**Abstract.** Background. Medical, social and economic relevance of osteoporosis is caused by reducing quality of life, increasing disability and mortality of the patients as a result of fractures due to the low-energy trauma. This study is aimed to examine the associations of metabolic syndrome components, bone mineral density (BMD) and trabecular bone score (TBS) in menopausal women with non-vertebral fractures. 

**Materials and methods.** 1161 menopausal women aged 50–79 years were examined and divided into three groups: group A included 419 women with increased body weight (body mass index (BMI) — 25.0–29.9 kg/m²), group B — 442 females with obesity (BMI > 29.9 kg/m²) and group C — 300 women with metabolic syndrome (diagnosis according to International Diabetes Federation criteria, 2005). Dual-energy X-ray absorptiometry (Prodigy, GE Medical systems, Lunar, Madison, WI, USA, 2005) was used for measuring lumbar spine (L1-L4), femoral neck, total body and forearm BMD and bone quality indexes (last using Medimaps software). Data were analyzed using Statistica 6.0 package. 

**Results.** A significant increase of lumbar spine (L1-L4), femoral neck, total body and ultradistal radius BMD was found in women with obesity and metabolic syndrome compared to the pre-obese ones (p < 0.001). TBS was significantly higher in women with increased body weight compared to obese and metabolic syndrome patients. Analysis showed a significant positive correlation between waist circumference, triglycerides level and BMD of lumbar spine and femur. Significant negative association was found between serum high-density lipoproteins (HDL) level and BMD of investigated sites. 

**Conclusions.** The TBS (L 1-L4) indexes positively correlated with HDL level. Despite the fact that BMD indexes were better in women with metabolic syndrome, the frequency of non-vertebral fractures was significantly higher in this group of patients. 

**Keywords:** bone mineral density; trabecular bone score; metabolic syndrome; fracture
include state of cortical bone macro-geometry and trabecular bone micro-architecture, presence damages and cracks in it, which can be calculated by index trabecular bone score (TBS), patented by MED-I maps (m. Bordeaux, France) in 2006 [3]. In our opinion, evaluation of TBS is important to perform this work.

Scientists paid much attention to the study of the relationships between metabolic syndrome and osteoporosis. Abdominal obesity, high glucose (as a result of insulin deficiency or insulin resistance), high triglycerides and low high density lipoproteins which are the main components of metabolic syndrome have significant impact on bone tissue and fractures development but published research results are contradictory [4, 7, 13, 15]. The discrepancy of opinions prompted this investigation.

The purpose of our study was to evaluate the relationships between metabolic syndrome components and BMD, TBS in postmenopausal women with low-trauma non-vertebral fractures.

Materials and methods

The study involved 1161 postmenopausal women aged 50–79 years (mean age — 63.977 ± 7.961 years; mean body mass index — 31.587 ± 4.739 kg/m²; mean waist circumference — 92.524 ± 11.466 cm; mean duration of menopause period — 13.858 ± 8.014). Patients were divided into three groups: A — 419 women with increase body weight (pre-obese) defined on the basis of WHO criteria [14], BMI 25.0–29.9 kg/m² (mean age — 63.983 ± 8.283 years; mean body mass index — 27.547 ± 1.906 kg/m²; mean waist circumference — 79.995 ± 4.511 cm; mean duration of menopause period — 13.809 ± 8.004), B — 442 women with obesity — BMI ≥ 30.0 kg/m² (mean age — 63.884 ± 7.619 years; mean body mass index — 34.418 ± 3.864 kg/m²; mean waist circumference — 100.464 ± 6.726 cm; mean duration of menopause period — 13.627 ± 8.280). Additionally groups were divided according to the presence of low-trauma non-vertebral fractures (202 female had them in history (NVF) and 959 women were without fractures (WF) in the past).

BMD of lumbar spine (L₁–L₄), femoral neck, total body and forearm was measured by the DXA method (Prodigy, GE Medical systems, Lunar, Madison, WI, USA, 2005).

TBS at the L₁–L₄ was evaluated by TBS iNsight® software (Med-Imaps, Pessac, France) which was installed on DXA machine.

One-way ANOVA test and correlation analysis were performed with usage of Statistical Package 6.0 ©StatSoft, Inc, results presented as M ± SD. Associations between continuous variables were examined by Pearson correlation coefficient, significance set at p < 0.05.

