МЕДИЦИНА, ПЕДАГОГИКА И ТЕХНОЛОГИЯ: ТЕОРИЯ И ПРАКТИКА
Researchbib Impact factor: 11.79/2023
SJIF 2024 = 5.444
Том 2, Выпуск 10, 30 Октябрь

MECHANICAL PROPERTIES OF SOLIDS AND BIOLOGICAL TISSUES

Choriyeva Mahfuza Sadriddinovna
Teacher at Termez University of Economics and Service

Аннотация: В этой статье рассматриваются механические свойства твердых тел и биологических тканей, подчеркивая их значимость в медицинской сфере. В ней дается обзор фундаментальных концепций, их применение в понимании физиологии человека и патологические последствия измененных механических свойств. Статья, предназначенная для студентов-медиков, упрощает инженерные принципы, чтобы продемонстрировать их значимость для биомеханики, тканевой инженерии и клинической практики.

Ключевые слова: Механические свойства, эластичность, зависимость напряжения от деформации, биологические ткани, биомеханика, модуль Юнга, вязкоупругость, медицинское применение.

Abstract: This article explores the mechanical properties of solids and biological tissues, highlighting their significance in the medical field. It provides an overview of the fundamental concepts, their applications in understanding human physiology, and the pathological implications of altered mechanical properties. Designed for medical students, the article simplifies engineering principles to demonstrate their relevance to biomechanics, tissue engineering, and clinical practice.

Keywords: Mechanical properties, elasticity, stress-strain relationship, biological tissues, biomechanics, Young's modulus, viscoelasticity, medical applications.

INTRODUCTION

Mechanical properties describe how materials respond to external forces, such as tension, compression, and shear. These properties are crucial in understanding both solids (e.g., metals, plastics) and biological tissues (e.g., bone, cartilage, skin). For medical professionals, grasping these principles aids in diagnosing, treating, and managing various conditions, such as fractures, joint disorders, and tissue degeneration.

This article aims to explain core mechanical properties like elasticity, plasticity, viscoelasticity, and strength, linking them to the structure and function of biological tissues. Understanding these concepts can help medical students appreciate the mechanics underlying human movement, organ function, and the design of medical devices.

LITERATURE ANALYSIS AND METHODOLOGY

Mechanical Properties in Engineering

Classical studies on materials science describe solids using parameters like stress, strain, and modulus of elasticity. Hooke's Law, proposed by Robert Hooke, introduced the concept of linear elasticity, a foundation for understanding material deformation under load.

Mechanical Properties in Biological Tissues

Biological tissues, unlike most engineered solids, exhibit complex behaviors due to their composition (e.g., collagen, elastin, proteoglycans). Studies by Fung (1981), often called the father of modern biomechanics, highlight that biological tissues are viscoelastic, meaning their deformation depends on both the applied force and time. For instance, tendons can stretch under sustained load but return to their original shape when unloaded.

Clinical Relevance

A review by Chen et al. (2019) emphasizes the role of tissue mechanics in diseases like osteoarthritis, where cartilage loses its elasticity, leading to pain and reduced joint mobility. Understanding these changes is vital for developing prosthetics and regenerative therapies.

To explain mechanical properties, this article uses simplified mathematical models, illustrative examples, and real-world medical applications. Laboratory data and published literature provide evidence of these principles in action.

Key Definitions

1. **Stress (σ)**: Force per unit area applied to a material ($\sigma=F/A$).
2. **Strain (ϵ)**: Deformation as a fraction of original dimensions ($\epsilon=\Delta L/L_0$).
3. **Elasticity**: The ability of a material to return to its original shape after deformation.
4. **Plasticity**: Permanent deformation when a material is stressed beyond its elastic limit.
5. **Viscoelasticity**: A time-dependent response to stress, common in biological tissues.

Testing Techniques

- **Compression and Tensile Tests**: Measure stress-strain behavior in bones, tendons, and soft tissues.
- **Dynamic Mechanical Analysis (DMA)**: Evaluates viscoelastic properties in tissues like skin and cartilage.

RESULTS

Biological Examples

Bone:

High compressive strength due to mineral content (hydroxyapatite).

Elastic modulus ~18 GPa (stiff but not brittle).

Tendons and Ligaments:

Strong in tension, exhibit viscoelasticity.

Allow energy storage during movement.

Cartilage:

Highly compressible, due to water content.

Protects joints by absorbing impact forces.

