

Adaptation of reformation of physiological functions of the organism of the 400 m hurdlers during hypoxic training

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Abstract:

Purpose: research of the adaptation mechanisms of the 400 m hurdlers' organism in the process of the normobaric hypoxic trainings. Results: ten sessions of hypoxic influence are conducted during the recurrent breathing in the reserved space. Interval of the hypoxic training is carried out on the basis of reaction of organism by the gradual decline of volume of oxygen (O₂) in a breathing air. During the reverse breathing in the reserved space the indexes of the cardiovascular system (an arteriotony systole and diastole, frequency of heart-beats) and respiratory system (pulmonary ventilation, breathing frequency, coefficient of O₂, percent accumulations of CO₂ and percent index of O₂) Application of regressive analysis is allowed to define the main factors of providing of the recurrent breathing duration. Research materials testify to the necessity of realization of the hypoxic trainings because an increase of adaptiveness to the hypoxia is the mechanism of development of the special capacity of 400 m hurdlers. Conclusions: research results deepen information about the features of mechanisms of adaptation to certain competition activity. Plugging in the training process the interval hypoxic training assisted more considerable increase of anaerobic capacity of the 400 m hurdlers.

Keywords: adaptation, the 400 m hurdling, recurrent breathing, hypoxia.

Introduction

The level of sporting preparation is carried out due to development of functional possibilities depending on physical, technique, tactic, psychological and the integral training activity. Conditional division of the preparation process on relatively independent parties makes it possible to put in order knowledge about its structural state and also to systematize methods and facilities and so that to work out the checking and training process control system [3, 15, 18].

In the real conditions of training process none of these parties of preparation are revealed solitary but in permanent interdependence.

It is well-proven that achievement of sporting results is possible only at harmonic combination of all parties of preparedness [2, 3, 6].

This scientific thesis is of especially important value at preparation of the 400 m hurdles.

The 400 m running and especially hurdling is one of the most heavy types of sport which researchers named it as "run killer" (Quercetani R.L., 2005).

It is established by some researchers that the most essential factors which determine the load of activity during a 400 m hurdling is a level and duration of influence of hypoxia [12, 15], also individual sensitiveness to the lack of oxygen.

Absence of objective data about technology of hypoxic preparation of the 400m hurdlers defined tendency of our researches.

Materials and methods.

Participants. 18 sportsmen took part in researches 16-18 years of age having a level of preparation of the first sporting ranking and candidate of masters of sport in the 400m hurdling.

A **research design** is supposed to set the impact of hypoxic influence on the organism of sportsmen by method of recurrent breathing in the sack of Douglas of volume of 30 liters.

An examinee breathed of air from this sack, and an expirate on a hose again went back into the sack. Time of the possible breathing by the recurrent expirate was fixed [10, 19].

During the tests the safety of athletes was controlled and the also proper progress of the training. The study was conducted in accordance with the Helsinki Declaration. The study was approved by the ethics

committee of the Kharkov State Academy of Physical Culture. All participants gave informed consent and were acquainted with the procedure of the study.

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 hypotheses 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.

With the purpose of establishment of mechanisms of adaptation in providing of maximal possibility of the recurrent breathing a regressive analysis which determines the role of every factor in the hypoxic productivity was used in the reserved space. Application of incremental reverse regression enables to define the most meaningful factors in providing of adaptation to the hypoxic conditions.

Results of research and their discussion

During the series of the recurrent breathing the maximal time of breathing was fixed at which certain frequency of breathing was held. The analysis of the obtained data testifies to obvious linear dependence between duration of breathing in reserved space and the indexes of FeCO_2 increase and FeO_2 decline in exhalation (table 1).