Results and discussion

We found that women with increased body weight have a significantly lower BMD of lumbar spine (A — 0.986 ± 0.178 g/cm², B — 1.109 ± 0.181 g/cm²; C — 1.120 ± 0.199 g/cm²; F = 63.814; p < 0.001); femoral neck (A — 0.809 ± 0.126 g/cm², B — 0.872 ± 0.134 g/cm²; C — 0.880 ± 0.149 g/cm²; F = 32.097; p < 0.001), total body (A — 0.876 ± 0.139 g/cm², B — 0.968 ± 0.146 g/cm²; C — 0.978 ± 0.160 g/cm²; F = 57.366; p < 0.001) and ultra-distal forearm (A — 0.378 ± 0.076 g/cm², B — 0.436 ± 0.080 g/cm²; C — 0.435 ± 0.088 g/cm²; F = 67.582; p < 0.001) compared to women with obesity and metabolic syndrome. The bone tissue quality (TBS L₁–L₄) was significantly

| Groups of patients | Subgroups of patients | BMD lumbar spine (L₁–L₄), g/cm² | P |
|--------------------|-----------------------|-------------------------------|---|
| A                  | Without fractures (n = 358) | 0.992 ± 0.180 | > 0.05 |
|                    | With non-vertebral fractures (n = 61) | 0.955 ± 0.164 | |
| B                  | Without fractures (n = 365) | 1.119 ± 0.183 | < 0.001 |
|                    | With non-vertebral fractures (n = 77) | 1.059 ± 0.163 | |
| C                  | Without fractures (n = 236) | 1.139 ± 0.199 | < 0.001 |
|                    | With non-vertebral fractures (n = 64) | 1.052 ± 0.860 | |

| Groups of patients | Subgroups of patients | BMD femoral neck, g/cm² | P |
|--------------------|-----------------------|--------------------------|---|
| A                  | Without fractures (n = 358) | 0.814 ± 0.130 | > 0.05 |
|                    | With non-vertebral fractures (n = 61) | 0.780 ± 0.101 | |
| B                  | Without fractures (n = 365) | 0.879 ± 0.135 | < 0.001 |
|                    | With non-vertebral fractures (n = 77) | 0.834 ± 0.119 | |
| C                  | Without fractures (n = 236) | 0.888 ± 0.153 | > 0.05 |
|                    | With non-vertebral fractures (n = 64) | 0.852 ± 0.133 | |
higher in women with increased weight in comparison with metabolic syndrome female (A — 1.188 ± 0.151, B — 1.169 ± 0.163; C — 1.157 ± 0.173 g/cm²; F = 3.479; p < 0.05).

BMD of lumbar spine (L₁–L₄) was significantly higher in patients of groups B and C without fractures (table 1).

BMD of femoral neck was significantly lower in female with obesity and non-vertebral fractures (table 2). BMD of total body and ultradistal radius significantly better in all groups of women without fractures compared to patients with non-vertebral fractures (table 3, 4). TBS (L₁–L₄) was significantly higher in patients without fractures in the groups of

| Groups of patients | Subgroups of patients | Bone mineral density, g/cm² | P |
|--------------------|-----------------------|-----------------------------|---|
| A                  | Without fractures (n = 358) | 0.884 ± 0.140 | < 0.001 |
|                    | with non-vertebral fractures (n = 61) | 0.832 ± 0.119 | |
| B                  | Without fractures (n = 365) | 0.977 ± 0.148 | < 0.001 |
|                    | With non-vertebral fractures (n = 77) | 0.928 ± 0.129 | |
| C                  | Without fractures (n = 236) | 0.991 ± 0.163 | < 0.001 |
|                    | With non-vertebral fractures (n = 64) | 0.931 ± 0.140 | |

| Groups of patients | Subgroups of patients | Bone mineral density, g/cm² | P |
|--------------------|-----------------------|-----------------------------|---|
| A                  | Without fractures (n = 358) | 0.382 ± 0.077 | < 0.05 |
|                    | With non-vertebral fractures (n = 61) | 0.354 ± 0.071 | |
| B                  | Without fractures (n = 365) | 0.442 ± 0.079 | < 0.001 |
|                    | With non-vertebral fractures (n = 77) | 0.410 ± 0.083 | |
| C                  | Without fractures (n = 26) | 0.442 ± 0.088 | < 0.001 |
|                    | With non-vertebral fractures (n = 64) | 0.407 ± 0.842 | |

