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THE IMPACT OF THE HARDWARE POSITIVE OSCILLATORY EXPIRATORY PRESSURE ON THE EXTERNAL RESPIRATORY FUNCTION OF ELITE SWIMMERS DURING THE ACUTE PERIOD OF THE MOUNTAIN ADAPTATION

A.B Kochergin[1], M.D. Didur[2], A.A. Kusnetsov[3], B.A. Dyshko[4]
[1]SBI SSOR of water sports “Ekran”, St. Petersburg, Russia
[2]Human Brain Institute, St. Petersburg, Russia
[3]Povolzhskiy State Academy of Physical Culture, Kazan’, Russia
[4]LLC “Sport Technology”, Moscow, Russia

Key words: elite swimmers, mountain training, respiratory system, training device of complex impact on respiratory muscles in motion, breathing with positive oscillatory expiratory pressure, spirometry.

Annotation. A relevant scientific purpose of this study was to find measures and methods of training aimed at speeding up the adaptation of the respiratory system of elite swimmers to the middle altitude conditions. Assessment of the effect of positive oscillatory expiratory pressure, implemented by using the "New Breath" training devices on the respiratory system responses of elite swimmers when moving from the plain to the middle altitude and during the “acute period” of mountain adaptation. Indicators of external respiration were evaluated by spirometry in the “Forced exhalation” and “Maximal voluntary ventilation” tests. The study involved 13 male and 14 female swimmers, who formed an experimental and control group. Athletes of the experimental group trained using the "New Breath" training devices. It was found that using the "New Breath" training devices of integrated effects on the respiratory system of athletes in movement during training of elite swimmers in the acute period of mountain training contributes to a more intensive increase in the indicators of forced respiratory maneuvers and bronchial patency, accelerates the adaptation of the respiratory system of elite swimmers, both men and women, to the middle altitude conditions.

Introduction. The main purpose of training camps (TC) in mountains is an increase of possibilities of functional systems of an athlete’s organism, including the respiratory system [1, 2, 6, 9]. When evaluating possibilities of the respiratory system, dynamics of gas composition of expired and alveolar air, lung ventilation

and its components in working process of step-type increasing power, consumed oxygen and etc. were examined [6, 9]. It is also known [6, 9, 11], that moving from the plain to the middle altitude (1600-2000 m) already has an effect on features of functional systems of athletes' organism. Lately, a training device of integrated effect on the respiratory system "New Breath", developed and manufactured in Russia, is used during training of elite athletes [1, 3-5]. The device creates positive oscillatory expiratory pressure and the "hypoxic-hypercapnic" air environment, controlled with the intensity of a training exercise, reproducing reduced oxygen content in the middle altitude atmosphere on the plain with a simultaneous increase of CO_2 content in inhaled air [3-5]. The device contributes to the intentional development of strength and power of respiratory muscles with a simultaneous purification of airways from sputum due to the creation of positive oscillatory expiratory pressure [3-5, 7].

We implied that the use of the "New Breath" training device during the initial period of mountain training of elite swimmers (men and women) would allow to harmonize responses of urgent adaptation of the athletes' respiratory system to the middle altitude conditions.

The main purpose of this study is to evaluate the efficiency of integrated effect of the "New Breath" devices on adaptation dynamics of indicators of external respiration functions of athletes when moving from the plain to the middle altitude and on the 7th day after the beginning of training camps at an altitude of 1600 m.

Methods and organization. The study was conducted in two periods:

1 period – during training camps conditions on the base of the "Volga" swimming club (Volgograd) (19.04-10.05.2001);

2 period – during training camps conditions on the base of the "Dombay" resort settlement (Karachay-Cherkess Republic) (11.05-01.06.2001).

27 elite swimmers (13 men and 14 women) with Master of Sports – Master of Sport of International Class qualifications, specialized in various swimming styles, participated in the study. All participants, after conducting the training camps on the plain moved to the middle altitude of 1600 meters above sea level, where the training camps continued. When arriving on the mountains, the participants, men and women, were divided into two groups – experimental and control groups. Six men were included in the control group (the first group), seven – in the experimental group (the second group); women were also divided, 7 each, into two groups (the first group – experimental group, the second group – control group). All groups were trained according to the unified training program based on TC, the purpose of which was an increase of aerobic capacities of swimmers' organism during work on the

level of threshold of aerobic metabolism [1, 8]. Participants of the experimental groups were performing 25% of training using the "New Breath" training device.