Table 1. Indexes of duration of the recurrent breathing and functional state during the first session of the recurrent breathing for the 400 m hurdlers

T, min	FeCO_2 , %	FO_2 , %	Respiration volume litre per min. ⁻¹	Heart beats per min.	Coefficient O_2 , ml/per min.
7,5±0,03	1,8±0,01	19,3±0,07	9,36±0,002	65±0,7	37±1,4
6,6±0,01	4,0±0,02	17,0±0,1	10,64±0,011	71±0,78	33±0,9
5,6±0,01	5,4±0,01	15,5±0,07	11,7±0,01	71±0,9	35±0,7
4,0±0,03	6,1±0,01	14,3±0,12	12,16±0,03	74±1,01	31±0,4
3,1±0,04	6,3±0,01	14,1±0,13	11,9±0,04	82±1,01	29±1,0
2,6±0,01	6,7±0,03	13,8±0,12	11,88±0,02	94±1,0	30±0,4
2,2±0,01	7,2±0,02	13,0±0,08	12,12±0,03	100±1,58	31±0,7
1,8±0,02	7,4±0,03	12,4±0,12	12,8±0,01	102±1,53	26±0,9
1,7±0,03	7,5±0,01	12,3±0,09	13,02±0,05	105±1,23	26±1,1
0,7±0,02	7,7±0,02	11,8±0,09	14,08±0,03	107±1,22	27±1,2

The presented materials of research testify to the gradual decline of every series of the recurrent breathing and considerable change of correlation of CO_2 and O_2 . Thus, duration of the recurrent breathing in the tenth series as compared to the first diminishes on 90,7%. As conformity to law it assisted to the increase of FeCO_2 by 61,5% and decline of FeO_2 diminished by 42,5% ($p < 0,001$).

In the tenth series of recurrent respiratory volume (DO_2 , liter) on 1,75%, that caused the increase of respiration volume by 45% due to frequency of breathing. It was observed an increase of heart beats by 36,2% and diminishing of coefficient O_2 by 27,1% ($p < 0,001$).

Analyzing the research materials it is possible to conclude that a permanent increase of FeCO_2 in expiration is a stimulant of the increase of pulmonary ventilation, it rises due to the increase of breathing frequency despite of some decline of respiratory volume; the increase of ventilation of lungs was 45%, and decline of respiratory volume – 1,75%. It is significant that the increase of rate of HB took place in parallel to the increase of breathing frequency and was 36,2% ($p < 0,001$).

The research results are analogical to reference data [5, 15, 19] which indicate that increase of FeCO_2 by 7% frequency of breathing rises sharply. At the less indexes of accumulation of CO_2 considerable increase of breathing frequency was not observed. It can indicate to the decline of sensitiveness of respiratory center for the 400 m hurdlers to such strong stimulus, as CO_2 , that is explained by long duration of adaptation to the conditions of the training and competition activity. At the same time the increase of concentration of FeCO_2 by 8% considerably affects respiratory center.

Thus, compensatory mechanism during the recurrent breathing is an increase of indexes of ventilation of lungs and frequency of heart beats in the reserved space.

Normobaristic interval hypoxic training of the 400 m hurdlers proceeded 10 sessions, each of which made 10 series. The presented materials of the research (table. 2) testify to the considerable increase of every series of the recurrent breathing and increase of levels of the functional state. Thus, general duration of the tenth session of the recurrent breathing was 39,9 min., that by 11,5% more than in the first session ($p < 0,001$).

Table 2. Indexes of the functional state and duration during the recurrent breathing after tenth session for the 400 m hurdlers

T, xB	FeCO ₂ , %	FO ₂ , %	DO ₂ , litr.	Respiration rate per min. ⁻¹	Respiration volume litre per min. ⁻¹	Heart beats per min	Coefficient O ₂ , ml/per min.
8,0±0,03	1,8±0,01	19,3±0,07	0,72±0,01	12±0,09	8,64±0,01	65±0,7	39±0,4
7,1±0,07	4,0±0,02	17,0±0,1	0,76±0,04	13±0,08	9,88±0,02	72±0,78	38±0,5
6,6±0,03	5,4±0,02	15,5±0,07	0,78±0,01	14,0±0,1	10,93±0,03	71±0,9	35±0,7
4,5±0,04	6,3±0,01	14,3±0,03	0,76±0,02	15±0,11	11,40±0,02	73±0,8	33±0,1
3,6±0,01	6,5±0,03	14,1±0,01	0,70±0,03	16±0,09	11,20±0,01	81±1,01	30±0,4
2,6±0,01	6,9±0,04	13,8±0,02	0,66±0,01	17±0,09	11,22±0,02	94±1,0	30±0,7
2,8±0,02	7,4±0,03	13,0±0,08	0,64±0,04	18±0,09	11,48±0,03	99±1,5	33±0,6
1,8±0,01	7,6±0,03	12,4±0,06	0,64±0,01	19±0,11	12,16±0,02	102±1,5	28±0,5
1,7±0,02	7,8±0,01	12,3±0,05	0,63±0,03	20±0,12	13,40±0,05	104±1,2	28±1,1
1,7±0,03	8,0±0,02	11,8±0,09	0,64±0,02	21±0,11	13,44±0,03	108±1,21	27±0,7

