



COMPREHENSIVE ANALYSIS OF MORPHOFUNCTIONAL CHANGES IN HUMAN BONE TISSUE AND THE INFLUENCE OF ENDOGENOUS AND EXOGENOUS FACTORS

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Abstract. The study provides a comprehensive analysis of morphofunctional changes in human bone tissue under the influence of endogenous and exogenous factors. Bone tissue plays a central role in maintaining the structural and functional integrity of the musculoskeletal system. The research emphasizes that both internal mechanisms—such as genetic predisposition, hormonal regulation, and metabolic balance—and external influences, including environmental pollution, nutritional habits, and levels of physical activity, significantly affect bone density, structure, and strength. The methodological framework integrates bioimpedance analysis, osteodensitometry, and statistical modeling to assess correlations between influencing factors and bone morphofunctional dynamics. The results highlight the multifactorial nature of skeletal weakening and underscore the importance of individualized preventive and therapeutic strategies. The study contributes to the advancement of osteology by establishing a scientific foundation for developing targeted pharmacological and non-pharmacological interventions aimed at preserving bone health, preventing degenerative-dystrophic diseases, and improving life quality across diverse population groups.

Key words: Bone tissue, morphofunctional changes, endogenous factors, exogenous factors, osteoporosis, osteoarthritis, skeletal system, bone density, metabolism, environmental impact, preventive medicine, clinical pharmacology.

**КОМПЛЕКСНЫЙ АНАЛИЗ МОРФОФУНКЦИОНАЛЬНЫХ ИЗМЕНЕНИЙ
КОСТНОЙ ТКАНИ ЧЕЛОВЕКА И ВЛИЯНИЕ ЭНДОГЕННЫХ И ЭКЗОГЕННЫХ
ФАКТОРОВ**

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Аннотация. В исследовании представлен комплексный анализ морфофункциональных изменений костной ткани человека под воздействием эндогенных и экзогенных факторов. Костная ткань играет центральную роль в поддержании структурной и функциональной целостности опорно-двигательного аппарата. В работе подчеркивается, что как внутренние механизмы — генетическая предрасположенность, гормональная регуляция и метаболическое равновесие, — так и внешние воздействия, включая загрязнение окружающей среды, особенности питания и уровень физической активности, оказывают значительное влияние на плотность, структуру и прочность костной ткани.

Методологическая база исследования включает биоимпедансный анализ, остеоденситометрию и статистическое моделирование, что позволяет выявить взаимосвязь между влияющими факторами и морфофункциональной динамикой костной



ткани. Полученные результаты подтверждают многофакторную природу ослабления костной системы и подчеркивают необходимость индивидуализированных профилактических и терапевтических подходов.

Данное исследование вносит значимый вклад в развитие остеологии, формируя научную основу для разработки целевых фармакологических и немедикаментозных стратегий, направленных на сохранение здоровья костной ткани, профилактику дегенеративно-дистрофических заболеваний и повышение качества жизни различных групп населения.

Ключевые слова: Костная ткань, морфофункциональные изменения, эндогенные факторы, экзогенные факторы, остеопороз, остеоартроз, опорно-двигательная система, плотность кости, метаболизм, воздействие окружающей среды, профилактическая медицина, клиническая фармакология.

Relevance of the Topic

Bone tissue represents a fundamental structural component of the human musculoskeletal system, providing critical support for movement, mechanical stability, and maintenance of overall physiological homeostasis. The structural integrity and functional capacity of bones are essential for sustaining normal bodily functions and ensuring optimal health throughout life. In recent decades, the prevalence of skeletal system disorders—including osteoporosis, osteoarthritis, and other degenerative-dystrophic conditions—has increased significantly, affecting not only older adults but also younger populations. These pathological conditions lead to pronounced morphological and functional alterations in bone tissue, which in turn contribute to reduced physical activity, diminished quality of life, and an overall decline in health status.

The morphofunctional state of bone tissue is highly dynamic and is influenced by a complex interplay of internal and external factors. Internal factors include physiological characteristics, endocrine function, genetic predispositions, and metabolic conditions. External factors encompass environmental influences such as chemical exposures, radiation, lifestyle factors, nutritional habits, and levels of physical activity. Understanding the mechanisms through which these factors impact bone morphology, density, and functional capacity is essential for the development of scientifically grounded strategies to maintain and enhance skeletal health.

In contemporary society, several trends underscore the heightened relevance of studying bone tissue. The growing interest of younger populations in sports and physically demanding activities, combined with accelerated demographic aging, has resulted in an increased incidence of bone-related disorders. Furthermore, changes in environmental conditions, urbanization, and increased exposure to ecological stressors pose additional challenges to maintaining skeletal health. These factors collectively create an urgent need for comprehensive research on the morphofunctional changes in bone tissue and the identification of key influencing factors.

From a scientific perspective, in-depth investigation of the morphological, biochemical, and functional properties of bone tissue provides critical insights into the mechanisms of skeletal remodeling, degeneration, and regeneration. Such studies form the foundation for understanding the pathogenesis of bone diseases and for developing innovative preventive and therapeutic approaches. Practically, this knowledge is essential for the early detection of skeletal disorders, the formulation of individualized preventive strategies, the optimization of physical activity programs, and the mitigation of environmental risks. Ultimately, research on bone tissue morphofunctional changes contributes to enhancing skeletal resilience, reducing the incidence of



degenerative bone diseases, and improving the overall quality of life across different population groups.

