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THE FORMATION AND MINERALIZATION OF BONE TISSUE UNDER DIFFERENT REGIMES OF MOTOR ACTIVITY IN THE AGE ASPECT

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Summary

A deep study of the adjustment processes of bone, its structure, chemical composition, adaptive capacity is a necessary condition for clarification of the influence of labor, sports and a number of trades that occur in connection with the scientific - technical progress on the body. The organization and simulation of the different modes of motor activity does not fully meet the training process rights in physical education and sport. However, the results obtained in this pilot study are related to the disclosure of general biological laws based on individual and genetically determined characteristics of individuals, knowledge of which will serve as a morphological substantiation of the training process and prediction of structural changes in the skeleton at various modes of exercise, injury prevention, and the development of osteoporosis. As follows:

1. Intense exercise causes slowdown in growth and osteoclastic resorption of humeri and their structural elements by young and mature animals. By animals with severe senile changes there observed significant destructive changes in all parts of the humeri. Morphometric research methods allow confirming maximal destructive bone changes in the group of senile animals and minimal ones – by mature animals.

2. In turn, moderate exercise is a deterrent of involute changes in humeri. In the group of young animals there is observed deceleration of the narrowing processes of the growth plate width and increase of osteoblasts activity, what was indirectly manifested in increase of the bones size and their structures by experimental animals. In the group of animals with severe senile changes there was marked slowdown of bone demineralization. It was determined that the effect of the different regimes of exercise on morphogenesis processes depends on age, as well as intensity and duration of exercise.

3. Results of the study have both theoretical and practical importance because they provide methodological basis for the study of adaptive changes in bone system, determining a range of its transformation. Ability to predict training exercises and target use graduated physical exercises with the aim to correct skeletal structural changes depending on age was experimentally confirmed.

Keywords: exercise, endurance, macro - micro elements, humerus.

Резюме

Глибоке вивчення процесів перебудови кісткової тканини, її будови, хімічного складу, адаптаційних можливостей є необхідною умовою вияснення закономірностей впливу праці, спорту та ряду професій, що виникають у зв'язку з науково-технічним прогресом, на організм. Організація і моделювання різних режимів рухової активності не в повній мірі відповідає тренувальним процесам людини у фізичній культурі та спорті. Однак результати, отримані при даному експериментальному дослідженні, мають відношення до розкриття загальнобіологічних закономірностей, основаних на індивідуальних і генетично обумовлених особливостях індивідуумів, знання котрих послужить морфологічним обґрунтуванням тренувального процесу і прогнозуванню структурних перетворень в скелеті при різних режимах рухової активності, запобіганню травм та розвитку остеопорозу.

Ключові слова: **фізичні навантаження, витривалість, макро-мікро елементи, плечова кістка.**

Problem statement and analysis of recent. Effect of exercise on human body in whole and structure of long bones has been generally studied by many authors for several decades but today it is actual in sports medicine, sports and physical culture.

Functional anatomy researches combine experimental-morphological studies that focus on the impact of living conditions, work, sports, exercise on formation and structure of

the whole body and on its individual organs. Bone has always been an interesting object of research and it has been particularly actively studied over the past decades [1, 3, 4].

But today study of the skeleton bones has not lost its relevance [2]. Conditions of human life, environment, food are changed, new sports appear. The impact of the last on the body usually requires detailed study [6-8]. All these changes affect the growth and development of bones, especially at a young age. Bone system is a complex and labile in functionally and morphologically. It responds to various internal and external factors. Polyfunctionality determines the primary difficulty in studying functional morphology of the musculoskeletal system. Despite the fact that in modern literature there are sufficient data devoted to influence of dynamic physical activities on growth and development of long bones, there is no compete clarity on this issue.

The aim of the study. The thesis is prepared within the complex scientific research theme of I. Horbachevskyy Ternopil State Medical University "Secondary osteoporosis: pathogenetic mechanisms of formation and progression, clinical-instrumental and biochemical markers of early diagnosis, prevention and treatment" (state registration nr. 0104U004523), a part of which is the scientific research work of the Department of Human Anatomy themed «Study of corrective factors on the course of experimental osteoporosis. The study is reaction of organism dehydration, different regimes of exercise on the structure of long bones and physical development, depending on the impact of vegetative status». During its fulfilling the authors studied the growth and formation of bones skeleton by exercise in the age aspect.

