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EFFECT OF WHOLE BODY VIBRATION ON BONE NANOCOMPOSITES ORGANISATION AND PREVENTION OF BONE MINERAL DENSITY LOSS IN OVARIOECTOMIZED RATS

Introduction. Osteopenia is a multifactorial condition that develops under estrogen deficiency and reduced mechanical loading. Experimental models of postmenopausal osteoporosis enable investigation of bone remodeling mechanisms and evaluation of corrective interventions.

Aim. To experimentally evaluate the effect of low-intensity whole-body vibration on bone remodeling, mineral component, and nanocomposite structural organization in ovariectomized rats.

Materials and Methods. The study was performed on Wistar rats divided into three groups: SHAM-operated, ovariectomized (OVE), and ovariectomized treated with whole-body vibration (OVE+WBV; 50 Hz, 0.3 g, 30 min/day, 5 days/week) over 24 weeks. Bone remodeling markers (osteocalcin, alkaline phosphatase, TRAP-5b) were assessed, and the structural characteristics of the mineral phase were analyzed using X-ray diffraction.

Results. Ovariectomy resulted in a significant decrease in the bone mineral component as early as week 8, which persisted throughout the study. Whole-body vibration prevented early bone loss during weeks 8–16, as evidenced by higher crystalline phase fraction and increased crystallite size compared to the OVE group. Biochemical markers confirmed increased bone remodeling after ovariectomy, while vibration partially modulated these changes. At week 24, the effect of vibration was no longer statistically significant.

Conclusions. Low-intensity whole-body vibration attenuates early post-ovariectomy bone loss and modulates bone remodeling processes, reflected by changes in biochemical markers and mineral phase structure. The effect is most pronounced during the early post-ovariectomy period.

KEY WORDS: whole body vibration; bone remodeling; bone mineral density; osteoporosis; bone nanocomposites; X-ray diffraction

INTRODUCTION. Nowadays, osteoporosis has become a socio-economic problem, given the ever-growing population of our planet. Therefore, prophylaxis and early detection of individuals with osteopenia are important due to the high risk of bone fractures [1-4]. Also, osteopenia is commonly observed in young people, particularly in young women with sex hormone deficiency [5-7]. Several studies indicate that the impact of mechanical pressure in such persons increases the physiological response of bone adaptation. According to this hypothesis, physical activity slows bone remodeling and allows retaining its mineral density. Consequently, it can counterbalance the calcium homeostasis affected by conditions of estrogen deficiency and prevent bone mineral loss after menopause. Exercises (physiological mechanical stimulation) can slow down bone remodeling [8-14] and are considered an effective treatment of

postmenopausal osteoporosis as a supplement to pharmacotherapy.

In this study, we evaluated the physiological mechanisms of bone remodeling under conditions of ovariectomy, as well as the structural organization of the bone mineral component represented by hydroxyapatite, and the non-physiological influence of mechanical stimulation on the experimental model of postmenopausal osteopenia. The vibration was selected as a form of non-physiological mechanical stimulation since its beneficial effect can be easily applied to humans in the form of simple physical exercises and equipment. Previously, we described the effect of industrial vibration on bone metabolism [15] and potentially harmful side effects of vibration on other tissues (except bones), particularly muscles, using the resonance frequencies with a high-level acceleration and prolonged exposure time [16]. Per our research needs, we chose vibration parameters with safe frequency and low level of acceleration to avoid side effects in other tissues.

MATERIALS AND METHODS. Animal model

The experimental study was performed on 54 male rats of the Wistar line weighing 180-200 g, kept under the same vivarium conditions. All animal experiments were conducted in compliance with bioethical principles per the provisions of the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes, Ethics Commission Report № 10, 16.12.2019, LNMU. The experimental rats were divided into 3 groups, 18 rats in each: SHAM-surgery group, I experimental group – ovariectomized rats (OVE), II experimental group – ovariectomized rats + whole body vibration (OVE+WBV). All experimental rats were weighed every two weeks (fig. 1A). After the 8th, the 16th and the 24th week, six animals from each group were removed from the experiment by decapitation under general intraperitoneal urethane anesthesia at 0.3 g/kg.

Whole-body vibration

Vertical vibration oscillations were modeled using a 250W APC Rain-60 vibration pump with the maximum pressure of 7 bar and a voltage regulator of the AFC-120 model. A vibrating platform with the container, where the experimental group of rats was placed, was attached to the stem of the vibrating pump. The level of vibration acceleration was the following: $3.0 \text{ m/s}^2 - 0.3 \text{ g}$. The rats were exposed to WBV for 30 minutes, 5 days per week, for 24 weeks.

