Peculiarities of respiratory functions in qualified swimmers exposed to multidirectional physical loads

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ABSTRACT

The peculiarities of the swimmers' respiratory system response to a special physical load were studied. The swimmers of high sports qualification aged 16–18 years old, who specialize in swimming at distances of various lengths, underwent the examination. At the first stage, we used exercises aimed at enhancing the anaerobic work power in swimming. At the second stage, the parameters of the swimmers' respiratory system response to the load in aerobic and anaerobic zone were studied. At the third stage of the study, the changes of the swimmers' respiratory functions under physical loads at the level of MOC (maximum oxygen consumption) were researched. The investigation of respiratory system functions of stayer swimmers was conducted with the use of a Spirolab-3 spirometer (spirograph). We found that the recovery of qualified swimmers can be activated when aerobic and anaerobic mechanisms of energy metabolism are combined. The results of the study confirm that the swimmers' respiratory functions influence the processes of recovery of their working capacity after being exposed to multidirectional physical loads. The sprinters' anaerobic mechanisms of muscle function are better developed. The stayers' aerobic mechanisms of energy metabolism function better. In order to activate the recovery of qualified swimmers, it is advisable to combine aerobic and anaerobic mechanisms of energy metabolism.
Keywords: Respiratory functions; Sprinter swimmers; Stayer swimmers; Direction of load.

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INTRODUCTION

The effect of training load on activation of the swimmers' physiological functions can be seen in mobilization of adaptation potential of the sportsmen' organism (Aspenes, & Karlsen, 2012; Bakayev, & Bolotin, 2020; Bolotin, & Ponimasov, 2020). The increased level of fitness is accompanied by enhanced potential and efficiency of its transformation into main sports results. The activation of metabolic processes in the swimmers' organism throughout the yearly cycle of sports training forms a basis for improvement of adaptation mechanisms (Amaro, et al., 2017; Bolotin, & Bakayev, 2020; Burton, et al., 2005; Dalamitros, Manou, & Pelarigo, 2014; Espinosa-Mendez, et al., 2020).

Better sports results are achieved not only by increased potential for physical load tolerance but also due to the ability for fast and full recovery of body functions lowered by sports training (Costa, et al., 2012; Ferreira, et al., 2016). Along with its extent and intensity, the specificity of physical load is an important factor, which contributes to enhancing the swimmers' special endurance. Development of such ability is possible through the use of training exercises and their reasonable combination in the swimmers' training process. Optimal planning and implementation in the training process of systemic application of special training means activates recovery processes of the working capacity after training work is completed (Leko, Siljeg, & Greguranic, 2019).

The control function of the training process ensures achievement of the target parameter values during sports training and thus allows to reach the required sports result in swimming. The peculiarities of the swimmers' respiratory system individual response to the training load serve as an informative indicator of adaptation shifts in the physiological loop of training process regulation (Bolotin, & Bakayev, 2017; Miller, Hankinson, & Brusasco, 2005; Morales, & Arellano, 2019; Sousa, et al. 2013).

MATERIAL AND METHODS

In order to improve the methods for regulation of training of swimmers having various sports specialization we performed a study concerning peculiarities of the sportsmen respiratory system response to a special swimming physical load. The participants of the study were the swimmers aged 16–18 years old having sports qualification of master of sports.

The subjects were divided in three test groups. The first group included athletes specializing in freestyle swimming for the distance of 100 m (8 subjects). The second group included swimmers who compete in freestyle swimming for the distance of 400 m (10 subjects). The third group consisted of stayer swimmers specializing in freestyle swimming for the distance of 1,500 m (7 subjects). The main part of training sessions was differentiated as to be aimed at increasing anaerobic power, aerobic and anaerobic productivity, aerobic work-supporting mechanisms. Testing was carried out at the beginning and at the end of a training session.

At the first stage, we used exercises aimed at enhancing the anaerobic work power in swimming. The task consisted of 4 series of 8 sections, 25 m each, of freestyle swimming. The swimmers were allowed to have rest after each section till their pulse recovered to 120 beats/min, the duration of rest time between series was 5 min.

At the second stage, the parameters of the swimmers' respiratory system response to the loads in aerobic and anaerobic zone were studied. For that purpose, they were given a task to swim 4 sections of 200 m each in freestyle under total coordination. The duration of rest time after swimming a section was 30 s.

At the third stage, we studied changes in the swimmers' respiratory function response to physical loads at the level of MOC (maximum oxygen consumption), which was aimed at enhancing basic endurance. At this session, it was required to swim 3,000 m (within 40 minutes).

