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Model for Stamina Development in Biathletes Based on the Combined Application of Respiratory Exercises

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Abstract

Studies have shown that the adaptation of biathletes' bodies to different loads takes place gradually from stage to stage due to the development of stamina in the framework of the combined use of respiratory exercises. The process of adaptation and change in functional parameters characterizing physical performance and functioning of external respiration occurs mainly due to the expansion of the range of application of the means that expand the capabilities of the cardiorespiratory system of the biathlete's body. The use of respiratory exercises with and without exercise machines in combination with aerobic exercises of moderate, medium, and maximum intensity allows expanding the reserve and functional capabilities of the biathlete's body. This allows achieving more significant positive changes in general and specific physical fitness, physical performance, functional fitness, breathing capacity and biathlete reserves, as well as the rates of response to different loads during training sessions.

Key words: *training model, biathletes, stamina development, respiratory exercises*

Introduction

Competitive activity makes high demands on the levels of the physical and functional fitness of athletes (Bolotin, & Bakayev, 2017a; Dempsey, Amann, Harms, & Wetter, 2012). This fully applies to the preparation of biathletes. The content of biathletes' training requires improvement and searching for new effective training tools and methods. The biathletes' preparation for competitions is aimed at solving multiple tasks. Moreover, among the variety of tasks, the primary focus should be placed on the task of preparing and expanding the functional capabilities as well as the adaptive reserves of their bodies. The solution to this task is due, first of all, to the specific features of the competitive activity of biathletes, which is characterized by high mental and physical tension.

It is known that stamina reflects the level of physical preparedness of biathletes for competitive activity. The study of scientific works and practical experience shows that respiratory exercises, which are nonspecific means for developing stamina and have a wide range of action on the bodies of athletes, have great potential (Bakaev, Bolotin, & Vasil'eva, 2015; Bakaev, Bolotin, & Aganov, 2016). They enhance the effect of training exercises performed and increase the level of physical performance (Batzel, Kappel, Schneditz, & Tran, 2007; Bohuslavska, Furman, Pityn, Galan, & Nakonechnyi, 2017; Bolotin, Bakayev, & You, 2018; Bolotin, & Bakayev, 2016; Przybyła et al., 2016; Vogiatzis et al., 2007; Bolotin, & Bakayev, 2017b; Bakayev et al., 2018).

The purpose of the study is to create optimal conditions with the help of experimental methods for increasing the indicators of reserve capacity and the body's resistance to oxygen deficiency in biathletes.

Methods

To solve the tasks, the following methods were used: analysis of scientific and methodological literature, testing (including functional tests), pedagogical experiments, and mathematical statistics methods.

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Analysis of the scientific and methodological literature included the study and summary of the works of domestic and foreign experts on the problem of the development of stamina in biathletes based on the use of respiratory exercises in various compositions. In the course of this analysis, the types of breathing, respiratory exercises, development of physical qualities, and the role of the respiratory system in the manifestations of stamina and physical performance of biathletes were studied.

Pedagogical testing was conducted to assess the overall physical fitness of biathletes. The following tests were used as indicators of general preparedness: standing long jump (cm); pull-ups (quantity); hip pull-over (quantity); shuttle run 10 × 10 (s); running 100 m (s); running over rough terrain for 5 km (s); 1 km and 3 km runs in a stadium.

The Spirolab III device was used to study and analyse the indicators of the respiratory system of biathletes. This device allows determining the forced vital capacity of the lungs, inspiratory capacity, expiratory capacity, maximum ventilation of the lungs, setting breathing pattern, and measuring oxygen saturation in the blood and pulse. The following indicators were studied: the vital capacity of the lungs (VC), forced vital capacity of the lungs (FVC), maximum voluntary ventilation (MVV), vital expiratory capacity (EVC), forced inspiratory volume in the first second (FIV 1).