Method of ovariectomy of the rat

Rat was fixed in the dorsal recumbent position. Before the surgery, 1 ml of 10% glucose solution was administered to prevent hypoglycemia. We used 0.3 g/kg of urethane solution for general anesthesia (fig. 1B). For each rat, the dose was selected individually after weighing. The operating field was irradiated with a solution of betadine, the animal was covered with a sterile diaper to comply with the rules of asepsis and compliance with the temperature regime. Lower median laparotomy and revision of the abdominal cavity were performed. The horns of the uterus were removed with tweezers. Ligatures (vicryl 4-0) were placed on the ovarian ligament itself, between its sac and on the horns of the uterus, through the mesovar. Uterine horns and mesovarium (rich in fat) were cut off to reduce infectious postoperative complications. The second ligature was applied dorsally to the ovarian ligation bag to ligate the ovarian artery and vein. Then cut off the ovary and horn fragments. Separate sutures are applied to the wound (PDS 3-0 thread). One day after the laparotomy with ovariectomy, animals had a standard diet and were kept separately in individual plastic cages for seven days.

Determining bone remodeling markers in plasma

Blood sampling was performed at 10 AM, after a night fasting. EDTA plasma, after

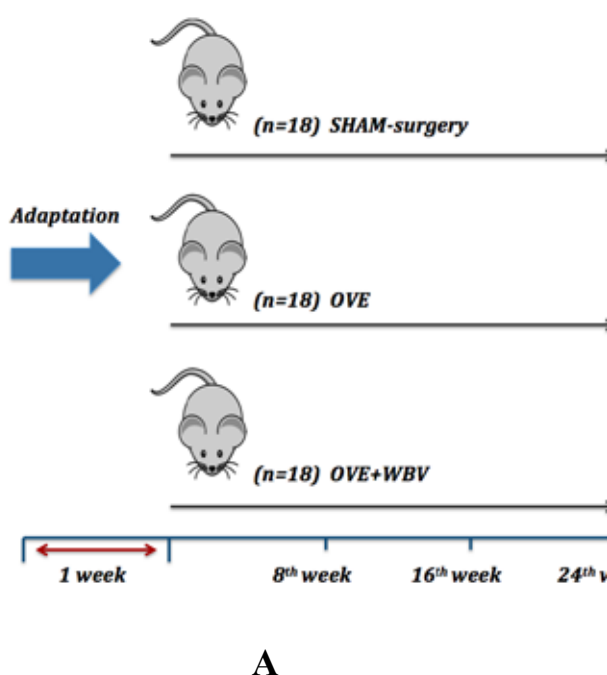
**A****B**

Figure 1. A – Experimental design. B – Preparation of the removed ovaries with uterine horns

centrifugation, was collected in Eppendorf microtubes and stored at -20 °C. Concentrations of cytokines and bone remodeling markers in blood plasma were determined using commercial immune-enzyme analysis kits (ELISA). We determined leptin (anti-Leptin (rat), AdipoGen Life Sciences, osteocalcin (DRG® Mouse Osteocalcin ELISA); Mouse Tartarate Resistant Acid Phosphatase 5b (TRAP5b) ELISA Kit, MyBioSource. Microplate reader Stat Fax 2100 capable of measuring absorbance at 450 nm, with the correction wavelength set at 540 nm or 570 nm. Tartarate resistant acid phosphatase 5b (TRAP5b): Intra-assay Precision CV% <8%. Three samples of known concentration were tested twenty times on one plate to assess. Inter-assay Precision: CV% <10%. Three samples of known concentration were tested in twenty assays to assess. Leptin: Intra-assay Precision CV% <5.9% (n 5); Inter-assay Precision: CV% <11.5% (n 3). Osteocalcin: Intraassay variation: 6% (95% limits) Interassay variation: 8% (95% limits). Alkaline phosphatase (APT) activity was determined using standard NPP Filisit-Diagnostika LLC kits, Stat Fax 303Plus Analyzer at 490 nm. Intra-assay Precision CV% <7% (n 20); Inter-assay Precision: CV% <7% (n 3). Cytokine concentrations were determined by standard curve. All analyses performed per the manufacturer's instructions.

