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Original Article

Dynamics of special physical preparedness of 16-18-year-old rugby players under hypoxic influence

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Abstract:

Purpose: to determine the possibility of increasing the level of special physical preparedness of rugby players of 16-18 years old by means of hypoxic influences. Results: after 10 sessions of hypoxic action during return breathing in confined space and circular special training, a significant increasing of the special physical preparedness level is observed. These results are based on the patterns of adaptation of the organism to a gradual decrease in the volume of oxygen (O2) in the respiratory air. In the process of integral hypoxic training (IHT), were recorded the cardiovascular parameters (blood pressure systolic and diastolic, heart beats) and respiratory systems (lung ventilation (LV), breathing rate (BR), coefficient of the use of oxygen (CO O2)). In addition, the percentage of carbon dioxide (PCO2) and oxygen (PO2) in the exhaled air was determined. To establish the dependence of the level of special physical readiness, a linear multiple regression analysis was used that determines the role of each factor in performing complex technical elements of the game technique. The application of reverse step regression has made it possible to establish the most important factors. Materials of the study: indicate the need to include in the training process hypoxic effects. Competitive activity of rugby players is carried out under constant hypoxic influences. Inclusion of integral hypoxic training and special hypoxic effects promotes an increase in the level of anaerobic working capacity. Conclusions: results of research have determined the adaptation patterns of the oxygen transport system of rugby players of 16-18 years to hypoxic influences. Inclusion in the training process of interval hypoxic training contributed to a more significant increase in general and special physical preparedness, which gives grounds for using hypoxic training tools in sports practice.
Key words: adaptation, Rugby League, hypoxia, interval hypoxic training.

Introduction

Modern level of sports achievements, according to the leading scientists of physical culture and sports [19, 20] exacerbated sports competition in competitive activities at various levels. This puts forward higher requirements for the system of training athletes. It is proved that increasing level of efficiency of the training process is carried out in the presence of a system-structural approach. Now it is proved that the system of training in game sports and especially in rugby is based on subjective approaches, rather than on objective information about the functional state and level of special preparedness of athletes. However, there are already materials of in-depth studies [3, 10, 16, 17], which indicate that the management of the training process must be carried out in conditions that are as close to competitive and on the basis of quantitative characteristics of special physical and technical preparedness [1, 14, 15, 18].

Modern Rugby League requires high demands to the level of physical qualities, functional capabilities, which are manifested in hypoxic conditions. [25]. Motor activity of rugby players is characterized by great variability of the performed movements, which are different in character and structure. These are individual, group, command actions performed in the constant changing of the situation in the static and dynamic modes [9, 12, 13, 21]. Continuous motor activity is 70-120 seconds, which is provided by anaerobic capacity. Therefore, the performance of training assignments should occur with maximum intensity to increase the level of hypoxic resistance [25, 29]. The lack of objective data on the technology of hypoxic preparation of rugby players, the role of hypoxic effects in special physical preparedness and determined the direction of these studies.

Materials and methods

Participants

26 athletes-rugby players (12 attackers and 14 defenders) aged 16-18 years who had the level of training of the first sports category and the candidate for the master of sports of Ukraine took part in the research.

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The design of the study suggested the development of a hypoxic training technique, which consisted of two parts:

1. method of return breathing in the closed space (Douglas bag with a volume of 30 liters);

2. circular training, which included 5 tasks performed at the maximum rate of 15 seconds. The transition from one exercise to another passed without rest. Circuit training included such tasks: 1. Jump in place with pulling your knees to your chest (count times); 2. Benchpress with mass 25 kg (count times); 3. Tackle after (count times); 4. Sit-up on the hips on vault (count times); 5. Shuttle run 3x10 m (count times).

