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Bone Mineral Density and Trabecular Bone Score in Ukrainian Women with Obesity

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Abstract**—**Obesity and osteoporosis are the two diseases whose increasing prevalence and high impact on the global morbidity and mortality, during the two recent decades, have gained a status of major health threats worldwide. Obesity purports to affect the bone metabolism through complex mechanisms. Debated data on the connection between the bone mineral density and fracture prevalence in the obese patients are widely presented in literature. There is evidence that the correlation of weight and fracture risk is site-specific. This study is aimed at determining the connection between the bone mineral density (BMD) and trabecular bone score (TBS) parameters in Ukrainian women suffering from obesity. We examined 1025 40-89-year-old women, divided them into the groups according to their body mass index: Group A included 360 women with obesity whose BMI was ≥30 kg/m^2, and Group B – 665 women with no obesity and BMI of <30 kg/m^2. The BMD of total body, lumbar spine at the site L1-L4, femur and forearm were measured by DXA (Prodigy, GEHC Lunar, Madison, WI, USA). The TBS of L1-L4 was assessed by means of TBS iNsight® software installed on our DXA machine (product of Med-Imaps, Pessac, France). In general, obese women had a significantly higher BMD of lumbar spine, femoral neck, proximal femur, total body and ultradistal forearm ($p<0.001$) in comparison with women without obesity. The TBS of L1-L4 was significantly lower in obese women compared to non-obese women ($p<0.001$). The BMD of lumbar spine, femoral neck and total body differed to a significant extent in women of 40-49, 50-59, 60-69 and 70-79 years ($p<0.05$). At same time, in women aged 80-89 years the BMD of lumbar spine ($p=0.09$), femoral neck ($p=0.22$) and total body ($p=0.06$) barely differed. The BMD of ultradistal forearm was significantly higher in women of all age groups ($p<0.05$). The TBS of L1-L4 in all the age groups tended to reveal the lower parameters in obese women compared with the non-obese; however, those data were not statistically significant. By contrast, a significant positive correlation was observed between the fat mass and the BMD at different sites. The correlation between the fat mass and TBS of L1-L4 was also significant, although negative. Women with vertebral fractures had a significantly lower body weight, body mass index and total body fat mass in comparison with women without vertebral fractures in their anamnesis. In obese women the frequency of vertebral fractures was 27%, while in women without obesity – 57%.

Keywords**—**Bone mineral density, trabecular bone score, obesity, women.

I. Introduction

THE combined effect of osteoporosis and obesity on the morbidity and mortality of the population worldwide is addressed by the numerous recent studies [1], [3], [5], [6], [12]. It has also been reported that age and female gender increase the risk of developing both obesity and osteoporosis [6].

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Body weight is generally considered a strong predictor of bone mass in both males and females [6], which positively correlate with bone mineral density and negatively - with fracture risk, according to the results of numerous laboratory and clinical studies [8]. Many researchers have reported that in healthy premenopausal and postmenopausal women the total body fat is positively related to the bone mineral density, which is commonly considered the most important measurable determinant of fracture risk, and that the decreased body weight leads to bone loss [6].

Obesity undermines the healthy bone metabolism through the following set of mechanisms. Because both adipocytes and osteoblasts are derived from a common multipotential mesenchymal stem cell, obesity may increase adipocyte differentiation and fat accumulation while decreasing osteoblast differentiation and bone formation. Obesity is associated with a chronic inflammation. Increase in the rate of circulating and tissue proinflammatory cytokines is likely to promote osteoclast activity and bone resorption through modification of the receptor activator of NF-B (RANK)/ RANK ligand/osteoprotegerin pathway. Furthermore, the excessive secretion of leptin and/or decreased production of adiponectin by adipocytes in obesity may either directly affect bone formation or indirectly affect bone resorption through up-regulated pro-inflammatory cytokine production. Finally, the high fat intake may interfere with the intestinal calcium absorption and therefore decrease calcium availability for the bone formation [2]-[4], [7], [9], [12].

