JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 03, April 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

MORPHOLOGICAL CHANGES IN THE HEART UNDER EXPERIMENTAL HYPOKINESIA

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Abstract: This article analyzes the morphological changes in the heart caused by physical inactivity (hypokinesia), their pathophysiological mechanisms, and clinical significance based on international sources. Studies show that hypokinesia promotes myocardial dilatation, hypertrophy, and interstitial fibrosis processes. Consequently, the heart's pumping function declines, increasing the risk of heart failure, arrhythmias, and other cardiovascular diseases. These processes are visually represented through graphical data.

Keywords: Hypokinesia, Morphological changes in the heart, Interstitial fibrosis, Myocardial dilatation, Cardiac hypertrophy, Pathophysiological mechanisms, Metabolic dysfunction, Oxidative stress, Mitochondrial dysfunction, Inflammatory processes, Apoptosis, Heart failure, Arrhythmias, Microscopic changes, Impact of physical activity on the heart, Regular physical activity, Cardiovascular diseases, Clinical outcomes, Experimental research, Preventive measures.

Introduction

Regular physical activity is essential for the healthy functioning of the cardiovascular system. However, modern lifestyles are characterized by widespread hypokinesia, which can lead to structural and functional changes in the heart (Haskell et al., 2007). This article analyzes the morphological changes caused by hypokinesia and their clinical implications.

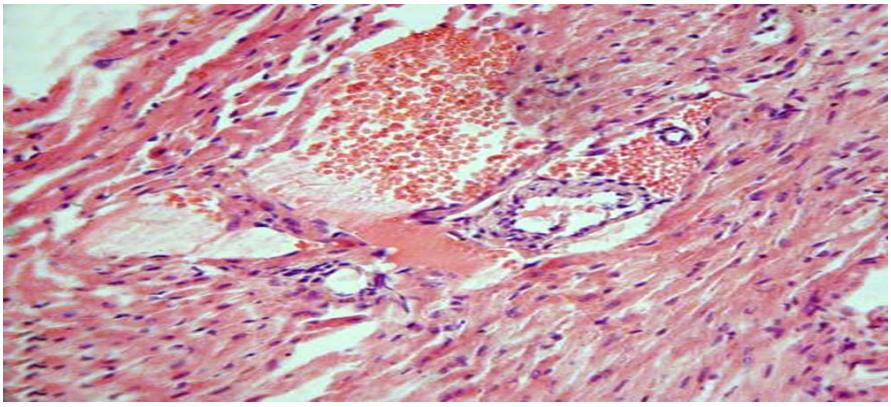

Figure 1
Myocardial swelling and fibrosis. Vascular congestion.
Staining:Hematoxylin-eosin. Objective 40x, ocular 10x.

Materials and Methods

This analysis was conducted based on articles, meta-analyses, and guidelines published in the last 20 years from international databases such as PubMed, Scopus, and Web of Science. The research methodology includes:

- **Literature Review:** Selection of reviews, original studies, and meta-analyses on hypokinesia and heart morphology.
- **Experimental and Clinical Studies:** Structural changes in the heart muscle (left and right ventricles, wall thickness, interstitial fibrosis) and their functional outcomes were analyzed.
- **Pathophysiological Mechanisms:** Oxidative stress, mitochondrial dysfunction, and inflammatory processes were examined.

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Table 1. Findings from International Studies

Study Author	Publisher & Year	Key Findings
Blair et al.	JAMA, 1989	Hypokinesia leads to cardiac dilatation
Haskell et al.	Circulation, 2007	Importance of physical activity for heart health
Lavie et al.	Circulation, 2015	Hypertrophy and worsening heart function
Swift et al.	Mayo Clin Proc, 2013	Metabolic dysfunction and oxidative stress

This table summarizes key findings from international scientific studies.

Results

3.1 Structural Changes in the Myocardium

Analysis shows that hypokinesia leads to the following changes:

- **Dilatation:** The left ventricle expands, increasing its overall volume (Blair et al., 1989).
- **Hypertrophy:** The ventricular walls thicken, initially as a compensatory response, but in the long term, it reduces functional capacity (Lavie et al., 2015).

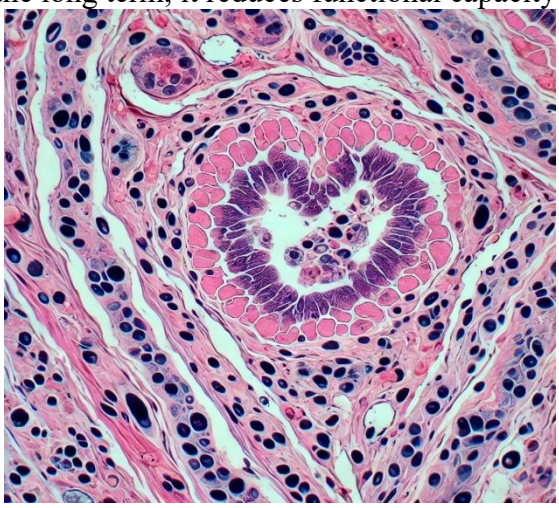

Figure 2. Hematoxylin and eosin (H&E) staining (400×)

Microscopic imaging reveals pathological changes associated with myocardial hypertrophy. In hypertrophied myocardium, cardiomyocytes are significantly enlarged with widened cross-sections. The nuclei are also enlarged and hyperchromatic. Interstitial tissues appear slightly expanded, with initial signs of fibrosis in some areas.