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

Statistical analysis

Generalization of the studied characteristics was assessed by mean arithmetic value, standard deviation and error of mean arithmetic. Confidence of differences between mean values was stated by Student's t-criterion. Assessment of statistical hypothesizes based on 5% significance level. For statistical processing of data we used licensed program Microsoft Excel (2010). Statistical analysis of the received results was conducted, considering recommendations on Microsoft Excel tables' usage for computer data analysis.

Results and discussions

The conducted researches and their discussions confirm necessity of search of methods of management of training process. The level of athletic preparedness is formed due to the development of functional capabilities, which are carried out due to physical, technical and hypoxic training [19, 20]. Therefore, the use of breathing in the confined space contributed to the overall development of the oxygen transport system and hypoxic productivity (Table 1).

Analyzing preliminary research materials, a gradual decrease in the duration of recurrent respiration in the confined space in each series and a significant change in the ratio of the voltage of carbon dioxide ($FeCO_2$) and oxygen (FeO_2) was established. The duration of recurrent respiration at the beginning of the experiment in the tenth series decreased by 88.4%, and after hypoxic training by 81.4%. This was facilitated by the mobilization of the oxygen transportation system. Thus, an increase in increased in respiratory minute volume of 8.7% ($p<0,05$) and heart beats (HB) of 7.3% was observed, which ensured the necessary ventilation of respiration. An increase in the parameters of respiratory minute volume and heart beats (HB) promoted an increase in the content of FO_2 in the exhaled air by 9.8% and a decrease in $FeCO_2$ by 9.5%).

Another type of hypoxic training, according to studies [7, 26], is circular training (Figure 1). The ten-day course of performing special motor actions in acute anaerobic regime promoted a reliable increase in all the parameters of the circular training: 1st – by 30.2%, 2nd – by 27.2%, 3rd – by 33.3%, 4th – by 19.2% and the 5th – by 21.4%.

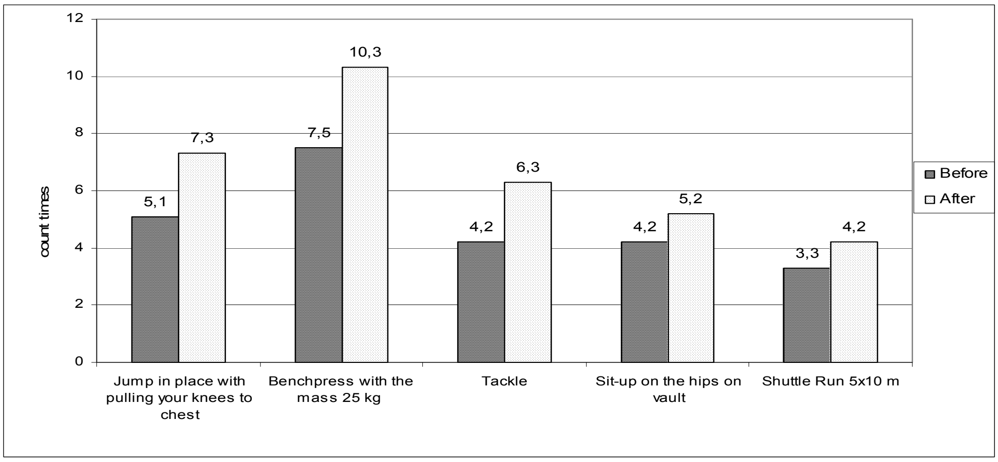

Fig. 1. Dynamics of test scores of rugby players 16-18 years old before and after hypoxic training

The results of general physical preparedness testify to an increase in the indicators as a result of the influence of hypoxic training (Table 2). However, in both groups there are unreliable changes. So athletes aged 16-17 years old have an unreliable increase in two indicators: "run at 400 m" (2.2%) and "running 12 minutes" (1.6%). In the of 17-18 years old group rugby players one indicator is observed, which has no reliability of increase – "running 12 minutes" (2.1%). The largest percentage increase is observed in "tightening from the hinge". In the first group, the result increased by 41.4%, in the second group by 33.3%.

