RUSSIAN JOURNAL OF
SPORTS SCIENCE
2023, Vol. 2 (2)

Publication date: 01.06.2023
DOI: 10.24412/2782-6570-2023_02_02_4
UDC 796; 615.835.3; 578.834.1

INFLUENCE OF HYPEROXIC MIXTURE ON THE FUNCTIONAL STATE OF THE EXTERNAL RESPIRATION SYSTEM OF ATHLETES WHO HAD COVID-19 AND TRAIN IN MIDDLE ALTITUDE

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Annotation. The objective was to evaluate an effect of the inhalation course with the hyperoxic gas mixture on the functional state of the external respiration system of athletes who had COVID-19 and train in middle altitude. The study included 19 male athletes of following specialties: taekwondo, mountaineering, triathlon, badminton, underwater sports (qualifications: Candidate for Master of Sports, Master of Sports, Master of Sports of International Class, Honored Master of Sports). The athletes were divided into two groups: the experimental (who had COVID-19) and control (who did not have COVID-19). During the study (the inhalation course included not less than 7 procedures every day), the functional capabilities of the external respiration system in a form of increased gas exchange in the lungs, bronchial dilation and increased patency, were improving.

Keywords: hyperoxic mixture, athletes, COVID-19, external respiration, training camp, middle altitude.

Introduction. The pandemic associated with the SARS-coV-2 virus (COVID-19), which humanity has faced in the last three years, has significantly affected high performance sports, identifying new urgent problems for sports medicine experts. A need occurred in the development and application of methods that effectively restore the functional state of the respiratory and cardiovascular systems, increase working capacity of athletes, who had COVID-19 and resumed to training, as well as training in extreme conditions, e.g. middle altitude. Currently athlete training in hyperbaric hypoxia conditions has been firmly established in the practice of high performance sports. It is considered both as a way of successful preparation to competitions in the mountains and as a factor of mobilizing functional reserves of an athlete during their preparation to competitions on the plains [1-3]. However, athletes, who had COVID-19 and resumed to training in extreme conditions, need a specific approach, since high altitude hypoxia may be associated with high risks [4-5], despite the fact that hypoxia is a potentially effective preventive and therapeutic measure [6-8]. Taking into account different strategies of athlete preparation in middle altitude, application of mixtures with high oxygen content may become an additional way to support and recover their functional state. In sports practice, hyperoxic mixtures are already used for functional state correction and working capacity improvement [9-11]. There are data on influence of hyperoxic mixtures on functional capabilities of the respiratory system [12]. However, effect of these mixtures on the respiratory system of athletes, who had COVID and resumed to training, is understudied, but is an important and relevant aspect of sports practice, since the respiratory system is the main target of COVID-19.

The purpose of this work: to evaluate effect of an inhalation course with a hyperoxic gas mixture on the functional state of the external respiration system of athletes, who had COVID-19 and resumed to training in middle altitude.

Methods and organization. The study took place in the Center of Biomedical Technologies (FSBI “North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency”), in middle altitude

(Maloe Sedlo mountain, 1240 m, Kislovodsk), during training camps in the "Yug Sport" enterprise. The study included 19 male athletes of the following specialty: taekwondo (3 people), mountaineering (3), triathlon (4), badminton (4), underwater sports (5), age – 16 to 34 years (qualifications: Candidate for Master of Sports, Master of Sports, Master of Sports of International Class, Honored Master of Sports). All athletes are the members of the national teams of Russia. During the study, the athletes did not stop training (2-3 times a day). Among 19 athletes, 11 had COVID-19 and were included in the experimental group (EG), while the other 8 – in the control group (KG).

At the beginning of training camps, we have conducted a monitoring survey that included measurement of the external respiration function, blood saturation and heart rate (HR). Evaluation of the external respiration function was made with the MicroLoop portative spirometer (CareFusion, US). Following indices were analyzed: vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), Tiffeneau index – FEV1/FVC ratio, peak expiratory flow (PEF), maximum flow rate at the level of large, medium and small bronchi (MFR15, MFR50, MFR75), as well as due values calculated according to gender, age, height and ethnicity. Research of blood oxygen saturation (SpO_2) and heart rate (HR) was carried out with the ESTECK System Complex (LD Technology, US).