To assess the performance of the respiratory system, timed expiratory capacity was used. In a sitting position, after resting, the biathletes took several deep breaths and held their breath as they exhaled (not to the maximum). The timed expiratory capacity was assessed according to the following indicators: "Excellent" - breath holding for more than 40 s; "Good" - from 30 to 40 s; "Satisfactory" - from 25 to 30s; "Bad" - less than 25 s.

To assess the state of the respiratory system during inhalation breath holding, Stange's test was used. In a sitting position, after a five-minute rest, the biathletes took 2-3 deep breaths in and out, and then, after a deep inhalation, held their breath. Stange's test was assessed according to the indicators: "Excellent" - more than 60 s; "Good" - 40 to 60 s; "Average" - from 30 to 40 s.

To assess the state of the respiratory system, Serkin's test was also used. The test run consisted of three phases: 1st phase - holding breath when inhaling (sitting), 2nd phase - holding breath when exhaling immediately after 20 squats for 30 seconds, 3rd phase - holding breath when inhaling after 1 minute of rest.

Testing of biathletes' body reserves was carried out using the "Sources of Health" (Istoki Zdorovya) hardware-software apparatus, with which the level of functional and adaptive reserves of their bodies was assessed.

For the athletes psycho-diagnostics, the following tests were used: traffic lights, snake, tremor and tapping test.

The "Traffic Light" test (determines complex visual-motor reaction of biathletes in ms). At the command "Go!", red lights start blinking erratically, and the subject must quickly respond to the switching off of the left light by pushing the left button with the left hand, to the switching off of the right light - with the right hand and to the switching off of the middle light - simultaneously with both hands, with the hand on the button at all times. The subjects were given three attempts for each hand; the best and worst attempts were discarded, and the intermediate result was recorded.

The "Snake" test (determines dynamic tremor, which is associated with the attention properties, visual acuity of biathletes, etc.). At the "Go!" command, the subject put a stylus at the beginning of the "snake" maze and, at the first touch, began to move along the snake with the timer being activated. In the course of the test, a touch record was performed. When performing the test, the subject had to try to outline all the figures over the entire length of the maze with a length of 60 cm and a width of 3 mm, and touch the edges as little as possible. The scoreboard showed the time in seconds and the number of edge touches. When performing this test, the needle of the stylus should not go beyond the edges of the maze.

The "Tremor" test (determines static tremor). At the "Go!" command, the subject inserted a stylus needle into a 3 mm hole, and the timer was activated when the edge of the hole was first touched. This test was performed for 30 seconds. At the end of time, the number of touches was displayed on the board. When performing this test, the needle of the stylus should not come out of the hole.

The "Tapping" test (determines lability, mobility, nature of arousal state, as well as the speed of the neuromuscular system). At the command "Go!", the subject began to beat a 2.5 by 2.5 cm square with a stylus in the form of a needle-pen for 30 seconds at a maximum rate.

The pedagogical experiment was carried out to assess the effectiveness of the developed model for stamina development in biathletes based on the use of respiratory exercises. Development of stamina in biathletes in the experimental group was carried out based on the integrated use of respiratory exercises. This approach to training biathletes enabled describing this process step by step and schematically present a model of stamina development based on the integrated use of respiratory exercises.

The model included the tasks, principles, structure and content of the biathlete training method, assessment of the methodology implementation, organizational and methodological features, and the planned result.

The main objectives for the implementation of the biathlete training model

1. Mastering respiratory exercises and using them during physical training.
2. Optimization of the process of biathletes physical training.
3. Increase in the level of functional preparedness of biathletes.
4. Control over adaptation to physical loads.

Experimental model effectiveness was assessed according to the results of the indicators of preparedness, possibilities of external respiration, physical performance and adaptive reserves of the biathletes' bodies.

In this study, for the quantitative analysis of the experimental data of the study, a system for statistical processing of the results was used. Mathematical-statistical processing of the results was carried out using Microsoft Excel 7.0 software.

