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AGE FEATURES OF O_2 MASS TRANSFER REGIMES IN ADOLESCENTS' BODY AT REST

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The results of complex studies of the quantitative relationship between the stage-by-stage mass transfer of O_2 and the efficiency of cardiorespiratory system functioning in relation to its consumption in adolescents' body under conditions of relative rest are presented.

The results obtained show that in adolescents, the modes of mass transfer of O_2 in the body and the nature of the respiratory and circulatory systems functioning in relation to its consumption have a number of age-related differences compared with adult men. So, in adolescents, the external respiration system at rest functions less economically than in adults. Each liter of O_2 consumed by adolescents is extracted from almost 3 liters more than in adults the amount of air ventilated per minute through the lungs. The volumetric indicators of blood circulation are also higher in adolescents, which may indicate the influence of neuro-humoral rearrangements in the body during the pubertal period. The coefficient of oxygen utilization by tissues from arterial blood in adolescents turned out to be significantly higher, which may characterize a higher tension of tissue metabolic processes.

Key words: O_2 mass transfer regime; cardiorespiratory system functioning; adolescents at rest

Introduction. Advances in physiology [1, 5], biochemistry [6], laws of chemistry, e.g. Avogadro's law, and advances in other natural sciences have made it possible to approach the assessment of individual stages of mass transfer of respiratory gases in humans of different ages, sex, state of physical fitness, different functional states. The conditions that ensure the correspondence of the stage-by-stage mass transfer of O_2 to the oxygen demand of the body have not yet been fully elucidated.

The vast literature provides a huge amount of information about the functions of the adolescent's organism both at rest and during physical activity. The neurohumoral restructuring of vital processes occurring in the body of adolescents has a significant impact on regulatory changes in both somatic and vegetative processes [7, 8]. At the same time, the characteristics of general gas exchange, respiratory function of blood, various indicators of the cardiovascular system, metabolic metabolism in adolescents have been studied quite well [9].

However, very few scientific works are devoted to the analysis of efficiency and economy of the external respiration and blood circulation functions, which ensure the gradual movement of O_2 in adolescents' body. There are practically no data on the quantitative characteristics of the intake of O_2 into the lungs, alveoli, blood, transport of its arterial and mixed venous blood, as well as the ability of tissues to utilize the delivered O_2.

In a complex system of oxygen supply to tissues, oxygen transport function of blood is of particular importance [10]. Despite the fact that it is one of the main factors on which the provision of O_2 delivery to oxygen demand depends, it has not been studied enough in adolescents.

An integrated approach makes it possible to quantitatively and qualitatively assess the process [10] of the stage-by-stage mass transfer of O_2 in the body and the conditions that ensure its promotion and utilization which is a great importance.

The purpose. To assess quantitatively and qualitatively the conditions of mass transfer of O_2 in the body of adolescents in a state of relative rest.

Organization and research methods. 14 adolescents aged 14-15 years old (weight 57.5 kg) and 13 adult men aged 22-26 years old (weight 71.7 kg) have been examined. The persons under examination were not actively involved in sports. The study of the parameters obtained were recorded at rest in a sitting position after 10 minutes of rest.

A complex systemic approach was used to assess the nature of the relationship between the economy of the respiratory and circulatory systems relative to the gradual promotion of O_2 in the body and its consumption [11].

All the subjects (or their parents) gave informed consent to participate in the examination and process their personal data (Order of the Ministry of Health of Ukraine dated January 21, 2016 N 29). The examinatione were done in compliance with moral and ethical principles in accordance with the main provisions of the World Medical Association Declaration of Helsinki (1994, 2000, 2008) and the positive decision of the Commission on Bioethics of National University of Physical Education and Sports of Ukraine (Kiev).

Statistical processing of the experimental material obtained was carried out with the use of standard application programs "Windows-XP" and "Microsoft Excel".

Results and its discussion. The first stage of O_2 entry into the body is the external respiration system. The researches carried out and the analysis of the results obtained showed that adolescents in a state of relative rest have higher values of pulmonary and alveolar ventilation, respiratory volume and frequency of respiratory cycles (Table 1) than adult men have, although the ratio of alveolar ventilation to the pulmonary turned out to be significantly lower. This indicated that although the regulatory effect on the external respiration system is activated in adolecents to a greater extent than in adults, the efficiency of gas exchange processes has not yet reached the levels of the latter.

Table 1. External respiration indicators in adolescents and adults at rest

Age groups	Ve - pulmonary ventilation, ml / min	Va - alveoli. ventilation, ml / min	Va / Ve, %	Vt –res. volume, ml	F - respiratory rate. in min
Adolescents	1097.5 ±743.0*	7958.5 ± 467*	73.0* ± 1.9	649.0 ± 90	16.8 ± 1.27
Adults	8000.3 ±607.4	6246.9 ± 560	78.0 ± 1.2	555.5 ± 120	14.4 ± 1.83

Note: * - the difference is reliable

A similar picture is observed when analyzing the functioning of the hemodynamic system (Table 2). All volumetric indicators of blood circulation, although unreliable, turned out to be larger in adolescents, which could indicate the influence of neuro-humoral rearrangements in the body during pubertal period of a body's development [2, 3, 4].