The individual changes of frequency of heart beats, frequencies and breathing depths under act of hypoxic influences represent the joined character of co-operation of reactions of the system

of breathing and circulation of blood. For example, if the index of FeCO₂ goes down there is a decline of indexes of heart beats. To positive influence of the hypoxic training testifies circumstance that function, breathing in such terms promotes the adaptation possibilities. The evidences of it are research materials. Thus, after the first session of the recurrent breathing in the tenth series FeCO₂ rose by 5,9%, and FeO₂ went down by 7,5%. After the tenth session FeCO₂ rose by 1,5%, and FeO₂ – by 3,5% (p<0,001).

For determination of mechanisms of adaptation in providing of burst anaerobic performance method of the regressive analysis which determines the role of every factor in providing of the hypoxic productivity was used.

The brought mathematical models over of regressive analysis show co-operation of intersystem and intrasystem connections in adjusting of duration of the recurrent breathing (formula 1).

$$T_{\min 1} = 3,75 \times \text{FB} + 7,58 \times \text{DO} + 2,19 \times \text{HB} - 1,25 \times \text{CO O}_2 - 0,37 + \\ + \text{FB}_{\text{T exhalation}} + 0,93 \times \text{FeCO}_2 + 3,05 \times \text{FeCO}_2 + 0,27 \times \text{LV} + 0,17 \times \text{FB}_{\text{T inhalation}} \quad (\text{formula 1})$$

where T_{min1} is duration of the recurrent breathing in the first session; FB is breathing frequency; DO is a respiratory volume; HB is frequency of heart beats; CO O₂ is a coefficient of the use of oxygen; FB_{T exhalation} is a volume of the forced exhalation; FeCO₂ is a concentration of carbon dioxide in an exhalation; FeO₂ is a concentration of oxygen in an exhalation; LV is a vital capacity of lungs; FB_{T inhalation} is a volume of the forced inhalation.

Thus, equalization of multiple regression defined that during realization of the first sessions of the recurrent breathing determinatives which provide urgent adaptation to the hypoxia are breathing frequency, respiratory volume and frequency of heart beats. It confirms equalization of reverse incremental regression (formula 2).

$$T_{\min} = 7,58 \times \text{RF} + 4,57 \times \text{DO} + 3,75 \times \text{HB} \quad (\text{formula 2})$$

where T_{min} is duration of the recurrent breathing in the first session; DO is a respiratory volume; HB is frequency of heart beats.

Thus, the mechanism of urgent adaptation is limited by the range of functional possibilities of breathing and circulation of blood.

In the process of experiment after the tenth session of the recurrent breathing in the reserved space adaptation reactions to the hypoxia was changed considerably. Equalization of multiple regression has the such appearance of intercommunication of providing factors (formula 3).

$$T_{10\min} = 6,32 \times \text{CO O}_2 + 5,48 \times \text{FeO}_2 + 3,12 \times \text{FR} + 2,58 \times \text{DO} - 2,81 \times \text{HB} - \\ - 1,25 \times \text{LV} + 3,15 \times \text{FeCO}_2 + 0,58 \times \text{FB}_{\text{T inhalation}} + 0,47 \times \text{FB}_{\text{T exhalation}} \quad (\text{formula 3})$$

where T_{10min} is duration of the recurrent breathing in a tenth session; CO O₂ is a coefficient of the use of oxygen; FR is breathing frequency; DO is a respiratory volume; HB is frequency of heart beats; LV is a vital capacity of lungs; FeCO₂ is a concentration of carbon dioxide in an e exhalation; FB_{T inhalation} is a volume of the forced inhalation; FB_{T exhalation} is a volume of the forced exhalation.