Results

Biathlete training effectiveness is largely determined by the functional capabilities of their body. Practice has shown that the low level of physical performance and functional capabilities of the respiratory system of the body reserve capacity creates negative prerequisites for the development of physical qualities and motor abilities of biathletes.

The following indicators were identified as indicators characterizing the physical performance and functionality of biathlete breathing: 1- PWC 170 (kg / m / min); 2- MOC (ml); 3- MEI (cu); 4- expiratory reserve volume (ERV) (l); 5- ventilation per minute (VE) (l); 6- respiratory volume (TB) (l); 7- inhalation capacity (IC); 8- forced inspiratory volume (FIVC) (l).

The following indicators were identified as indicators characterizing the reserve capacity and the biathlete body's resistance to oxygen deficiency: 1- Stange's test (s); 2- timed expiratory capacity (s); 3- Serkin's test No.1 (s); 4- Serkin's test No.2 (s); 5- Serkin's test No. 3 (s); 6- General reserves (cu); 7- Physical reserves (cu); 8- Mental reserves (cu); 9 - Adaptation reserves (cu).

Determination of physical performance and functional capabilities of biathletes' breathing at the beginning of the experiment indicates the absence of significant differences between the mean values of the experimental and reference groups (P> 0.05). The obtained data on the functional capabilities of biathletes' breathing during the experiment are shown in Table 1.

Table 1. Indicators of Physical Performance and Functional Capabilities of Respiration in Biathletes of the Experimental and Reference Groups

No.	Parameters	Periods	Gr.	Stage 1	Stage 2	Stage 3	Stage 4
1	PWC 170 (kg/m /min)	Start	CG	1146.70±35.46	1193.85±67.67	1246.05±41.77	1297.70±59.42
			EG	1139.35±119.88	1184.10±68.10	1238.70±38.90	1284.85±56.63
			p	0.794	0.652	0.568	0.488
		End	CG	1164.40±38.02	1216.85±67.76	1263.70±45.42	1321.70±62.33
			EG	1208.70±25.09	1293.35±76.23	1390.85±52.12	1463.75±62.13
			p	0.000	0.002	0.000	0.000
2	MOC (ml)	Start	CG	2906.40±60.60	2992.25±63.75	3288.35±209.7	3517.55±198.01
			EG	2939.70±78.62	2969.45±50.88	3232.50±115.50	3487.90±58.52
			p	0.142	0.219	0.304	0.525
		End	CG	2920.90±19.48	3014.00±63.21	3309.60±209.11	3540.80±196.48
			EG	3013.10±118.74	3129.00±65.34	3486.85±148.55	3666.65±61.53
			p	0.001	0.000	0.004	0.009
3	MEI (c.u.)	Start	CG	408.30±11.54	411.40±5.56	432.30±15.79	432.10±8.60
			EG	404.35±9.38	412.80±4.53	434.45±8.98	434.65±5.96
			p	0.242	0.388	0.6	0.283
		End	CG	413.00±5.88	419.25±5.62	439.60±15.48	435.70±9.52
			EG	425.00±12.39	447.95±11.60	468.40±18.52	474.00±8.05
			p	0.000	0.000	0.000	0.000
4	Expiratory reserve volume (ERV) (l)	Start	CG	0.33±0.36	0.45±0.46	0.85±0.74	0.60±0.82
			EG	0.31±0.33	0.47±0.46	0.85±0.93	0.64±0.77
			p	0.879	0.879	0.996	0.866
		End	CG	0.37±0.36	0.45±0.46	0.87±0.67	0.70±0.92
			EG	0.71±0.27	0.82±0.54	1.29±0.80	0.93±0.60
			p	0.002	0.025	0.148	0.400
5	Vent/min (VE)	Start	CG	9.75±5.29	23.00±7.79	23.14±9.43	12.55±7.83
			EG	9.92±4.87	22.95±7.55	23.05±8.77	12.28±8.71
			p	0.917	0.986	0.974	0.919
		End	CG	10.24±5.16	23.00±7.08	23.19±9.78	12.59±8.01
			EG	13.85±5.48	25.79±6.04	27.74±6.29	13.84±7.77
			p	0.039	0.188	0.088	0.6
6	Respiratory volume (TB) (l)	Start	CG	0.28±0.23	0.94±0.30	0.74± 0.32	0.64±0.34
			EG	0.31±0.26	0.90±0.25	0.71±0.39	0.66±0.40
			p	0.763	0.634	0.774	0.862
		End	CG	0.30±0.22	0.97±0.30	0.75±0.18	0.69±0.35
			EG	0.44±0.26	1.17±0.23	0.95±0.26	0.91±0.31
			p	0.09	0.021	0.009	0.000
7	Inhalation Capacity (IC) (l)	Start	CG	4.23±0.71	3.83±0.63	3.71±1.00	4.04±1.08
			EG	4.24±1.04	3.79±0.49	3.75±1.05	4.03±1.04
			p	0.983	0.817	0.895	0.978
		End	CG	4.31±0.83	3.84±0.67	3.78±1.03	4.08±0.69
			EG	4.67±0.89	4.57±1.05	4.33±0.70	5.33±1.39
			p	0.2	0.012	0.056	0.001
8	PWC 170 (kg/m /min)	Start	CG	4.25±0.08	2.91±1.25	3.48±0.94	3.84±0.99
			EG	4.23±0.08	2.95±0.81	3.47±0.93	3.83±0.88
			p	0.35	0.894	0.975	0.976
		End	CG	4.30±0.10	2.93±1.19	3.51±0.87	3.85±0.99
			EG	4.53±0.31	3.35±0.41	4.25±0.55	5.33±1.33
			p	0.002	0.147	0.003	0.000

