

# Bone Mineral Density and Quality, Body Composition of Women in the Postmenopausal Period

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**Abstract**—In the diagnostics of osteoporosis, the gold standard is considered to be bone mineral density; however, X-ray densitometry is not an accurate indicator of osteoporotic fracture risk under all circumstances. In this regard, the search for new methods that could determine the indicators not only of the mineral density, but of the bone tissue quality, is a logical step for diagnostic optimization. One of these methods is the evaluation of trabecular bone quality. The aim of this study was to examine the quality and mineral density of spine bone tissue, femoral neck, and body composition of women depending on the duration of the postmenopausal period, to determine the correlation of body fat with indicators of bone mineral density and quality. The study examined 179 women in premenopausal and postmenopausal periods. The patients were divided into the following groups: Women in the premenopausal period and women in the postmenopausal period at various stages (early, middle, late postmenopause). A general examination and study of the above parameters were conducted with General Electric X-ray densitometer. The results show that bone quality and mineral density probably deteriorate with advancing of postmenopausal period. Total fat and lean mass ratio is not likely to change with age. In the middle and late postmenopausal periods, the bone tissue mineral density of the spine and femoral neck increases along with total fat mass.

**Keywords**—Osteoporosis, bone tissue mineral density, bone quality, fat mass, lean mass, postmenopausal osteoporosis.

## I. INTRODUCTION

**O**STEOPOROSIS is the most common metabolic skeletal disease characterized by low bone mass and the abnormality of bone tissue micro-architectonics that leads to increasing bone fragility and an increased risk of fractures. The disease mostly occurs in elderly women, as a result of bone mass loss due to estrogen deficiency in this period [1]-[4]. Postmenopausal osteoporosis occurs in women 10-20 years after menopause, and is characterized by fractures of those skeletal parts where the trabecular (spongy) bone tissue is predominant - vertebral bodies, distal forearm (Colles' fracture). This form of osteoporosis is a major public health problem in developed countries. Foreign experts believe that the disease has already reached epidemic proportions. Approximately one third of all women 65-years and over has

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at least one osteoporotic bone fracture [12]-[14]. The gold standard in the osteoporosis diagnostics is, by all accounts, bone mineral density (BMD); however, indicators of X-ray densitometry can determine the risk of osteoporotic fractures only to a certain degree. In this regard, the search for new methods reflecting not only mineral density but also bone quality is being performed. One of these methods is the Trabecular Bone Score (TBS) indicator. For the last three years in most countries, including Ukraine, TBS indicators have actively been studied in connection with primary and secondary osteoporosis [5]-[11]. The TBS indicator provides a global assessment of bone tissue quality. This method's value lies in its reproducibility and discriminatory ability, sensitivity to changes during the disease or treatment, and also possibility of assessing the risk of osteoporotic fractures. According to the results of many studies that have shown the relationship of excess body weight with risk reduction of osteoporotic fractures, obesity is usually perceived as "protection against the development of osteoporosis". BMD increase, the main risk determinant of osteoporotic fractures, was observed in overweight women, which can partly be explained by increased estrogen levels generated by extragranular androgens in adipose tissue, and increased "loading" effect of fat mass on bone tissue [4].

Since total body weight consists of fat mass (FM) and lean mass, some researchers have tried to determine how they are causing structural and functional abnormalities in the bone tissue: was it due to the overall negative impact of obesity or to increased FM impacting individual health? So far there is no clear answer to this question. Some studies have identified FM as the main factor of protection against fractures, while others found that low-fat weight has a stronger relation with BMD [4].

The aim of this study is to examine the bone quality and mineral density, fat and lean mass of women depending on the duration of the postmenopausal period (PMP).

## II. MATERIALS AND METHODS

At the Department of Clinical Physiology and Pathology of the Musculoskeletal System by SI "D.F. Chebotarev State Institute of Gerontology NAMS of Ukraine", 179 women in the premenopausal and postmenopausal periods were examined. The average age of patients was  $58.5 \pm 0.4$  years; the duration of the PMP –  $11.6 \pm 0.6$  years. The patients were divided into the following groups: A – women in the premenopausal period – 18 (45-53 years, average age -

49,1±0,5 years); B – women in PMP with a duration of less than 5 years – 32 (44-58 years, average age – 53,4±0,6 years); C – women in PMP with a duration of 5-9 years – 39 (48-67 years, average age – 58.0±0.7 years); D – women in PMP with a duration of 10-14 years – 56 (52-70 years, average age – 60.8±0.5 years); E – women in PMP with a duration of 15-20 years – 34 (58-72 years, average age – 60.0±0.7 years).

