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MECHANICAL PROPERTIES OF SOLIDS AND BIOLOGICAL TISSUES

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ABSTRACT

This article discusses the mechanical properties of solid bodies and biological tissues, methods for determining their physical and mechanical parameters, and their significance in medicine and biophysics. A comparative analysis was conducted between the properties of solid materials, including elasticity, plasticity, strength, hardness, and deformation, and the mechanical behavior of biological tissues. The study examined the mechanical resistance of bone, cartilage, muscle, and connective tissues, as well as the influence of external forces on them, based on reliable scientific literature. The viscoelastic nature of biological tissues, their deformation characteristics, and their role in biomechanical processes were analyzed using modern scientific sources. The findings demonstrate the important role of mechanical properties in medicine, traumatology, orthopedics, and the development of biomaterials.

Keywords: solid bodies, biological tissues, mechanical properties, elasticity, deformation, biomechanics, viscoelasticity, biomaterials.

INTRODUCTION

In modern biophysics and medicine, studying the mechanical properties of solids and biological tissues has acquired significant scientific and practical importance. Bone, cartilage, muscle, and connective tissues in the human body are constantly subjected to external and internal mechanical stresses. The mechanical durability, elasticity, deformation characteristics, and strength of these tissues are fundamental factors in ensuring the normal physiological functioning of the organism. Therefore, the in-depth study of the biomechanical properties of biological systems remains a pressing issue in modern medicine, traumatology, orthopedics, dentistry, and biomaterials technology.

Solid mechanics is a crucial branch of classical physics that examines the deformation and mechanical behavior of bodies under the influence of external forces. Parameters such as elasticity, plasticity, hardness, brittleness, and strength are the primary indicators defining the physical-mechanical state of materials. Biological tissues, unlike simple solids, are complex viscoelastic systems that deform in a time-dependent manner under mechanical loads. In particular, while bone tissue possesses high strength, cartilage and muscle tissues are distinguished by their elastic and shock-absorbing (damping) properties.

In recent years, research in biomechanics and medical materials science has enabled the study of the mechanical properties of biological tissues at the molecular and cellular levels. Modern diagnostic methods, including ultrasound elastography, computed tomography, and biomechanical modeling technologies, have expanded the possibilities for assessing tissue deformation. This plays a vital role in the early detection of various diseases, the improvement of prosthetic and implant materials, and the development of regenerative medicine.

The purpose of this article is to analyze the basic mechanical properties of solids and biological tissues based on scientific literature, to conduct a comparative study of their biomechanical features, and to highlight their practical significance in medicine. During the research, the elasticity, deformation, and viscoelasticity indicators of biological tissues are analyzed based on modern scientific sources, and their role in clinical practice is evaluated.

LITERATURE REVIEW

Scientific research on the mechanical properties of solids and biological tissues is closely linked to the development of physics, biophysics, biomechanics, and medicine. Early studies in this field primarily analyzed the deformation, elasticity, and strength of solids based on the laws of classical mechanics. Later, it was discovered that biological tissues possess a complex viscoelastic nature, and studying their mechanical properties became a distinct scientific direction in bioengineering and clinical medicine.

The theory of elasticity developed by the English scientist Robert Hooke is one of the fundamental laws of solid mechanics. According to Hooke's Law, the deformation of a body is directly proportional to the force acting upon it. This law is also applied to explain the initial elastic deformations of biological tissues. Subsequently, Thomas Young developed the concept of the modulus of elasticity (Young's modulus), which was introduced as a key parameter for evaluating the mechanical resistance of materials.

In modern research within biophysics and biomechanics, the mechanical behavior of biological tissues is evaluated as a complex viscoelastic system. Biomechanical theories developed by Yuan-Cheng Fung provided a profound explanation of the deformation characteristics of biological tissues. His scientific works analyzed the mechanical response of bone, muscle, and blood vessel walls in relation to external loads. Fung emphasized that, unlike simple elastic bodies, biological tissues possess time-dependent deformation properties.

Research conducted by representatives of the Russian school of biophysics has extensively studied the relationship between the microstructure of biological tissues and their mechanical strength. In particular, it has been scientifically proven that collagen fibers and mineral components of bone tissue ensure its high mechanical durability. Studies have noted a decrease in the elastic modulus of bones due to osteoporosis, degenerative diseases, and age-related changes.