Table 1. Indicators of the reaction of the oxygen transport system of rugby players 16-18 years before and after exposure to hypoxic training (n=26)

T, min		$FeCO_2$, %		FO_2, %		Respiratory minute volume litre per min		Heart beats per min		CO O_2, мl/per min	
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
7,00±0,01	7,50±0,03	1,80±0,02	2,30±0,03	18,30±0,03	19,20±0,07	8,80±0,03	9,40±0,01	66,20±0,70	64,40±0,40	38,40±0,60	32,10±0,40
6,60±0,03	6,90±0,04	4,30±0,01	4,00±0,07	15,00±0,03	17,70±0,06	9,10±0,05	10,60±0,01	69,30±0,31	71,20±0,60	34,80±0,20	33,20±0,50
5,30±0,02	5,80±0,04	5,70±0,03	5,40±0,04	14,50±0,07	15,20±0,02	11,60±0,02	12,20±0,02	73,70±0,73	72,20±0,27	36,80±0,70	34,30±1,20
3,80±0,01	4,30±0,06	6,70±0,06	6,10±0,02	13,30±0,03	14,40±0,02	11,10±0,04	12,20±0,01	76,60±0,81	74,30±0,67	34,80±0,60	31,30±0,40
3,30±0,02	3,50±0,04	7,30±0,03	6,40±0,08	12,80±0,05	14,30±0,02	11,00±0,06	11,90±0,04	84,20±0,73	81,80±0,61	32,30±0,20	28,70±0,70
2,80±0,03	3,10±0,06	6,90±0,04	6,30±0,02	12,50±0,06	13,80±0,01	11,20±0,05	12,00±0,03	96,30±0,81	87,20±0,57	31,30±0,10	29,50±0,60
2,20±0,02	2,80±0,02	7,50±0,03	7,20±0,01	12,10±0,04	13,20±0,07	11,40±0,01	12,30±0,07	105,50±0,89	91,50±0,71	30,80±0,90	27,20±0,50
1,80±0,01	2,30±0,05	7,90±0,08	7,40±0,06	11,80±0,04	12,60±0,03	11,70±0,05	12,80±0,06	109,90±0,78	105,80±1,01	28,60±0,10	24,50±0,30
1,20±0,05	1,80±0,03	8,40±0,03	7,60±0,04	11,90±0,03	12,60±0,02	11,90±0,04	13,60±0,06	113,80±1,01	109,40±1,10	27,60±0,30	25,80±0,40
0,80±0,02	1,40±0,04	8,80±0,02	7,80±0,04	11,20±0,07	12,00±0,05	12,30±0,04	14,80±0,01	119,40±0,91	114,10±1,11	26,70±0,80	24,70±0,20

Remark: T_{min} is duration of the recurrent breathing in the first session; $FeCO_2$ is the concentration of carbon dioxide in an exhalation; FeO_2 is the concentration of oxygen in the exhalation; respiratory minute volume liter is increased in pulmonary ventilation; HB is heart beats; CO O_2 is the coefficient of the use of oxygen.

Table 2. Indicators of the general physical preparedness of rugby players 16-18 years before and after hypoxic training (n=26)