The respiratory system functions of stayer swimmers were studied with the use of a Spirolab-3 spirometer (spirograph). The device configuration allows for automatic functional interpretation of spirometry at 11 possible levels of test quality management. The device allows to determine the inspiratory and expiratory capacity, breathing pattern and blood oxygenation level. The spirometer was used to calculate a test acceptance index, perform the quality control and assess the test results.

For the adequate interpretation of spirometry results, the obtained data was compared with normal and predicted values calculated on the basis of swimmers' anthropometric characteristics. Then, the estimated values were compared with sportsmen' empirical data, which might significantly differ from predicted values.

During the study, three the most informative spirometry parameters were measured:

- Vital capacity of lungs (VC);
- Forced vital capacity (FVC);
- Forced expiratory volume in one second (FEV1).

For VC measurements, prior to conducting the test, subjects made several smooth breathing movements, then the deepest possible breathing in, and after it, slow and the fullest possible breathing out into the breathing tube of the device. While the test was done, the monitor displayed respiratory volume/time curve.

For FVC measurements, prior to conducting the test, subjects made several smooth breathing movements, then a slow and deep breathing in, then a full breathing out. It was further followed by informative part of the test: the fastest and deepest possible breathing in.

When measuring forced expiratory volume in one second, the subject made several forced breathing movements at a rate of 30 cycles per minute. The test was completed within several seconds, and the monitor displayed recorded values of measured parameters.

RESULTS AND DISCUSSION

Table 1. Dynamics of indicators of respiratory functions during training on the development of anaerobic performance of swimmers, $\bar{x} \pm m$ (l).

Group	Data	To load	After loading	Growth.%
Sprinters	VC	4.78 ± 0.6	5.04 ± 0.4	5.43
	FVC	4.81 ± 0.2	4.83 ± 0.5	0.41
	FIV1	3.66 ± 0.5	4.51 ± 0.6	25.27
Medium stayers	VC	4.87 ± 0.4	5.05 ± 0.7	3.69
	FVC	4.81 ± 0.7	4.83 ± 0.2	0.41
	FIV1	3.91 ± 0.6	4.13 ± 0.5	5.62
Stayers	VC	5.25 ± 0.7	4.71 ± 0.3	-10.28
	FVC	5.13 ± 0.1	5.00 ± 0.8	-2.53
	FIV1	4.76 ± 0.4	4.59 ± 0.8	-3.70

Note: VC - vital capacity of lungs, FVC - forced vital capacity, FIV1 - forced expiratory volume in one second.

Table 1 shows the parameters of changes in the swimmers' respiratory system exposed to physical loads in anaerobic training regime.

The obtained results evidence that the sportsmen' respiratory system reacts differently to physical loads depending on swimmers' sports specialization.

At the beginning of the training session, the parameter values of sprinter swimmers were as follows: VC – 4.78 ± 0.6 L; FVC – 4.81 ± 0.2 L; FEV1 – 3.66 ± 0.3 L. At the end of the training session, VC was 5.04 ± 0.4 L (increase by 5.43%); FVC was 4.83 ± 0.5 L (increase by 0.41%); FEV1 was 4.51 ± 0.6 L (increase by 25.27%). Before the start of the training session, the respiratory function parameter values of the middle stayer swimmers were as follows: VC – 4.87 ± 0.4 L; FVC – 4.81 ± 0.7 L; FEV1 – 3.91 ± 0.6 L, and, once the training session was over, these were as follows: VC – 5.05 ± 0.7 L; FVC – 4.83 ± 0.2 L; FEV1 – 4.13 ± 0.5 L.

Before the start of the training session, the results of the stayer swimmers were as follows: VC – 5.25 ± 0.7 L; FVC – 5.13 ± 0.1 L; FEV1 – 4.76 ± 0.4 L. Once the training session was over, the parameter values of respiratory functions dropped to the following levels: VC – 4.71 ± 0.3 L; FVC – 5.00 ± 0.8 L; FEV1 – 4.59 ± 0.8 L.

It was found that the work done in swimming under anaerobic regime caused the swimmers' organism to react differently depending on their specializations. The swimmers of the 1st group showed the highest increase in FEV1 values (25.27%). The increase in FEV1 values of the swimmers of the 2nd group given the physical load was 5.62%. The swimmers of the 3rd group showed a drop in FEV1 value by 3.70%.

The respiratory system response of the 2nd and 3rd swimmer groups proved to be significantly lower as compared to the results shown by the swimmers of the 1st group. The sportsmen specializing in sprinter swimming showed a more pronounced response to anaerobic load than stayer swimmers. It is explained by the sprinter swimmers' ability to consume the maximum air volume in the first seconds of the exposure to a special load in swimming.