Materials and methods. White rats were chosen by us as an object for study because they have relatively short life cycle and continuous growth of skeleton bones; this allows following the processes of osteogenesis during the short period of time. To solve this problem an experiment was conducted on 180 white mongrel laboratory male-rats. All animals were divided into three age groups of 60-120 days (young rats) weighing 120-180 g, 140-200 days, weighing 200-250 g (mature rats) and 560-620 days (senile rats) weighing 300-400 g. Choice of these age groups was made according to the classification of Makhinko V.M. and Nikitina V.N. (1977). Complex of the used methods allowed highlight the problem of influence of dynamic exercise on growth and functional features of animals' long bones in age aspect in a certain way. Considering the fact that the bone is minerals depot, study of the chemical composition of bones was conducted. Water content in the bones was determined by the difference of wet and dried in the oven at 105 ^{o}C bone to constant weight. Then the dried bones were burned in a muffle furnace at a temperature of 450 ^{o}C. Ash weight served as an indicator of the total amount of minerals in bone. At spectrophotometer UV-115 (method of

Semenko B.A., Moldakulova M.M. (1980)) quantitative content of Ca, K, Na, Mg, Cu, Mn, Zn, Fe and Pb was determined. Amount of phosphate was determined at the photoelektrocalorimeter by Brig. Digital material as an experiment result was statistically processed using Styudent's criterion on a PC using Microsoft Excel (USA). Probability of error of less than 5 % ($p<0,05$) was considered as reliable.

Research results. The water content in the bones of young animals after moderate exercise of the dynamic nature (20, 40, 60 days) of the experiment increased by 18,40±0,48 (0,13 %); 18,67±0,60 (1,47%); 19,08±0,49 (2,16 %), respectively. By animals of the same age group, which underwent intense exercise, water content in the bones is significantly reduced – by 18,10±0,62 (1,52 %); 17,25±0,56 (4,69 %); 16,38±0,44 (5,08 %), respectively (fig. 1). Similarly, data of water content changed in humeri by mature animals, which underwent moderate and intense exercise of dynamic character for 20, 40, 60 days of the experiment (Fig. 1).

Bones of senile animals react to moderate exercise with increase of water amount which is 29,99±1,73 (0,21 %); 30,01±0,63 (0,36 %); 30,39±1,41 (0,14 %). By animals of the same age, which underwent intense exercise, water content for 20, 40 days of the experiment significantly reduced – by 22,01±0,29 (5,38 %); 20,63±0,36 (7,14 %); in 60 days this figure increased by 18,81±0,28 (3,13 %) (Fig. 1).

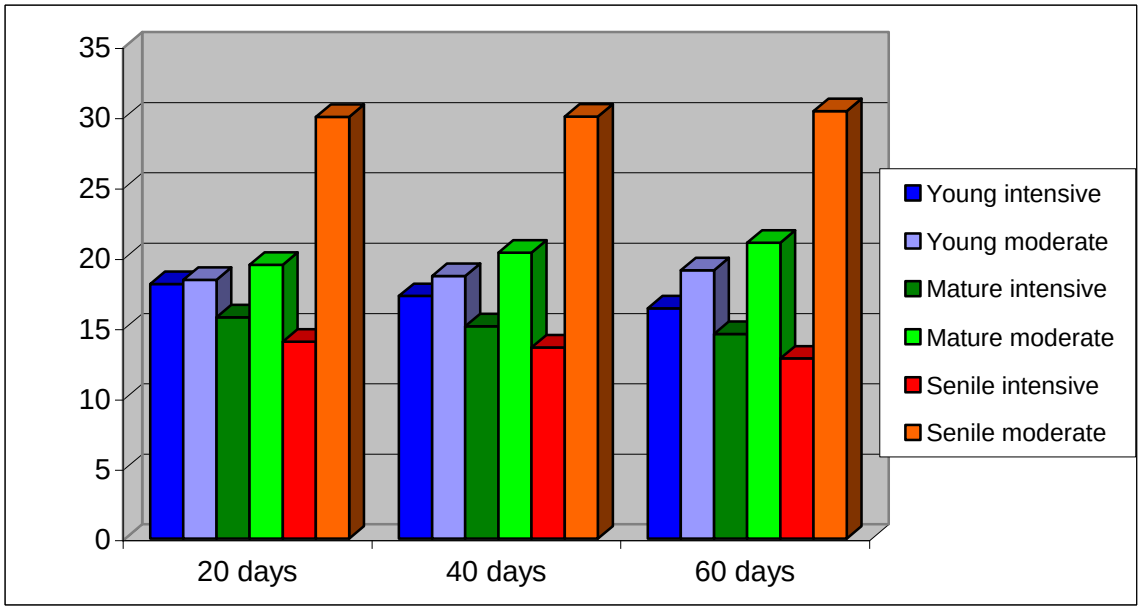

Fig. 1. Percentage correlation of water in humeri of animals by intense and moderate exercise