Before moving to the mountains, after moving and on the seventh day of the "acute period" of mountain training [9], a spirometry with the use of the PC-based "Spiro-Spectrum" spirometer manufactured by Neurosoft in Russia was performed [7, 9]. The spirometer is meant for examining the external respiration function by using the spirography method and registration of "flow-volume" curve of the forced exhalation. Characteristics received from the "Forced exhalation" and "Maximal voluntary ventilation" tests were examined and analyzed. The tests were conducted by the method described in the manual [7, 9].

In order to conduct the "Forced exhalation (FVC)" test, next features were analyzed:

– forced vital capacity in full exhalation (FVC, l);

– peak expiratory flow (PEF, l/min);

– maximal expiratory flow on the level of 25% of the FVC (MEF 25, l/min);

– maximal expiratory flow on the level of 50% of the FVC (MEF 50, l/min);

– maximal expiratory flow on the level of 75% of the FVC (MEF 75, l/min);

– exhalation time of 100% FVC (ET, sec);

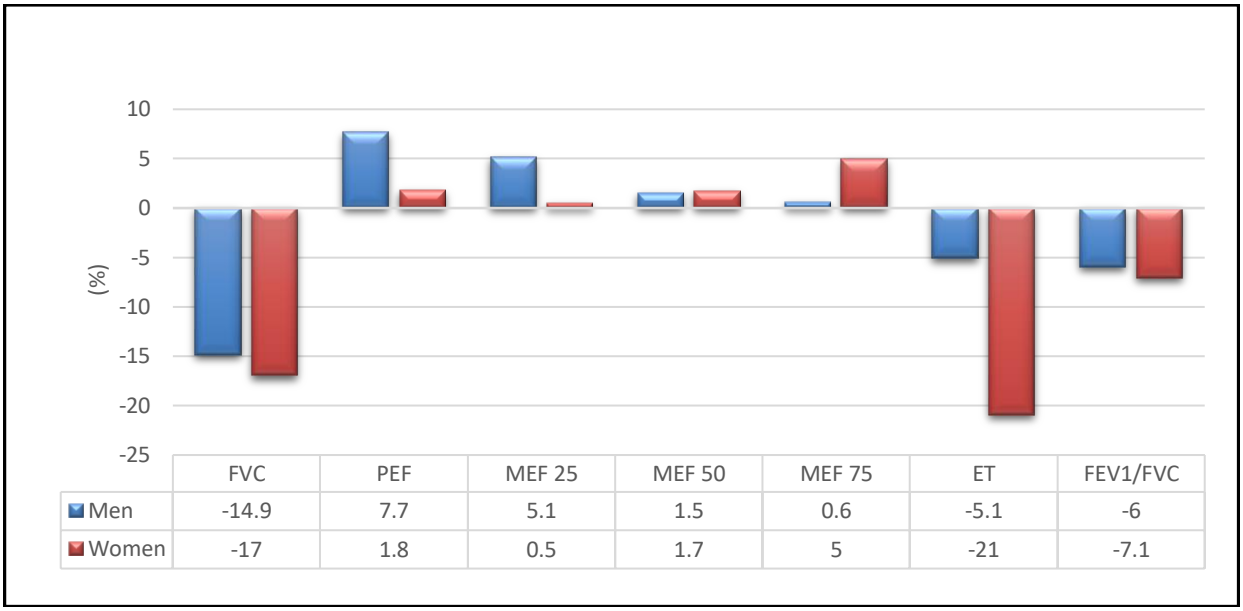
– the Tiffeneau-Pinelli index (FEV1/FVC, %), where FEV1 – is the forced expiratory volume in 1 second of the "Forced exhalation" test.

When conducting the "Maximal voluntary ventilation (MVV)" test, the maximal voluntary ventilation (MVV, l/min), respiratory rate (RR, cycle/min), and respiratory volume during maximal voluntary ventilation (RV MVV, l) were analyzed.

A standard program for mathematical data analysis (Microsoft Excel 2019), which includes counting of descriptive indicators (sample means, standard deviations), was used for analyzing dynamics of average values of the studied features by groups.

Results and discussion. The study was divided into two stages. The dynamics of examined features of the external respiration for men and women during moving from the plain to the middle altitude were analyzed on the first stage. On the second stage, the effect of the "New Breath" training devices on adaptation of the respiratory system of elite swimmers to the middle altitude conditions was evaluated.

The dynamics of indicators of the external respiration of elite swimmers during moving from the plain to the middle altitude (separately for men (n=13) and women (n=14)) were shown in % in Fig. 1 and 2.



