



Functional state of the circulatory and respiratory systems in highly qualified athletes when using hyperbaric oxygenation in training conditions in the middle mountain region

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Abstract

Objective of the study was to study of the dynamics of the functional state of the circulatory and respiratory systems in highly qualified athletes using HBOT in training conditions in mid-mountains.

Methods and structure of the study. The study of the effects of HBO in the training of athletes in mid-mountain conditions was carried out during training camps with 11 highly qualified female athletes at an altitude of 1240 meters in Kislovodsk, on Mount Maloe Sedlo. The course of HBOT procedures was carried out in a BaroOx 1.0 pressure chamber with the following parameters: excess pressure – 30 kPa, oxygen content – 93±2%, air flow – 45 l/min, compression/decompression rate – 6 kPa/min. The duration of one procedure is 30 minutes, the course is at least 7 procedures, 1 procedure per day.

Results and conclusions. Positive effects of the use of HBOT in female athletes during training in mid-mountain mountains were observed after the course in terms of heart rate variability parameters in the form of an increase in parasympathetic activity, while after the 1st session the power indicators of very slow waves indicated a hyperadaptive reaction. After a course of 7 procedures, changes in central hemodynamics also occurred: vascular tone and blood pressure decreased. The general condition caused by increased tone of the parasympathetic part of the autonomic nervous system in women led to a relaxing effect, including on the respiratory muscles

The results obtained allowed the authors to propose an effective strategy for training athletes in mid-altitude areas, designated as «Live high - train high, recover with additional oxygen». This method is recommended for general recovery of the body after a training day, micro- and mesocycle, and during the off-season training period.

Keywords: athletes, functional state, cardiovascular system, respiratory system, mid-altitude, hyperbaric oxygenation.

Introduction. Hyperbaric oxygenation (HBO) is an artificial increase in the oxygen capacity of the blood due to additional dissolution of oxygen in the plasma as a result of an increase in the partial pressure of oxygen in the inhaled gas mixture due to an increase in the total barometric pressure of the external environment [5].

The use of HBO to improve the functional capabilities of athletes in a number of studies has shown a positive effect, consisting in improving the functional state and increasing physical and mental performance [1, 2, 3, 4, 6, 7]. Scientists have also noted that under HBO conditions, not only accelerated recovery of the body occurs, but also an expansion of physiological

reserves, as evidenced by the achievement of initial values by most of the studied indicators by the 30th minute of recovery, and then even exceeding them [4]. However, the issue of using HBO to restore athletes in the conditions of training in the mid-altitude areas remains unexplored.

Objective of the study was to identification of the dynamics of the functional state of the circulatory and respiratory systems in highly qualified female athletes using HBO in training conditions in the mid-altitude areas.

Methods and structure of the study. The study of the effects of HBO in the preparation of athletes in

mid-mountain conditions was conducted during the training camp at an altitude of 1240 meters in Kislovodsk, on the Maloye Sedlo mountain, among 11 highly qualified female athletes (CMS, MS; mixed group in sports: sambo, cross-country skiing, figure skating, handball).

The course of HBO procedures was carried out in the BaroOx 1.0 pressure chamber using a Covidien LLC mask, USA, in a preset program with the following parameters: excess pressure - 30 kPa, oxygen content - $93 \pm 2\%$, air flow - 45 l/min, compression/decompression rate - 6 kPa/min. The duration of one procedure is 30 minutes, the course is at least 7 procedures daily, body position - reclining. The study of central hemodynamics and heart rate variability (HRV) parameters was conducted using the ESTECK System Complex (LD Technology, USA). Spirometry parameters of athletes were determined using the Carefusion MicroLab Mk8 spirometer (South Wales, UK).

All participants gave informed consent to participate in the study in accordance with the World Medical Association Declaration of Helsinki (WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects, 2013), as well as permission to process personal data. The study was approved by the Bioethics Committee of the Federal State Budgetary Institution SKFNC FMBA of Russia.