Table 2. Dynamics of indicators of respiratory functions in the process of training an aerobic-anaerobic orientation, $\bar{x} \pm m$ (l).

Group	Data	To load	After loading	Growth.%
Sprinters	VC	4.45 ± 0.4	4.87 ± 0.2	9.43
	FVC	4.54 ± 0.2	4.86 ± 0.5	7.04
	FIV1	3.95 ± 0.3	4.49 ± 0.1	13.61
Medium stayers	VC	4.24 ± 0.1	4.52 ± 0.6	6.60
	FVC	4.61 ± 0.7	4.74 ± 0.8	2.80
	FIV1	3.91 ± 0.4	4.13 ± 0.7	5.62
Stayers	VC	4.87 ± 0.2	5.05 ± 0.6	3.69
	FVC	4.01 ± 0.8	4.11 ± 0.7	2.49
	FIV1	4.11 ± 0.1	4.23 ± 0.2	3.17

Note: VC - vital capacity of lungs, FVC - forced vital capacity, FIV1 - forced expiratory volume in one second.

Table 2 shows the parameter values of the swimmers' respiratory system response to the aerobic-anaerobic loads.

The obtained results of the swimmers' respiratory system response to aerobic- anaerobic loads showed positive changes in all test groups.

The swimmers of the 1st group showed a greater response to loads than the swimmers of the 2nd and 3rd groups. The optimal activation of the respiratory function of the sportsmen' organism takes place.

Table 3. The dynamics of respiratory function indicators during training for the development of basic endurance, $\bar{x} \pm m$ (l).

Group	Data	To load	After loading	Growth. %
Sprinters	VC	2.84 ± 0.02	3.41 ± 0.10	20.07
	FVC	3.96 ± 0.06	4.14 ± 0.11	15.0
	FIV1	3.6 ± 0.05	3.79 ± 0.06	5.27
Medium stayers	VC	4.71 ± 0.06	4.85 ± 0.04	3.11
	FVC	5.57 ± 0.09	5.77 ± 0.02	5.26
	FIV1	4.09 ± 0.12	4.78 ± 0.05	18.78
Stayers	VC	4.79 ± 0.08	4.95 ± 0.06	3.34
	FVC	5.47 ± 0.06	5.78 ± 0.07	5.66
	FIV1	4.04 ± 0.07	4.88 ± 0.02	20.79

Note: VC - vital capacity of lungs, FVC - forced vital capacity, FIV1 - forced expiratory volume in one second.

Table 3 shows the changes in the parameter values of the swimmers' respiratory functions in the course of training aimed at enhancing basic endurance.

The obtained results of the swimmers' respiratory system response to a load aimed at enhancing basic endurance showed positive changes in the respiratory functions of the swimmers of all specializations. The swimmers of all test groups demonstrated a significant increase in FEV1 values. It was found that the respiratory system of sprinter swimmers and stayer swimmers reacts intensively to the physical load in aerobic zone at the MOC level. It was established that stayer swimmers have better developed mechanisms of muscle metabolism involving oxygen as compared to sprinters and middle stayer swimmers. Under the conditions of prolonged cyclical work, sprinter swimmers and middle stayer swimmers develop a high oxygen debt, which leads to pronounced fatigue. It means that the required level of fitness in swimming with aerobic training sessions was insufficient. The respiratory function parameter values demonstrate the need in swimming in high power range for 30–40 minutes. As a result of increased intensity of work done by the swimmers' cardiorespiratory system, MOC percentage and tissue oxygenation reaches the maximum possible level.

CONCLUSION

The respiratory system response of the swimmers, who specialize in swimming for various distances, to multidirectional loads has its own peculiarities. Sprinter swimmers have better developed anaerobic mechanisms of muscle activity, while stayer swimmers have better functioning aerobic mechanisms of energy metabolism. The differences in respiratory function response of sprinter swimmers and stayer swimmers to multidirectional loads influence the processes of their working capacity recovery. In order to activate the recovery of qualified swimmers, it is advisable to combine aerobic and anaerobic mechanisms of energy metabolism, as well as to develop them to the maximum possible level in the course of training process.

AUTHOR CONTRIBUTIONS

Conceptualization and methodology: A.B. and O.P .; Software: V.B .; Data curation: O.P., A.B., V.B. and V.V.; Data analysis: V.B., V.V. and O.P.; Original draft article preparation: A.B. and V.B .; English editing: V.B., and V.V .; All authors revised the manuscript and agreed to publish this version of the manuscript.

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