X-ray diffraction

To study the ultrastructure of the femur bone mineral component we used the method of X-ray diffraction analysis. The femur was dried at 110 °C in a drying cabinet. The X-ray diffraction spectra of the samples were obtained on an automated X-ray diffractometer in Cu K α radiation ($\lambda=1.5418$ Å), monochromatized by reflection from a plane (002) of a single pyrographite crystal, mounted on a diffracted beam [17-21]. We used the Bragg-Brentano focusing scheme ($\theta-2\theta$). The diffraction patterns were recorded in the continuous movement mode of the detector with an angular velocity of 2°/min, a constant value of the integration time $\tau = 1$ s., x-ray tube voltage at $U = 26$ kV, and anode current at $I = 15$ mA. To determine the contents of the amorphous phase, which is manifested by the presence of diffuse halo at small scattering angles, the scattering angles $2\theta=15-37,5^\circ$ were decomposed into separate maxima corresponding to the scattering by the amorphous and crystalline phases.

The background diffraction patterns in this range of scattering angles were approximated by a linear function. The volume fraction

of the crystalline phase represented by hydroxyapatite was determined through the following formula: $X=I_a/I$, where I_a is the integral intensity of hydroxyapatite, and I is the total integral intensity. The average crystallite size was determined by the Debye-Scherrer formula per the diffraction maximum (002) extension: $L=\lambda/(\beta \cos(\theta))$, where $\lambda=0,15148$ nm is the wavelength of the x-ray radiation, β is the physical half-width of the maximum (002), 2θ is the reflection diffraction angle (002) of the crystalline phase

Statistical analysis

Statistical analysis of the data was performed in StatSoft STATISTICA 8.0.360. In the STATISTICA package, the comparison of two average samples of normally distributed features (Student's t-criterion) was implemented in the *Basic Statistics/Tables* module. The t-test, independent, by variable submodule, was used for two different general summations. One-way ANOVA is implemented in the Breakdown & one-way ANOVA submenu of the Basic Statistics and Tables module. Friedman's test was used for statistical verification of groups at different time periods (Comparing multiple dep. samples (variables) module Nonparametrics).

RESULTS. Body weight

The body weight in I group (OVE) increased to 308.0 ± 8.6 g in the 24th week, and in rats OVE+WBV group to 274.2 ± 5.07 g, respectively ($p>0.05$), fig. 2.

Determining bone remodeling markers in plasma

The rats of the first experimental group gained weight, though these values were statistically insignificant. To determine the correlation between the regulation of body weight and bone metabolism, we evaluated leptin levels in plasma. Leptin is the primary hormone involved in the regulation of body weight. Therefore, to assess energy metabolism, it is advisable to determine its concentration. In the 8th week of the experiment, we observed increase in leptin levels in OVE group by 2.1 times compared to the SHAM group. In the second group (OVE+WBV), the level increased only by 54%. At 16th week leptin level were 2.2 times higher than in SHAM group and gradually decreased by 24th week (fig. 3). WBV slowed increasing leptin level, which exceeded SHAM by 63% at 16th week, and by the 24th week the level increased by 2,3 times. However, leptin levels increased for 24 weeks in the SHAM group ($p<0.01$) and OVE+WBV group ($p<0.01$). Regression analysis of the rats' weight and

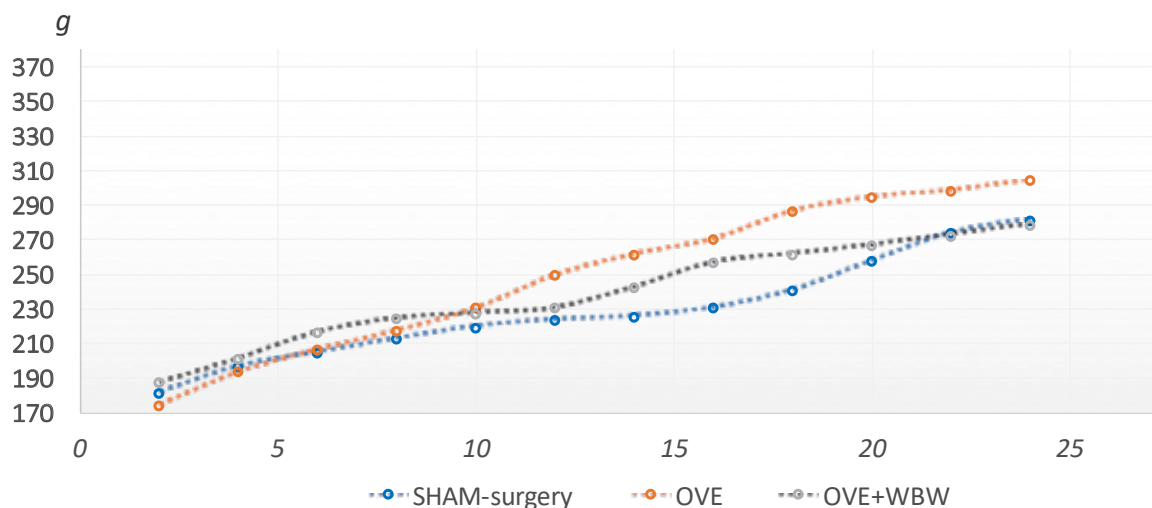


Figure 2. Body weight.

