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Mini Review

Human Body Temperature: what does it Really Reflect? Mini Review

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Abstract:

Everyone knows what human body temperature is and what it is normally (36.1–37.2 °C). Physicians know that this temperature is regulated by thermoregulation – the ability of warm-blooded organisms to maintain a constant body temperature, lowering or raising it when necessary.

Introduction

Everyone knows what human body temperature is and what it is normally (36.1–37.2 °C). Physicians know that this temperature is regulated by thermoregulation – the ability of warm-blooded organisms to maintain a constant body temperature, lowering or raising it when necessary. Temperature can change due to the influence of the external environment, increase with physical activity, consumption of certain foods, stress, feelings of fear, and even intense mental work.

It is known that the first large-scale study of average body temperature was conducted in 1851 by the German physician Carl Wunderlich. At that time, he took about 1 million temperature measurements in the armpit of 25,000 individuals and determined that the average normal body temperature for a healthy person was 36.6°C. Today, nearly 170 years later, the norm is considered not a specific number, but a range from 35.5°C to 37.6°C. It is implied that the figures on the thermometer also reflect the temperature of the dense parts (cells, tissues, and organs) of the body.

However, we believe that the concept of body temperature not only in humans, but also in homeothermic organisms in general, needs to be clarified, since this term does not really correspond to its name. Namely, the temperature measured by existing thermometers can only reflect the temperature of circulating blood, not of cells. The general opinion of experts is as follows: "the analysis of thermal homeostasis in the human body and homeothermic animals. It is shown that the temperature in the internal tissues of the body (the core of the body) is high and relatively consistent because it is maintained via heat transfer through the blood flow" [1]. This statement needs clarification.

The thing is, the heat cannot transfer from the blood to the cells for the following reasons: 1) in homeothermic organisms, the temperature (*T*) in the cells is higher than in the circulating blood [2]. Therefore, the transfer of heat from circulation system to cells is impossible, because the second law of thermodynamics; 2) cells, with rare exceptions (endothelial cells lining the inner surface of blood vessels) are not in direct contact with blood; 3) the readings of thermometers reflect *T* only circulating blood, where the thermometry is performed, and not *T* inside the cells.

We cannot know *T* inside cells because of diversity of organelles in it. There is no method that allows measuring cell *T* as a whole, since the existing ones can only work with organelles (nucleus, mitochondria, ribosomes, or ER). In the same way, we cannot speak about human body temperature because of the heterogeneity of its constituent cells, tissues and organs. There are 230 types of cells functioning in the human body, which differ in their metabolic rate, cell cycle and the amount of heat they produce. Therefore, the term human body temperature lacks common sense, since thermometers reflect the *T* of circulating blood in the capillaries of the part of the body where the thermometry is performed, but not the cells. Since it is impossible to measure the temperature of cells and bodies, the thermophysical characteristics of a human can still be judged by the thermal conductivity of their body [3].

It is accepted that the main task of thermoregulation is to maintain a relatively constant core body temperature, meaning cells, tissues and organs, to ensure their normal function. From the point of view of physiologists, this is accomplished by the transfer of thermal energy from circulating blood to cells [1], a possibility of which we question.

We believe that the task of thermoregulation is not the preservation of optimal *T* in the body, but the preservation of structural and functional integrity of cell membranes. As indicated above, cellular *T* cannot be affected by heat from the circulation system. In addition, the generally accepted opinion that maintaining a temperature range of 35-41 ºC is acceptable, for example, for the normal functioning of enzymes may be controversial. This is evidenced by the following facts: 1) it is now established that the temperature of mitochondria is about 50 ºC [1]; 2) enzymes can work even at *T* 100 ºC and higher (in thermophilic bacteria); 3) the temperature inside cells is not regulated by generally recognized physiological mechanisms, i.e., by transfer of heat from circulating blood [1], but is determined by the laws of physics [3,4,6].

As is known, cell membranes are known to be very sensitive to *T* fluctuations and their structural and functional integrity depends on it (*T*). Since the *T* of the cell in homeothermic organisms is always higher than the *T* of circulating blood, it is to be expected that cell membranes are under the constant and directed action of thermal energy from the inner side of the cells [6]. Therefore, the only protection of cell membranes from dangerous overheating is the circulating blood, whose temperature is lower than the cell temperature and is regulated by the organ-based (the hypothalamus, the sweat glands, the skin, and the circulatory system) thermoregulatory system. Since intracellular *T* is unregulated, the task of cell thermoregulation is only to remove excess metabolic heat outside the cell in a timely manner [5].

To the possible question of why this idea has not been discussed until now, the answer may be simple: Until recently, the existence of thermoregulation at the level of individual cells was not known [4-6]. Cell thermoregulation (CT) refers to the process of dissipating excess metabolic heat outside the interphase cell. Since the temperature of the nucleus is higher than that of the cytoplasm, the cell uses a dense layer of condensed chromatin (CC) around the nucleus as a thermal conductor to release excess heat into the cytoplasm. The heat energy is then transferred to the intercellular fluid and further into the circulation system. In this sense, CT is a unidirectional flow of heat energy directed from the nucleus to the cytoplasm through the CC, which consists of chromosomal heterochromatin regions (HRs). The layer of CC around the nucleus is the densest and, accordingly, the most heat conductive structure in the interphase cell. CT refers to the cell's ability to effectively equalize the temperature difference between different areas, primarily between the nucleus and cytoplasm. This ability of cells is determined by the quantitative and qualitative composition of chromosomal HRs in CC.

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