	FVC	PEF	MEF 25	MEF 50	MEF 75	ET	FEV1/FVC
Men	-14.9	7.7	5.1	1.5	0.6	-5.1	-6
Women	-17	1.8	0.5	1.7	5	-21	-7.1

Fig. 1. Dynamics of features of the external respiration of athletes (in %) in the FVC test during moving from the plain to the middle altitude.

When performing the FVC test, which was conducted on the first day of presence on the middle altitude, a decrease of analyzed volume and time features of the external respiration, both in men and in women, was registered (Fig. 1). The FVC indicator was decreased by 14,9% in men and by 17% in women. The maximal expiratory flow on the level of 25% of the FVC was decreased in comparison with the indicator of the plain by 5,1% in men, in women – by 0,5%. Relevant decreases of the maximal expiratory flow on the level of 50% of the FVC were almost equal in men and women – 1,5 and 1,7% respectively. However, the maximal expiratory flow on the level of 75% of FVC is significantly different between men and women – 0,6% and 5,0% respectively. The given phenomenon is seemingly related to the impact of height on a decrease of bronchial patency, bronchial smooth muscles of medium-sized and large bronchi of athletes and muscles contributing to a strong and fast exhalation, as required by methods of performing the FVC test. Significant difference in the relevant decrease of the exhalation time of the 100% FVC, 5,1% in men and 21% in women respectively, because a relative decrease of the modified Tiffeneau-Pinelli index (6% in men and 7,1% in women) also indicates a decrease of bronchial patency.

The observed changes in the indicators of the external respiration function in athletes show an impact of conditions of training camps, which are the middle altitude conditions.

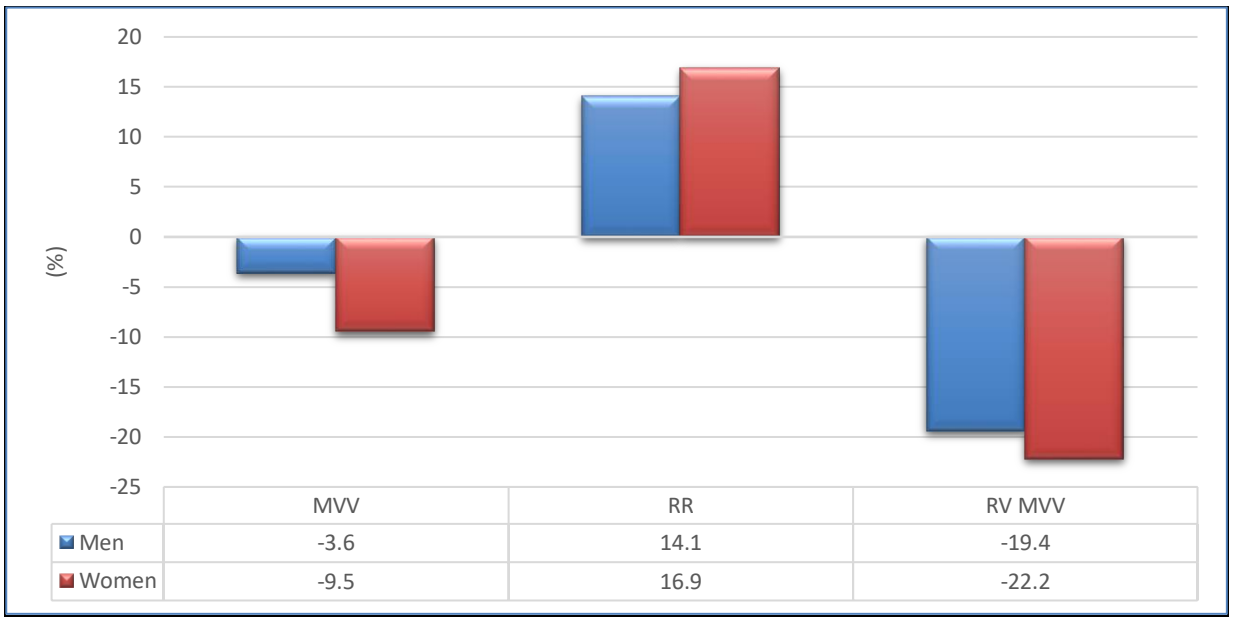


Fig. 2. Dynamics of the external respiration indicators (%) in the MVV test in male (n=13) and female (n=14) elite swimmers during moving from the plain to the middle altitude.

During the MVV test, after moving to the middle altitude, an increase of the respiratory rate by 14,1% in men and 16,9% in women was registered (Fig. 2). However, the maximal voluntary ventilation of lungs was decreased by 3,6% in men and 9,5% in women, which causes a decrease of the respiratory volume during the maximal voluntary ventilation by 19,4% and 22,2% respectively (Fig. 2).