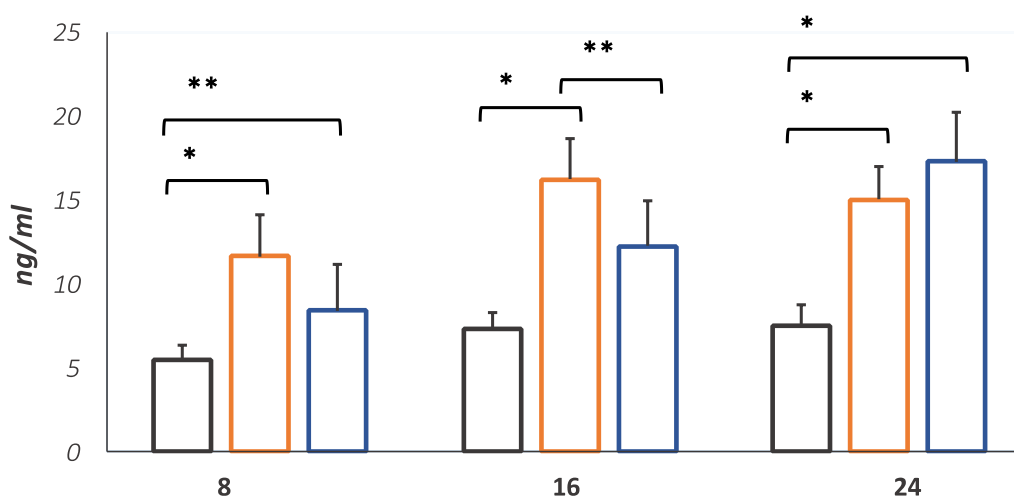


Figure 3. Leptin levels in serum (ng/ml)

□ – SHAM-surgery; □ – OVE; □ – OVE+WBW

* – groups differ statistically $p < 0.01$;

** – groups differ statistically $p < 0.05$.

leptin level in the first experimental group showed that the mass is directly proportional to the amount of leptin and is described with the equation. $\text{Weight} = 53.13 + 14.74 \cdot \text{leptin}$ with a correlation coefficient of 0.79. For the second group (OVE+WBV) $\text{Weight} = 176.74 + 5.99 \cdot \text{leptin}$ with the correlation coefficient of 0.98.

To determine bone remodeling we investigated bone formation markers – osteocalcin, alkaline phosphatase and bone resorption marker – TRAP-5b, tab. 1. In the 8th week of the experiment, we observed an increase in osteocalcin level, especially in the OVE+WBV group ($p < 0.01$), though in the OVE group the increase was statistically

insignificant ($p > 0.05$). The level of alkaline phosphatase was statistically significant solely in the OVE+WBV group ($p < 0.05$). It is worth noting that the concentration of TRAP-5b, unlike the two previous markers, changed statistically in the 8th week of the experiment in both: I ($p < 0.01$) and II experimental groups ($p < 0.05$). In the 16th week, bone remodeling markers showed significant changes in the rats' blood that were statistically significant in all study groups ($p < 0.01$). This is likely to indicate the ongoing bone remodeling process and the activity of osteoclasts and osteoblasts during the experiment. We have not found statistically significant changes in bone metabolism in

Table 1 – Quantitative analysis of bone formation (osteocalcin, alkaline phosphatase) and resorption (5b-isoform of tartrate-resistant acid phosphatase)