| Groups of patients | Subgroups of patients | Trabecular bone score (TBS) | P |
|--------------------|-----------------------|-----------------------------|---|
| A                  | Without fractures (n = 358) | 1.194 ± 0.151 | < 0.05 |
|                    | With non-vertebral fractures (n = 61) | 1.152 ± 0.439 | |
| B                  | Without fractures (n = 365) | 1.179 ± 0.150 | < 0.001 |
|                    | With non-vertebral fractures (n = 77) | 1.119 ± 0.171 | |
| C                  | Without fractures (n = 236) | 1.156 ± 0.177 | > 0.05 |
|                    | With metabolic syndrome (n = 73) | 1.158 ± 0.156 | |

| Groups of patients | Subgroups of patients | Triglycerides level, mmol/l | P |
|--------------------|-----------------------|-----------------------------|---|
| A                  | Without fractures (n = 358) | 1.057 ± 0.393 | > 0.05 |
|                    | With non-vertebral fractures (n = 61) | 0.996 ± 0.288 | |
| B                  | Without fractures (n = 365) | 1.035 ± 0.332 | > 0.05 |
|                    | With non-vertebral fractures (n = 77) | 1.006 ± 0.273 | |
| C                  | Without fractures (n = 236) | 1.643 ± 0.708 | > 0.05 |
|                    | With non-vertebral fractures (n = 64) | 1.465 ± 0.668 | |

| Groups of patients | Subgroups of patients | HDL level, mmol/l | P |
|--------------------|-----------------------|------------------|---|
| A                  | Without fractures (n = 358) | 1.523 ± 0.037 | > 0.05 |
|                    | With non-vertebral fractures (n = 61) | 1.579 ± 0.327 | |
| B                  | Without fractures (n = 365) | 1.501 ± 0.319 | > 0.05 |
|                    | With non-vertebral fractures (n = 77) | 1.546 ± 0.272 | |
| C                  | Without fractures (n = 236) | 1.148 ± 0.229 | < 0.001 |
|                    | With non-vertebral fractures (n = 64) | 1.252 ± 0.325 | |
women with increased body weight and obesity ($p < 0.05$) (table 5).

The analysis of the metabolic syndrome laboratory components (serum triglycerides and HDL indexes) was carried out. We established significantly higher triglycerides level ($A = 1.049 \pm 0.381 \text{ g/cm}^2$, $B = 1.030 \pm 0.322 \text{ g/cm}^2$; $C = 1.605 \pm 0.703 \text{ g/cm}^2$; $F = 162.669$; $p < 0.001$) and significantly lower HDL level ($A = 1.531 \pm 0.372 \text{ g/cm}^2$, $B = 1.509 \pm 0.314 \text{ g/cm}^2$, $C = 1.170 \pm 0.256 \text{ g/cm}^2$; $F = 126.832$; $p < 0.001$) in patients with metabolic syndrome. There was no difference of triglycerides level in female with non-vertebral fractures and without them in all investigated groups (table 6). The level of HDL was significantly lower in patients with non-vertebral fractures and metabolic syndrome (table 7).

In analysis of metabolic syndrome components, the waist circumference component was positively associated with

![Figure 1. Correlation between waist circumference and BMD of (A) lumbar spine (L1–L4), (B) femoral neck, (C) trabecular bone score](image1)

![Figure 2. Correlation between triglycerides serum level and BMD of (A) lumbar spine (L1–L4), (B) femoral neck, (C) trabecular bone score](image2)
BMD of lumbar spine and femur (fig. 1). The study reveals significant positive correlation between serum triglycerides level and both investigated BMD sites (fig. 2). A number of investigators have suggested relationship in accordance with our own findings [2]. It was found a significant positive correlation between HDL serum level and TBS and inversely association with BMD of lumbar spine and femur (fig. 3).

We calculated the percentage of non-vertebral fractures in anamnesis (fig. 4).

Low-trauma non-vertebral fractures occurred in 14.6 % female with increased body weight, 17.4 % of women with obesity and 21.3 % of patients with metabolic syndrome.

It was not found significant differences in the frequency of non-vertebral fractures in the groups of women with obesity and increased body weight or metabolic syndrome ($\chi^2 = 1.312$, $p > 0.05$ and $\chi^2 = 1.780$, $p > 0.05$, respectively), but it was significant in the groups of pre-obese female and patients with metabolic syndrome ($\chi^2 = 5.590$, $p < 0.05$). The similar results were found by other investigators [9].