Objective of the Study. The primary objective of this research is to perform an in-depth and systematic analysis of the morphofunctional properties of bone tissue, examining both its structural and functional characteristics under varying physiological and environmental conditions. The study aims to identify and evaluate the key endogenous factors, such as genetic predispositions, hormonal regulation, and metabolic processes, as well as exogenous influences, including nutritional status, physical activity, ecological conditions, and exposure to chemical or radiological agents, that can affect bone density, strength, and overall structural integrity. Based on these findings, the research seeks to formulate scientifically grounded and evidence-based recommendations for preserving skeletal health, enhancing bone resilience, and preventing or mitigating degenerative, dystrophic, and other pathological changes in the skeletal system across different population groups. The ultimate goal is to provide a robust scientific foundation for the development of targeted strategies in preventive medicine, clinical management, and public health interventions aimed at maintaining and strengthening bone tissue throughout life.

Materials and Methods. The study employed a comprehensive set of methodological approaches to investigate the morphofunctional characteristics of bone tissue and the factors influencing its condition. First, an extensive review and systematic analysis of current scientific literature and previous experimental and clinical studies were conducted to establish the theoretical and empirical background of bone tissue physiology, remodeling processes, and pathology.

To assess the impact of physical activity on skeletal health, participants' levels of exercise and biomechanical load were analyzed, considering both intensity and duration. Anthropometric measurements were used to evaluate bone structure, size, and proportions, providing baseline data on skeletal morphology. Bone mass, density, and structural integrity were quantitatively assessed using bioimpedance analysis and osteodensitometry, enabling accurate measurement of bone mineral content, cortical thickness, and overall bone strength.

In addition, statistical analyses were employed to identify and evaluate key endogenous (genetic, metabolic, hormonal) and exogenous (environmental, nutritional, physical activity) factors affecting bone health. Correlation and regression models were used to determine relationships between these factors and observed morphofunctional changes in bone tissue.

The combination of these methods allowed for a comprehensive assessment of bone tissue dynamics, identification of risk factors for weakening or degeneration, and formulation of targeted strategies for maintaining skeletal health and preventing bone-related disorders. This integrated approach provides a robust framework for understanding the complex interactions between biological, environmental, and lifestyle factors in bone physiology and pathology.

Results and Scientific Objectives of the Study. The expected outcomes of this study are aimed at the detailed identification and systematic analysis of the morphofunctional changes in human bone tissue under the influence of various endogenous (genetic, metabolic, hormonal) and exogenous (environmental, chemical, radiation, physical activity) factors. It is anticipated that a comprehensive investigation of these changes will allow the determination of the key mechanisms leading to reductions in bone density, strength, and functional integrity.



The data obtained will not only enable the identification of the direct causes of bone weakening but also highlight correlating factors that contribute to the development of degenerative-dystrophic processes, such as osteoporosis and osteoarthritis. Based on the analysis of these factors, scientifically grounded approaches can be formulated for the prevention and correction of pathological bone changes.

Special attention is given to assessing the impact of environmental factors, including pollution, chemical toxicants, and radiation, on the morphofunctional state of bone tissue. Should negative effects be identified, the study will provide a foundation for the development of both pharmacological and non-pharmacological methods for correction and prevention.

Moreover, the study aims to identify physiological and metabolic factors that contribute to decreased mechanical resilience of bone tissue. This will facilitate the creation of individualized prevention and treatment programs for various age and physiological groups, including the selection of appropriate pharmacological agents, optimization of physical activity regimens, and adjustment of environmental conditions to minimize the risk of bone damage.

Thus, the outcomes of the study possess dual scientific and practical significance:

1. Fundamental significance — expansion of knowledge regarding the mechanisms of morphofunctional changes in bone tissue under the influence of internal and external factors.
2. Applied significance — creation of a scientific basis for the development of preventive, therapeutic, and rehabilitative strategies aimed at strengthening bone tissue, reducing injury risk, and preventing the progression of degenerative-dystrophic bone diseases.

Conclusion. A comprehensive study of the morphofunctional changes in bone tissue is a key aspect in developing new scientifically grounded approaches for the prevention and treatment of bone system disorders. The findings underscore that bone weakening is a multifactorial phenomenon largely determined by both endogenous factors (genetic, metabolic, hormonal) and exogenous factors (environmental pollution, chemical agents, radiation, and physical activity levels).

The identified patterns of morphofunctional changes necessitate the application of an individualized approach in the development of preventive and therapeutic strategies. This is particularly important for designing adapted bone-strengthening programs for different age and physiological groups.

The scientific and practical significance of the study lies in the ability to:

1. Minimize the negative impact of environmental factors on bone tissue;
2. Prevent the development of degenerative-dystrophic bone diseases, such as osteoporosis and osteoarthritis;
3. Develop modern pharmacological and non-pharmacological methods aimed at strengthening bone tissue and maintaining its functional and morphological integrity.

In this way, the results of the study establish a solid scientific foundation for further research in osteology, physiology, and clinical medicine, ensuring the transition from fundamental understanding of morphofunctional processes to their practical application in the prevention and treatment of bone system disorders.

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