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Optimization Of The Physical And Functional State Of Female Students By Means Of Hypoxic Exposure.

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ABSTRACT

The performance of any motor actions with high intensity occurs under conditions of normobaric hypoxia. Adaptation to hypoxia is considered as a factor of optimization of functionality when exposed to physical exertion. Purpose: to improve physical preparedness and the level of functional systems by the method of hypoxic effects. Participants in the study: students aged 17-20 years in the amount of 72 people. The assessment of the level of physical preparedness and the state of the oxygen-transport system has been carried out. Results: an increase in the level of physical preparedness and oxygen-transport system with no significant changes in functional systems was found, which indicates the absence of stress during hypoxic exposures and is evidence of the efficiency of the oxygen-transport system and reflects the optimal adaptation potential of students of non-special faculties. Conclusion: the use of hypoxic effects optimizes the effect of physical exertion on the body and contributes to the improvement of physical preparedness and functional state.

Keywords: physical preparedness, hypoxic effects, adaptation, functional state.

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INTRODUCTION

Physical education is one of the important means of harmonious development of students, preservation of health and socialization in modern society. Therefore, in higher educational institutions it is necessary to create modern systems of physical education and the necessary conditions for students to master the basic means of improving physical performance and their functional state (Aghyppo O. et al., 2016).

Analysis of the dynamics from course to course of physical performance and functional status in 65% of students is below the standard level, and causes a decrease in the level of health (Imas E. & Michuda A., 2015 and Malenyuk T.V. & Kosovskaya A.V., 2015).

The sharp decline in physical preparedness causes not only a decrease in academic performance, a decrease in the level of health, but also ultimately causes a sharp decline in economic production (Bailey D.M., Daves B. & Baker J., 2000; Buultjens M. & Robinson P., 2011 and Demchenko Anastasiia, 2018).

In recent times, a significant amount of scientific research has appeared that is dedicated to optimizing physical education in order to increase the level of physical performance of students (Castelli D.M., Hilman C.H., Buck S.M. & Erwin H.E., 2007 and Darst P.W. et al., 2009).

One of the features of the process of physical education of students of an unsportsmanlike profile is the use of special techniques that do not cause significant stress on the oxygen transport system (Kozlov S.A., 1997 and Krivoschekov, S.G., Divert, V.E., & Divert R.M., 2015). The use of the system of normobaric hypoxic effects optimizes the process of physical education of female students of non-sports faculties, which determines the relevance of this study (Rovniy Anatoly, Pasko Vladlena & Galimskyi Volodymyr, 2017 and Rovniy Anatoly et al., 2018).

Purpose of the research.

To improve physical preparedness and the level of functional systems by the method of hypoxic effects.

METHODS AND ORGANIZATION OF RESEARCH

Participant. Female students aged 17–20 years in non-sports profiles in the amount of 72 people.

Procedure (research organization). A method of hypoxic training was developed, which consisted of two parts:

1. method of return breathing in a confined space;
2. circuit training.

Method of return breathing in a confined space. The subject breathed into a 30 l Douglas bag. For 10 episodes with an interval of 20 s. The duration of respiration in each series was measured. After the cessation of breathing, the air from the bag was pumped through the gas clock and the indicators of the oxygen-transport system were determined. 10 such sessions were held at the end of the training session;

Circuit training included 5 tasks performed at a maximum pace of 15 seconds each. Circuit training included such tasks:

1. jumping on the spot pulling the knees to the chest (number of times);
2. push-ups (number of times);
3. squatting (number of times);
4. lifting the body from the support lying on the hips (number of times);
5. lying on the stage on the back, legs bent at the knees with an emphasis on the floor, lifting the body (number of times).

To establish the role of hypoxic training in increasing anaerobic performance, multiple regression analysis was used, which determines the role of each factor in the adaptation mechanism, as well as in the implementation of test tasks.