Group		Weeks after surgery					
		8		16		24	
		Mean $\pm$ SEM	SD	Mean $\pm$ SEM	SD	Mean $\pm$ SEM	SD
Osteocalcin (ng/ml)	SHAM _{surg}	40,22 $\pm$ 2,82	6,36	37,78 $\pm$ 3,58	8,0	39,35 $\pm$ 2,97	6,64
	OVE	45,25 $\pm$ 3,12	6,99	50,25 $\pm$ 2,75*	6,15	47,75 $\pm$ 5,31	11,87
	OVE+WBV	63,4 $\pm$ 3,77*	8,42	57,65 $\pm$ 2,97*	6,64	52,33 $\pm$ 3,94*	8,81
APT, (U/L)	SHAM _{surg}	311,77 $\pm$ 9,6	21,47	225,47 $\pm$ 11,29	25,25	188,90 $\pm$ 7,24	16,18
	OVE	334 $\pm$ 13,15	29,41	322,27 $\pm$ 14,26 *	31,89	239,0 $\pm$ 17,68 *	39,53
	OVE+WBV	350,23 $\pm$ 14,45*	32,34	308,82 $\pm$ 14,39 *	32,18	229,68 $\pm$ 19,10*	42,71
TRAP5b, (U/L)	SHAM _{surg}	4,8 $\pm$ 0,3	0,67	4,07 $\pm$ 0,33	0,73	4,18 $\pm$ 0,51	1,14
	OVE	6,39 $\pm$ 0,34*	0,75	7,46 $\pm$ 0,52*	1,17	7,76 $\pm$ 0,53*	1,19
	OVE+WBV	6,04 $\pm$ 0,43*	0,95	7,13 $\pm$ 0,52*	1,16	7,95 $\pm$ 0,42*	0,94

the 24th week of the experiment in the OVE group with osteocalcin level ($p>0.05$), but the changes in the concentrations of APT and TRAP-5b went on ($p<0.05$). In the OVE+WBV groups, osteocalcin levels ($p<0.05$) and TRAP-5b remained high ($p<0.01$), unlike the APT concentration where the changes were insignificant ($p>0.05$).

X-ray diffraction

The diffraction spectra of the samples were obtained on an automated X-ray diffractometer in Cu K α radiation by monochromatized reflection from the plane (002) of a single graphite crystal mounted on a diffracted beam. The calculations of the crystalline phase of the rat femur are shown in figure 4. According to the spectra in the 8th week $\rightarrow$ 16th week $\rightarrow$ 24th-week sequence, the volume fraction of the crystalline phase is slightly increased ($p>0.05$) in the SHAM group of the rats. In the OVE group, there is a significant decrease in the absolute amount of hydroxyapatite in the 8th-16th weeks and stabilization of this process in the 24th week while compared to the SHAM group. WBV prevented an early post-ovariectomy bone loss in the 8th-16th weeks. Rats after ovariectomy affected by vibration showed statistically higher ($p<0.05$) values of the crystalline phase compared to the SHAM group over the same period. Although vibration had a positive effect on the bone tissue of the rats after ovariectomy in the 8th-16th weeks, in the 24th week, this effect was not statistically significant. While assessing bone remodeling mechanisms, it is important to evaluate the amorphous phase, which is represented mainly by collagen, since it is layered with hydroxyapatite. This process is necessary to understand the mechanisms of bone mineral loss, table 2.

Discussion

The role of female sex hormones in bone metabolism is to regulate the amount and activity of osteoclasts. The regulation is done through a direct cytokine-induced effect on osteoclast proliferation, which causes modulation and differentiation of the stromal/osteoblastic cell population which supports osteoclastogenesis. Changes in osteoclast activity are probably mediated through affecting their apoptosis [22, 23]. Several scientific studies have shown that reducing the level of sex steroids increases the rate of osteoclasts and osteoblasts formation in the bone marrow via increasing the production and activity of those cytokines that are involved in osteoclastogenesis and osteoblastogenesis [24]. *In vitro* studies have shown the ability of estrogens to stimulate the production of osteoprotegerin by the cell line of human osteoblasts [23-25]. Consequently, decreased estrogen levels contribute to the increased viability and functional activity of osteoclasts. Unlike the estrogens' pro-apoptotic effect on osteoclasts, they, like androgens, have a pronounced anti-apoptotic effect on osteoblasts and osteocytes. Therefore, reducing the level of these steroids causes a decreased life expectancy of the latter [22, 23]. The increased rate of bone remodeling processes that develop in estrogen deficiency might cause increased production of osteoblasts and osteoclasts. Also, it can disrupt the balance between the resorption and bone formation processes, that is provoked, on the one hand, by increasing the time of functional activity and reduction of osteoblast functional activity time, on the other.

