Osteoporosis is a metabolic skeletal disease characterized by bone mineral density reduction, which may lead to an increased risk of bone fractures. Obesity is a condition of excessive body fat that causes or aggravates many public health problems. As it is easy to be measured, body mass index is widely used as an index of the degree of obesity.

**Material and Methods.** The study included 1,372 female orthopedic patients between the ages of 30 to 79 years who visited the Clinical Centre of Vojvodina in Novi Sad to have a dual-energy x-ray absorptiometry (DEXA) examination in the period from March, 2010 to June, 2013. The following anthropometric data were collected: body mass index, body weight, height, dual-energy x-ray absorptiometry T-score and bone mineral density (BMD), as well as some other data. Results. The mean age was 62.08 years, the mean weight was 73.59 kg and the mean height was 1.6 m. There were 392 participants in the group of normal body mass index, 14 participants were overweight, and 966 were overweight and obese. In the overweight and obese group, 25.25% participants had osteoporosis, 35.4% had osteopenia and 39.33% had the normal T-score. In the underweight group, 57.14% of the participants had osteoporosis, 29.3% had osteopenia and 28.31% had the normal T-score. Conclusion. No strong correlation between body mass index and bone mineral density was found in our study, but it is obvious that there was a stronger correlation between body mass index and bone density of the total hip than between body mass index and bone mineral density of the lumbar spine.

**Key words:** Body Mass Index; Osteoporosis; Fractures; Bone; Obesity; Bone Density; Absorptiometry, Photon; Bone Diseases, Metabolic

Osteoporosis is a metabolic skeletal disease characterized by bone mineral density reduction (BMD), which may lead to an increased risk of bone fractures. Accelerated bone loss can be detected in premenopausal patients, in subjects with different diseases such as primary hyperparathyroidism, Cushing's syndrome, and thyrotoxicosis but it is generally reflected as a disorder in postmenopausal women. With the aging of the world's population, the occurrence of osteoporosis and its consequential fragility fractures is bound to increase significantly. Fragility fracture is defined by the World Health Organization as “...a fracture caused by injury that would be insufficient to fracture a normal bone... the result of reduced compressive and/or torsional strength of bone” [1–3]. Osteoporosis can be diagnosed based on low bone density as measured by osteodensitometry which is based on dual-energy x-ray absorptiometry (DEXA). Low bone mass (osteopenia) is defined as a T-score between −1.0 and −2.5 standard deviations (SD) from the mean for a healthy young adult.


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−2.49 by DEXA findings. Osteodensitometry T-score of −2.5 or lower (determined by the lowest calculation from the lumbar spine, femoral neck, or total femur T-score) is a diagnostic threshold for osteoporosis. A fragility fracture, fracture sustained on week force, regardless of DEXA results, entails the diagnosis of osteoporosis. Worldwide, osteoporosis causes more than 8.9 million fractures annually, resulting in an osteoporotic fracture every 3 seconds and 1 out of 3 women over the age of 50 years will experience osteoporotic fractures, as will 1 out of 5 men over the age of 50 years [4]. Such fractures frequently result in chronic pain, disfigurement, height loss, impairment in activities of daily living, loss of independence, and lower quality of life. The 1-year mortality rate for patients following a hip fracture is estimated to be 14–36% [4, 5]. Women with a vertebral fracture have a 1.2-fold greater age-adjusted mortality rate compared with women without fractures [5]. A 2005 estimate calculated $19 billion annually as the direct cost of fragility fractures [6].

Material and Methods

The study included female orthopedic patients who visited the Clinical Centre of Vojvodina in Novi Sad to have a DEXA examination in the period from March, 2010 to June, 2013. The following anthropometric data were collected: BMI, body weight, height, DEXA T-score and BMD, as well as other data such as hypertension, diabetes, thyroid malfunction, walking, smoking and drinking habits, dairy products consumption, prescribed drugs use, menopause onset, history of fracture and family history of fracture. Men were excluded from the study due to an unrepresentative number in the examined population.

While having their height and weight measured, the participants were dressed in light clothes and did not wear shoes. The BMI was calculated based on the formula weight (kg)/height (m)². According to the standard categorization of BMI by CDC [16] less than 18.5 is taken as underweight, 18.5–24.9 as normal, 25.0–29.9 as overweight, and 30.0 and above as obese. Dual-energy X-ray absorptiometry scans were performed and analyzed in line with the manufacturer’s recommendations. Lumbar spine T-scores (number of standard deviations (SD) above or below young adult mean BMD) and Z-scores (number of SDs above or below age-matched mean BMD) were calculated using the manufacturer’s USA white female reference values. According to the WHO classification T-score of −2.5 or lower was considered to be osteoporotic, between -2.5 and -1 was osteopenia, and above -1 was a normal finding.

