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## SECTION 23.

### MEDICAL SCIENCES AND PUBLIC HEALTH

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## DIAGNOSTIC MARKERS OF THE CARDIORESPIRATORY COUPLING EFFICIENCY

**Introduction.** Identification and establishment of diagnostic markers of cardiorespiratory integration is the one of the main clinical and physiological interests, especially for understanding the mechanisms of adaptation of the organism to environmental changes (hypoxia, hypercapnia, etc.), in various types of training of athletes, and in many diseases.

In same time, cardiorespiratory endurance (CRE) as an index of human health characterizes the ability of body to withstand prolonged physical activity. Cardiorespiratory endurance is closely related to the functional state of the cardiovascular and respiratory systems, which reflects the aerobic capacity of the body. The scientific data of the last three decades has shown that a low level of CRE is associated with an increased risk of developing cardiovascular diseases and increased mortality rate. In contrast, a high CRE level reflects a low risk of cardiovascular diseases, such as stroke, infraction and decreases the mortality rate. Thus, CRE should be considered as an important marker of cardiovascular and respiratory systems activity, which, unfortunately, is currently not studied enough in clinical practice [1].

Some researchers studied the reactions of the cardiorespiratory system under prolonged exposure to hypoxia, which is a scientific interest for understanding the mechanisms of adaptation of the body in conditions of oxygen deficiency and made the conclusion that the indicators sensitive to moderate normobaric hypoxia in rest state are the following: blood saturation (the

most sensitive indicator), efficiency of pulmonary ventilation, respiratory rate, respiratory coefficient, which were assessed in a state of operative rest for 1 hour using the MetaLyzer 3B ergospirometric system (Cortex, Germany). A significant change in the indicators of the cardiorespiratory system at an altitude of 4500 m occurs within 5 minutes after hypoxic exposure; therefore, for carrying out a normobaric hypoxic test, they recommended to use this particular height with duration of hypoxic exposure for 30 minutes [2].

Other researchers studied deviations in blood pressure and levels of CO<sub>2</sub> and O<sub>2</sub> in blood, which are monitored by peripheral chemoreceptors of carotid and aortic bodies and by central chemoreceptors of medulla oblongata, influencing on the respiratory and cardiovascular systems. The research involved swimmers and has shown the less sensitivity of heart to changes in the partial pressure of oxygen in the alveolar gas. At the same time, among swimmers of high sports qualification, the mechanisms of cardiorespiratory coupling were improved, which ensured an increase in the "accuracy" of physiological adjustment in changes of ventilation and cardiac responses to hypoxic and hypercapnic effects. For high-class athletes, the differences in the response of the cardiorespiratory system during breathing with a hypoxic gas mixture were not observed in comparison with athletes of lower qualifications, but, like swimmers, there was an improvement in the mechanisms of intersystem integration, that was reflected in improved gas exchange regulation in response to internal hypoxic hypercapnia, and manifested in increased pulmonary ventilation and in increased carbon dioxide pressure in the arterial blood. Improvement of intersystem integration ensured the optimal chemoreceptor responses to hypoxic and hypercapnic disturbances of the body's gas homeostasis and reflected the adaptive response of the cardiorespiratory system in high-class athletes under intense aerobic loads [3].

The researchers of the National University of Physical Education and Sports (Kyiv, Ukraine) together with the Academy of Physical Education and Sports (Gdansk, Poland) investigated the peculiarities of changes in the reactivity of the cardiorespiratory system after physical activity of various kinds and types associated with short-term and long-term adaptation of athletes to intense physical loading. Complex examination methods of the cardiorespiratory system reaction to hypoxic and hypercapnic shifts of respiratory homeostasis, also to test loads of different nature have shown that the changes in the reaction to hypercapnia during exercise related to acidemic shifts. An increase in the sensitivity of the ventilation response to CO<sub>2</sub>-H<sup>+</sup> stimuli on the background of acidemia was observed with a small degree of acidic shifts, as well as at the beginning of the load or with a relatively short total duration of exercise. Greater sensitivity to CO<sub>2</sub>-H<sup>+</sup> stimuli on the background of fatigue contributed to an increase in the level of respiratory compensation of metabolic acidosis and physical performance. With a significant severity of acidemia and at the end of exercise, the sensitivity of the ventilation response to CO<sub>2</sub>-H<sup>+</sup> stimulus was significantly reduced. During long-term adaptation of the body to intense muscular activity, the proportion of "neurogenic" stimuli in the respiratory response increased, which provided its greater resistance to the increasing degree of acidosis during physical activity [4].