Legend: PWC 170–test physical working capacity; MOC-max oxygen consumption; MEI-maximum endurance index; VE-ventilation per minute

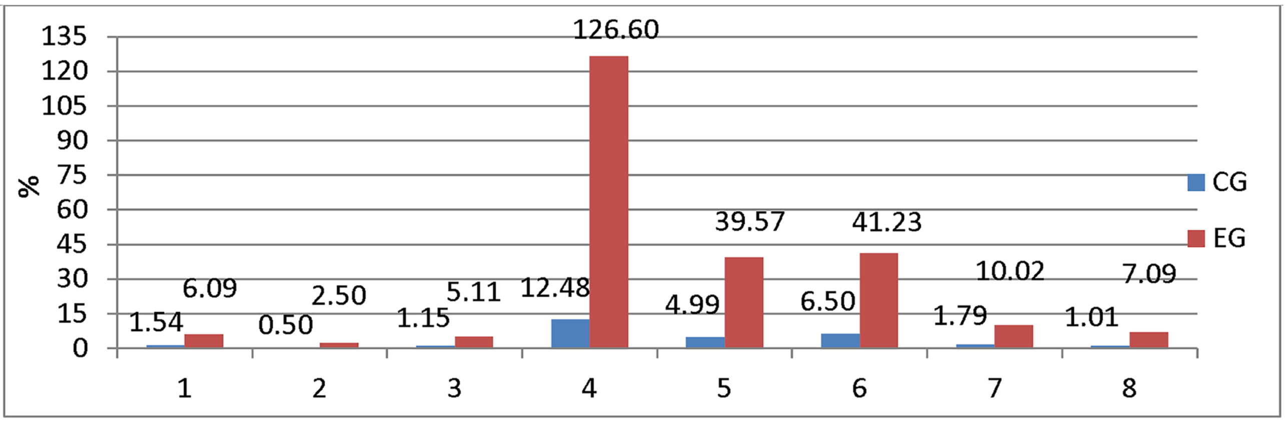
Determination of physical performance and functional capabilities of biathletes' breathing at the end of the experiment indicates the presence of significant differences between the mean values of the experimental and reference groups by several indicators (P< 0.05).

