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AGE AND SEX-RELATED STRUCTURAL AND FUNCTIONAL CHANGES OF BONE REMODELING DURING SIMULTATE ABDOMEN CT-SCANNING

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ABSTRACT
The aim of investigation was to study the structural and functional conditions of cortical and trabecular layers of lumbar vertebrae L_1-L_5 in different age groups.
Materials and methods: In order to assess BMD of the lumbar vertebrae 102 people18 to 75 years old was examined. Study of bone mineral density cortical and trabecular layer of lumbar vertebrae (L_1-L_5) performed by computed tomography in Hounsfield Units (HU) in terms of standard deviation (SD).
Results: The results of computed tomography showed a direct relationship of bone mineral density of lumbar vertebrae with age of examined persons. Osteoporosis and osteopenia was registered in 15% of men and 30% women in middle adulthood, in late adulthood – 35% and 50% respectively. During early old age osteopenia and osteoporosis are observed in 37,5% and 25% of men and 26% and 64% women. Osteoporosis in the middle old age has been reported in 50% of men and 75% of women
Conclusions: Results of the study showed a direct link between mineral density, age and gender. The middle adulthood age period was characterized by the highest mineral mass compared with the other age periods. Then there is a loss of bone mass throughout life, and with the onset of aging osteopenia and osteoporosis are recorded. It was investigated that in the early old age, loss of bone mass is mainly observed in female.

KEY WORDS: bone, bone mineral density, remodeling

INTRODUCTION

Bone tissue is a metabolic active system and its functioning ensured by the process of remodeling, which consists in the continuous replacement of bone plates, the formation of new osteons and trabeculae on the site of the resorbed ones. This process maintains a constant mineral bone mass throughout the entire life [1, 2, 3]. The structural and functional conditions of bone tissue depends on many factors, epidemiological studies indicate the dependence of the formation of bone tissue on age, sexual, ethnic characteristics, etc. [4, 5]. Randomized, multicentre studies in Europe and the United States have demonstrated that in the puberty and post-puberty period, bone mass is actively increasing, reaching its maximum by an average of 25-30 years. Then comes the period of equilibrium. The physiological decline in bone mass begins at approximately 35 years of age and increases in the first 5-10 years after menopause in women, 2-3% per year. In men loss of bone tissue is 0,3-0,4 % per year. From 65-70 years, the rate of loss of bone tissue is reduced and make 0,2-0,3 % per year for both sexes [6, 7, 8].

The imbalance of bone remodeling leads to the formation of osteopenia and osteoporosis – systemic or local disease of the skeleton with decreasing of bone mineral mass. This leads to increasing of bone fragility with subsequent risk of fractures. Particularly in women, the development of osteoporosis is associated with loss of bone mineral density (BMD), which occurs most often during menopause. At the same time, the deficiency of estrogen leads to a slower inhibition of osteoclasts, a decrease in the activity of osteoblasts, increases the sensitivity of cells to parathyroid hormone, enhances the synthesis of pro-reactive cytokines (IL-1, IL-6, IL-11, TNF) [9, 10].

Recent research shows that calcium, iodine, zinc and fluoride deficiencies, as well as sedentary lifestyle and bad habits can also affect the bone mineralization even in childhood and adolescence. In particular, the effect of iodine deficiency on bone tissue is indirect, but it plays a key role in the functioning of the thyroid gland hormones that are necessary in the regulation of normal growth for the development of the skeleton [11]. The problem of hypothyroidism is relevant for the endemic regions of Ukraine, which includes the Lviv region, where iodine deficiency tends to increase. Therefore, this problem is relevant for further our scientific work.

THE AIM

Investigate the structural and functional conditions of the cortical and trabecular layers of the lumbar vertebrae (L_1-L_5) in persons of different age groups living in the Lviv region.