The clinical examination of patients was conducted (patients taking medications or having diseases that affect bone metabolism were excluded from the study). The General Electric X-ray densitometer was used to perform the following studies: BMD of spine, femoral neck, and total body; body composition (total FM, lean mass); bone quality (according to the Medimaps installation). Analysis was carried out using

Statistica 8 software and included ANOVA single-factor dispersion and regression analysis. Reliability of results was found at  $p < 0.05$ .

### III. RESULTS

Table I shows the main clinical and anthropometric characteristics of patients in the surveyed groups. There was no likely impact of postmenopausal duration on the variability of anthropometric (height, weight, body mass index (BMI)) and clinical (menarche age, menopause age) characteristics. The likely impact of postmenopausal duration on age is determined by the patient distribution into groups depending on the length of postmenopausal period.

TABLE I  
MAIN CLINICAL, ANTHROPOMETRIC CHARACTERISTICS OF PATIENTS DUE TO MENOPAUSAL STATUS

Parameters	A	B	C	D	E	F	p
	M±SD	M±SD	M±SD	M±SD	M±SD		
n	18	32	39	56	34		
Age, years	49.1±2.2	53.4±3.6	58.0±4.5	60.8±4.1	65.1±3.8	69.7	<0.001
Age of menarche, years	13.59±1.94	13.6±1.59	14.00±1.26	13.55±1.48	13.4±1.56	0.77	un
Age of menopause, years	-	49.00±9.86	50.95±4.22	49.04±3.91	48.66±3.5	1.32	un
Duration of postmenopausal period, years	-	2.69±1.6	7.05±1.17	11.8±1.46	16.46±1.3	627.8	<0.001
Height, m	1.65±0.05	1.62±0.05	1.63±0.05	1.63±0.05	1.61±0.05	2.3	un
Weight, kg	66.00±10.5	68.5±10.1	67.7±9.9	66.5±8.2	67±8.7	0.3	un
BMI, kg/m <sup>2</sup>	24.1±3.2	26±3.6	25.5±3.6	25±3.1	25.9±2.9	1.3	un

Note: un – insignificant changes.

TABLE II  
MINERAL DENSITY, QUALITY AND INDICATORS OF THE EXAMINED PATIENTS' BODY COMPOSITION ACCORDING TO THEIR MENOPAUSAL STATUS

Parameters	A	B	C	D	E	F	p
	M±SD	M±SD	M±SD	M±SD	M±SD		
n	18	32	39	56	34		
BMD of lumbar spine (L1-L4), g/cm <sup>2</sup>	1.17±0.13	1.03±0.14	0.96±0.15	0.92±0.16	0.98±0.18	9.2	<0.001
BMD of femoral neck, g/cm <sup>2</sup>	0.96±0.11	0.86±0.10	0.82±0.10	0.79±0.10	0.83±0.12	9.4	<0.001
TBS	1.35±0.16	1.29±0.14	1.23±0.16	1.21±0.13	1.19±0.14	4.84	<0.001
FM, g	23802±7610	26923±7379	25060±7018	24069±6891	26954±6655	1.54	un
FM, %	36.6±6.9	40.2±6.0	37.6±6.8	37.1±7.0	40.1±5.4	2.21	un
Lean mass, g	39793±4276	39235±4713	40320±3904	39691±3565	39344±3432	0.43	un

Note: un – insignificant changes.

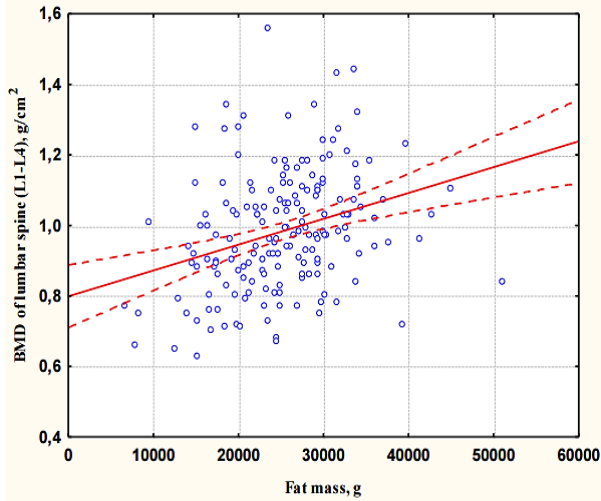
Table II shows the impact of postmenopausal period on BMD indicators at the lumbar spine and femoral neck, TBS, body composition.