Statistical data processing was performed using the Statistica 13.0 computer program. Comparison of parameters was performed using the nonparametric Wilcoxon test. The parameters are presented as medians and quartiles.

Results of the study and discussion. Comparison of the HRV parameters before the HBO sessions, immediately after the 1st session, 10 minutes after the 1st session and after the course of procedures in female athletes did not reveal statistically significant changes, but there was a tendency for the HR to decrease 10 minutes after HBO compared to the baseline level (Fig. 1A). For the HF parameter - the power of fast high-frequency waves, there was a positive tendency for it to increase 10 minutes after HBO in athletes who had not previously had COVID-19 (before – 758,38 (585,11; 1015,1) ms^2 ; 10 minutes after – 1734,57 (998,57; 2086,71) ms^2). The LF indicator – the power of slow low-frequency oscillations – significantly decreased after the HBO course (before – 731,07 (505,87; 984,3) ms^2 ; immediately after the 1st session – 711,66 (441,24; 894,39) ms^2 ; 10 minutes after the 1st session – 808,8 (619,2; 1086,15) ms^2 ; after the course – 426,23 (265,4; 940,66) ms^2). There

was also a tendency for the VLF index to decrease after the entire course of HBO, while after the 1st session it increased (up to – 665,24 (618,97; 848,75) ms^2 ; immediately after the 1st session – 695,94 (639,81; 992,72) ms^2 ; 10 minutes after the 1st session – 1219,29 (577,34; 1759,04) ms^2 ; after the course – 620,17 (414; 712,03) ms^2). There was a tendency for the tension index to decrease (Fig. 1B) immediately after the 1st session of HBO (before – 100,3 (73,8; 128,2) conventional units; immediately after the 1st session – 81,55 (39,7; 111,5) conventional units; 10 minutes after the 1st session – 48,35 (44,9; 113,35) conventional units; after the course – 107,3 (65,1; 149,4) conventional units).

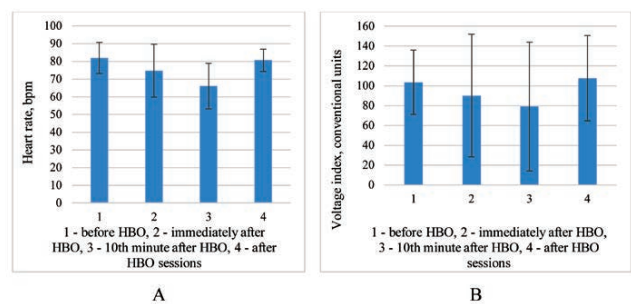


Fig. 1. Heart rate (A) and stress index (B) in highly qualified female athletes under the influence of hyperbaric oxygenation during training in mid-altitude conditions

When analyzing the central hemodynamic parameters, a decrease in the stiffness index (Fig. 2A) was observed, characterizing the blood pressure in large arteries both in one session and after a course of HBO procedures (before – 6,22 (5,26; 6,86) m/s; immediately after the 1st session – 6,02 (5,27; 6,29) m/s, $p < 0,05$; 10 minutes after the 1st session – 6,15 (6,02; 6,62) m/s; after the course – 5,94 (5,24; 6,56), $p < 0,05$) m/s.

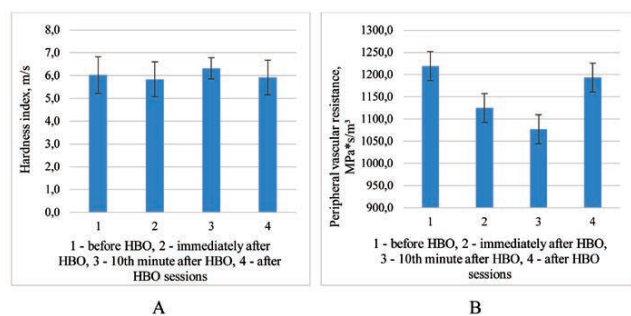


Fig. 2. Rigidity index values in highly qualified female athletes under the influence of hyperbaric oxygenation during training in mid-altitude conditions