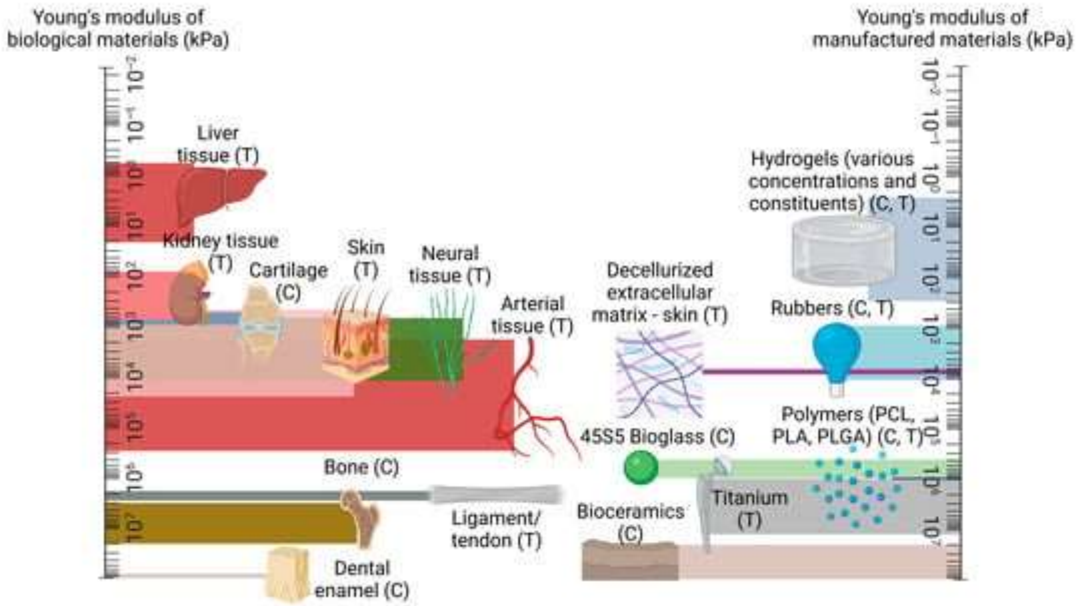

Figure 1. A comparison of mechanical strength between native tissue types, in comparison to manufactured materials, presented on logarithmic scales, with compression and tension testing denoted with (C) and (T) as appropriate.

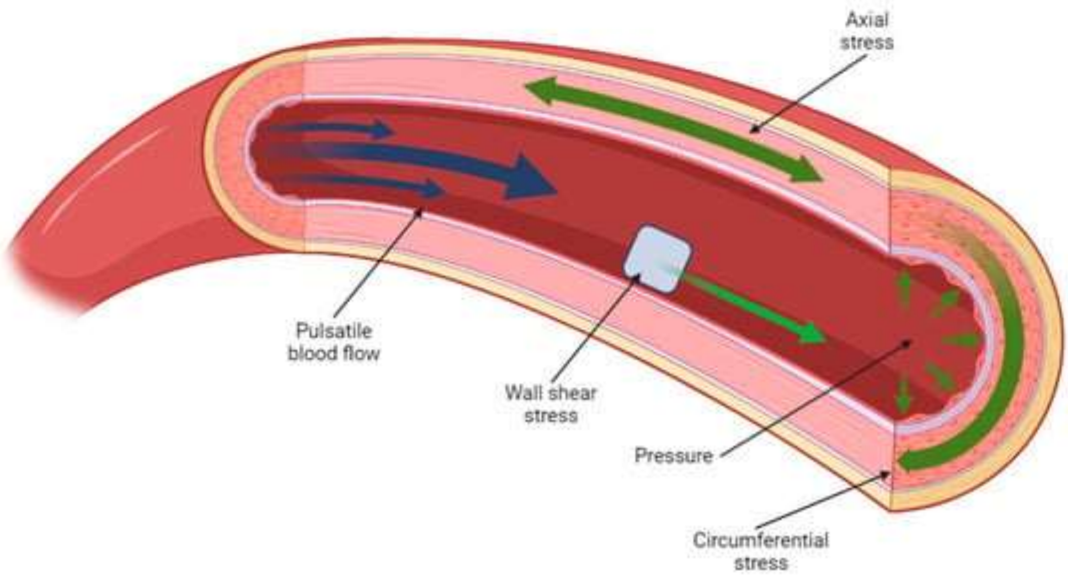

Figure 2. A cross-sectional diagram of arterial flow, illustrating the various load conditions present at any one time in the cardiovascular system.

Table 1. Mechanical Behavior of Solids vs. Biological Tissues

Property	**Solids (e.g., metals)**	**Biological Tissues**
Elasticity	Linear, follows Hooke's Law.	Nonlinear, often J-shaped stress-strain curve.
Plasticity	Exhibits clear yield point.	Rare; tissues often rupture instead.
Viscoelasticity	Minimal in solids.	Significant, e.g., tendons stretch over time.
Fracture Behavior	Sudden, brittle, or ductile failure.	Gradual failure with energy absorption.

Mechanical properties of biological tissues are highly adaptive, influenced by age, disease, and environmental factors. For example:

Bone Loss in Osteoporosis: Reduced mineral density weakens bone, increasing fracture risk.

Cartilage Degeneration in Osteoarthritis: Loss of elasticity leads to joint dysfunction and pain.

Clinical applications include:

Orthopedic Implants: Must mimic bone properties to avoid stress shielding.

Regenerative Medicine: Tissue scaffolds require appropriate mechanical properties for successful integration.

Rehabilitation Devices: Elasticity and viscoelasticity inform the design of braces and prosthetics.

CONCLUSION

Understanding the mechanical properties of solids and biological tissues is essential for medical students and practitioners. These principles bridge the gap between physics and medicine, enabling effective diagnosis and treatment of mechanical injuries and disorders. Mastery of these concepts aids in developing innovative medical solutions, from surgical implants to tissue engineering approaches.

REFERENCES

1. Fung, Y.C. (1981). Biomechanics: Mechanical Properties of Living Tissues. Springer-Verlag.

2. Chen, J., et al. (2019). "Viscoelastic Properties of Human Cartilage and Their Clinical Relevance." Journal of Biomechanics, 52(4), 123-132.

3. Hall, J.E. (2020). Guyton and Hall Textbook of Medical Physiology. Elsevier.

4. Humphrey, J.D. (2013). Cardiovascular Solid Mechanics: Cells, Tissues, and Organs. Springer.