In middle and late postmenopausal periods, BMD at the spine and femoral neck was increasing with total body fat.

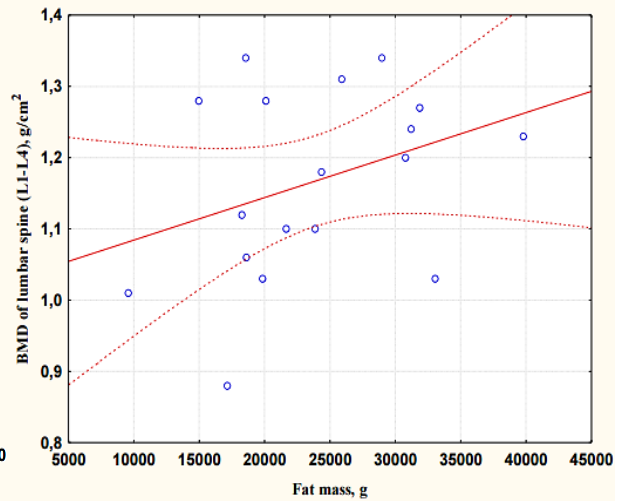
Bone tissue quality was probably decreasing with advancing postmenopausal duration ( $p < 0.000001$ ). The BMD at the spine was not changing dramatically in the late postmenopausal period, especially when compared with the early period; it can obviously be explained by the presence of osteophytes in the skeletal section of patients suffering from degenerative bone diseases.

Bone tissue mineral density at the femoral neck was likely decreasing with age ( $p < 0.000001$ ). The same dynamics (reduced mineral density) were observed for the whole skeleton ( $p < 0.000001$ ). The changes in total body fat and total lean mass in patients with various postmenopausal duration were improbable ( $p = 0.01$  and  $p = 0.05$  respectively).

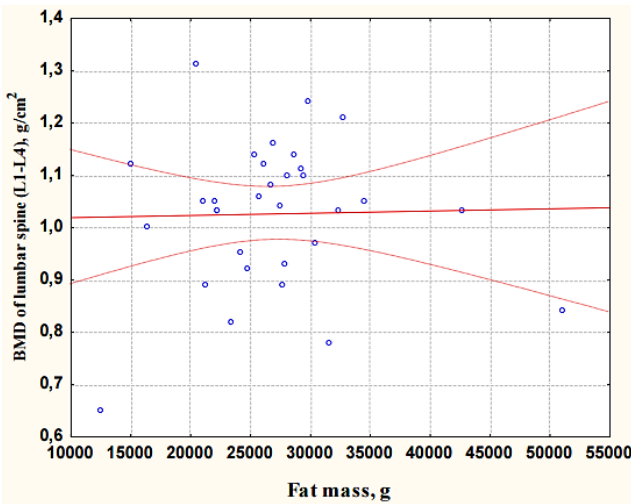
Regression analysis was also conducted on the mineral density and bone quality indicators of patients with different FM content, going through different menopausal periods, to obtain the following results: relationship among bone quality, mineral density and total FM of women in premenopausal period was found unjustified ( $p = 0.2$  and  $p = 0.2$ , respectively).



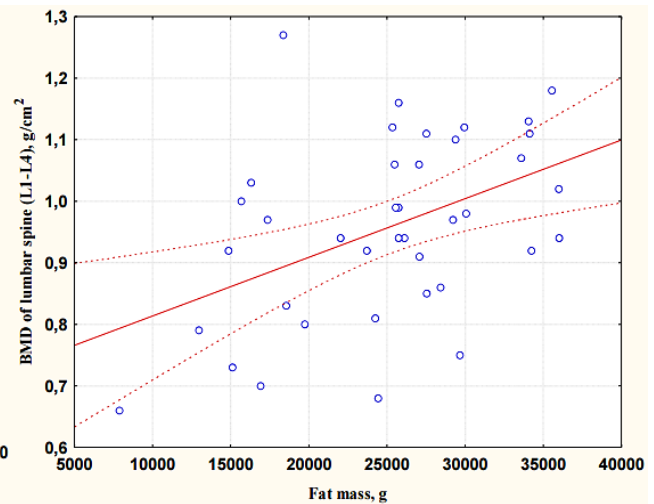
(a)