Tests	16-17 years				17-18 years			
	Before	After	t	p	Before	After	t	p
Run at 30 m from the high start, s	4,60±0,07	4,40±0,07	2,50	<0,05	4,50±0,08	4,30±0,06	3,30	<0,01
Run at 60 m from the high start, s	8,80±0,09	8,40±0,06	3,20	<0,01	8,60±0,04	8,20±0,01	4,70	<0,01
Run at 100 m from the high start, s	13,50±0,10	13,00±0,09	3,50	<0,01	13,20±0,09	12,80±0,05	4,50	<0,01
Run at 400 m, s	70,00±1,40	65,00±1,20	2,20	>0,05	65,00±1,05	61,30±0,67	4,70	<0,01
Running 12 min, m	2700,00±64,09	2900,00±73,04	1,56	>0,05	2800,00±11,07	3100,00±17,20	1,30	>0,05
Jump in length, cm	220,00±3,12	240,00±3,05	2,50	<0,05	230,00±1,05	250,00±0,75	3,16	<0,01
Triple jump from place, cm	680,00±7,15	720,00±8,05	2,70	<0,05	700,00±2,15	752,00±1,17	3,85	<0,01
Jump up from space, cm	42,15±0,95	52,32±0,73	3,60	<0,01	45,27±1,21	52,25±1,21	3,57	<0,01
Bending / Extending the hands from the lying position, count times	44,15±0,79	51,72±0,81	3,50	<0,01	42,50±1,17	50,00±1,12	3,33	<0,05
Tightening from the hinge, count times	7,50±0,53	12,30±0,27	3,20	<0,01	8,50±0,61	12,70±0,27	3,08	<0,05
Benchpress, kg	70,50±1,12	83,70±0,79	3,60	<0,01	78,50±1,17	87,70±0,75	4,68	<0,01
Lifting the bar on the chest, kg	80,70±1,15	95,50±1,25	4,70	<0,001	80,70±1,27	91,30±1,65	2,65	<0,05
Squats with shoulder straps, kg	100,50±1,12	115,30±1,53	4,50	<0,001	105,60±1,51	125,30±1,43	3,71	<0,05

Analyzing the indices of special physical readiness (Table 3), a positive effect of hypoxic training was determined. In general, positive changes in indices are observed in both groups. However, in both groups there are also unreliable results. For example, in the group of 16-17 years old athletes, unreliable changes were observed in the indicators "a kick and catching of ball from move" where the improvement was only 1.4% and "shot on gates", where the improvement was only 1.2%. The greatest improvements are observed in the test tasks:"run at 30 m" (14.2%), "catching the ball after 1 minute strike" (19.5%), "tackle after 30 s" (18.3%).

Table 3. Indicators of special physical preparedness of rugby players 16-18 years before and after hypoxic training (n=26)

Tests	16-17 years				17-18 years			
	Before	After	t	p	Before	After	t	p
30 m run with a ball, s	4,90±0,05	4,70±0,03	7,60	<0,001	4,70±0,05	450±0,10	4,00	<0,01
5 min run, m	1350,00±21,19	1550,00±23,07	8,20	<0,05	1450,00±91,19	1650,20±47,13	0,87	>0,05
Shuttle run (5x10 м), s	7,10±0,07	6,60±0,04	8,70	<0,01	6,90±0,06	6,60±0,07	5,40	<0,001
A pass of ball in pair after 1 min, count times	38,50±0,15	40,40±0,27	2,50	<0,05	40,03±1,07	43,80±0,95	1,36	>0,05
Tackle after 30 s, count times	7,70±0,03	8,40±0,07	10,90	<0,001	8,60±0,09	9,20±0,06	7,16	<0,001
A kick of ball "lob", m	26,50±0,87	30,80±0,95	2,30	<0,05	28,70±1,14	34,30±1,25	1,69	>0,05
Catching the ball after 1 minute strike, count times	7,80±0,07	9,70±0,06	8,80	<0,001	8,20±0,04	8,90±0,06	11,60	<0,001
A kick and catching of ball from move, count times	8,30±0,03	8,60±0,10	1,36	>0,05	8,80±0,11	9,30±0,09	5,00	<0,001
A shot on distance from hands, m	32,60±0,21	38,80±0,41	5,50	<0,001	38,80±0,75	45,60±0,07	2,82	<0,05
"Drop-kick", m	32,20±0,36	36,80±0,41	4,20	<0,01	34,40±0,27	40,80±0,21	6,50	<0,001
Shot on gates, m	37,50±0,75	38,80±0,52	1,25	>0,05	33,50±0,87	40,60±0,27	7,30	<0,001

In the 17-18 age group there are two unreliable changes in the indicators: "running 5 minutes" (1.2%) and "a kick of ball "lob" (1.4%). The most significant changes were observed in the exercises: "a pass of ball in pair after 1 min" (15.1%), "a shot on gates" (17.4%), "drop-kick" (15.6%).