The results of the biathletes from the experimental groups were significantly higher than the results demonstrated by the biathletes from the control groups.

In the test results, no significant differences were observed in expiratory reserve volume (ERV) at stages 3 and 4, ventilation per minute (VE) at stages 2, 3 and 4, respiratory volume (TB) and inspiratory capacity (IC) at stage 1, forced inspiratory volume (FIVC) at stage 2; however, the average values of the indicators for biathletes of the experimental groups are higher than those for the control groups biathletes.

When analysing the obtained data on the state of physical performance and functional capabilities of respiration in the studied groups of biathletes, it should be noted that over the period of the experiment, the growth rates of the indicators in the experimental groups were significantly higher than those in the control groups (Figures 1-4).

The biathletes of the reference and experimental groups at the first stage of the experiment had the following increase results: PWC 170 - 1.54% and 6.09%; MOC - 0.50% and 2.50%; MEI - 1.15% and 5.11%; Expiratory reserve volume (ERV) - 12.48% and 126.60%; Ventilation per minute - 4.99% and 39.57%; Respiratory volume (TB) - 6.50% and 41.23%; Respiratory volume (TB) - 1.79% and 10.02%; Forced inspiration volume (FIVC) - 1.01% and 7.09% (Figure 1).



Legend: 1-PWC 170 (kg/m/min); 2-MOC (ml); 3-MEI (cu); 4-expiratory reserve volume (ERV); 5-Vent/min. (VE); 6-Respiratory volume (TB); 7-Inhalation capacity (IC); 8-Forced inspiratory volume (FIVC)

Figure 1. Increase in the indicators of physical performance and functional capabilities of biathletes' breathing for the first period of the experiment

The biathletes of the reference and experimental groups at the second stage of the experiment had the following increase results: PWC 170 - 1.93% and 9.23%; MOC - 0.73% and 5.37%; MEI - 1.91% and 8.52%; Expiratory reserve volume (ERV) - 0.22% and 74.52%; Ventilation per minute - 0.03% and 12.38%; Respiratory volume (TB) - 2.87% and 29.91%; Respiratory volume (TB) - 0.17% and 20.66%; Forced inspiration volume (FIVC) - 0.91% and 13.47% (Figure 2).

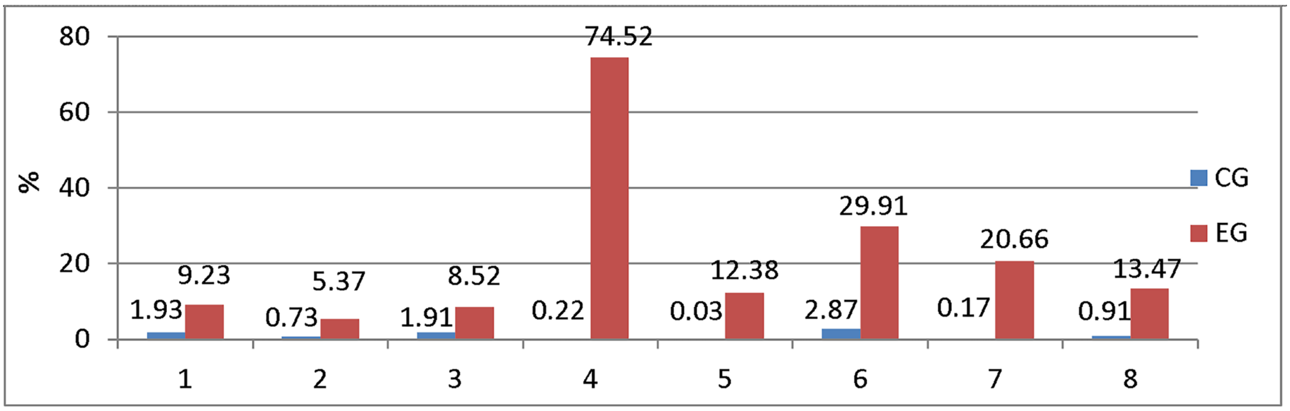


Figure 2. Increase in the indicators of physical performance and functional capabilities of biathletes' breathing for the second period of the experiment