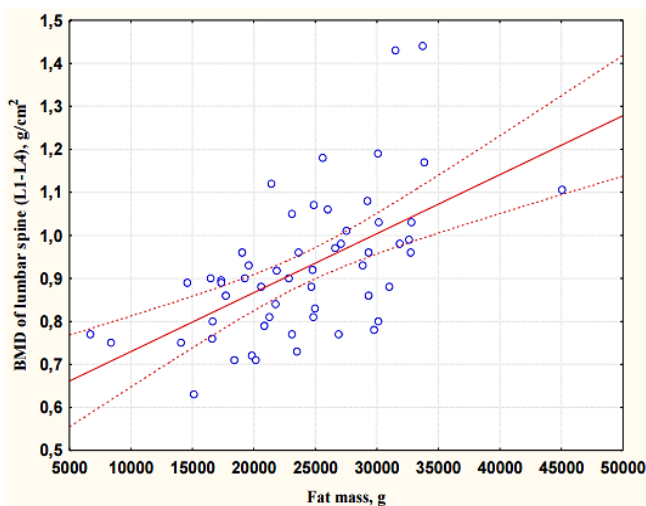
(b)



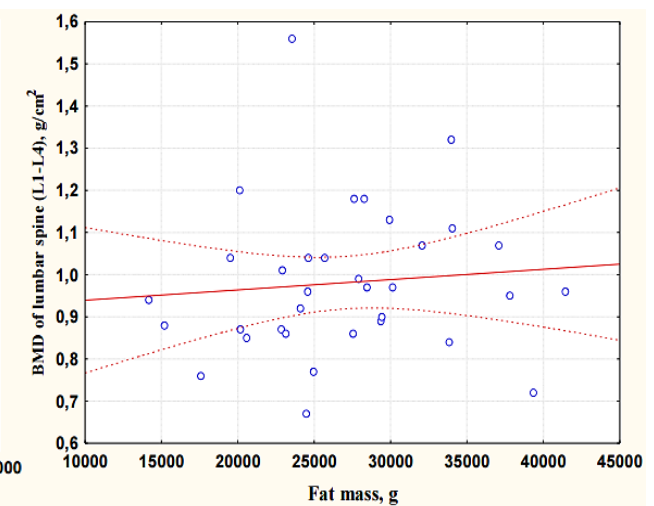
(c)



(d)



(e)



(f)

Fig. 1 Relation between lumbar spine mineral density indicators and body fat depending on postmenopausal period duration. Note. (A) general group:  $BMD = 0.80 + 0.000007 \times FM$ ;  $r = 0.31$ ;  $p = 0.00003$ ; (B) women in the premenopausal period; (C) women in PMP of less than 5 years; and (D) women in PMP of 5-9 years; (E) women in PMP of 10-14 years; (F) women in PMP of 15-19 years

In the early postmenopausal period (duration of 0-4 years) this relationship was equally improbable ( $p=0.9$  and  $p=0.5$ , respectively). In the middle postmenopausal period (menopause duration of 5-9 years), the regression relationship between the bone indicators and total body fat indicators was insignificant ( $p=0.4$ ). However, probable links were found between BMD at the spine, femoral neck and total FM of women in postmenopausal period: with increasing total FM, BMD at the spine ( $p=0.008$ ) and femoral neck ( $p=0.00004$ ) was significantly increasing. In the late postmenopausal period (menopause duration of 10-15 years), similar results were observed. The regression relationship between bone quality indicators and total FM indicators was improbable ( $p = 0.3$ ), and with the growth of total FM accompanied the increase of bone tissue mineral density at the spine ( $p=0.000004$ ) and at the level of femoral neck ( $p=0.0001$ ) (Fig. 1).

#### IV. CONCLUSION

The postmenopausal period duration is likely to affect the dynamics of bone quality and mineral density of spine and femoral neck. The probable positive correlation was established between the rate of total FM and BMD of spine and femoral neck in the middle and late postmenopausal periods. The increase of FM during the above mentioned periods has an osteoprotective role for women during menopause.

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