WEARABLE LASER DOPPLER FLOWMETRY DEVICES FOR ASSESSING THE EFFECT OF HYPER- AND HYPOVENTILATION RESPIRATORY YOGA EXERCISES ON PERIPHERAL BLOOD FLOW PARAMETERS

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Yoga breathing exercises are an arbitrary change in the minute volume of breathing (MVB) upward (hyperventilation) and downward (hypoventilation) with the maximum respiratory volume (MRV) and corresponding changes in gas exchange. The aim of this work was to assess the effect of hypo- and hyperventilation yoga breathing exercises on the parameters of peripheral blood flow and their relationship with parameters of spirometry and gas analysis.

The study included 22 conditionally healthy volunteers (16 men and 6 women). Blood perfusion was registered by distributed system of portable analyzers "LAZMA-PF" (SPE "LAZMA" Ltd., Moscow). The devices have identical channels for recording skin microcirculation by laser Doppler flowmetry, which also allows evaluating the work of peripheral blood flow regulation mechanisms.

The devices were fixed symmetrically to the right and left on the forehead, third fingers and first toes. Study was carried out at 3 stages: stage 1 and 3 implied normal uncontrolled breathing; at stage 2 volunteers achieved hypoventilation (respiratory rate 1-1.5 times per minute (regime 30:30 and 20:20) and hyperventilation (respiratory rate 2-3 times per minute (regime 15:15 and 10:10)), that was confirmed by spirometry and gas analysis (spirometer MAS-2C («Belintelmed», Belarus)).

The MVB of volunteers increases significantly in regime 10:10, such a breathing mode is called hyperventilation. For all study participants, breathing at 20:20 and 30:30 led to a significant decrease in the MVB, that is, hypoventilation.

Hyperventilation mode is characterized by a significant decrease in partial pressure of CO2 in exhaled air at the end of exhalation (PetCO2) and an increase in the content of O2 in the exhaled air (FeO2). For the hypoventilation regime, the opposite results were obtained – there was a significant increase in PetCO2 and a significant decrease in FeO2. The hemoglobin saturation (SpO2) significantly decreases in regime 30:30.

In the forehead skin there is a slight increase in the average value of the amplitude of myogenic oscillations after hypoventilation compared with the values of this parameter after hyperventilation. This may indicate an increase in the number of functioning capillaries in the forehead skin of some volunteers. Similar changes are observed in the fingers of the hands in the normalized amplitudes of oscillations of neurogenic and myogenic genesis, which is a consequence of a decrease in the tone of the microvessels of the arterial department. The opposite situation is observed in the toes: the oscillation amplitudes of the neurogenic range are slightly higher in volunteers after performing full breathing in hyperventilation than in hypoventilation.

Fluctuations near the frequency of 1 Hz are caused by the propagation of a pulse wave through the vessels, and the amplitudes of these fluctuations characterize the flow of arterial blood into the microvascular bed. The found correlation of the amplitude of cardiac oscillations with MVB and SpO2 min can characterize the consistency of the respiratory system and the delivery of oxygenated blood to cells. This is also confirmed by the statistically significant correlation of the VB and nutritive blood flow, reflecting the effective perfusion. Statistically significant correlations were found between SpO2min and the amplitudes of neurogenic oscillations that cause vasoconstriction and vasodilation of microvessels through their innervation, that is, the neurogenic tone of arterioles depends in some way on blood oxygenation.

Hypoventilation mode leads to the appearance of a significant ($p<0.05$) inverse correlation of FeO2 during full respiration and the amplitudes of respiratory genesis after exercise in all areas of the study: the correlation coefficient r is -0.53 for the supraorbital arteries, -0.5 for the fingers and -0.43 for the toes. It is possible that an increase in the amplitudes of respiratory oscillations is a manifestation of a compensatory reaction of the body: with a significant decrease in oxygen in the blood due to low-frequency breathing, a subsequent increase in the excursion of the chest occurs.

The results obtained can be useful in studying the peculiarities of the mechanisms of oxygen delivery to biological tissues, and will also allow us to develop an instrumental method for monitoring the performance of full breathing exercises and their effectiveness in rehabilitation.

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