The results of this study confirm the decrease in the bone mineral component in rats after ovariectomy. Given the growth of

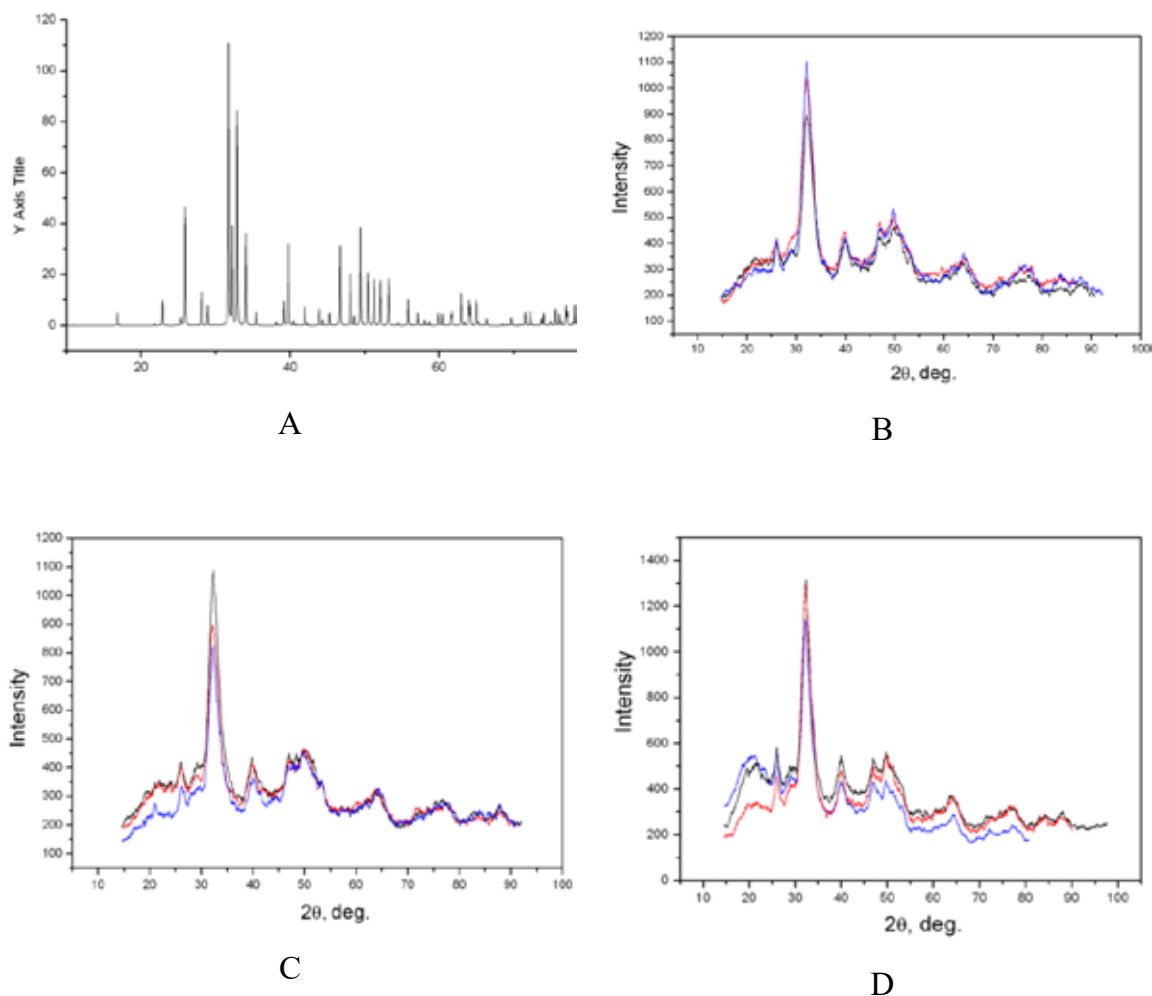


Fig. 4. **A** – X-ray diffraction patterns of hydroxyapatite, **B** – SHAM-surgery group; **C** – I-group (OVE); **D** – II-group (OVE+WBV). ν 8th week; ν 16th week ν 24th week. The diffraction spectra of the samples were obtained on an automated X-ray diffractometer in Cu K α radiation by monochromatic reflection from the plane (002) of a single graphite crystal mounted on a diffracted beam. The spectra were recorded in the continuous moving mode of the detector at the 2 deg/min speed. To determine the integral intensity of the hydroxyapatite reflex, we chose a reflex in 30-37° angular range since its intensity is the highest. Although this reflex consists of four reflexes of hydroxyapatite with Miller indices (211); (112); (300); (202), the diffraction angles from crystallographic planes with these indices are close to 31,741°; 32,179°; 32,868° and 34,045°.