MATERIALS AND METHODS

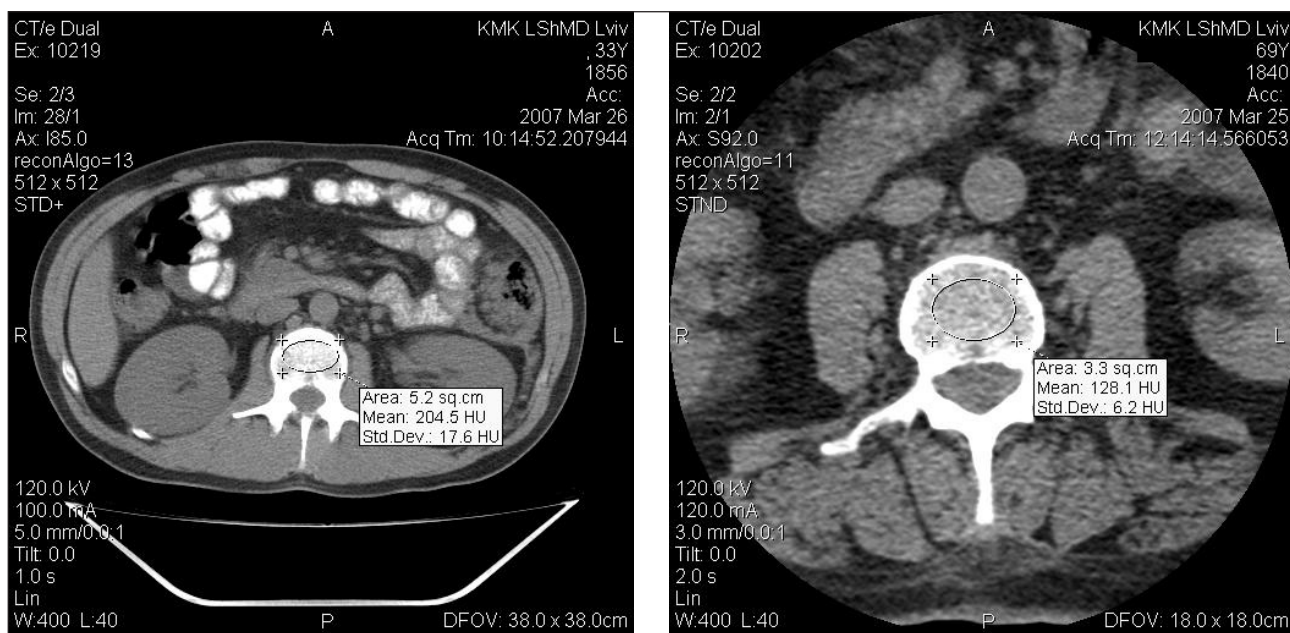In order to assess the BMD of the lumbar vertebra, 102 patients aged 18 to 75 years were examined. The patients

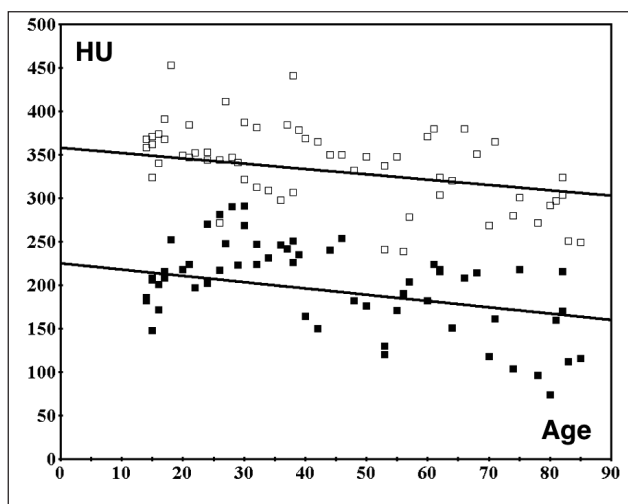**Fig. 1.** Vertebral attenuation measurement of BMD (HU) using the ROI method

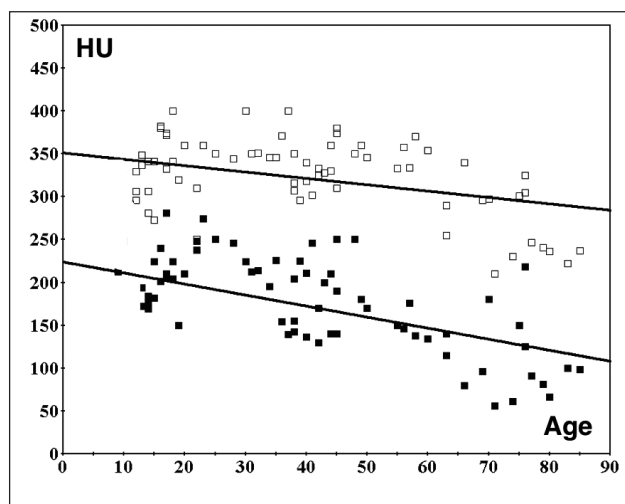**Fig. 2.** BMD (HU) of trabecular (■) and cortical (□) layers L1-L5 in men

