Abstract

The presence of isolated low bone density of a single lumbar vertebra (difference of above 1 SD T-score between two adjacent vertebrae without a probable explanatory reason) seems to be one of the unsolved issues in clinical densitometry. The present study aims to investigate the epidemiology of the latter mentioned difference in BMD. In a prospective manner 4027 apparently healthy Bulgarian women between 50 and 65 years of age underwent a scan of the lumbar spine (L1–L4) on a DXA machine – Hologic Discovery A. The data were collected and analysed with the statistical package SPSS. In the observed group the incidence of the difference of above 1 SD T-score between two adjacent lumbar vertebrae without a causal visible abnormality is quite low – 1.34% (n = 54). In the study population, the mean T-score was 1.49 (±0.469 SD) and the difference itself was between –1 and –2.6 SD T-score. A consensus statement and a guideline for further clinical management of patients with this finding are necessary to be created.

Key words: DXA, lumbar spine, difference of above 1 SD T-score

Introduction. A lot of opportunities for evaluation of the determinants of bone mineral density (BMD) have been revealed with the advent of magnetic-resonance imaging (MRI) and dual-energy X-ray absorptiometry (DXA); hence the thorough research and understanding of the pathological mechanisms behind
the bone metabolic diseases. Many women have been found to have isolated low bone mineral density of a single lumbar spine vertebra on a DXA scan (difference of above 1 SD T-score between two adjacent vertebrae without an obvious tenable pathology), and this remains one of the unsolved topics in clinical densitometry \cite{1,2}. Even in the latest official positions of the International Society of Clinical Densitometry (ISCD) – 2019, the problem is discussed just upon experts’ opinion level (level of evidence C) \cite{3}. After thorough literature review no researches were found related to the epidemiology, etiology, predictive value and clinical utility of this phenomenon. From a clinical point of view, it could be due to a disease leading to decreasing of bone density of the abnormal vertebra or to another pathology falsely elevating the density of the adjacent ones \cite{1,3,4}. The problem itself is confounded by the numerous lumbar spine bone metabolic diseases, which could influence BMD and overlap in the elderly, such as: Modic type I, Modic type II, Modic type III; ossification of the longitudinal ligaments; osteophytes; degenerative disc disease; vertebral haemangioma; bone neoplasms; metastases, etc. \cite{1,2,4}.

**Materials and methods.** The aim of the hereby presented study is to conduct via DXA a representative epidemiological study to evaluate the difference of above 1 SD T-score BMD between two adjacent vertebrae without a visible abnormality, which might be the cause for it.

In our prospective research, we included 4500 perimenopausal women, who underwent lumbar spine DXA scan (L1–L4) after signing an informed consent. Their short anamnesis and medical records were also collected and evaluated. The inclusion criteria were: clinically healthy Bulgarian women between 50 and 65 years of age, whose body mass index (BMI) is 21–30 kg/m$^2$. The exclusion criteria were any history or data for: oncological diseases; autoimmune diseases; severe degenerative lumbar spine changes (scoliosis, spondylolisthesis, osteochondrosis); severe spine trauma or any vertebral fracture; severe internal medicine or CNS diseases, immobilisation, secondary osteoporosis; long-term treatment with medications altering bone mineral density.

The conducted clinical approaches were, as follows: taking patient’s medical history, doing physical examination, collecting and evaluating one’s medical record. DXA was used as main imaging modality. The scans of the lumbar spine (L1–L4) were performed and analysed on a DXA machine Hologic Discovery A according to the official positions of ISCD from 2015 and 2019 and the manufacturer’s manual. The utilised software version was 13.3.3. BMDCS/Hologic was used for a reference database. For the purpose of our epidemiological research of lumbar spine BMD DXA scans of 4500 women were analysed.

**Statistical methods.** Data collection was performed using IBM SPSS Statistics, Version 22 (Armonk, New York). In descriptive analysis, categorical variables were presented as percentages and absolute numbers, and continuous variables were presented as the mean and range.
**Ethical approach.** The patients were aware of the necessity and the plausible consequential risks of performing a DXA scan. They underwent one only after signing an informed consent.