The biathletes of the reference and experimental groups at the third stage of the experiment had the following increase results: PWC 170 - 1.42% and 12.28%; MOC - 0.65% and 7.87%; MEI - 1.69% and 7.81%; Expiratory reserve volume (ERV) - 2.90% and 51.83%; Ventilation per minute - 0.22% and 20.36%; Respiratory volume (TB) - 1.28% and 33.38%; Respiratory volume (TB) - 1.81% and 15.26%; Forced inspiration volume (FIVC) - 0.83% and 22.23% (Figure 3).

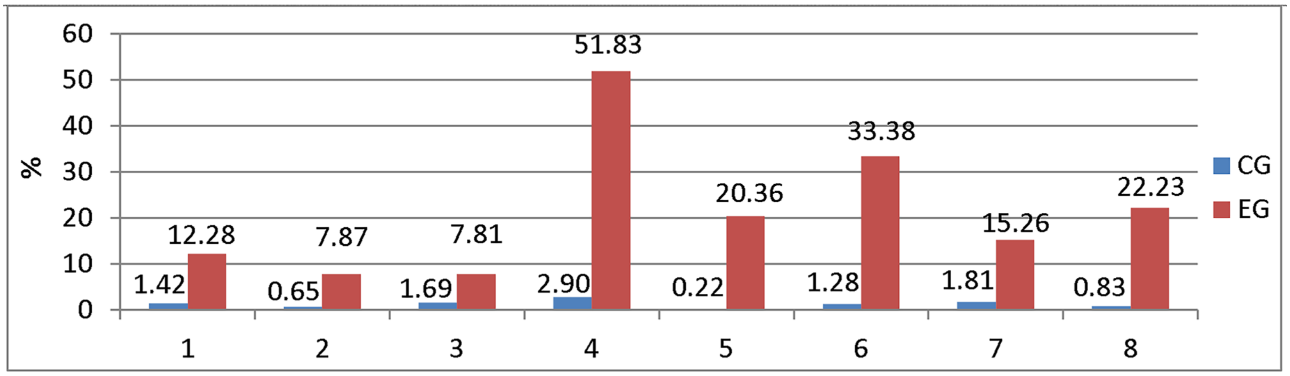


Figure 3. Increase in the indicators of physical performance and functional capabilities of biathletes' breathing for the third period of the experiment

The biathletes of the reference and experimental groups at the fourth stage of the experiment had the following increase results: PWC 170 - 1.85% and 13.92%; MOC - 0.66% and 5.12%; MEI - 0.83% and 9.05%; Expiratory reserve volume (ERV) - 16.76% and 44.78%; Ventilation per minute - 0.28% and 12.66%; Respiratory volume (TB) - 6.54% and 36.87%; Respiratory volume (TB) - 0.95% and 32.37%; Forced inspiration volume (FIVC) - 0.12% and 39.11% (Figure 4).