Then all test subjects passed the inhalation course with the hyperoxic gas mixture. To create the mixture, we used the JAY-10 oxygen concentrator (Longfian, China). The oxygen concentration amounted to 93±3%, productive capacity – 5 l/min, exposure time – 20 min. The mixture was taken into the respiratory tract through the mask. The inhalations took place every day, the course took not less than 7 procedures. At the end, we have conducted an additional survey.

The statistical data processing was made with the nonparametric Wilcoxon matched pair test and the Mann-Whitney U-test from the Statistica 6.0 software. The difference between the values was deemed significant if $p<0.05$. The data is presented in a form of mean (M) and square root deviation (sd).

Results and discussion. It is known that at the initial stage of staying in middle altitude, the blood oxygen saturation indices change. At the beginning of training camps, all athletes have decreased level of saturation (lower than 97%), which indicates hypoxia (table 1). The HR index remained within normal values in all athletes. The comparative analysis did not show statistically significant differences between the groups.

The external respiration indices in athletes of both groups are demonstrated in table 2.

We have found that values of VC related to the functional state of the external respiration system were within the standard limits in all athletes. FVC, FEV1 and Tiffeneau index (FEV1/FVC) that allow evaluating air passage through respiratory tracts were also within the normal values in all test subjects, which indicates an absence of obstructive disorders. The due values of mentioned indices in all athletes were slightly increased due to the respiratory system's adaptation to training activity aimed towards developing endurance. When assessing the MFR indices, we have discovered that higher values in both groups were identified in higher parts of the bronchi (MFR25), while the lowest ones – in lower parts (MFR75), which may be explained by air passage through bronchi of different calibers. According to all described indices, there were no statistically significant differences between the groups. The PEF analysis has shown that the index was higher in athletes of the experimental group ($p<0.01$).

After the inhalation course, there were no statistically significant changes for the saturation and HR indices in both groups. However, we have found a trend for a slight increase in saturation among all athletes: before the course in the experimental group – 93.9±1.75%, after – 94.1±1.69%; before in the control group – 93.1±1.07%, after – 93.9±2.41%. There was also a trend for a decrease in HR among all athletes, the index decreased to a greater extent in the experimental group: before the course – 75.6±9.05 beats/min, after – 71.9±8.76 beats/min. HR did not change substantially in the control group: before – 77.0±12.95 beats/min, after – 76.3±11.04 beats/min.

Table 1
Heart rate and blood oxygen saturation indices in athletes of both groups at the beginning of the training camps during while adapting to middle altitude hypoxia

№	Indices	EG	CG
1	HR, beats/min	75.6±9.05	77.0±12.95
2	SpO_2, %	93.9±1.75	93.1±1.07

Note: EG – experimental group; CG – control group; HR – heart rate; SpO_2 – blood oxygen saturation

Table 2
External respiration indices in athletes of both groups at the beginning of the training camps during while adapting to middle altitude hypoxia

№	Indices	EG	CG	P<
1	VC, l	6.2±1.11	6.0±0.76	-
2	% due	103.1±18.68	110.5±9.09	-
3	FVC, l	6.2±0.89	5.9±0.62	-
4	% due	107.4±15.27	113.3±7.76	-
5	FEV1, l	5.4±0.49	4.9±0.44	-
6	% due	112.0±11.9	112.3±6.65	-
7	FEV1/FVC %	86.6± 7.17	83.3±6.12	-
8	PEF, l/min	701.4±74.94	597.0±57.43	0.01
9	% due	111.8±13.03	101.5±8.96	0.04
10	MFR 25, l/s,	9.8±1.50	8.8±1.21	-
11	% due	111.2±17.79	106.5±13.16	
12	MFR 50, l/s	6.6±1.39	5.9±1.38	-
13	% due	114.5±24.0	107.5±22.68	
14	MFR 75, l/s,	3.2± 0.91	2.4±0.61	-
15	% due	114.7±29.98	91.2±21.83	