The next stage of the study was an evaluation of the impact of the "New Breath" respiratory training devices on reactions of the urgent adaptation of the external respiration system of elite swimmers during the acute period of the mountain adaptation [8].

The experiment's results are presented in tables 1, 2, 3 and 4. The relevant changes of examined indicators of the external respiration in the control (n=7) and the experimental (n=6) group of men are presented in the Table 1.

Table 1

Changes of parameters of the external respiration (the FVC test) in the experimental (1 gr., n=7) and the control (2 gr., n=6) group before and after using the "New Breath" training device during the weekly micro cycle in the conditions of the middle altitude (men, n=13)

The FVC test (men)	Parameters	1 group			2 group		
		before	after	grow rate (%)	before	after	grow rate (%)
	FVC, (l)	5,31±1,41	5.95±1.24	12	5.28±1.37	5.42±1.27	2,6
	PEF (l/sec)	7,40±0,39	7,63±0,48	3,1	7.34±0.43	7.47±0.56	1,8
	MEF 25 (l/sec)	7,09±0,58	7,42±0,70	4,6	7,1±0.68	7,31±0.75	2,9

	MEF 50 (l/sec)	5,52±1,17	5,96±1,01	8	5,51±0.87	5,71±1.08	3,6
	MEF 75 (l/sec)	3,46±1,20	4,14±1,36	19,6	3.43±1,19	3.81±1,31	11
	ET (sec)	2,02±0,52	1,62±0,43	-24,7	2.05±0.60	1.89±0.51	-8,5
	FEV1/FVC (%)	63,15±14,95	79,65±13,26	26,1	64.06±15.01	71.83±14.08	12

The analysis of data presented in the Table 1 revealed significant differences in growth rates of examined indicators due to the use of the "New Breath" training device by athletes. Thus, athletes of the experimental group with a decrease of the exhalation time, spent for the FVC test execution, an increase of the FVC by 12%, the peak expiratory flow by 3,1%, maximal expiratory flows 25-75% by 4,6-19,6% were revealed. In the control group, a decrease of the exhalation time by 8,5% is accompanied by an increase of the FVC volume by 2,6%, the peak expiratory flow by 1,8% and maximal expiratory flows 25-75% by 2,9-11% respectively, a change of the modified Tiffeneau-Pinelli index was by 26,1% in the experimental group and by 12% in the control group. The data obtained allow to conclude the fact that using the "New Breath" training device by elite male athletes during the acute period of the mountain training (during the first 7 days) contributes to:

– a more intense, in comparison with ordinary training measures, increase of indicators of the "flow-volume" curve, effectiveness of the external ventilation and improvement of bronchial potency;

– a more efficient process of the urgent adaptation of the respiratory system of athletes to the middle altitude conditions.

It is also important to note positive dynamics of the growth rate indicators in the MVV test of the maximal voluntary ventilation and respiratory volume during maximal voluntary ventilation both in the experimental group and control group (Table 2).

Table 2

Dynamics of parameters of the external respiration in the MVV test before and after the use of the "New Breath" training device during the first weekly micro cycle in the middle altitude conditions

Conditions	The MVV test (men)					
	MVV, l/min		RR, cycle/min		RV MVV, l	
	1 group	2 group	1 group	2 group	1 group	2 group
Beginning	147,18±13,96	148.56±12.54	73,0±15,35	72.8±14,62	2,05±0,38	2.02±0.44
End	159,35±14,53	155.42±13.79	73,0±12,73	74.12±13,18	2,31±0,51	2.24±0,64

Growth rate (%)	8,3	4,6	0	1,8	12,7	10,9

After using the “New Breath” training device during the weekly micro cycle, athletes of the experimental group, who had the MVV indicator of 159,35±14,53 l/min (growth rate is 8,3), did not have an increase of the respiratory rate, while athletes of the control group had the increased MVV up to 155.42±13.79 l/min (growth rate is 4,6%) due to an increase of the respiratory rate by 1,8%.

The analysis of dynamics of the external respiration during the FVC test performance in women revealed differences in the experimental (n=7) and control (n=7) groups (Table 3). In the experimental group, which used the “New Breath” training device, the FVC volume was increased by 2,5%, when the peak expiratory flow was increased by 2,5%. There was also an increase of maximal expiratory flows 25-75% by 3,3-8,6%, when the expiration time was decreased by 6,9% (Table 3). The mean value of the Tiffeneau-Pinelli index was increased by 19,1%. In the control group, the FVC volume was increased 1,3%, when the peak expiratory flow was also increased be 1,3%. Maximal expiratory flows 25-75% were increased by 1,3-3,5%, the Tiffeneau-Pinelli index was increased by 7%, the expiratory time of the 100% FVC, was decreased by 3,4% (Table 3).