In scientific works dedicated to the mechanics of cartilage tissue, its damping and load-distributing functions are the primary focus. Modern literature indicates that the proteoglycan and collagen content of cartilage determines its elasticity and resistance to compression. The mechanical properties of muscle tissues are characterized by active contraction and passive elasticity. Researchers have noted that the biomechanical properties of muscles are inextricably linked to the functioning of the neuromuscular system.

In recent years, matching the mechanical parameters of biological tissues with synthetic materials has become a major direction in biomaterials and regenerative medicine research. Numerous scientific sources emphasize the necessity of considering the elastic modulus, hardness, and deformation characteristics of biological tissues when creating implants, prostheses, and tissue engineering products. Research on creating biomaterials with mechanical properties similar to bone and cartilage tissue using nanomaterials and biocomposites is rapidly advancing.

The analyzed scientific literature shows that studying the mechanical properties of solids and biological tissues is of great scientific and practical importance not only for theoretical biophysics but also for clinical medicine, orthopedics, traumatology, and regenerative medicine. Deep research into the biomechanical properties of biological tissues allows for early diagnosis of diseases, development of modern biomaterials, and increased treatment efficiency.

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RESULTS

During the research, the mechanical properties of solids and biological tissues were comparatively analyzed based on modern biophysical and biomechanical literature. The obtained data indicated that the mechanical behavior of biological tissues is closely linked to their structural composition, the amount of extracellular matrix, and their functional roles. In particular, bone tissue exhibited high mechanical strength, showing significant resistance to compression and tension forces. In contrast, cartilage tissue performed a damping (shock-absorbing) function and was distinguished by its elastic deformation characteristics.

Biomechanical analysis revealed that biological tissues, unlike simple solids, possess viscoelastic properties. This state is characterized by the time-dependent retention of deformation after the application of an external force. It was determined that elasticity indicators are high in muscle and connective tissues, allowing them to provide a flexible response to mechanical loads. In bone tissue, the abundance of mineral substances was observed to increase its hardness and strength.

The analysis also identified that changes in the mechanical parameters of biological tissues are associated with various pathological conditions. In osteoporosis, a decrease in the elastic modulus of bones and an increase in brittleness were recorded. In degenerative cartilage diseases, a decrease in tissue elasticity was observed as a result of reduced collagen and proteoglycan content. These cases highlight the importance of biomechanical examinations in traumatology and orthopedic practice.

Table 1

Comparative description of the basic mechanical properties of solids and biological tissues

Object Type	Elasticity	Strength	Plasticity	Viscoelasticity	Primary Function
Metallic solids	Moderate	Very High	High	Low	Mechanical support
Ceramic materials	Low	High	Very Low	None	Pressure resistance
Bone tissue	Moderate	High	Low	Moderate	Body support
Cartilage tissue	High	Moderate	Moderate	High	Damping (Shock absorption)
Muscle tissue	Very High	Moderate	High	High	Ensuring movement
Connective tissue	High	Moderate	Moderate	High	Structural bonding

The table results show that the mechanical properties of biological tissues are formed in accordance with their physiological functions. Specifically, the high level of viscoelasticity in cartilage and muscle tissues plays a crucial role in softening mechanical shocks and ensuring flexibility during movement.

Table 2

Influence of pathological conditions on the mechanical properties of biological tissues

Pathological Condition	Affected Tissue	Mechanical Change	Clinical Consequence
Osteoporosis	Bone	Decreased strength	Increased fragility/fractures

Osteoarthritis	Cartilage	Decreased elasticity	Limited joint movement
Muscular dystrophy	Muscle	Reduced elastic fibers	Muscle weakness
Fibrosis	Connective tissue	Increased stiffness	Impaired tissue function
Scoliosis	Spinal tissues	Uneven load distribution	Posture deformation
Traumatic injury	Soft tissues	Deformation and rupture	Disrupted movement activity

The results indicated that any change in the mechanical properties of biological tissues significantly affects the functional state of the organism. Therefore, studying biomechanical parameters is of great scientific and practical importance in diagnostics, treatment, and regenerative medicine.

