
PHYSICS AND HEALTH: BODY TEMPERATURE, BLOOD PRESSURE, AND HEART RATE

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ABSTRACT:

This article analyzes the main physiological processes in the human body – body temperature, blood pressure, and heart rate – based on physical laws. These indicators are crucial factors determining the overall health, internal balance, and life activity of the organism. Each process is explained according to the corresponding physical laws of thermodynamics, hydrodynamics, and electrophysiology, and modern medical technologies used to monitor and measure these indicators are discussed. A systemic approach reveals the integral connection between physics and medicine, highlighting innovative opportunities in the field of healthcare.

Keywords: Biological physics, body temperature, blood pressure, heart rhythm, thermodynamics, hydraulics, ECG, pulse oximetry, heart physiology, healthcare technologies.

INTRODUCTION

The integration of modern medicine and physics plays a crucial role in the development of advanced methods for maintaining human health, diagnosing diseases, and treating illnesses. When considering the human body as a living system, all of its vital activities – blood circulation, heat production, muscle activity, breathing, and heartbeats – obey specific physical laws. Especially, physiological indicators such as body temperature, blood pressure, and heart rate reflect the overall condition, stress levels, and health of the organism.

In understanding these processes, fields such as biological physics, biomechanics, thermodynamics, and electrophysiology are of significant importance. Body temperature is the

energy exchange in the body, blood pressure represents the hydraulic form of blood flow, and heart rhythm is the result of the electrometric oscillations of the heart muscles.

Moreover, modern technologies used in medicine for measuring these indicators (thermometers, sphygmomanometers, ECG devices, pulse oximeters) are based on physical laws. Therefore, the application of physics in healthcare is becoming an increasingly important, innovative, and effective approach.

MAIN PART

1. Body temperature: energy exchange and thermoregulation

Body temperature is the result of the heat produced in the body and its dissipation into the external environment. This process is governed by the laws of thermodynamics, particularly the conservation of energy and heat exchange laws. Maintaining normal body temperature is a key indicator of physiological stability.

The primary sources of heat production in the body are metabolic reactions, such as digestion, muscle activity, heart contractions, and mitochondrial processes in cells.

If body temperature exceeds 38°C, it indicates fever, while a temperature below 35°C is a sign of hypothermia.

Thermoregulation, including sweating, blood circulation speed, and the expansion or constriction of skin capillaries, plays a decisive role in maintaining heat balance.

Body temperature results from the internal energy produced by the body and its exchange with the environment. This process follows the first law of thermodynamics:

$$\Delta Q = \Delta U + W$$

Where:

- ΔQ – heat added to the system (body),
- ΔU – change in internal energy,
- W – work done by the system.

In the context of the human body, heat is generated through metabolic activities, and excess heat is dissipated through mechanisms like sweating and vasodilation.

Additionally, Stefan–Boltzmann Law describes how heat is radiated from the body's surface:

$$P = \sigma AT^4$$

Where:

- P – power radiated,

- σ – Stefan–Boltzmann constant ($5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$), A – surface area of the body,
- T – absolute temperature (in Kelvin).

Modern digital thermometers and infrared cameras operate based on this principle to measure even small changes in body temperature.

2. Blood pressure: the cardiovascular system and hydrodynamic laws

Blood pressure is the force exerted by the blood on the walls of blood vessels as it is pumped by the heart. It depends on cardiac output, vascular elasticity, and blood volume and is explained by hydrodynamics and Poiseuille's law:

"When a liquid flows through a closed system, the pressure decreases proportionally to the resistance of the flow."

The heart functions as a living pump. With each contraction (systole), it pushes blood through the aorta, and the blood travels along the vessels. Normal blood pressure is 120/80 mmHg, which indicates the heart's power and the condition of the circulatory system.

Blood pressure is governed by principles of fluid mechanics, particularly Poiseuille's law, which models laminar flow in blood vessels:

$$Q = \frac{\pi r^4 \Delta P}{8 \eta l}$$

Where:

- Q – volumetric blood flow rate,
- r – radius of the blood vessel,
- ΔP – pressure difference,
- η – dynamic viscosity of blood,
- l – length of the vessel.

This shows that even small changes in vessel radius significantly affect blood flow and pressure.

Additionally, pressure as force per area is defined by:

$$P = \frac{F}{A}$$

Where:

- P – pressure,
- F – force exerted by the blood,
- A – cross-sectional area of the vessel wall.

Sphygmomanometers, based on these principles, help measure systolic and diastolic pressure with high accuracy.

3. Heart rhythm: periodicity, electrophysiology, and bioelectric phenomena

Heartbeats are the rhythmic contractions of the heart muscles, controlled by the natural pacemaker in the sinoatrial node. Each heartbeat generates an electrical impulse, which causes the heart muscles to contract and pump blood.

From a physical standpoint, heart rhythm is a vibration process. Any disturbance in this rhythm (arrhythmia) signals an imbalance in the heart's electrical activity, which can be detected through electrocardiography (ECG). ECG records the strength and periodicity of electrical impulses in the heart in graphical form.

Furthermore, pulse oximetry helps to determine heart rate and blood oxygen saturation. Modern technologies, especially Holter monitoring, enable continuous heart activity monitoring for 24-72 hours.

The human heart generates electrical impulses at regular intervals, leading to muscular contractions. From a physical perspective, the heartbeat can be modeled as a periodic oscillation:

$$f = \frac{1}{T}$$

Where:

- f – heart rate frequency (Hz),
- T – period of one heartbeat (s).

Moreover, the electrical signals propagating in the heart follow Ohm's law, which is fundamental in bioelectrical systems:

$$V = IR$$

Where:

- V – voltage (electrical potential),
- I – current,
- R – resistance of cardiac tissue.

These signals are detected and analyzed using electrocardiography (ECG) to assess heart function. Pulse oximeters, which also depend on optical physics, determine both heart rate and oxygen saturation using light absorption and reflection.

CONCLUSION

The vital signs of the human body – body temperature, blood pressure, and heart rate – are complex systems governed by physical laws. They are interconnected and serve as key indicators of the overall physiological state of the organism. In-depth analysis of these processes involves various physical fields, such as thermodynamics, hydrodynamics, electrophysiology, mechanics, and vibration theory.

Modern diagnostic devices, including ECGs, sphygmomanometers, pulse oximeters, and thermometers, are created based on physical laws and are essential for detecting any physiological changes in the body. Notably, medical devices based on artificial intelligence offer enhanced opportunities for early detection, analysis, and treatment of conditions like arrhythmia, hypothermia, and hypertension.

These indicators play a significant role not only in diagnosing diseases but also in promoting a healthy lifestyle, monitoring physical activity, managing stress, and even assessing the physical condition of athletes in sports medicine. The integration of physics and healthcare opens new doors for improving human health.

In conclusion, the principles and laws of physics are not only essential for understanding natural phenomena but also for analyzing the human body, diagnosing and preventing diseases, and promoting a healthy lifestyle. For specialists in healthcare, applying physics knowledge in practice is an inseparable part of modern medical approaches.

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