Equalization of the multiplied regression testifies that at the end of the tenth session the most essential value in providing of the protracted adaptation to the hypoxia has a coefficient of the use of oxygen. Equalization of reverse incremental regression determines two main factors in providing of duration of the recurrent breathing (formula 4).

$$T_{10\min} = 5,72 \times \text{CO O}_2 + 4,37 \times \text{FeO}_2 \quad (\text{formula 4})$$

where $T_{10 \text{ min}}$ is duration of the recurrent breathing in the tenth session; CO_2 is a coefficient of the use of oxygen; FO_2 is a concentration of oxygen in an exhalation.

Thus, realization of research of influence of the hypoxic training testifies that application of the recurrent breathing in the reserved space assists perfection of mechanisms of providing of anaerobic capacity of the 400 m hurdlers.

Discussion

In the process of training and competition activity the adaptation mechanisms of the functional systems of organism of sportsmen which provide the necessary level of the special capacity are formed. Establishment of objective information about levels functional possibilities enables to define the level of preparedness of sportsmen and to effectively optimize a training process [1, 12, 14].

Hypoxic influences are widely used in a training process and are one of the effective methods of increase of the special capacity in any kinds of sport of submaximal intensity. The unification of the hypoxic training with modification of the physical loading allows to improve substantially the process of preparation control of sportsmen [12, 14, 16, 24].

Olivier Girard on the example of preparation of sprinters established (2016), that a hypoxia possessed more expressed influence than ambient temperature.

The special attention is deserved by materials of research of Heikki Rusko with coauthors (2004) in which the increase of efficiency of adaptation is shown at alternation hypoxic and normoxic loading, that allows to bring to the minimum harmful effects at the chronic hypoxia.

Positive hypoxic influences are presented in researches of Sybil M.G., Svysch Y.S. (2009), which show that the considerable increase of adaptation possibilities are related to maintenance of biochemical equilibrium. The presented researches over determination of perspective of study of these mechanisms of hypoxic adaptation for the 400 m hurdlers which determine objective general vital signs in adjusting and holding for some time of the stable state of homeostasis.

Adaptation of the systems of organism to the terms of hypoxic hypercapnia is a difficult integral reaction intrasystem and intersystem reformation of organism show up in which, that stipulate the specific capacity of the 400 m hurdlers [4, 5]. It scientific thesis is confirmed by our researches in the process of influence of normobaristic interval hypoxia. It is determined that after the first series of application of interval hypoxia the main factors of adaptation were breathing frequency and frequency of heart beats. After the tenth session the main factors of adaptation of hypoxia were indexes of coefficient of the use of oxygen (CO_2) and level of concentration of oxygen in an exhalation (FeO_2). Materials of our researches are confirmed by data, which testify that at the 400 m run the main factors of providing of capacity is an increase of the functional possibilities of an oxygen-transport system [20, 22].

At the same time fundamental researches [23] indicate that at the 400 m run for achievement of high sporting results important is a level of oxygen consumption, energetic value of the physical loading and adaptation backlogs of organism [7, 8].

Confirmation of our researches are research results [9, 11], which testify on the initial stages of hypoxic preparation of increase of FeO_2 is stimulant of increase of ventilation of lungs, which rises due to frequency of breathing at the insignificant decline of depth breathing.

One of the mechanisms of adaptation to the hypoxic loading is the rate of interchange of gases in lungs and delivery of oxygen blood to the working muscles [8, 19, 21].

Conclusions

Analyzing materials of the presented researches one can observe a variety of conclusions, which characterize the mechanisms of adaptation to the hypoxic loading. In our view all of them have a right to existence that is why, all these researches were conducted under various conditions, with different aims and different methods.

In our researches the main factors of adaptation to the hypoxic loading is a coefficient of the use of oxygen (CO_2) and concentration of oxygen in an exhalation (FeO_2).

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