There is further evidence that the relationship between weight and fracture risk is site-specific [6], [8], [10], [12]. The results of a meta-analysis of 60,000 men and women from 12 prospective, population based cohorts show that total fractures, osteoporotic fractures and hip fractures are all inversely correlated to the body mass index (BMI) in both men and women [6].

Several recent studies demonstrate that the obesity protects human body against fractures and at the same time that the obesity is a risk factor for certain types of fracture. Namely, the study by Hsu, carried out in a large cohort of Chinese men and women, shows that the frequency of nonspine fractures is significantly higher in the subjects with a higher percentage of body fat, independent of their body weight. The Global Longitudinal study of Osteoporosis in Women, a prospective cohort study involving 723 physician practices in 10 countries, has reported that fractures in obese women accounted for 23%

and 22% of all previous and incident fractures, respectively. By contrast, prospective study of the EPIC cohort reported that a higher body fat mass is associated with a lower risk of hip fracture amongst women. The risk of incident ankle and upper leg fractures was significantly higher in obese than non-obese women, while the risk of wrist fracture was significantly lower. An Italian study, carried out on 2,235 Italian postmenopausal women with fractures, reports that increased BMI is associated with a significantly higher risk of humerus fracture and a lower risk of hip fracture, but no relationship is seen between the BMI and either wrist or ankle fractures. Using data of the Womens' Health Initiative study on the postmenopausal women, Beck et al. report a significantly higher incidence of lower-extremity fractures in obese versus normal women and a significantly lower incidence of hip fractures [6].

Data on vertebral fractures in obese subjects are scarce, although an Italian study carried out on a small cohort of postmenopausal women associates a higher BMI with a higher likelihood of vertebral fractures, irrespective of the positive association between weight and BMD [6]. A study carried out on the Korean postmenopausal women reports that the high percentage of body fat and greater waist circumference correlate with an increased risk of vertebral fractures. The Tasmanian Older Adult Cohort study reports a positive association between the prevalent thoracic vertebral fractures and the BMI, total fat mass and waist circumference in females. However, there are no statistically significant associations between the BMI or body fat and vertebral fractures at lumbar spine in women [6].

The reasons for site-specific differences in fracture rate of the obese and non-obese individuals have not been conclusively established. However, it is consistently found that obesity is associated with the reduced levels of 25-hydroxyvitamin D, and that the fat mass and 25-hydroxyvitamin D serum levels are inversely related probably due to the sequestration of this fat soluble vitamin in the adipose tissue. In addition, the consequent increase in serum parathyroid hormone level reported in the obese individuals could have an adverse effect on cortical bone [6].

Thus, conflicting data suggest that there is a complex relationship between fat mass and bone mass, likely to depend on the patient's age, sex and ethnicity [11].

The aim of this study was to evaluate the bone mineral density (BMD) and trabecular bone score (TBS) in Ukrainian obese women.

II. Materials and Methods

1025 women aged 40-89 years (mean age – 62.7±9.7 years; mean height – 161.4±6.2 cm; mean weight – 73.9±13.8 kg, body mass index – 28.4±5.1 kg/m^2) were examined. The women were divided into the following groups depending on body mass index: A – 360 women with obesity, BMI≥30 kg/m^2 (mean age – 64.0±8.9 years; mean height – 160.7±5.9 cm; mean weight – 87.6±10.5 kg, body mass index – 33.9±3.5 kg/m^2), B – 665 women without obesity, BMI<30 kg/m^2 (mean age – 62.0±10.0 years; mean height – 161.7±6.4 cm; mean weight – 66.4±8.9 kg, body mass index – 25.4±2.8 kg/m^2).

BMD at total body, lumbar spine (L1-L4), femur and forearm was measured by the DXA method (Prodigy, GEHC Lunar, Madison, WI, USA).

TBS iNsight® software (Med-Imaps, Pessac, France) was installed on our DXA machine for the express purpose of assessing TBS at the L1-L4. The study results are presented in the following manner: M±SD.

We performed a one-way ANOVA test, multiple regression and correlation analysis. Significance was set at p<0.05. "Statistika 6.0" © StatSoft, Inc. was used for data processing purposes.