Table 2. Hemodynamic parameters in adolescents and adults at rest

Age groups	Minute blood volume, ml / min	Systolic blood volume, ml	Heart rate, beats/min
Adolescents	6329.0 ± 349.0	73.4 ± 4.03 *	86.8 ±3.71
Adults	5327.0 ± 161.8	63.7 ± 4.48 *	83.7 ± 5.6

Note: * - the difference is reliable

It was also revealed that the intensity of O_2 consumption in adolescents at rest is higher than in adults (Table 3). Similarly, the entire process of the stage-by-stage mass transfer of O_2 in the adolescents' body turned out to be higher. The volumetric O_2 mass transfer rate by arterial blood exceeded its consumption in both adolescents and adults by approximately the same (3.82 and 3.84 times, respectively), while the values of its consumption were different. It was transported by mixed venous blood in adolescents and adults in 2.84 times more than consumed (that is, the O_2 residue was almost 3 times higher than its use).

Table 3. O_2 mass transfer parameters in adolescents and adults at rest

Age groups	O2 transfer in the body, ml / min x kg				
	Consumed O_2	O_2 entry into lungs	Transfer of O_2 into alveoli	O_2 transport by arterial blood	O_2 transport by venous blood
Adolescents	5.65± 0.25*	32.61± 1.99*	25.4 ± 1.35*	25.4 ± 1.1*	14.8 ± 1.01*
Adults	3.64 ± 0.34	18.9 ± 1.94	14.9 ± 1.71	13.8 ± 0.85	10.2 ± 0.54

Note: * - the difference is reliable

Despite the fact that adolescents had higher values of O_2 consumption and its entry into the lungs, the coefficient of O_2 utilization in the lungs was lower in them than in adults (Table 4). At the same time, the ventilation equivalent in adolescents was significantly higher. This indicated that each liter of consumed O_2 was extracted by almost 3 liters per minute more than in adults the amount of air ventilated through the lungs. Thus, the characteristics presented indicate that the external respiration system in adolescents at rest functions less economically than in adults.

Table 4. Respiratory system economy in terms of O_2 consumption

Age groups	Indicators		
	Coefficient of O_2 use in the lungs, %	O_2 - respiratory effect cycle, ml O_2 / resp.cycle	Ventilation equivalent, CU
Adolescents	17.4 ± 0.52	22.9 ± 3.45	30.4 ± 0.82*
Adults	19.8 ± 0.78	23.5 ± 4.42	27.6 ± 1.09

Note: * - the difference is reliable

In contrast to the respiratory system, the functioning of the circulatory system in adolescents relatively to the consumption of O_2 did not differ so significantly (Table 5). There

were no significant differences in the values of O_2 effect of the cardiac cycle (oxygen pulse), the hemodynamic equivalent turned out to be practically the same - each liter of consumed O_2 consumed was extracted by tissues from approximately 20 liters of blood flowing through them per minute.

Table 5. Circulatory system economy in terms of O^2 consumption

Age groups	Indicators		
	Coefficient of O_2 utilization by tissues, %	O_2 - effect of cardiac cycle, ml O_2 / heart rate	Hemodynamic equivalent, CU
Adolescents	26.3 ± 1.28*	3.77 ± 0.37	19.8 ± 0.97
Adults	25.0 ± 0.79	3.16 ± 0.32	20.7 ± 0.74

Note: * - the difference is reliable

With such a similarity of indicators, the coefficient of oxygen utilization by tissues from arterial blood in adolescents was significantly higher, which could indicate a higher tension of tissue metabolic processes [6].

O_2 partial pressure (PO_2) in the alveolar air, arterial and mixed venous blood in adolescents was within the normal range for a given age (in the alveoli - 111.2 ± 0.08 mm Hg, which is slightly higher than in adults, in arterial blood it was 90.1 ± 1.38 and in mixed venous blood - 37.1 ± 0.64 mm Hg).

Conclusions. Thus, the results of the study obtained under conditions of relative rest showed that the nature of the mass transfer of O_2 and the functioning of the cardiorespiratory system in relation to its consumption in adolescents had a number of age differences in comparison with adult men.

Critical periods switch the body to a new level of ontogenesis, create a morphological and functional basis for the existence of an organism in new conditions of life (for example, the activation of certain genes ensures the emergence of a transitional period in adolescents), and sensitive periods adapt the functioning of the body to these conditions (restructuring processes in various organs and systems are optimized, the coordination of the activity of various functional systems is being established, adaptation to physical and mental stress at this new level of the organism's existence is ensured). This is the reason of the high sensitivity of the organism to external influences in sensitive periods of development [9].

As a continuation of our study, it is supposed to analyze the age-related characteristics of changes in O_2 mass transfer in the body of adolescents with muscle activity of varying intensity.

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