Note: EG – experimental group; CG – control group; VC – vital capacity; % due – percentage of due values; FVC – forced vital capacity; FEV 1 – forced expiratory volume in 1 second; FEV1/FVC – the Tiffeneau index; PEF – peak expiratory flow; MFR25, MFR50, MFR75 – maximal flow rate at the level of large, medium and small bronchi. Limits of standard values of the external respiration indices are presented according to L.L. Shik, N.N. Kanaev [13]

Dynamics of the external respiration indices of the experimental group athletes are presented in table 3. The study did not reveal statistically significant changes in these indices after the course. However, there was a trend for increasing FVC. PEF, MFR at the level of large, medium and small bronchi. FEV1 remained unchanged against the background of slight reduction of the Tiffeneau index.

Table 3

Comparative analysis of the external respiration indices in athletes of the experimental group before and after the inhalation course

№	Indicators	Experimental group	
		before	after
1	VC, l	6.2±1.11	6.2±1.01
2	% due	103.1±18.68	103.9±17.34
3	FVC, l	6.2±0.89	6.3±0.92
4	% due	107.4±15.27	109.7±16.39
5	FEV1, l	5.4±0.49	5.4±0.51
6	% due	112.0±11.9	111.7±12.45
7	FEV1/FVC, %	86.6±7.17	85.8±7.39
8	PEF, l/min	701.4±74.94	712.5±72.61
9	% due	111.8±13.03	112.8±12.85
10	MFR 25, l/s,	9.8±1.50	10.2±1.22
11	% due	111.2±17.79	112.6±13.67
12	MFR 50,l/s	6.6±1.39	7.0±1.69
13	% due	114.5±24.0	112.1±23.99
14	MFR 75, l/s	3.2±0.91	3.0±1.33
15	% due	114.7±29.98	102.9±23.02

Note: VC – vital capacity; % due – percentage of due values; FVC – forced vital capacity; FEV 1 – forced expiratory volume in 1 second; FEV1/FVC – ratio of forced expiratory volume in 1 second to forced vital capacity (the Tiffeneau index); PEF – peak expiratory flow; MFR 25, MFR 50, MFR 75 – maximal flow rate at the level of large, medium and small bronchi. Limits of standard values of the external respiration indices are presented according to L.L. Shik, N.N. Kanaev [13]

Increase of the LC index was found in athletes of the experimental group (before – 6.0±0.8, after – 6.1±0.8, $p<0.03$). There were no significant changes in other indices. However, a trend for increasing FVC and FEV1 was identified: before – 5.9±0.6 l, after – 6.0±0.8 l (FVC); before – 4.9±0.4 l, after – 5.0±0.8 l (FEV1).

Conclusion. Therefore, as a result of the inhalation course, we have identified a trend for increasing functional capabilities of the external respiration system of athletes, including those, who had COVID-19 and is training in middle altitude. This trend was manifested in increased gas exchange in the lungs, bronchial dilation and patency. Considering the fact that the course with inhaling a hyperoxic mixture during high-intensity training in middle altitude included not less than 7 procedures, the revealed trend for improving the external respiration system of athletes, who previously had COVID, reflects a necessity in conducting further research with greater sample number, taking into account the disease's severity and specificity of examined sports.

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For citation: Kushnareva Yu.V., Koryagina Yu.V., Abutalimova S.M., Popov A.N. Influence of hyperoxic mixture on the functional state of the external respiration system of athletes who had COVID-19 and train in middle altitude. *Russian Journal of Sports Science: Medicine, Physiology, Training*, 2023, vol. 2, no. 2. DOI: 10.24412/2782-6570-2023_02_02_4