Results

The study sample consisted of 1,372 women between the ages 30 and 79 years, their mean age being 62.08 years. The mean weight and the height of the study participants was 73.59 kg and 1.6 m, respectively. The study participants were divided by standard categorization of BMI set by the Centre for Disease Control (CDC) [16] into the group of normal BMI (392 participants), underweight (14 participants), and overweight and obese (966 participants) (Table 1).

In the overweight and obese group, 25.25% of the participants had osteoporosis, 35.4% had osteopenia and 39.33% had the normal T-score. In the normal BMI group, 42.34% of the participants had osteoporosis, 29.3% had osteopenia and 28.31% had the normal T-score. In the underweight group, 57.14% of the participants had osteoporosis, 21.42% had osteopenia and 21.42% had the normal T-score.

Discussion

Fat and bone are linked by many pathways providing a skeleton appropriate to the mass of adipose

**Table 1. BMI and T score in all groups of participants**

<table>
<thead>
<tr>
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<th>Underweight/Ostrepanjeni (BMI &lt; 18.5)</th>
<th>Normal/Idealna masa (BMI 18.5–24.9)</th>
<th>Overweight and obese/Gojazni (BMI &gt; 25.9)</th>
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<tbody>
<tr>
<td>Osteoporosis/Osteoporoza</td>
<td>8</td>
<td>166</td>
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<tr>
<td>Osteopenia/Osteopenija</td>
<td>3</td>
<td>115</td>
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<td>Normal finding</td>
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<td>14</td>
<td>392</td>
<td>966</td>
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Abbreviations

BMI – body mass index
DEXA – dual-energy x-ray absorptiometry
BMD – bone mineral density
CDC – Centre for Disease Control
SD – standard deviation
WHO – World Health Organization

Osteoporosis is a condition of excessive body fat that causes or aggravates many public health problems. As it is easy to be measured, body mass index (BMI) is widely used as an index of the degree of obesity. Although several studies have investigated the association between body mass index (BMI) and bone mineral density (BMD), the results are inconsistent.
tissue it is carrying. Leptin, adiponectin, adipocyte estrogens and insulin/amylin are involved in this connection. However, excessive body fat, and particularly abdominal fat, causes production of inflammatory cytokines which may consequently stimulate bone resorption, resulting in reduction of bone strength.

Traditionally, body weight is positively associated with BMD, from childhood through adulthood (with correlations to the order of 0.3 to 0.6) and obesity is believed to be protective against fragility fracture; many earlier studies support this view [7–10]. For example, hip fracture risk in women was increased by 7.4% for each unit decrease in body mass index (BMI) [8]. Our findings in those 1,372 cases correspond with this result since there is the lowest percentage of patients with osteoporosis in the overweight and obese group in comparison with the patients with normal BMI and underweight.

Body weight is usually considered a strong predictor of bone mass in both men and women. In fact, large-scale epidemiological studies have shown that increased body weight, or body mass index, is positively correlated with higher bone mineral density and with lowered risk of fragility fractures. The most prevalent explanation of this correlation is that a larger body mass causes greater mechanical loading on bone, which consequently increases BMD to accommodate the greater load [17]. In our group of participants we could not get a strong correlation between BMI and BMD, but it is obvious that there is a stronger correlation between BMI and BMD of the total hip than between BMI and BMD of the lumbar spine.

Contrary to this, more recent findings suggest that obesity may not be beneficial to bone health. Some studies have even shown that a higher body mass poses a significant risk factor for fragility fracture, especially for those occurring at sites other than the hip [11–14]. Obviously, most of the findings supporting a detrimental effect of body mass on fracture risk were deduced from bone mineral density (BMD) adjusted data. Individuals with higher BMI had greater risk of fracture than those with low BMI as shown in these studies after BMD effect had been controled [11, 14, 16]. For instance, in a prospective study on elderly women, a greater risk of hip fracture before adjustment for BMD was associated with lower BMI, but the association was reversed after including BMD in the statistical model [16]. Similar adjustment needs to be done with the data obtained by our study which included an even bigger group of participants (approximately 3,000 over a period of 6 years during which DEXA was performed for our orthopedic patients).

## Conclusion

No strong correlation between body mass index and bone mineral density was found in our study, but it is obvious that there was a stronger correlation between body mass index and bone mineral density of the total hip than between body mass index and bone mineral density of the lumbar spine.

### References