Fig. 3. BMD (HU) of trabecular (■) and cortical (□) layers L1-L5 in women

were divided into 10 groups that consisted of 5 age periods: early adulthood (18-30 years), middle adulthood (30-45 years), late adulthood (45-60 years), early old age (60-75 years) middle old age (75-90 years). Investigation of mineral density of lumbar vertebrae bone tissue (L_1-L_5) was performed by computer tomography (CT) GE / e Dual CT scanner using a standard gauge with a thickness of 3 mm, a peak voltage of 120.0 kV and a current of 496 mA. Data was processed using the eFilm Workstation 3.4.0, 34 bit (Merge Healthcare, USA, 2013) program on the Windows 7 Professional SP 1, 32 bit (Microsoft, USA, 2009) system.

The instrument was calibrated using phantoms of water, air, ethanol and potassium phosphate, which were scanned together with the subject. The values of the sections were corrected by the formula:

$$HU = 1000 \ (HU_b - Hu_w) \ / \ HU_w - HU_a$$

where:

HU_b – the average density of the scanning area of the spongy bone,

HU_w – the average density of the standard water in the phantom,

HU_a – the average density of the standard air in the phantom. The result of each subject was calculated by the formula:

$$HU = P_1 \ HU_1 + P_2 \ HU_2 + ... + P_n HU_n \ / \ P_1 + P_2 + ... + P_n$$

where:

P – the number of pixels in the area of the standard scan.

Density indices of the bone tissue of the trabecular layer of the lumbar vertebrae were determined according to CT criteria in the units of Hounsfield (HU) – ROI method, with standard deviation (SD), fig 1.

Table 1. Bone mineral density of the lumbar vertebra, HU

№	Age periods	BMD (HU)			
		Men		Women	
		Trabecular bone	Cortical bone	Trabecular bone	Cortical bone
1.	Early adulthood	223,0 ± 8,4	381,6 ± 21,8	203,9 ± 9,6	367,9 ± 10,0
2.	Middle adulthood	245,0 ± 9,9	367,4 ± 13,3	232,8 ± 7,7	360,1 ± 12,8
3.	Late adulthood	197,8 ± 16,5	331,5 ± 13,7	180,9 ± 8,9	341,2 ± 6,2
4.	Early old age	179,3 ± 15,5	328,1 ± 13,7	119,6 ± 13,2	303,1 ± 17,2
5.	Middle old age	145,3 ± 20,5	287,0 ± 10,3	116,0 ± 18,3	262,8 ± 14,2
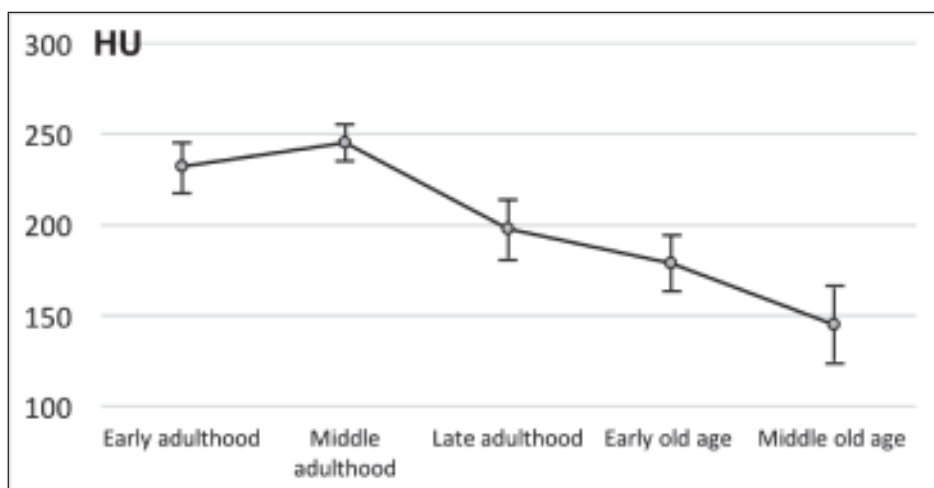
Fig. 4. Age dependence of BMD (HU) of lumbar vertebrae in men
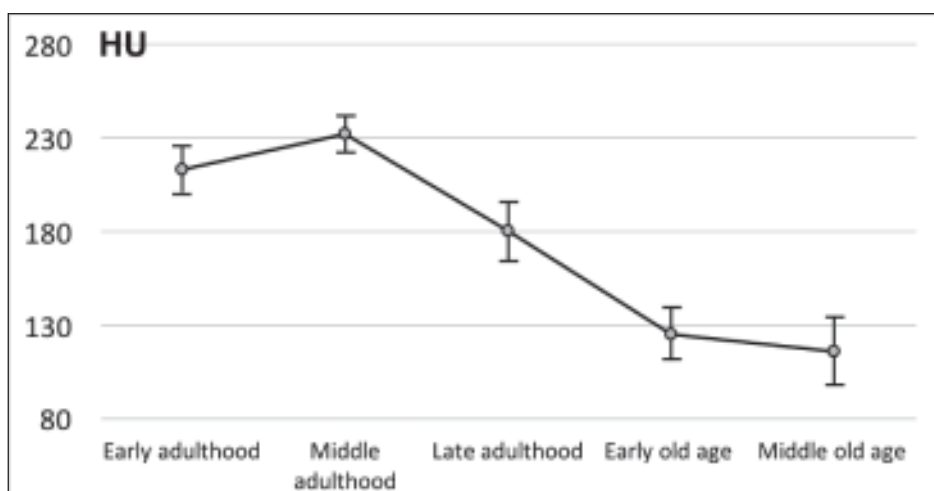
Fig. 5. Age dependence of BMD (HU) of lumbar vertebrae in woman