III. Results

In total group we found that obese women have significantly higher BMD of lumbar spine (A – 1.114±0.197 g/cm^2, B – 0.994±0.194 g/cm^2; F=87.52; p<0.001), femoral neck (A – 0.963±0.150 g/cm^2, B – 0.875±0.151 g/cm^2; F=31.03; p<0.001), proximal femur (A – 1.123±0.108 g/cm^2, B – 1.037±0.111 g/cm^2; F=78.84; p<0.001), total body (A – 1.123±0.108 g/cm^2, B – 1.037±0.111 g/cm^2; F=140.25; p<0.001) and ultra-distal forearm (A – 0.429±0.087 g/cm^2, B – 0.371±0.082 g/cm^2; F=113.76; p<0.001) in comparison with women without obesity. TBS (L1-L4) was significantly lower in obese women compared to non-obese women (A – 1.182±0.165, B – 1.216±0.141; F=12.00; p<0.001).

When we analyzed BMD depending on age, we determined that BMD of lumbar spine, femoral neck and total body significantly differ in women of aged group 40-49, 50-59, 60-69 and 70-79 years (p<0.05). At same time, in women aged 80-89 years BMD of lumbar spine (p=0.09), femoral neck (p=0.22) and total body (p=0.06) significantly not differ. Ultra-distal forearm BMD was measurably higher in women of all the age groups (p<0.05) (Table I-IV). By contrast, TBS of L1-L4 tended to decrease in obese women as compared to the non-obese ones; however, the data were not statistically significant (Table V).

TABLE I
BONE MINERAL DENSITY OF LUMBAR SPINE (L1-L4) IN UKRAINIAN OBESE AND NON-OBESE WOMEN

Age groups, years		BMD lumbar spine (L1-L4), g/cm^2	p
40-49	without obesity (n=74)	1.137±0.186	0.06
	with obesity (n=16)	1.236±0.192	
50-59	without obesity (n=195)	1.137±0.186	<0.001
	with obesity (n=96)	1.236±0.192	
60-69	without obesity (n=225)	0.954±0.179	<0.001
	with obesity (n=142)	1.109±0.200	
70-79	without obesity (n=144)	0.939±0.205	<0.001
	with obesity (n=93)	1.065±0.165	
80-89	without obesity (n=27)	0.942±0.187	0.09
	with obesity (n=13)	1.064±0.246	

Fat mass and BMD status showed a significant positive inter-relation at various sites. Correlation between fat mass and TBS (L1-L4) was significant and negative (Fig. 1).

TABLE II
BONE MINERAL DENSITY OF PROXIMAL FEMUR IN UKRAINIAN OBESE AND NON-OBESE WOMEN

Age groups, years		BMD proximal femur, g/cm^2	p
40-49	without obesity (n=74)	0.988±0.172	0.03
	with obesity (n=16)	1.094±0.153	
50-59	without obesity (n=195)	0.988±0.172	<0.001
	with obesity (n=96)	1.094±0.153	
60-69	without obesity (n=225)	0.866±0.141	<0.001
	with obesity (n=142)	0.974±0.132	
70-79	without obesity (n=144)	0.805±0.132	<0.001
	with obesity (n=93)	0.882±0.122	
80-89	without obesity (n=27)	0.739±0.103	0.43
	with obesity (n=13)	0.775±0.166	

TABLE III
BONE MINERAL DENSITY OF TOTAL BODY IN UKRAINIAN OBESE AND NON-OBESE WOMEN

Age groups, years		BMD total body, g/cm^2	p
40-49	without obesity (n=74)	1.136±0.097	0.004
	with obesity (n=16)	1.213±0.079	
50-59	without obesity (n=195)	1.136±0.097	<0.001
	with obesity (n=96)	1.213±0.079	
60-69	without obesity (n=225)	1.019±0.099	<0.001
	with obesity (n=142)	1.129±0.102	
70-79	without obesity (n=144)	0.975±0.104	<0.001
	with obesity (n=93)	1.070±0.092	
80-89	without obesity (n=27)	0.937±0.105	0.06
	with obesity (n=13)	1.015±0.142	