Table 3

Dynamics of the external respiration indicators in the FVC test in the experimental (1 gr., n=7) group and the control (2 gr., n=7) group of women before and after using the “New Breath” training device during the acute period of the mountain adaptation

	Parameters	1 group			2 group		
		before	after	growth rate (%)	before	after	growth rate (%)
The FVC test (women)	FVC, (l)	3,93±0,36	4,03±0,33	2,5	3.87±0,39	3.92±0,37	1,3
	PEF (l/s)	5,46±0,75	5,60±0,67	2,5	5.49±0,75	5.56±0,61	1,3
	MEF 25 (l/sec)	5,37±0,81	5,55±0,68	3,3	5.37±0,76	5.44±0,71	1,3
	MEF 50 (l/sec)	4,08±0,92	4,49±0,74	10	4.09±1.01	4.22±0,82	3,1
	MEF 75 (l/sec)	2,31±0,56	2,51±0,63	8,6	2.29±0,64	2.37±0,74	3,5
	ET (sec)	1,73±0,47	1,61±0,43	-6,9	1.75±0,47	1.69±0,49	-3,4
	FEV1/FVC (%)	65,61±16,24	78,16±10,56	19,1	66.52±11.73	71.24±11.56	7

After the first weekly micro cycle, both in the experimental group and control group of women, an increase of indicators of the maximal voluntary ventilation and

the respiratory volume during maximal voluntary ventilation was registered. However, after using the "New Breath" training devices throughout the first weekly micro cycle, athletes of the experimental group, who had the MVV indicator of 110,51±4,68 l/min (growth rate is 5,7%), did not have an increase in the respiratory rate (Table 4). On the contrary, there was a decrease of the respiratory rate per minute by 1,1%. Athletes of the control group have the increased MVV up to 106.76±4,68 l/min (growth rate is 3,3%), when the respiratory rate was also increased by 0,2%.

Observed changes indicate an efficiency of using the "New Breath" training devices during the first weekly micro cycle of the mountain training of elite female athletes in order to increase adaptation possibilities of the respiratory system.

Table 4

Changes of the external respiration parameters (the MVV test) before and after using the "New Breath" training device during the weekly micro cycle in the middle altitude conditions (women, n=14)

Conditions	The MVV test (women)					
	MVV, l/min		RR, cycle/min		RV MVV, l	
	1 group	2 group	1 group	2 group	1 group	2 group
Before	104,57±6,06	103.3±5.98	73,33±13,7	72.97±12.9	1,45±0,19	1.48±0.21
After	110,51±4,68	106.76±4,68	72,5±9,74	73.12±7,01	1,57±0,18	1.53±25
Growth rate (%)	5,7	3,3	-1,1	0,2	8,2	3,3

Conclusion.

1. Moving of elite athletes from the plain to the middle altitude of 1600 m could be accompanied by a decrease of the external respiration indicators in the "Forced exhalation" and "Maximal voluntary ventilation" tests.

2. Using the positive oscillatory expiratory pressure with the use of the "New Breath" devices by elite swimmers during the acute period of the mountain training (the first weekly micro cycle) accelerates the adaptation of the respiratory system of male and female athletes to the middle altitude conditions, contributing to a more intense, in comparison with ordinary training measures, increase of the effectiveness of the external respiration and bronchial potency.

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Information about the authors: Kochergin Aleksandr Borisovitch – Candidate of Pedagogical Sciences, Associate Professor, Coach, Instruction Coordinator of the Department of Sports Work of the SBI SSOR of water sports "Ekran", Saint Petersburg, e-mail: ekran.school@mail.ru, sporttec.alex@yandex.ru; **Didur Mikhail Dmitrievich** – Doctor of Medical Sciences, Professor, Director of the Institute of Human Brain, Saint Petersburg, e-mail: office@ihb.spb.ru; **Kuznetsov Aleksei Aleksandrovich** – Vice-President of the RT Swimming Federation, 2nd year Post Graduate Student of the Povolzhskiy State Academy of Physical Culture, Sports and Tourism, Kazan', e-mail: info@sportacadem.ru;

Dyshko Boris Aronovich – Doctor of Biological Sciences, General Director of the LLC “Sport Technology”, Moscow, e-mail: sporttec@yandex.ru.