Average values of the mineral density were more than + 216.7 – considered as normal BMD (> -1 SD), the value from + 216.7 to +148.6 – osteopenia, (-1 – (- 2,5) SD) and were less than + 148.6 – osteoporosis (≤ 2.5 SD) [1, 10].

RESULTS AND DISCUSSION

The results showed a direct dependence of BMD of the trabecular and cortical layers of the lumbar vertebrae to the age and sex. It has been established that mineral bone mass is actively increasing in early adulthood, tab. 1, fig 2, 3.

In males of this age group, the mineral density of bone tissue was 223,0 ± 8,4 for the trabecular layer and 381,6 ± 21,8 for the cortical layer, respectively. For females: for the trabecular layer – 203,9 ± 9,6 and for the cortical layer 367,9 ± 10,0, respectively. Middle adulthood was characterized by the highest mineral mass, compared with other age periods. Mineral density – 245,0 ± 9,9 and 367,4 ± 13,3 for trabecular and cortical layers in males and 232,8 ± 7,7 and 360,1 ± 12,8 females, respectively. As a result, osteopenia was recorded in 15 % of the examined men and in 30 % of the female population.

Late adulthood is characterized by a gradual loss of bone mass. Especially this dependence is observed in the examined subjects of the female sex. In particular, osteopenia was detected in 35% of men and 52% of women, and osteoporosis – 12% and 24% respectively. The reason

for accelerated bone remodeling in this age is the lack of sex hormones, which is typical during menopause. The average density of bone tissue in the subjects of the late adulthood was 197,8 ± 16,5 and 331,5 ± 13,7 for men and 180,9 ± 8,9 and 341,2 ± 6,2 for women. During early old age osteopenia and osteoporosis are observed in 37,5% and 25% of men and 26% and 64% of women. Osteoporosis in the middle old age has been reported in 50% of men and 75% of women, fig 4, 5.

CONCLUSIONS
The mineral density of the trabecular and cortical vertebrate layers in male and female was estimated using CT. It has been established that mineral bone mass is actively increasing in early adulthood. The middle adulthood age period was characterized by the highest mineral mass compared with the other age periods. Then there is a loss of bone mass throughout life, and with the onset of aging osteopenia and osteoporosis are recorded. It was investigated that in the early old age, loss of bone mass is mainly observed in female subjects. The reason for accelerated bone remodeling in this age is the lack of sex hormones that occurs during the menopause.

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Conflict of interest:
The Authors declare no conflict of interest

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article