Table 2 – Structural parameters of femur samples

Group/week	X_{cr}	$B_{(002)}, ^\circ$	L, nm
SHAM 8th week	0,831	1,113 $\pm$ 0,052	12,0 $\pm$ 0,9
SHAM 16th week	0,890	1,183 $\pm$ 0,035	11,0 $\pm$ 0,5
SHAM 24th week	0,856	1,163 $\pm$ 0,060	11,3 $\pm$ 0,9
OVE 8th week	0,877*	1,718 $\pm$ 0,090	6,6 $\pm$ 0,4
OVE 16th week		1,497 $\pm$ 0,043	7,9 $\pm$ 0,3
OVE 24th week		1,137 $\pm$ 0,027	11,7 $\pm$ 0,4
OVE+WBV 8th week	0,873	1,144 $\pm$ 0,057	11,6 $\pm$ 0,9
OVE+WBV 16th week	0,867*	0,918 $\pm$ 0,027	16,4 $\pm$ 0,8
OVE+WBV 24th week		0,911 $\pm$ 0,037	16,6 $\pm$ 1,2

remodeling markers in the blood of the rats that underwent ovariectomy, it is clear that bone remodeling is stimulated in these animals. Artificial deficiency of sex hormones is likely to

accelerate the physiological remodeling of the bones, causing accelerated loss of the mineral component. Further on, this metabolic process slows down somewhat, but it does not prevent

further bone demineralization. In our study, the loss of femoral bone mineral mass was more pronounced in the early postoperative period (8 weeks). In the 16th and 24th weeks of the experiment, it slowed down somewhat but the tendency remained. In this experimental model, vibration with the 50 Hz frequency and the vibration acceleration level of 3.0 m/s² (0.3 g) prevented early post-ovariectomy bone loss in the 8th-16th weeks of the experiment. It proved virtually ineffective in the 24th week. Although the difference was not statistically significant in the 24th week of the study, the vibration allowed maintaining a higher rate of the mineral component and the amorphous phase throughout the experiment. It should be noted that in all periods of the experiment, mechanical influences prevented the rapid loss of mineral bone mass.

Literature data indicate that the increase in body fat, which was observed in our experiment, might affect bone metabolism [26-28]. Since adipocytes and osteoblasts originate from the common multipotential mesenchymal stem cell, obesity might enhance adipocyte differentiation and fat accumulation, while reducing osteoblast differentiation and bone formation. Nonetheless, these data remain controversial. A slight increase in proinflammatory cytokines, which can be observed in postmenopausal obesity, might increase osteoclast activity and bone resorption through alterations in the RANK/RANKL/OPG system [28, 29, 31-34]. Leptin is involved in the regulation of body weight and reflects not only the amount of accumulated fat, but also changes in energy metabolism. This is a signal for adaptation to the new conditions of existence. The increase of rat's body weight led to an increase leptin level, $p < 0.05$. In our experiment WBV reduces leptin levels, $p > 0.05$ comparing with the first experimental group. According to the literature, an increase in the amount of leptin, as observed in our animal model, can have a negative impact on bone metabolism [35, 36]. Experimental data correlate with the levels of remodeling markers in the blood: induced loss of mineral mass of the femur is associated with an increase marker of bone resorption – TRAP5b (25%, $p < 0.05$) and bone formation marker – osteocalcin (11.2%, $p > 0.05$) at the 8th week, compared with the SHAM group. From 16 to 24 weeks, TRAP5b increased by 45.5% ($p < 0.05$) and 47.1% ($p < 0.05$), respectively, and osteocalcin increased by 24.9% ($p < 0.05$) and 17.6% ($p > 0.05$), respectively. The

level of TRAP5b in the experimental groups increases over time ($p < 0.05$), compared with the SHAM group ($p > 0.05$). The level of alkaline phosphatase increased rapidly by 30.2%-21% at 16th-24th weeks, $p < 0.05$, at 8th weeks it was not statistically significant, $p > 0.05$. Instead, WBV allowed normalizing its level to 18% ($p > 0.05$) compared with the SHAM group at the end of the experiment. It should be noted that the level of alkaline phosphatase in all groups decreases over time. Concentration of osteocalcin increased under the influence of mechanical stimuli by 36.5% – 44.5% – 24.7% ($p < 0.05$) during the experiment. However, its level did not change statistically significantly relative to time in all groups. These results indicate an increase in collagen metabolism in both experimental groups, that explains the rapid loss of BMD.

Thus, vibration has a suppressing effect on bone remodeling processes stimulated by pre-estrogen deficiency during the artificial menopause. Remodeling under these conditions is inhibited in the early post-ovariectomy period while osteopenia has not yet developed. We should mention that in our experimental model, the vibration did not lead to an increase in the bone mineral component. It caused a decrease in rats' weight, though the figure was not statistically significant.