DISCUSSION

The results of this study demonstrate significant similarities and differences between the mechanical properties of solids and biological tissues. While the laws of classical solid mechanics serve as an essential theoretical foundation for explaining certain mechanical features of biological systems, the complex structure of biological tissues distinguishes them significantly from simple elastic bodies. In particular, the viscoelastic nature of biological tissues ensures a time-dependent response to deformation. This characteristic is a vital physiological mechanism in protecting the organism from mechanical damage.

During the research, bone tissue was confirmed to be one of the biological structures with the highest mechanical strength. Mineral components within the bone, specifically hydroxyapatite crystals, increase its hardness and pressure resistance. At the same time, the presence of collagen fibers maintains a certain degree of elasticity in the bone. This indicates that bone is a biomaterial that is simultaneously rigid and relatively flexible. As noted in the literature, a decrease in mineral density with age leads to the mechanical weakening of bones and increases the risk of developing osteoporosis.

The biomechanical properties of cartilage tissue also hold distinct scientific importance. The research results showed that cartilage possesses high elasticity and damping capacity. This feature is linked to the complex spatial arrangement of collagen fibers and proteoglycans. Cartilage's resistance to compression forces allows for an even distribution of mechanical loads within the joints. In degenerative diseases, the disruption of these structural components causes a decrease in cartilage elasticity and limits joint function.

The mechanical properties of muscle and connective tissues play a major role in ensuring the movement activities of the organism. Muscle tissue possesses active contraction properties, converting mechanical energy into biological movement. Connective tissues provide mechanical bonding between organs and tissues, granting them structural stability. Research has found that increased stiffness in these tissues during fibrous and degenerative processes disrupts their physiological functions.

The results of the discussion show that studying the mechanical properties of biological tissues is of great importance for modern clinical practice. In traumatology and orthopedics, determining the biomechanical parameters of bones and cartilage is crucial for selecting treatment tactics. Furthermore, in the creation of biomaterials and implants, using materials that match the elastic modulus and deformation indicators of biological tissues improves the biological compatibility of the implant with the organism.

In recent years, the development of biomechanical modeling, 3D bioprinting, and regenerative medicine technologies has enabled a deeper study of the mechanical properties of biological tissues. Modern research is focused on bringing artificial biomaterials as close as possible to the mechanical parameters of natural tissues. This will serve as an important scientific basis for creating individual prostheses, artificial organs, and tissue engineering products in the future.

CONCLUSION

The study of the mechanical properties of solids and biological tissues is one of the important scientific directions of biophysics, biomechanics, and clinical medicine. During the research, it was determined that the mechanical behavior of biological tissues is inextricably linked to their structural composition, intercellular substances, and physiological functions. It has been scientifically established that the high strength of bone tissue, the damping properties of cartilage, and the elasticity of muscle and connective tissues are the key factors ensuring the mechanical stability of the organism.

The research results showed that biological tissues, unlike simple solids, possess viscoelastic properties. This state ensures that tissues provide a flexible response to external mechanical loads. Additionally, significant changes in the mechanical parameters of biological tissues were identified in pathological conditions such as osteoporosis, osteoarthritis, and fibrosis, confirming the importance of biomechanical diagnostics in clinical practice.

Deeply studying the mechanical properties of biological tissues holds great scientific and practical significance in traumatology, orthopedics, regenerative medicine, and the creation of biomaterials. The development of modern biomechanical modeling and biomaterial technologies is expanding the possibilities for producing implants and prostheses that are maximally compatible with biological systems.

In summary, the complex study of the mechanical properties of solids and biological tissues serves as an important scientific basis not only for the development of theoretical biophysics but also for diagnosing diseases, increasing treatment efficiency, and creating innovative biomaterials.

REFERENCES

1. Биофизика — Москва: Владос, 2015.
2. Медицинская и биологическая физика — Москва: ГЭОТАР-Медиа, 2018.
3. Биомеханика — Москва: Наука, 2012.
4. Физика биологических тканей — Санкт-Петербург: Питер, 2016.
5. Основы биофизики — Москва: Медицина, 2014.
6. Биомеханика опорно-двигательного аппарата — Москва: Практика, 2017.
7. Механика материалов и биологических тканей — Москва: Академия, 2019.
8. Биофизика клетки — Москва: Высшая школа, 2013.
9. Медицинская биофизика — Санкт-Петербург: СпецЛит, 2020.
10. Физические основы прочности биологических тканей — Москва: Наука, 2011.