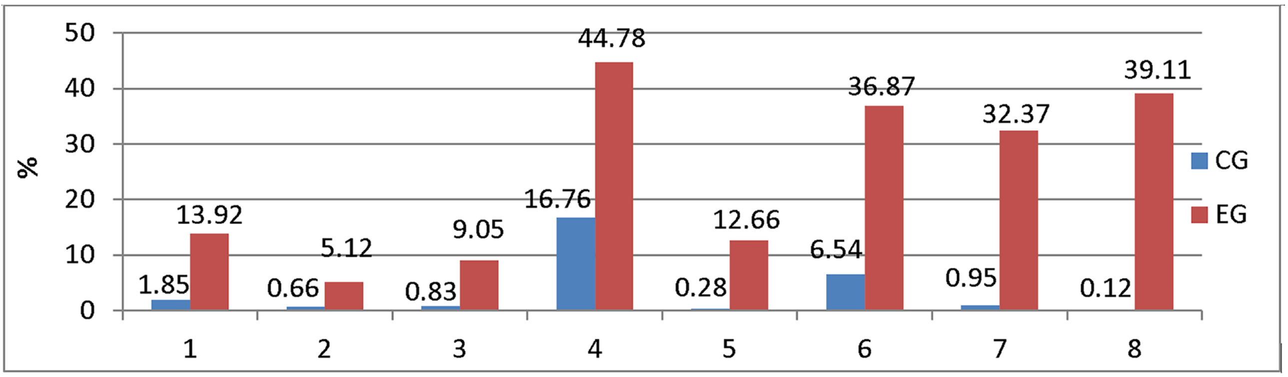


Figure 4. Increase in the indicators of physical performance and functional capabilities of biathletes' breathing for the fourth period of the experiment

Discussion

Analysing the data of growth rates, we can conclude that, during the experiment period, there is an improvement in the performance of the reference and experimental group biathletes at all stages of training. However, the increase in performance in the experimental groups is significantly higher than that in the reference groups.

Summarizing the results of the study, we can conclude that the use of the method of developing stamina based on the integrated use of respiratory exercises has created optimal conditions for improving the indicators of physical performance and the functional capabilities of breathing in the experimental group biathletes.

The obtained indicators of reserve capacity and body resistance to oxygen deficiency in the biathletes are presented in Table 2.

Table 2. Indicators of Reserve Capacity and Resistance of the Biathletes' Body to Oxygen Deficiency in the Experimental and Reference Groups during the Experiment

No.	Parameters	Periods	Gr.	Stage 1	Stage 2	Stage 3	Stage 4
1	Stange's test (s)	Start	CG	87.00±18.87	94.75±18.55	84.40±12.39	61.40±11.54
			EG	88.30±5.00	94.30±19.69	83.45±12.60	61.10±12.03
			p	0.767	0.941	0.811	0.936
		End	CG	89.00±5.74	96.70±18.77	85.95±8.64	63.05±12.07
			EG	97.80±5.59	103.45±18.57	92.30±11.13	66.95±13.03
			p	0.000	0.26	0.065	0.065
2	Timed expiratory capacity (s)	Start	CG	75.20±10.68	83.10±17.32	73.35±8.26	51.80±10.50
			EG	75.00±3.60	83.70±18.01	72.85±8.32	50.80±14.43
			p	0.937	0.915	0.85	0.803
		End	CG	77.40±5.34	85.50±17.32	73.70±8.58	53.35±10.06
			EG	85.60±4.12	92.40±18.06	81.90±8.43	56.85±14.30
			p	0.000	0.225	0.012	0.012

