the BMD Legs and Lean Legs (r = 0.67, p < 0.05); between the BMD Pelvis and Spine with Lean Total (r = 0.52, p < 0.05), and between the BMD Total and Lean Total (r = 0.51, p < 0.05), Lean Arms (r = 0.62, p < 0.05) and Lean Gynoid (r = 0.51, p < 0.05) were established.

So, the results of the performed tests confirm the interrelation of a human somatotype and development of osteodeficient conditions evidencing that with reduction of the lean body mass mostly due to the muscular tissue the BMD reduces. Thus, the cause circle of interrelation of the osteoporosis systemic formation mechanisms in case of COPD is completed.

**Conclusions**

1. Reduction of the bone mineral density in patients with COPD directly depends on the disease stage and patients’ age. The most deviated mineral density indices can be observed in the patients with the 3rd and 4th stage of COPD. In this case sensitive areas in which structural and functional changes of the bone tissue manifest earlier than in the other areas are represented by the lumbar spine that evidences the highest sensitivity of the tra-
becular bone to systemic metabolic disorders in case of COPD.

2. Increase of the number of patients with obesity visceral type in the 1st (16.67%) to the 3rd stage of COPD (66.67%) and reduction of the number of persons with signs of overweight in the 4th stage (66.67%) can be observed that confirms the systemic influence of COPD.

3. Established direct correlation relationships of BMD and lean body mass confirm the systemicity of osteoporosis formation mechanisms in case of COPD.

References

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ASMENŲ, SERGANČIŲ LĖTINE OBSTRUKCINE PLAUČIŲ LIGA, KŪNO SUDĖTIS IR KAULŲ MINERALŲ TANKIS

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Santrauka

Tyrimo tikslas. Įvertinti kaulų mineralų tankio (KMT) ir kūno sudėties rodiklius pacientams, sergantiems lėtine obstrukcine plaučių liga (LOPL).

Tyrimo metodai. Ištirta skirtingo amžiaus, lyties ir ligos stadijos 30 asmenų, sergančių LOPL. Kūno sudėtis (viso kūno liesoji masė, viso kūno riebalų ir procentinė riebalų dalis audiiniuose) buvo išmatuota taikant dvisrautės radioabsorbcimetrojų metodą (DXA). Statistinė analizė atlikta taikant STATISTICA 6.1 programą.

Rezultatai. Ištyrus kaulinio audinio būklę, asmenims sergantiems LOPL, nustatyta statistiškai reikšmingas mažas stburo L1–L4 T-lygmo ir Z-lygmo, Ward’o trikampio, stipinuko KMT asmenims III-ios stadijos LOPL ir mažiausios šių tirtų rodiklių vertės nustatytos esant IV-ai stadijai. Tyrimo metu šiose tirtose vietose kaulinio audinio struktūriniai ir funkcinių pakitimai pakitimui pasireiškė anksčiau nei kad kitose juosmeninės stuburo dalies vietose. Tai leidžia įtarti didžiausią trabekulinio kaulo jautrumo sisteminiam medžiagų apykaitos sutrikimui LOPL atveju. Nustatyta teigiamas tiesioginė koreliacija tarp kojų KMT ir kojų liesosios masės ($r = 0,67$, $p < 0,05$); tarp stuburo KMT, dubens KMT ir viso kūno liesosios masės ($r = 0,52$, $p < 0,05$), tarp viso kūno KMT ir viso kūno liesosios masės ($r = 0,51$, $p < 0,05$), rankų liesosios masės ($r = 0,62$, $p < 0,05$) ir liesosios masės ginoidinėje srityje ($r = 0,51$, $p < 0,05$).

Išvados. Tyrimo rezultatai nurodo, kad yra ryšys tarp žmogaus somatotipo ir osteodeficitinių būklų išsivystymo, o maža liesoji masė nustatoma dėl raumeninio audinio ir KMT mažėjimo.

Raktazodžiai:
kaulų mineralų tankis, kūno sudėtis, lėtinė obstrukcine plaučių liga