After the first session, the PSS values decreased (before – 1207,6 (1132,9; 1243,8) MPa*s/m³; immediately after the 1st session – 1180,3 (975,5; 1243,5) MPa*s/m³, p<0,05; 10 minutes after the 1st session – 1062,9 (823,15; 1330,2) MPa*s/m³, p<0,05; after the course – 1156,6 (1074,3; 1342,5) MPa*s/m³ (Fig. 2 B) and BPd (before – 67 (64; 74) mm Hg, p<0.05; immediately after the 1st session – 64 (59,5; 69,5) mm Hg, p<0,05; 10 minutes after the 1st session – 65,5 (61,5; 70) mm Hg; after the course – 64 (61; 69)) mm Hg.

According to the indicators of external respiration function, after the course of HBO, FVC statistically significantly decreased (before – 4,25 (4; 4,77) l; after the course – 4,13 (3,85; 4,53) l, p<0,02).

Conclusions. Thus, the positive effects of HBO in highly qualified female athletes in the conditions of training in the mid-altitude areas according to the HRV parameters were manifested in the form of an increase in parasympathetic activity after the entire course. Changes in the functional indices of central hemodynamics in athletes under the influence of HBO consisted of a decrease in vascular tone of blood pressure and a hyperadaptive reaction after the 1st HBO session. The general condition caused by an increase in the tone of the parasympathetic division of the ANS in women led to a relaxing effect, including on the respiratory muscles. In general, this method is recommended for general recovery of the body after a training day, micro- and mesocycle, and in the off-season training period. The results obtained allowed us to propose an effective strategy for training athletes in the mid-altitude areas, which we designated by analogy with the existing ones [6, 7], as «Live high - train high, recover with additional oxygen».

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References

1. Koryagina Yu.V., Ter-Akopov G.N., Nopin S.V. Sovremennyye tekhnologii i efekty gornoy i gipoksicheskoy podgotovki sportsmenov. *Kurortnaya meditsina*. 2017. No. 3. pp. 170-174.
2. Ter-Akopov G.N., Koryagina Yu.V., Abutalimova S.M. Vozdeystviye gipoksii srednegorya i kislorodoterapii na dinamiku funktsionalnogo sostoyaniya kardiorespiratornoy sistemy organizma sportsmenov, perebolevshikh COVID-19. *Teoriya i praktika fizicheskoy kultury*. 2023. No. 8. pp. 44-46.
3. Chernyak A.V., Neklyudova G.V., Naumenko Zh.K., Pashkova T.L. Funktsiya vneshnego dykhaniya u sportsmenov, zanimayushchikhsya lyzhnymi gonkami i konkobezhnym sportom. *Pulmonologiya*. 2019. No. 29 (1). pp. 62-69.
4. Shchurov A.G., Dmitriev G.G., Endaltsev B.V. Dinamika vosstanovleniya funktsionalnogo sostoyaniya sportsmenov posle fizicheskoy nagruzki v usloviyakh giperbaricheskoy oksigenatsii. *Teoriya i praktika fizicheskoy kultury*. 2016. No. 2. pp. 37-39.
5. Branco B.H., Fukuda D.H., Andreato L.V., Santos J.F., Esteves J.V., Franchini E. The Effects of Hyperbaric Oxygen Therapy on PostTraining Recovery in Jiu-Jitsu Athletes. *PLoS ONE*. 2016. Vol. 11. № 3 P. e0150517.
6. Ishihara A. Mild hyperbaric oxygen: mechanisms and effects. *J Physiol Sci*. 2019. Vol. 69. No. 4. pp. 573-580.
7. Sperlich B., Zinner C., Hauser A., Holmberg H.C., Wegrzyk J. The impact of hyperoxia on human performance and recovery. *Sports Med*. 2017. Vol. 47. No. 3. pp. 429-438.