Statistical analysis. The processing of the results of the research was carried out using the "Data Analysis" package of Microsoft Excel spreadsheets. Indicators of descriptive statistics (mean arithmetic mean, standard deviation and error of average value) were determined. The statistical reliability of differences in mean values was estimated by the Student's test, the differences were considered reliable when ($p < 0,05$).

RESULTS OF THE RESEARCH

During the return breathing sessions, the maximum breathing time and the oxygen transport system parameters were recorded. Analysis of the research materials indicates a clear linear relationship between the indices of the duration of respiration in a confined space and the saturation indices of carbon dioxide ($FeCO_2$) and oxygen (FeO_2) in exhaled air. The course of hypoxic training was carried out three times a week on days when students did not exercise. There were 10 sessions of return breathing, 10 episodes in each session.

The analysis of the research materials indicates a clear linear relationship between the indices of the duration of respiration in a confined space and the indices of an increase in carbon dioxide tension ($FeCO_2$) and a decrease in oxygen (FeO_2) in exhaled air (Table 1).

Table 1: Initial indicators of the reaction of the oxygen-transport system of first-year female students after exposure to normobaric hypoxia (n=68)

T, min	$FeCO_2$, %	FeO_2 , %	BC, l	RR, number of times	RMV, l/min	HR, beats/min	OUF_2 , ml/min
4,50±0,03	2,80±0,07	19,25±0,01	0,58±0,01	18,50±0,09	10,53±0,62	65,00±0,70	32,23±0,48
4,30±0,01	5,13±0,01	17,00±0,03	0,54±0,03	19,00±0,04	10,26±0,17	71,10±0,70	33,30±0,78
4,00±0,07	5,35±0,04	15,30±0,04	0,52±0,04	19,35±0,02	10,06±0,11	74,30±0,60	33,50±0,41
3,60±0,03	6,18±0,03	14,21±0,03	0,48±0,05	18,60±0,07	8,92±0,09	82,10±0,50	29,50±0,11
3,10±0,04	6,75±0,04	13,85±0,07	0,51±0,03	18,20±0,01	9,28±0,06	94,10±0,70	30,30±0,71
2,60±0,01	7,23±0,02	13,00±0,05	0,49±0,07	19,12±0,03	9,36±0,08	100,50±0,50	29,00±0,61
2,20±0,03	7,44±0,07	12,40±0,08	0,44±0,06	20,00±0,01	8,81±0,05	105,20±0,73	32,66±0,51
1,80±0,02	7,65±0,01	12,10±0,09	0,40±0,03	21,00±0,03	9,60±0,07	107,50±0,91	26,30±0,55
1,40±0,06	7,83±0,04	11,81±0,04	0,43±0,04	21,125±0,04	9,08±0,05	107,40±0,82	25,60±0,35
0,80±0,03	8,01±0,06	11,38±0,02	0,46±0,05	20,50±0,07	9,61±0,03	109,30±0,35	25,01±0,32

The duration of return breathing in the tenth series of the first session decreased by 82,0%. This was due to an increase in $FeCO_2$ by 92,5% and a decrease in FeO_2 by 7,5%. It is characteristic to note that the increase in heart rate by 7,6%, occurs in parallel with the RMV by 69,6%, which occurs due to the increase in RR by 50,0% despite the fact that BC decreased by 19,5%.

Thus, the compensatory mechanism in the first series of return breathing is an increase in RMV and heart rate.

In order to determine the mechanisms of hypoxic adaptation of first-year female students, a regression analysis was used, which determines the role of each factor of the oxygen-transport system in ensuring hypoxic performance. The presented mathematical model shows the intersystem interaction in the regulation of the duration of return breathing. So, after the first series of hypoxic training (Formula 1), the level of significance and interaction of factors of the cardiorespiratory system of female students at the beginning of the first year is:

$$T_{min} = 4,57 \times RR + 3,39 \times RMV + 3,58 \times HR - 1,75 \times OUF_2 - 1,37 \times BC + 1,05 \times FeCO_2 + 2,15 \times FeO_2, \quad (1)$$

where T_{min} – total duration of recurrent respiration; RR – respiratory rate; RMV – respiratory minute volume; HR – heart rate; OUF_2 – oxygen utilization coefficient; BC – breathing capacity; $FeCO_2$ – concentration of carbon dioxide in the exhaled air and FeO_2 – oxygen concentration in the exhaled air.