Number of minerals by animals of young age, which during 20, 40, 60 days underwent

moderate exercise, significantly increases (Fig. 2), by animals of the same age, which underwent moderate exercise, their content reduced by 57,67±1,55 (2,30 %); 62,51±2,71 (4,69 %); 70,27±1,80 (5,08 %), respectively.

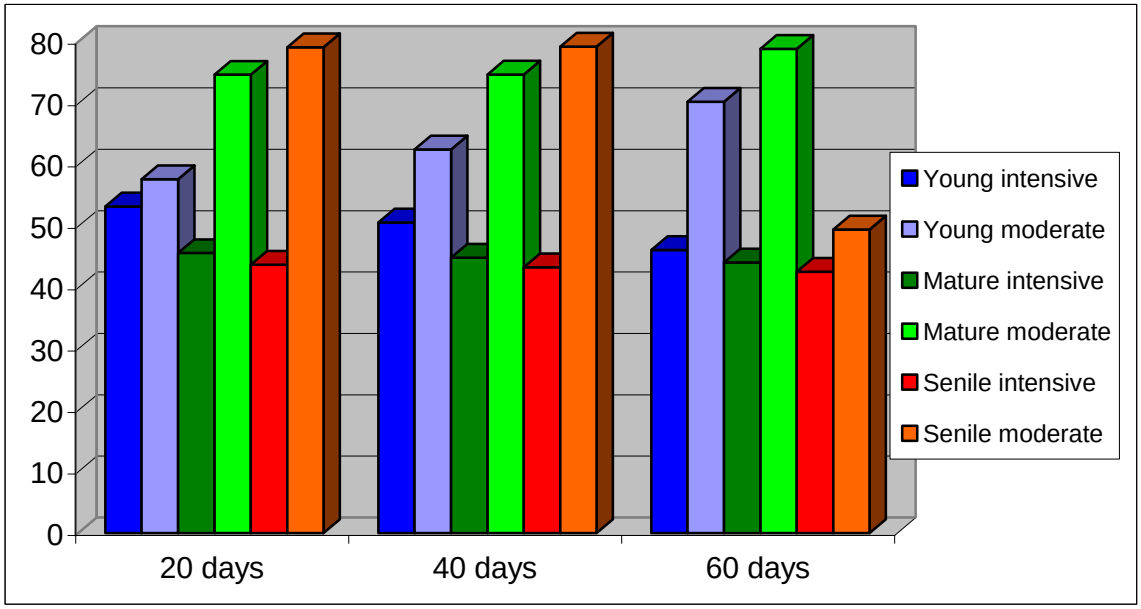

Fig. 2. Percentage correlation of minerals (on dry substance) in humerus of animals by intense and moderate exercise

By mature animals, after moderate exercise of 20, 40, 60 days total quantity of minerals increases by 74,69±1,98 (4,82 %); 74,70±1,96 (3,97 %); 78,91±2,12 (5,61 %), respectively, and after intense stress their number decreased by 45,63±1,02 (1,76 %); 44,83±0,95 (5,32 %); 44,09±1,35 (9,43 %), respectively (see. Fig. 2).

This figure increases by senile animals, which, within two months of the experiment, underwent moderate physical dynamic activity by 79,16±1,92 (0,94 %); 79,27±1,93 (1,58 %); 83,46±1,26 (1,77 %). By animals of the same age, which underwent intensive exercise, the total amount of minerals significantly reduces, respectively, 63,72±1,17 (0,73 %); 53,32±1,20 (2,61 %); 49,57±1,11 (8,99 %) (see Fig. 2).

Young animals, which during 20, 40, 60 days of the experiment underwent moderate exercise, react with increase of the amount of calcium in humerus (Fig. 3), while the intense activity during the entire experiment led to lowering the calcium level 23,05±1,56 (2,64 %); 21,76±0,53 (5,60 %); 19,96±0,48 (8,26 %), which can cause osteoporotic symptoms.