TABLE IV
BONE MINERAL DENSITY OF ULTRADISTAL RADIUS IN UKRAINIAN OBESE AND NON-OBESE WOMEN

Age groups, years		BMD ultradistal radius, g/cm^2	p
40-49	without obesity (n=74)	0.434±0.081	0.001
	with obesity (n=16)	0.508±0.063	
50-59	without obesity (n=195)	0.434±0.081	<0.001
	with obesity (n=96)	0.508±0.063	
60-69	without obesity (n=225)	0.360±0.075	<0.001
	with obesity (n=142)	0.426±0.079	
70-79	without obesity (n=144)	0.327±0.073	<0.001
	with obesity (n=93)	0.401±0.088	
80-89	without obesity (n=27)	0.295±0.063	0.004
	with obesity (n=13)	0.380±0.110	

TABLE V
TRABECULAR BONE SCORE (L1-L4) IN UKRAINIAN OBESE AND NON-OBESE WOMEN

Age groups, years		TBS (L1-L4)	p
40-49	without obesity (n=74)	1.352±0.124	0.21
	with obesity (n=16)	1.310±0.101	
50-59	without obesity (n=195)	1.352±0.124	0.16
	with obesity (n=96)	1.310±0.101	
60-69	without obesity (n=225)	1.199±0.120	0.15
	with obesity (n=142)	1.177±0.162	
70-79	without obesity (n=144)	1.141±0.129	0.68
	with obesity (n=93)	1.134±0.148	
80-89	without obesity (n=27)	1.105±0.157	0.47
	with obesity (n=13)	1.066±0.162	