Using the method of inverse step-by-step regression, the most important factors in ensuring the duration of the return breathing (Formula 2):

$$T_{min} = 5,63 \times RR + 5,37 \times BC + 3,93 \times HR, (2)$$

where T_{min} – duration of recurrent respiration; RR – respiratory rate; BC – breathing capacity; HR – heart rate.

To establish the level of dependence of physical performance at the beginning of the first course of the oxygen transport system, the equation was calculated stepwise regression (Formula 3):

$$PWC_{170} = 7,45 \times T_{min} + 4,37 \times RMV + 3,32 \times BC - 3,12 \times RR + 2,75 \times FeO_2 + 2,56 \times HR - 1,75 \times OUF_2 + 1,37 \times FeCO_2, (3)$$

where PWC_{170} – level of physical performance; T_{min} – duration of recurrent respiration; RMV – respiratory minute volume; BC – breathing capacity; RR – respiratory rate; FeO_2 – oxygen concentration in the exhaled air; HR – heart rate; OUF_2 – oxygen utilization coefficient; $FeCO_2$ – concentration of carbon dioxide in the exhaled air.

Applying the method of step-by-step return regression, the three most important factors for ensuring physical performance (Formula 4):

$$PWC_{170} = 6,38 \times T_{min2} + 5,73 \times RMV + 2,78 \times HR, (4)$$

where PWC_{170} – level of physical performance; T_{min2} – total duration of recurrent respiration; RMV – respiratory minute volume; HR – heart rate.

Conducting normobaric interval training for 10 sessions at the end of each semester contributed to an increase in the level of physical preparedness of female students at the end of the first year (Table 2).

Thus, the result of 30 m running improved by 0,14 s ($p < 0,01$), while the shuttle running indicator 4x9 m improved by 0,51 s ($p < 0,001$).

Table 2: Dynamics of indicators of physical preparedness of female students in the first year (n=68)

Indicators	M±m	M±m	t	p
	Beginning of the experiment	End of the experiment		
Running 30 m, s	5,48±0,04	5,34±0,07	3,42	<0,01
Jogging 1200 m, min	9,21±0,03	9,01±0,02	2,47	<0,05
Standing long jump, cm	149,63±1,43	165,32±1,23	2,38	<0,05
Push-ups, number of times	7,40±0,17	17,13±0,43	4,72	<0,001
Lifting the torso in the saddle from a prone position, the number of times	29,50±0,15	33,27±0,12	3,18	<0,01
Squatting on two legs, number of times	24,87±0,18	35,77±0,12	4,85	<0,001
Torso leaning forward from a sitting position, cm	14,73±0,47	19,47±0,26	3,44	<0,01
Shuttle run 3x10, s	11,74±0,07	11,23±0,05	5,29	<0,001

Hypoxic training contributed to improved results in the types of speed-strength endurance. Thus, push-ups indicators increased by 9,77 times ($p < 0,001$), lifting the body from the prone position by 3,77 times

($p < 0,01$), squatting on two legs by 10,9 times ($p < 0,001$). In addition, hypoxic training contributed to an improvement in the rate of walking by 0,20 min. ($p < 0,05$).

For a more complete characterization of the level of physical performance, we conducted a cycle-ergometric study PWC₁₇₀. At the beginning of the first course, this indicator was equal to 628,14±1,55 kg m/min, which corresponds to a level below the average. At the end of the first year students showed a lower result by 4,8%, which corresponds to an average level ($p < 0,05$).

Indicators of hypoxic stability of female students at the end of the first year increased significantly compared with initial data (Table 3).

