Wearable multimodal analyzers in the study of the microcirculatory bed and oxidative metabolism of biotissue

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Currently, there is a surge of interest in wearable diagnostic devices with the possibility of daily monitoring of the functional state of the human body, for example, microcirculatory-tissue systems. The first such development is the «LAZMA PF» analyzer ((LAZMA Ltd, Russia; in EU/UK this device is produced by Aston Medical Technology Ltd., UK as «FED-1b»), which makes it possible to study the microvasculature and oxidative metabolism of biological tissues [1]. The design features of these devices make it possible to record index of microcirculation (perfusion) and NADH fluorescence intensity with less sensitivity to motion artifacts and with a larger diagnostic volume compared to stationary devices [2, 3]. The purpose of this work is to demonstrate the successful experience of using these devices in clinical practice.

Analyzers with wireless data transmission implement the methods of laser Doppler flowmetry (LDF) and fluorescence spectroscopy (FS), which allows for complex diagnostics of microcirculatory-tissue systems of the human body. The analyzers were used in the form of their distributed system (of 2 or 4 devices) in various parts of the upper and lower extremities of a human body [1, 4] without the use of functional tests in various fields of medicine – endocrinology (type 1 and 2 diabetes), cardiology (arterial hypertension), rehabilitation (post-covid rehabilitation), physiotherapy (hatha yoga breathing exercises), sports and space [1] medicine. The time of registration of the microcirculatory-tissue system parameters (I_m – index of microcirculation, A_{NADH} – normalized amplitude of the biotissue coenzyme NADH) averaged for 10 min.

Studies in patients with diabetes mellitus have shown a decrease in I_m and nutritive blood flow in the lower extremities and an increase in the upper extremities. The results indicate the body's attempts to compensate for microcirculation disorders in the upper extremities. Studies of women with pregestational diabetes revealed a decrease in the oscillatory activity of microcirculatory-tissue systems in patients and an increase in A_{NADH}. Patients with post-COVID syndrome had reduced values of I_m and nutritive blood flow, as well as increased oscillatory activity of blood flow. In the study of the effect of hypo- and hyperventilation yoga breathing exercises on the parameters of peripheral blood flow, a correlation was found between the parameters of blood microcirculation and gas analysis during free breathing and hypoventilation. Also, for the first time, a technique has been developed for measuring the microcirculatory bed and oxidative metabolism of biotissues of cosmonauts limbs during the period of acute adaptation to microgravity conditions and readaptation after the completion of a space flight. The results obtained in this study confirmed the redistribution of circulating blood volume to the upper part of the body during the first few days of space flight and the normalization of blood flow on the 6th day of flight.

Thus, data on the state of the microcirculatory bed and oxidative metabolism of biotissue, recorded using wearable multimodal analyzers when solving various diagnostic problems in clinical conditions, make it possible to more comprehensively and reliably assess the relationship and dynamics of oxygen utilization by tissues.

The study was supported by the Russian Science Foundation grant № 23-25-00522.

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