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No.	Parameters	Periods	Gr.	Stage 1	Stage 2	Stage 3	Stage 4
3	Serkin's test No. 1 (s)	Start	CG	57.50±5.45	59.80±4.64	61.10±5.22	58.60±7.16
			EG	57.30±2.27	59.90±5.12	60.50±6.56	57.05±4.39
			p	0.88	0.949	0.751	0.415
		End	CG	59.60±5.15	61.40±5.11	62.50±4.99	60.00±7.15
			EG	64.70±2.62	65.90±7.18	68.20±7.67	61.90±5.43
			p	0.000	0.028	0.008	0.008
4	Serkin's test No. 2 (s)	Start	CG	17.75±2.81	24.70±2.99	27.05±4.49	28.30±4.50
			EG	17.90±1.86	24.30±3.53	28.25±5.04	28.95±5.23
			p	0.843	0.701	0.431	0.676
		End	CG	19.25±3.58	26.90±3.45	29.80±5.06	29.85±4.33
			EG	24.80±2.65	30.85±3.05	34.85±5.26	35.00±4.87
			p	0.000	0.000	0.004	0.004
5	Serkin's test No. 3 (s)	Start	CG	35.80±3.37	43.95±4.25	59.10±5.93	59.75±4.54
			EG	35.70±2.90	43.30±5.02	60.35±6.82	59.10±7.38
			p	0.92	0.661	0.54	0.739
		End	CG	39.30±5.32	45.65±4.34	61.10±5.48	61.05±5.01
			EG	42.70±3.40	50.15±5.44	68.05±7.47	64.80±8.73
			p	0.021	0.006	0.002	0.002
6	Total reserves (c.u.)	Start	CG	41.45±3.76	40.40±4.02	39.85±6.54	38.10±6.75
			EG	41.95±3.20	41.00±3.60	40.85±5.19	38.55±5.62
			p	0.653	0.622	0.595	0.82
		End	CG	42.15±2.94	42.35±4.85	42.25±6.94	40.10±7.37
			EG	51.55±4.10	46.50±5.57	47.10±5.63	46.75±46.75
			p	0.000	0.016	0.02	0.02
7	Physical reserves (c.u.)	Start	CG	20.00±3.45	23.85±3.10	24.45±3.75	26.50±3.32
			EG	20.20±3.05	24.05±1.90	25.25±5.99	25.95±4.43
			p	0.847	0.807	0.616	0.659
		End	CG	21.50±3.44	26.30±3.45	26.85±3.76	28.45±3.75
			EG	29.50±4.20	30.20±3.52	31.75±5.85	35.60±7.71
			p	0.000	0.001	0.003	0.003
8	Mental reserves (c.u.)	Start	CG	57.50±4.97	59.70±3.77	59.35±6.53	58.45±6.85
			EG	57.85±5.46	62.85±3.60	59.75±5.78	59.50±5.86
			p	0.833	0.49	0.839	0.605
		End	CG	59.00±5.43	61.75±4.13	60.95±6.20	61.00±6.87
			EG	68.50±5.17	68.80±4.30	67.90±5.80	67.85±67.85
			p	0.000	0.000	0.007	0.007
9	Adaptation reserves (c.u.)	Start	CG	75.25±3.18	72.75±5.07	70.15±6.18	69.35±6.67
			EG	75.85±4.16	73.25±5.19	70.80±6.01	70.10±6.21
			p	0.611	0.76	0.738	0.738
		End	CG	76.85±4.73	75.00±4.95	72.25±6.23	71.75±6.81
			EG	84.30±4.37	79.00±6.30	77.10±6.54	79.00±8.28
			p	0.000	0.032	0.021	0.021

The determination of indicators of reserve capacity and resistance of the body to the lack of oxygen in biathletes at the end of the experiment indicates the presence of significant differences between the mean values of the experimental and reference groups according to several indicators ($P < 0.05$).

When analysing the obtained data on the state of reserve capacity and body resistance of biathletes to the oxygen deficiency in the studied groups, it should be noted that throughout the experiment, the growth rates of the indicators in the experimental groups were significantly higher than those in the control groups.

Summarizing the study results, we can conclude that the use of an experimental technique allowed us to create optimal conditions for increasing the indices of reserve capacity and the body's resistance to oxygen deficiency in the experimental groups.

Thus, the obtained results confirm the feasibility of arranging and conducting training sessions using the developed tools for stamina development based on the integrated use of respiratory exercises.

Improvement in the process of arranging and expanding the content of physical training for biathletes using multidirectional means aimed at developing stamina and the integrated use of breathing exercises creates favourable conditions for the further development of the adaptive capabilities of the functional systems of their body. This contributed to the effectiveness of the competitive activity of biathletes.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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