Table 3: Summary indicators of the oxygen-transport system indicators of the reaction of the oxygen-transport system of female students after exposure to normobaric hypoxia (n=68)

T, min	FeCO ₂ , %	FeO ₂ , %	BC, l	RR, number of times	RMV, l/min	HR, beats/min	OUF ₂ , ml/min
5,60±0,03	3,90±0,03	19,15±0,03	0,62±0,07	17,50±0,09	10,85±0,07	66,00±0,13	31,32±0,21
5,30±0,01	4,70±0,04	18,30±0,02	0,58±0,03	18,20±0,04	10,55±0,08	70,10±0,15	33,30±0,17
5,10±0,07	5,30±0,07	17,10±0,04	0,52±0,05	18,82±0,02	10,91±0,12	74,40±0,31	34,20±0,31
4,60±0,03	6,15±0,02	15,80±0,05	0,48±0,04	18,60±0,04	9,28±0,06	78,50±0,18	29,50±0,21
3,90±0,04	6,55±0,04	14,20±0,02	0,46±0,02	17,80±0,03	8,18±0,08	94,50±0,21	30,30±0,18
3,20±0,07	7,20±0,03	13,40±0,03	0,44±0,04	19,20±0,01	8,44±0,03	100,80±0,27	29,20±0,32
2,60±0,03	7,50±0,05	13,00±0,01	0,46±0,07	19,80±0,07	9,10±0,08	105,80±0,21	27,30±0,18
2,20±0,04	7,70±0,08	12,80±0,04	0,44±0,06	20,20±0,03	8,93±0,04	107,80±0,29	26,80±0,31
1,80±0,05	7,95±0,03	12,40±0,05	0,46±0,08	20,60±0,05	9,47±0,07	109,80±0,31	26,20±0,28
1,40±0,04	8,00±0,06	12,10±0,05	0,45±0,05	20,80±0,04	9,36±0,08	109,50±0,43	25,80±0,31

Thus, the indicator of total breathing time in a closed space increased from 27,3 minutes to 35,7 minutes, i.e. by 29,6%. The indicator of carbon dioxide tension in exhaled air (FeCO₂) increased by 59,5%. The breathing capacity (BC) decreased by 6,8% slightly in the tenth series, but the respiratory rate (RR) increased by 5,0%, which provided a slight increase in the respiratory minute volume (RMV) by 5,0%.

A slight increase (by 8,0%) in the heart rate ensured faster delivery of oxygen to working muscles, which significantly increased the level of PWC₁₇₀ on 4,1% ($p < 0,05$).

Undoubtedly, an increase in PWC₁₇₀ contributed to the increased resistance of the oxygen-transport system to hypoxic exposure. To prove this assumption, a regression analysis was performed on the role of oxygen transport system factors in increasing the physical performance of female students at the end of the first year (Formula 5):

$$PWC_{170} = 7,85 \times T_{min2} + 5,84 \times OUF_2 + 4,88 \times FeO_2 + 3,75 \times RMV + 2,86 \times HR - 2,48 \times BC + 2,32 \times RR + 1,28 \times FeCO_2, \quad (5)$$

where PWC₁₇₀ – physical performance indicator at the end of the first course; T_{min2} – total breathing time in confined space; OUF₂ – oxygen utilization coefficient; FeO₂ – oxygen concentration in the exhaled air; RMV – respiratory minute volume; HR – heart rate; BC – breathing capacity; RR – respiratory rate and FeCO₂ – concentration of carbon dioxide in the exhaled air.

The calculation of the mathematical model of the return step-by-step regression revealed the most important factors of the oxygen-transport system in ensuring the physical performance of first-year female students (Formula 6):

$$PWC_{170} = 5,88 \times T_{min2} + 4,47 \times HR + 4,28 \times OUF_2, \quad (6)$$

where PWC₁₇₀ – level of physical performance; T_{min2} – total breathing time in confined space; HR – heart rate and OUF₂ – oxygen utilization coefficient.