Throughout the experiment calcium content is significantly increased by mature animals, which underwent moderate exercise (Fig. 3). By animals of the same age intense

exercise during 20 days lead to increase of calcium only by 18,32±0,40 (2,62 %), while in 40 and 60 days, there is a significant reduction of calcium – by 17,79±0,47 (1,95 %); 17,49±0,45 (6,31 %).

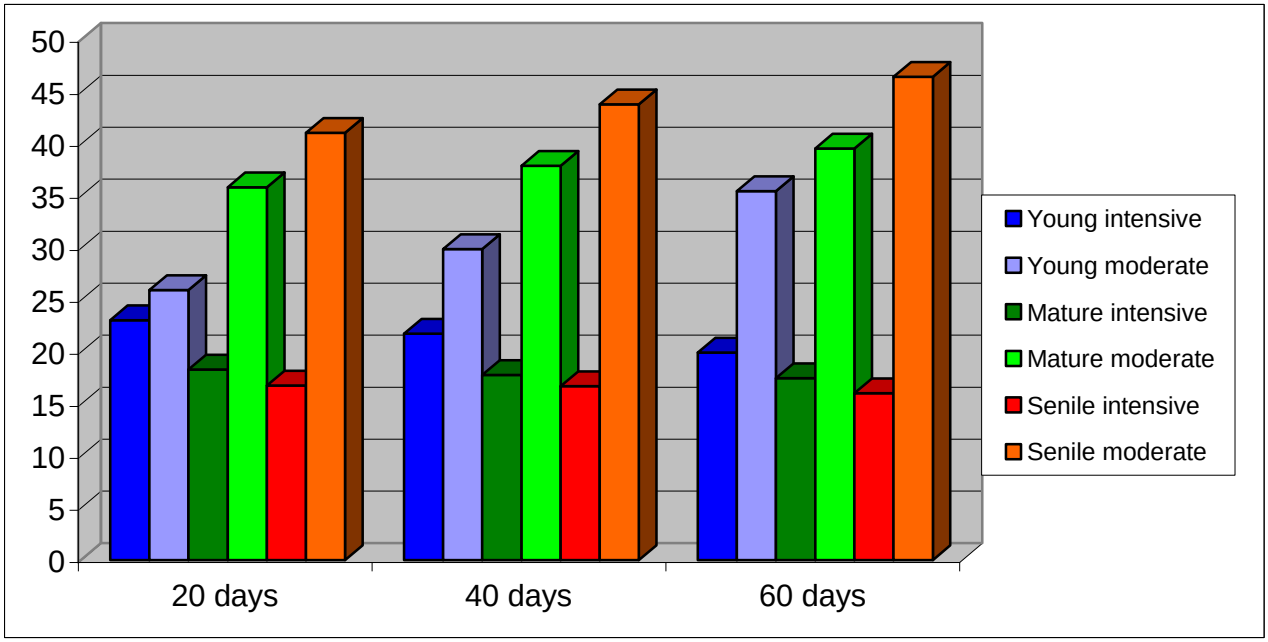

Fig. 3. Percentage correlation of calcium at humerus of the animals by intense and moderate exercise

By senile animals after moderate exercise during (20, 40, 60 days) experiment calcium amount increases, by 41,08±1,00 (1,23 %); 43,81±1,12 (5,17 %); 46,46±1,01 (7,63 %) respectively. After intense exercise, this figure is significantly reduced – by 36,77±0,35 (2,02 %); 31,71±0,45 (4,67 %); 30,04±0,42 (3,24 %) (Fig. 3).

Humeri of young animals respond to two-month moderate exercise with considerable increase of phosphorus content (Fig. 4). By animals of the same age, which underwent intense exercise, phosphorus significantly reduced – by 12,04±0,29 (1,95 %); 11,31±0,24 (6,07 %); 10,48±0,27 (7,34 %), respectively, during 20, 40, 60 days of the experiment.

Similar are the data we observe by mature animals, which underwent moderate and intense exercise of dynamic nature during the two-month experiment (Fig. 4).