CONCLUSIONS. Through our study, we have discovered that low-acceleration vibration slows down bone remodeling processes in young rats after ovariectomy. This does not cause severe bone damage and slows down the mineral component loss. The fact that non-physiological mechanical stimulation has similar effects on bones in different biological objects allows us to extrapolate our results to humans. Although the vibration had a positive effect on bone tissue in young rats, this effect was not statistically significant in older rats after ovariectomy. Our data suggest that non-physiological vertical mechanical oscillations are an effective means of preventing early post-ovariectomy bone deterioration in the animal model. The described vibration effects might be beneficial for understanding bone metabolism under different conditions. Also, it can be used to prevent osteopenia and supplement its treatment in various pathologies, particularly in postmenopausal women.

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CONFLICT OF INTEREST. None.

AUTHOR CONTRIBUTIONS: Kostyshyn N.M. – Conceptualization, Methodology, Investigation, Data curation, Writing – original draft; Korda M.M. – Writing – review, editing, Supervision.

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AVAILABILITY OF DATA AND MATERIALS: all data generated or analyzed during this study are included in this published article.

INFORMATION ON THE USE OF ARTIFICIAL INTELLIGENCE: The authors certify that, in the course of conducting the research and preparing this manuscript, they did not use any generative artificial intelligence tools or services to perform any of the tasks listed in the Generative Artificial Intelligence Delegation Taxonomy (GAIDeT, 2025). All stages of the work – from conceptualization to final editing – were carried out exclusively by the authors, without the use of generative artificial intelligence.

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ТЕРНОПІЛЬСЬКИЙ НАЦІОНАЛЬНИЙ МЕДИЧНИЙ УНІВЕРСИТЕТ ІМЕНІ І. Я. ГОРБАЧЕВСЬКОГО МОЗ УКРАЇНИ

ВПЛИВ ЦІЛОТІЛОВОЇ ВІБРАЦІЇ НА СТРУКТУРУ КІСТКОВИХ НАНОКОМПОЗИТІВ ТА ЗАПОБІГАННЯ ВТРАТІ МІНЕРАЛЬНОЇ ЩІЛЬНОСТІ КІСТОК У ЩУРІВ З ВИДАЛЕНИМИ ЯЄЧНИКАМИ

Анотація

Вступ. Остеопенія є важливою медико-біологічною проблемою, що розвивається, зокрема, в умовах дефіциту естрогенів та зниження механічного навантаження на кісткову тканину. Експериментальні моделі постменопаузального остеопорозу дозволяють досліджувати механізми ремоделювання кістки та оцінювати ефективність коригуючих впливів.

Мета дослідження. Експериментально оцінити вплив загальної вібрації з низьким віброприскоренням на ремоделювання кісткової тканини, мінеральний компонент та структурну організацію кісткових нанокомпозитів у щурів після оварієктомії.

Матеріали і методи. Дослідження проведено на щурах лінії Wistar, розподілених на групи: SHAM-контроль, оварієктомія та оварієктомія + загальна вібрація (50 Гц, 0,3 g, 30 хв/добу, 5 днів/тиждень). Тривалість експерименту – 24 тижні. Оцінювали маркери ремоделювання кісткової тканини (остеокальцин, лужна фосфатаза, TRAP-5b), а також структурні параметри мінерального компоненту методом рентгенівської дифракції.

Результати. Після оварієктомії відзначалося статистично значуще зниження мінерального компоненту кістки вже на 8-му тижні з подальшим збереженням цієї тенденції. Застосування вібрації запобігало ранній втраті кісткової маси у період 8-16 тижнів, що супроводжувалося вищими показниками кристалічної фази та більшими розмірами кристалітів порівняно з групою оварієктомії. Біохімічні маркери свідчили про активізацію ремоделювання після оварієктомії, тоді як вібрація частково модулювала ці процеси. На 24-му тижні статистично значущий ефект вібрації зменшувався.

Висновки. Загальна вібрація в експериментальній моделі оварієктомії сповільнює ранні процеси втрати мінерального компоненту кістки та модифікує ремоделювання кісткової тканини, що проявляється змінами біохімічних маркерів і параметрів кристалічної структури. Найбільш виражений ефект спостерігається у ранній постоварієктомічний період.

КЛЮЧОВІ СЛОВА: загальна вібрація; ремоделювання кісткової тканини, мінеральна щільність кістки, остеопороз, кісткові нанокомпозити, рентгенівська дифракція.

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