**Conclusions**

Menopausal women with obesity and metabolic syndrome have a significantly higher BMD at all measured sites compared to females with pre-obesity. TBS is significantly lower in women with non-vertebral fractures and increased body weight or obesity. A significant positive correlation is established between waist circumference, triglycerides level and BMD of lumbar spine and femoral neck. Correlation between HDL level and BMD at all levels is significant and negative. At the same time it is positively associated with TBS indexes. There is no significant difference in frequency of low-trauma non-vertebral fractures in the groups of pre-obese and obese women. At the same time, the incidence of osteoporotic non-vertebral fractures is significantly higher in female with metabolic syndrome in compared to other patients Metabolic syndrome may not protect from any type of fractures but future investigations are necessary.

**Conflicts of interests.** Authors declare the absence of any conflicts of interests that might be construed to influence the results or interpretation of their manuscript.

**References**

1. Bliuc D, Nguyen ND, Milch VE, Nguyen TV, Eisman JA, Center JR. Mortality risk associated with low-trauma
Согласно критериям Международной федерации диабета с метаболическим синдромом (диагноз установлен ожирением (ИМТ > 29,9 кг/м²) и в группу В — 300 женщин (ИМТ) — 25,0–29,9 кг/м²), группу Б — 442 женщины с повышенной массой тела (индекс массы тела), 419 женщин в постменопаузальном периоде в возрасте 50–79 лет (n = 1161) были обследованы и разделены на три группы: в группу А вошли 419 женщин, в группу Б — 442 женщины с ожирением и метаболическим синдромом в отличие от пациенток с предожирением, TBS был значительно выше у женщин с ожирением и метаболическим синдромом в отличие от пациенток с предожирением (p < 0,001). TBS был значительно выше у женщин с избыточной массой тела по сравнению с пациентками с ожирением и метаболическим синдромом. Анализ показал значительную положительную корреляцию между окружностью талии, уровнем триглицеридов и МПКТ.
Зв’язок метаболічного синдрому і мінеральної щільності кісткової тканини, показника якості трабекулярної кісткової тканини у жінок у постменопаузальному періоді з невертебральними переломами

Резюме. Актуальність. Медична, соціальна й економічна значимість остеопорозу обумовлена зниженням якості життя, збільшенням інвалідності та смертності пацієнтів у результаті переломів, викликаних низькоенергетичною травмою. Мета дослідження: вивчити кореляцію компонентів метаболічного синдрому, мінеральної щільності кісткової тканини (МЩКТ) і показника якості трабекулярної кісткової тканини (trabecular bone score — TBS) у жінок у постменопаузальному періоді з невертебральними переломами. Матеріали та методи. Пацієнтки в постменопаузальному періоді віком 50–79 років (n = 1161) були обстежені і розподілені на три групи: до групи А увійшли 419 жінок із підвищеною масою тіла (індекс маси тіла (ІМТ) — 25,0–29,9 кг/м2), групи Б — 442 жінки з ожирінням (ІМТ > 29,9 кг/м2) і до групи В — 300 жінок із метаболічним синдромом (діагноз установлений відповідно до критеріїв Міжнародної федерації діабету, 2005). Двохенергетична рентгенівська абсорбціометрія (Prodigy, GE Medical systems, Lunar, WI, USA, 2005) використовувалася для визначення МЩКТ поперекового відділу хребта (L1–L4), шийки стегнової кістки, всього скелету і передпліччя і показників якості кісткової тканини (останніх — за допомогою програмного забезпечення Medimaps). Дани аналізувалися за допомогою програми Statistica 6.0. Результати. Значне збільшення МЩКТ поперекового відділу хребта (L1–L4), шийки стегнової кістки, всього скелету і ультрадистального відділу променевої кістки було виявлено в жінок з ожирінням і метаболічним синдромом на відміну від пацієнток із предожирінням (p < 0,001). TBS був значно вищим у жінок із підвищеною масою тіла порівняно з пацієнтками з ожирінням і метаболічним синдромом. Аналіз показав значну позитивну кореляцію між окружністю талії, рівнем тригліцеридів і МЩКТ поперекового відділу і стегнової кістки. Установленний значний негативний зв’язок між рівнем ліпопротеїнів високої щільності (ЛПВЩ) у сироватці крові та МЩКТ досліджуваних ділянок.

Висновки. TBS (L1–L4) позитивно корелює з рівнем ЛПВЩ. Незважаючи на те що показники МЩКТ були кращими у жінок із метаболічним синдромом, частота невертебральних переломів у цій групі була значно вищою.

Ключові слова: мінеральна щільність костної тканини; показник якості трабекулярної кісткової тканини; метаболічний синдром; перелом