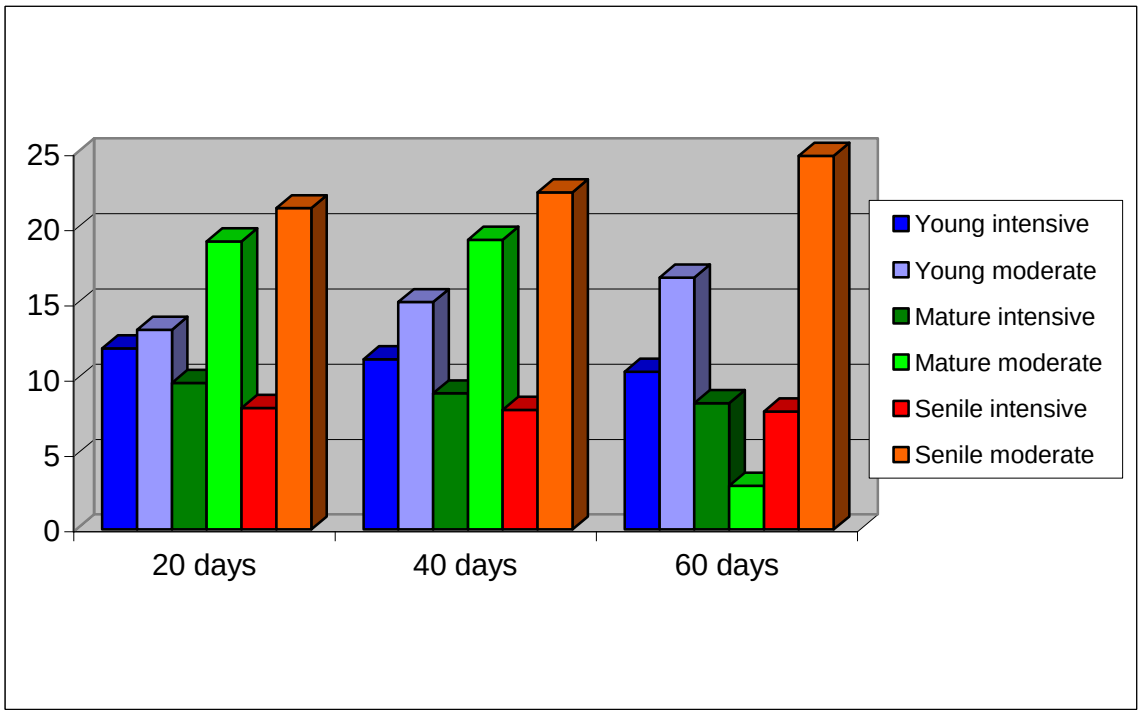

Fig. 4. Percentage correlation of phosphorus at humerus of the animals by intense and moderate exercise

We observe an increase in phosphorus in the bones of senile animals, which, during 20, 40, 60 days of the experiment, underwent moderate exercise by 21,36±0,64 (0,56 %); 22,42±0,57 (4,43 %); 24,85±0,43 (8,31 %). Significant reduction of phosphorus occurs in humeri of senile animals, which underwent intense exercise (Fig. 4).

CONCLUSIONS

The use of a single methodological approach and set of adequate research methods on a large homogeneous experimental material allowed explaining patterns of morphological structure change of the long bones by animals under conditions of different regimes of exercise in different age groups. Established:

1. Intense exercise causes slowdown in growth and osteoclastic resorption of humeri and their structural elements by young and mature animals. By animals with severe senile changes there observed significant destructive changes in all parts of the humeri. Morphometric research methods allow confirming maximal destructive bone changes in the group of senile animals and minimal ones – by mature animals.

2. In turn, moderate exercise is a deterrent of involute changes in humeri. In the group of young animals there is observed deceleration of the narrowing processes of the growth

plate width and increase of osteoblasts activity, what was indirectly manifested in increase of the bones size and their structures by experimental animals. In the group of animals with severe senile changes there was marked slowdown of bone demineralization. It was determined that the effect of the different regimes of exercise on morphogenesis processes depends on age, as well as intensity and duration of exercise.

3. Results of the study have both theoretical and practical importance because they provide methodological basis for the study of adaptive changes in bone system, determining a range of its transformation. Ability to predict training exercises and target use graduated physical exercises with the aim to correct skeletal structural changes depending on age was experimentally confirmed.

Discussion. The results obtained in this pilot study are related to the disclosure of general biological laws based on individual and genetically determined characteristics of individuals, knowledge of which will serve as a morphological substantiation of the training process and prediction of structural changes in the skeleton at various modes of exercise, injury prevention, and the development of osteoporosis.

Prospects for further research in this direction. Further study of morphogenesis processes depending on age and gender, and the intensity and duration of physical activity in the dynamics of early and late manifestations of adaptation processes in the tissue that will enable the development of new methods of correction in systemic disorders in animals.

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