Analyzing the results of the influence of hypoxic influences, generally positive changes in the indices of general and special physical preparedness have been established. Of all the indices, we determined the three most characteristic indices characterizing the specificity of the motor activity of the rugby players: "a kick and catching of ball from move", "tackle after 30 seconds", and "a shuttle run 3x10 m".

In order to determine the mechanisms of support in performing these motor tests, the regression analysis method was applied, which establishes the role of each factor in the oxygen transport system in providing hypoxic performance.

Formula 1 shows the dependency and interrelation of the factors of the cardiorespiratory system in providing the exercise – "a kick and catching of ball from move for 1 minute" in the first group.

$$N_1=5,37xBR+3,78xBR_{T\ exhalation}+3,39xHB–2,51xDO+2,15xCO\ O_2+1,95x\ FeCO_2+1,36xBR_{T\ inhalation}+0,72xVC+0,21xFO_2 \text{ (formula 1)}$$

where N_1 – number of times performing the exercise; BR is breathing rate; $BR_{T\ exhalation}$ is the volume of the forced exhalation; HB is heart beats; DO is the respiratory volume; $CO\ O_2$ is the coefficient of the use of oxygen; $FeCO_2$ is the concentration of carbon dioxide in an exhalation; $BR_{T\ inhalation}$ is a volume of the forced inhalation; VC is the vital capacity of lungs; FO_2 is the concentration of oxygen in the exhalation.

Applying the method of step-by-step regression feedback, the most important factors are established in ensuring the execution of the "A kick and catching of ball from move for 1 minute" (formula 2).

$$N_2=3,81xRV+2,82xBR_{T\ inhalation}+1,57xHB \text{ (formula 2)}$$

where N_2 – number of kicking and catching of a ball; RV is the respiratory volume; $BR_{T\ inhalation}$ is a volume of the forced inhalation; HB is heart beats.

In the second group of rugby players, when performing the first exercise, this dependence was established by the method of reverse regression (formula 3):

$$N_3=5,72xHB+4,43xFO_2–3,38xCO\ O_2 \text{ (formula 3)}$$

where N_3 – number of kicking and catching of a ball; HB is heart beats; FO_2 is the concentration of oxygen in the exhalation; $CO\ O_2$ is the coefficient of the use of oxygen.

When performing the second test (formula 4), the inverse step regression equation looks like this:

$$N_4=5,63xRV–3,58xBR_{T\ exhalation}+2,53xBR_{T\ inhalation} \text{ (formula 4)}$$

where N_4 – number of athletes tackle of the 16-17 years old; RV is the respiratory volume; $BR_{T\ exhalation}$ is the volume of the forced exhalation; $BR_{T\ inhalation}$ is a volume of the forced inhalation.

Rugby players of 17-18 years have a slightly different dependence on ensuring the performance of the test (formula 5):

$$N_5=5,63xVC–3,58xBR_{T\ inhalation} \text{ (formula 5)}$$

where N_5 – number of athletes tackle of the 17-18 years old; VC is the vital capacity of lungs; $BR_{T\ exhalation}$ is the volume of the forced exhalation; $BR_{T\ inhalation}$ is a volume of the forced inhalation.

When performing the third test, the mathematical model of reverse step regression includes such factors (formula 6):

$$B_1=2,38xBR+2,23xHB+0,97xRV \text{ (formula 6)}$$

where B_1 – time of performing shuttle run 3x10 m first group; BR is breathing rate; HB is heart beats; RV is the respiratory volume.