The conducted studies have determined the mechanisms for ensuring the physical performance of first-year female students of non-specialized faculties without causing significant stresses of the oxygen-transport system. It is hypoxic effects that increase the stability of the oxygen-transport system during exercise.

DISCUSSION

One of the main problems of improving the professional suitability of students in various specialties is the proper level of physical development, physical preparedness and health. However, at present the level of physical development and the state of health of students is constantly decreasing with each year of study (Hochachka P.W., Rupert J.I. & Monge C., 1999; Houli E.T. & Frenks B.D., 2000; Kolchinskaya A. Z., Tsiganova T. N. & Ostapenko, L. A. , 2003; Hill M., 2007 and Novitskaya N.A., 2015).

Scientific studies of the traditional system of physical education in higher educational institutions do not meet modern requirements and do not provide the necessary level of physical development of students. In addition, the need to change the system of physical education is also caused by the transition to a credit-modular system of education (Shevchenko O.V. & Vinogradova L.S., 2013 and Serorez T., 2014).

One of the most relevant systems of physical education in the conditions of the Bologna process should be an optional (sectional) form of organization of physical education classes in universities of Ukraine, which is widely developed (Blagoy A. & Lysakova N., 2013 and Belyak Yu.I., 2014).

Conducting a theoretical analysis, established diverse types of organization of optional classes in physical education among students (Zaitsev S.S., 2010 and Stadnyk Svitlana, 2018).

At the same time, the majority of researchers propose to use the system of sectional classes in combined shaping as a system of physical education in universities, which includes the development of physical qualities, rhythmic gymnastics and sports games (Hochachka P.W., Rupert J.I. & Monge C., 1999; Hill M., 2007; Zaitsev S.S., 2010 and Stadnyk Svitlana, 2018).

In the process of conducting sectional lessons on combined shaping, adaptation mechanisms of the body systems of students are formed, which provide the necessary level of physical development and health (Bultjens M. & Robinson P., 2011 and Kosovskaya A.V., 2015).

Recently, hypoxic effects are widely used, which do not cause excessive stresses of the body systems, but contribute to an increase in functional activity, which ultimately ensures an increase in the level of physical development and health in general. The combination of physical exertion with hypoxic effects allows you to significantly optimize the process of physical education (Hochachka P.W., Rupert J.I. & Monge C., 1999; Rovniy Anatoly Stepanovitch, Pasko Vladlena Vitaliivna & Grebeniuk Oleg Viktorovich, 2017; Rovniy Anatoly, Pasko Vladlena & Martyrosyan Artur, 2017 and Rovniy Anatoly, Pasko Vladlena, Dzhym Viktor & Yefremenko Andriy, 2017).

This is confirmed by the results of our research, which significantly improved the indicators of physical development and physical performance in terms of PWC₁₇₀. It has been established that one of the main mechanisms of adaptation to hypoxic effects is the rate of gas exchange in the lungs and the delivery of oxygen by blood to working muscles (Zaitsev S.S., 2010 Rovniy Anatoly, Pasko Vladlena, Stepanenko Dmytro & Grebeniuk Oleg, 2017 and Rovniy Anatoly et al., 2018).

CONCLUSIONS

Considering the issue of restructuring the system of physical education in higher educational institutions, studying the existing studies of this problem, it is necessary to make a conclusion about its inexpediency - hasty and non-systematic loads cause an unwillingness to exercise. It is necessary theoretically and practically to cause students motivation for systematic classes.

Conducted research and literature data indicate that the sectional sessions as a combined shaping include a wide variety of physical exercises that form the students' motivation to regular physical exercise.

A very important issue in the method of physical education of students is the optimization of physical activity. The carried out studies recommend including hypoxic effects into the system of combined shaping, which do not cause significant stresses of the functional systems and form an increase in the adaptation mechanisms to physical loads.

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