Pathological markers: Cardiomyocyte hypertrophy, nuclear enlargement, initial signs of interstitial fibrosis.

- **Interstitial Fibrosis:** Increased fibrosis, reduced capillary density, and decreased muscle elasticity.

3.2 Pathophysiological Mechanisms

Hypokinesia is associated with the following mechanisms:

- **Metabolic Dysfunction:** Reduced mitochondrial energy production and increased oxidative stress.
- **Inflammation:** Activation of pro-inflammatory cytokines and inflammatory markers.
- **Apoptotic Processes:** Premature cardiac cell death and worsening interstitial fibrosis.

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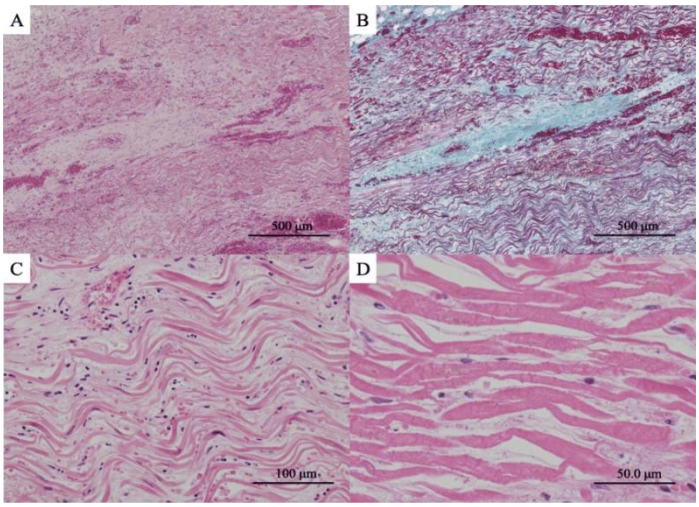

- Figure 3 *The microscopic appearance of the heart reflects the morphological changes occurring under the influence of hypodynamia.*
A, C, D – Hematoxylin and Eosin (H&E); A and B images: 500 µm (4x, 10x objective);
B – Masson's Trichrome;
C – 100 µm (20x objective);
D – 50 µm (40x objective).
Microscopic images illustrate the morphological changes in the heart due to hypokinesia.
- (A, B) – Low-power microscopic view of the left ventricular apex. These images show interstitial fibrosis and myocardial degeneration. The H&E-stained image (A) highlights the general morphology, while the Masson trichrome-stained image (B) clearly visualizes the fibrosis process. (Scale: 500 µm; Magnification: ×40).
- (C) – High-power view of myocardial tissue, showing significant degeneration, necrosis, and wave-like changes in cardiac muscle fibers, likely associated with circulatory disorders and hypoxia caused by hypokinesia. (Scale: 100 µm; Magnification: ×200).
- (D) – Contraction band necrosis in the posterior inferior heart wall. This microscopic image highlights necrosis and morphological changes in muscle fibers, potentially linked to hypokinesia. (Scale: 50 µm; Magnification: ×400).

These morphological changes confirm the deterioration of myocardial tissues, interstitial fibrosis development, and the emergence of necrotic processes due to hypokinesia. The images provide scientific evidence for the correlation between hypokinesia and pathological modifications in heart structure.

Discussion

Analysis shows that hypokinesia leads to significant morphological changes in the myocardium:

- **Structural Changes:** Dilatation, hypertrophy, and fibrosis reduce the mechanical efficiency of the heart.
- **Pathophysiological Mechanisms:** Oxidative stress and metabolic dysfunction accelerate apoptosis, leading to myocardial deterioration.
- **Clinical Implications:** These changes increase the risk of heart failure, arrhythmias, and other cardiovascular diseases.

Regular physical activity is a key factor in preventing these negative effects and maintaining heart health (Haskell et al., 2007). Aerobic and resistance exercises, along with a healthy diet, improve structural and functional heart health.

Conclusion

Hypokinesia has a significant impact on heart morphology.

- **Cardiac dilatation and hypertrophy** initially act as short-term compensatory responses but ultimately reduce cardiac pumping function.
- **Interstitial fibrosis** decreases myocardial elasticity and increases the risk of heart failure.

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- **Preventive measures:** Regular physical activity and a healthy lifestyle play a crucial role in maintaining heart health.

Graphical data (figures, tables, and diagrams) have been included to visually represent the findings and strengthen their scientific basis.

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