In the second group of 17-18 year-old athletes, this dependence of the assurance of the test is established (formula 7):

$$B_2=5,63xCO\ O_2+4,58xRV+2,58xBR_{T\ inhalation} \text{ (formula 7)}$$

where B_2 – time of performing shuttle run 3x10 m second group; $CO\ O_2$ is the coefficient of the use of oxygen; RV is the respiratory volume, $BR_{T\ inhalation}$ is a volume of the forced inhalation.

The carried out researches have defined the mechanism of interaction of indicators of oxygen-transport system in maintenance of performance of special tests. Examining the materials of the study from the positions of the game role it is established that, in general, the indices of general and special physical preparedness of attackers and defenders are almost the same as the average. Differences are observed more in terms of overall physical fitness. Thus, the attackers have statistically significant advantages in "run at 30 m, 60 m, 100 m", in "jump in length" and " triple jump from place". Defenders have advantages in "running 12 minutes " and in all strength exercises.

Discussion

In the process of training rugby players at a specialized basic stage, much attention is paid to speed-strength and special-technical preparedness. An important process at this stage is the search for tools and methods that enhance the functionality of the body of rugby players, since the realization of physical possibilities occurs through the functional systems of the organism [4, 6, 8]. In the process of competitive and training activities, adaptive patterns of the body's functional systems are formed, which provide the necessary level of special working capacity. The use of special research methods that provide objective information about the levels of functional changes makes it possible to optimize the training process taking into account the specificity of the motor activity [5, 22]. Currently, one of the effective methods of sports training in sports games and single combats is the normobaric interval hypoxic training, which, in a modification with hypoxic competitive loads, has a significant effect in the management of the training of athletes [2, 7].

Adaptation processes of the body systems to hypoxic hypercapnia is a complex integral reaction, during which intrasystemic and inter-system reconstructions are carried out, which determine the specific performance of athletes [23, 24]. This scientific position was confirmed in our studies in the process of applying hypoxic influences. The carried out researches have shown a role of various factors in performance of special impellent tests of the general and special physical readiness. So, when performing the first test in the first group, the main factors are the respiratory volume (RV), forced exhalation ($BR_{T\ exhalation}$) and heart beats (HB). When performing the second test, the main factors of the oxygen-transport system are the respiratory volume (RV), forced inspiration ($BR_{T\ inhalation}$) and forced exhalation ($BR_{T\ exhalation}$). When performing the third test, the determining factors are breathing rate (BR), heart beats (HB) and respiratory volume (RV).

In the second group, the same factors, the notes appear in different sequences. The materials of our studies confirm the data, which show that in the confrontations there is a high intensity of motor actions, in which the ability to work is to increase the functionality of the oxygen transport system [27, 28]. At the same time, fundamental research [7, 26]. It is evidenced that the level of oxygen consumption, the energy cost of physical exertion and the level of adaptive reserves are the weighty factor for achieving high sports results in regbilig [11, 26]. Our results are confirmed by the results of the study [22, 23, 24], which indicate that at the stages of hypoxic preparation, the increase in $FeCO_2$ is a stimulator of increased ventilation of the lungs, which occurs due to frequencies and depth of breathing.

Conclusions

The carried out researches have defined adaptable laws of oxygen transport system of rugby players of 16-18 years to hypoxic influences. Hypoxic normobaric training is an indispensable preparation tool, which involves breathing into the confined space and special hypoxic loads, such as circular training.

Presented hypoxic training contributed to a significant increase in the indicators of general and special physical preparedness. The application of regression analysis helped to establish the leading factors in the performance of test tasks. Thus, the leading factors in the performance of test tasks are: respiratory volume (RV), breathing rate (BR), forced inspiration ($BR_{T\ inhalation}$), forced exhalation ($BR_{T\ exhalation}$), heart beats (HB), the coefficient of the use of oxygen (CO O_2). The carried out researches give the bases for application of means of hypoxic training in sports practice.

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