**Results.** In order to investigate the epidemiology of the difference of 1 SD T-score between two adjacent vertebrae without a probable causative reason we performed DXA scans of L1–L4 (lumbar spine) on 4500 women. From them, 473 (10.51 %) were excluded from the final analysis due to poorly performed DXA exam, artefacts in the region of interest, poor patient positioning, etc. From the rest 4027, in 54 patients (1.34%) we observed a difference of above 1 SD T-score between two adjacent vertebrae without a clearly visible pathology (Table 1).

<table>
<thead>
<tr>
<th>Patients with a difference of above 1 SD without a clearly visible pathology for it</th>
<th>N</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Present</td>
<td>54</td>
<td>1</td>
</tr>
<tr>
<td>Absent</td>
<td>3973</td>
<td>99</td>
</tr>
<tr>
<td>Total</td>
<td>4027</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2 shows the conducted variation analysis of the variables age, T-score difference, BMD difference in 54 women with difference of above 1 SD T-score without an evident abnormality.

<table>
<thead>
<tr>
<th>Min</th>
<th>Max</th>
<th>SD</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>50</td>
<td>65</td>
<td>4.95</td>
</tr>
<tr>
<td>T-score difference</td>
<td>−1</td>
<td>−2.6</td>
<td>0.469</td>
</tr>
<tr>
<td>BMD difference (g/cm²)</td>
<td>0.023</td>
<td>0.6</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Figure 1 illustrates lumbar spine DXA scan of a woman from the study sample with a difference of 1.2 SD T-score between the two adjacent vertebrae L3 and L4. Figure 2 demonstrates lumbar MRI examination of the same woman, who lacks a lumbar disease, which could lead to the observed aforementioned difference of T-score between L3 and L4.

**Discussion.** So far globally there is neither any scientific research estimating the isolated low bone mineral density of a single lumbar vertebra in women, who underwent a DXA scan, nor one evaluating the capabilities of DXA as an imaging modality to predict vertebral pathology based on the parameters of the exam.
An explanation for the isolated low bone density of a single lumbar vertebra in women, who underwent a DXA scan, could be the presence or the absence of vertebral abnormality in the vertebra itself or the adjacent ones \[1,4\].

The power of the X-ray beam in DXA machines is quite low, therefore when a bone disorder is established, it exists for sure. The absence of visual presentation of one or the finding of lower bone density in a single vertebra could not exclude the presence of a focal disorder \[1,5\].

The basic X-ray exam has its place in the representation of osteoporotic changes \[2\]. The conventional radiography has slightly lower sensitivity in diagnosing osteoporosis. A reliable discriminative criterion for visual confirmation of osteoporosis with X-ray scan is a difference in BMD of above 30\% \[1\]. This
Fig. 2. Magnetic resonance imaging (MRI) T1W and T2W of the lumbar spine (L1–L4) of the same lady from Fig. 1

makes the ISCD recommendations for visual evaluation of the difference in BMD between two adjacent vertebrae quite uncertain [3].

Remarkably high incidence and overlapping of the lumbar bone metabolic diseases is established in numerous researches in women, resembling our study sample [1,2,4]. Schneider et al. [6] found that in women with osteoarthrosis the prevalence of osteoporosis is 14.4%. The vertebral haemangiomas rate of occurrence varies between 10 and 27% based on autopsy studies, MRI and X-ray images [7,8]. The frequency of Modic type II changes of the lumbar spine ranges between 15 and around 70% depending on the research methodology and the study sample [9-12].

Taking into account that the presence of various “hidden” for the DXA measurement lumbar pathology, whose only manifestation might be the difference of above 1 SD T-score between two adjacent lumbar vertebrae (L1–L4) without a visible abnormality [1,4], we consider that a consensus statement is necessary in order to approve a guideline for further steps when establishing it. In ISCD official positions 2019 it is discussed that the abnormal vertebra must be excluded from the final analysis, but no algorithm for following investigation is mentioned there [3].

Limitations of the study. In our study only the lumbar spine vertebrae (L1–L4) of Bulgarian women between 50 and 65 years of age were evaluated. Last
but not least, the capabilities of the used hardware – a DXA machine Hologic Discovery A could probably be a restrictive factor.

**Conclusion.** The incidence of the difference of above 1 SD T-score BMD between two adjacent lumbar vertebrae (L1–L4) without an obvious pathology in the observed group of apparently healthy Bulgarian women between 50 and 65 years of age is low – 1.34%.

**REFERENCES**


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