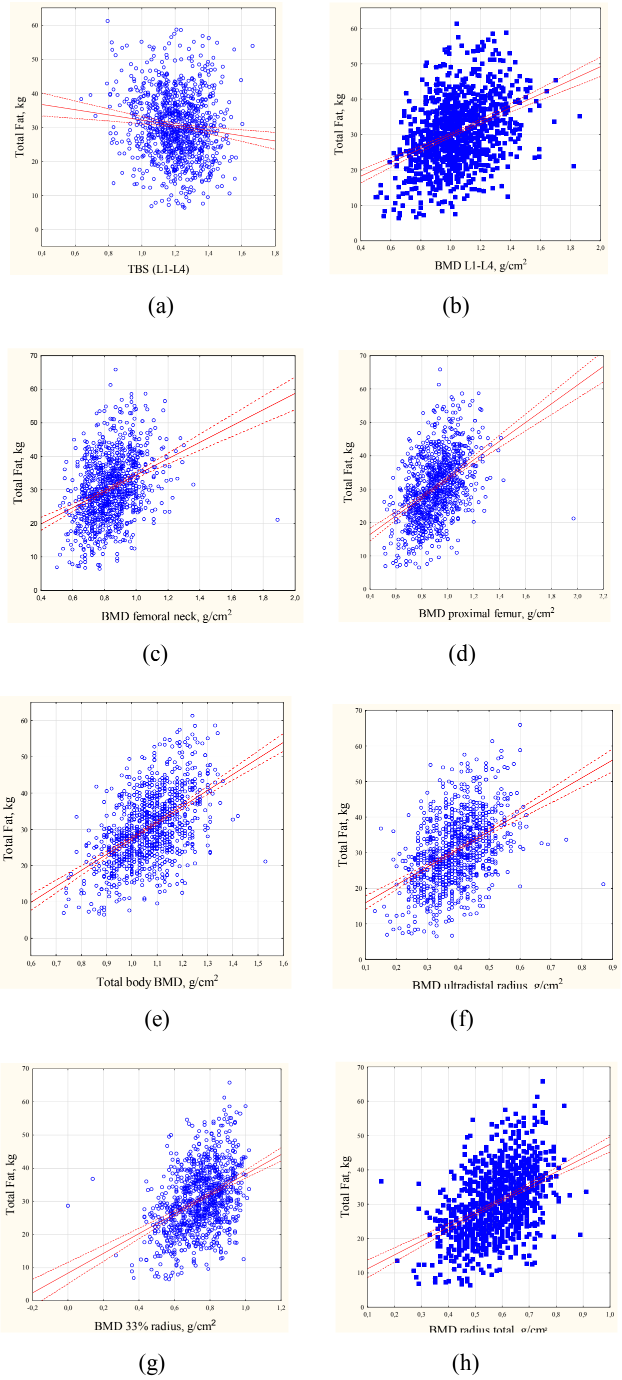

Fig. 1 The correlation between fat mass and TBS (L1-L4), BMD lumbar spine (L1-L4), femoral neck, proximal femur, total body, ultradistal radius, 33% radius, and radius total Note. Linear regression equations: (a) Total Fat, kg = 39.774 - 7.619*TBS (L1-L4); r=-0.12; t=-3.65; p=0.0003. (b) Total Fat, kg = 10.516 + 19,325* BMD lumbar spine (L1-L4), g/cm^2; r=0.40; t=11.36; p<0.001. (c) Total Fat, kg = 10.103 + 24.339* BMD femoral neck, g/cm^2; r=0.34; t=11.36; p<0.001. (d) Total Fat, kg = 5.152 + 28.001* BMD proximal femur, g/cm^2; r=0.44; t=15.35; p<0.001. (e) Total Fat, kg = -16.670 + 44.183* BMD total body, g/cm^2; r=0.52; t=19.06; p<0.001. (f) Total Fat, kg = 10.977 + 49.971*BMD ultradistal radius, g/cm^2; r=0.45; t=15.64; p<0.001. (g) Total Fat, kg = 8.373 + 29.831*BMD 33% radius, g/cm^2; r=0.40; t=13.62; p<0.001. (d) Total Fat, kg = 7,167 + 40,301*BMD radius total, g/cm^2; r=0.43; t=15.04; p<0.001

We determined that women with vertebral fractures had significantly lower body weight (71.50±13.23 kg vs. 75.72±14.58 kg; p=0.01), body mass index (28.29±4.96 kg/m^2 vs. 28.41±5.24 kg/m^2; p=0.03) and total fat mass (28.44±9.85 kg vs. 32.21±9.23 kg; p=0.002) in comparison with women without vertebral fractures in their anamnesis. The total lean mass did not differ in women depending on presence of vertebral fractures (40.44±4.38 kg vs. 41.62±5.77 kg; p=0.07) (Fig. 2).

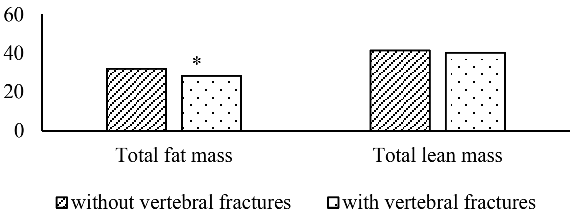

Fig. 2 Fat and lean masses (kg) in women depending on presence of vertebral fractures in their anamnesis; * - significant difference between groups (p<0.05)

In obese women frequency of vertebral fractures was 27%, in women without obesity – 57% (Fig. 3).

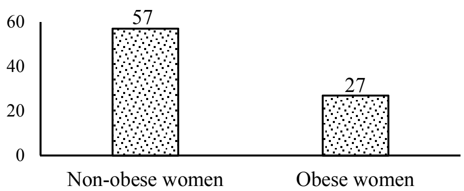

Fig. 3 Frequency (%) of vertebral fractures in obese and non-obese women

IV. Conclusion

Ukrainian obese women have significantly higher BMD at all measured sites compared with women without obesity. TBS (L1-L4) was not significantly differing in examined women depending on age. The study results reveal a significant positive inter-relation between fat mass and BMD. Correlation between fat mass and TBS (L1-L4) was significant and negative. Women with vertebral fractures had significantly lower body weight, body mass index and total body fat mass in comparison with women without vertebral fractures in their anamnesis. In obese women frequency of vertebral fractures was 27%, in women without obesity – 57%.

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