As well other researchers (Lviv University of Physical Culture, Ukraine), studied the dynamics of the functional state of the cardiorespiratory system of patients with respiratory diseases. It was revealed that patients with COPD had a lower level of functional condition of the cardiorespiratory system than patients with pneumonia or with bronchial asthma. They showed the lowest levels of blood saturation, vital lungs capacity, forced expiratory volume, peak exhalation rate and higher than normal respiratory rate. Exacerbation of COPD has a significant impact on the health of patients and significantly reduces the functional state of the respiratory and cardiovascular systems [5].

Recently researchers have also focused on the examination of autonomic and cardiorespiratory function in adolescents with scoliosis. Comparative analysis of the results of adolescents with scoliosis and healthy people has shown that the Kerdo index was several times higher in the group with scoliosis, and this pattern is typical for both females and males. Obtained

results indicate that extremely powerful sympathetic activation is found in children with scoliosis and persists in later life. The highest rate of Robinson index was found in healthy adolescent girls. The highest values of stroke volume at rest was found in adolescent girls with scoliosis but no difference was detected in values of cardiac output at rest among almost healthy and children with scoliosis [6].

Physical training has a beneficial effect on the cardiorespiratory system increasing the level of the functional state and nonspecific resistance of the body. Currently there are many scientific data showing the results of the researches about the influence of physical load during educational process of students. Some scientists represented results of research showing that the state of the cardiorespiratory system of students practically did not change or worsened during exercise in conditions of high anthropogenic load. The positive dynamics of the state of the cardiorespiratory system was observed among students who trained under conditions of low anthropogenic load. It was determined that the functional state of the cardiorespiratory system of the students' organism is more influenced by the state of the environment than physical load [7].

According to the results of many studies, cardiorespiratory endurance is an important prognostic marker of cardiovascular diseases. The available knowledge regarding the cardiorespiratory endurance and its relationship to health indicators, enabling health professionals to optimize the prevention and treatment of cardiovascular diseases. Currently, most experts consider the indicator of maximum oxygen consumption, which reflects aerobic capacity, as the most optimal and objective measure for assessing cardiorespiratory endurance. The maximum oxygen consumption allows assessing the highest rate of oxygen utilization by human organs and tissues at its maximum or exhausting physical activity. Cardiorespiratory endurance can be investigated by means of indicators of the performed load on the treadmill or bicycle ergometer. In a number of studies, the cardiorespiratory endurance has been shown as a more powerful predictor of mortality risk compared to traditional risk factors such as hypertension, smoking, obesity, hyperlipidemia, and type 2 diabetes. Numerous studies also depict the cardiorespiratory endurance in the context of improving survival through the metabolic equivalent value which is a unit of assessment of the metabolic oxygen consumption of muscle activity [8].

Researchers from Italy and Belgium proposed a simulator that allows to reproduce the main physiological phenomena occurring during exercise in the cardiovascular and respiratory systems such as an increased cardiac output and its distribution between active and inactive regions, increased heart rate and vascular tone by resetting the baroreflex, changes of peripheral vascular resistance as a result of a combination of metabolic and baroreceptor control, central and peripheral arteriovenous difference, increased pulmonary ventilation due to a change in the partial pressure of O<sub>2</sub> and CO<sub>2</sub> during training session. Moreover, the simulator can create the cardiac insufficiency, caused by failure of the control mechanisms. The simulator is useful in prediction of cardiorespiratory dysfunction in different stages of pathologies [9]. Continuous monitoring of vital indicators of cardiorespiratory integration is becoming increasingly important. Scientists from Italy present a wireless sensor belt, suitable for simultaneous recording the respiratory rate and cardiac signals (ECG in 2 leads) using a single channel of reception. The adopted method is based on 50 kHz current introduced into the chest of the subject through a pair of textile electrodes and on the detection of transverse voltage envelopes obtained from a pair of different built-in electrodes that's is the best way for daily use [10, 11, 12].

**Conclusion.** The various studies indicate a significant interest in the topic of cardiorespiratory integration; however, the topic requires further deepening and study of the parameters of systems adaptation and the application of the obtained data to clinical practice.

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