COMPARATIVE ANALYSIS OF THE CHANGES IN THE CARDIO-PULMONARY TEST FOLLOWING A PROLONGED INTERVAL NORMOBARIC HYPOXIC TRAINING OF TRACK AND FIELD MIDDLE AND LONG DISTANCE RUNNERS

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The artificial normobaric hypoxia is ever more used for the preparation of competitors practicing disciplines for endurance. Its advantage is because there are no changes in the location, climatic conditions and barometric pressure. Thus it follows that the adaptation to the lack of oxygen passes easier in comparison with the real high mountain condition (Zelenkova et al 2016; Maleev D. 2016; Potapov, Maleev 2016) if the basic requirements for the combination of the two factors hypoxia and physical load are followed. Being a factor of life importance for the organism hypoxia can provoke functional and structural adaptation changes (Krastev, Iliev 1970; Bailely, Davies 1997; Bernardi L. et al 2001; Bonova I. 2016). Depending on the hypoxia degree and the intensity of the physical load appear as well the changes under supervision, which can be both general referring to the complete contingent of the persons under supervision and single referring to the separate individual. Most generally said, the changes can be immediate starting right after the organism is within the hypoxic media and lasting, called long-term ones (Chapman et al 2013; Chapman et al 1998; Flaherty et al 2016). This is the main theses of a range of authors for setting apart both stages of adaptation to the hypoxia known as: a stage of unstable adaptation (initial adapting) and the stage of stable adaptation (lasting adapting). Lung hyperventilation is observed during the unstable adaptation, alkaline-acid equilibrium shifts towards alkaline direction, which is due to the hyper ventilation and increased release of carbon dioxide, increase of the sub maximal cardiac frequency when the maximal cardiac debit is decreased or preserved (Mcardle W. et al 1996; Randall W. 2007). Lung hyperventilation stays during the stage of the long term adaptation but the alkaline reserve is decreased, the sub maximal cardiac debit is decreased to the level prior hypoxia but the maximal cardiac debit is decreased, the concentration of hemoglobin and the number of the erythrocytes is increased. The authors mentioned presume that the number of the capillaries, of the mitochondria is increased; increased are the aerobe enzymes in the muscles too.

Purpose of the study

The aim of this study is to prepare comparative analysis of the functional indicators changes prior and after a six-week experimental methodology of training with normobaric hypoxia applied to track and field middle and long distance runners.

Tasks of the study

1. Study of the functional indicators changes at a level corresponding to the aerobe threshold prior the beginning and immediately after the end of a six-week normobaric hypoxic training;
2. Study of the functional indicators changes at a level corresponding to the anaerobe threshold prior and immediately after a six-week normobaric hypoxic training;

The authors realized the experimental study according to a scientific project of "Vassil Levski" National Academy of Sport during the months of April, May and June 2017; they compared the changes of the

indicators corresponding to various levels of intensity after a long hypoxic training.

Methodology

We have selected twelve higher students – middle and long distance competitors and divided them into two groups, experimental and control ones while each group covered equal number of persons. Prior the beginning of the experiment, we have tested both groups by a incremental cardio-pulmonary test up to refusal for defining the functional capacity. The experimental group have been training for six week according to specially developed methodology of the training. The speed of running is individual for each person under study and corresponds to seventy percent of the maximal oxygen consumption (VO₂max). The quantity of the hypoxic irritator increases each new week by simulated 500 meter height above sea level while the speed stays constant until the end of the experiment. The competitors have three training sessions per week and then pass

to new simulated height. The control group is also preparing for participation in the summer national championship for middle and long distance runs but without a normobaric hypoxic training. The experiment continued during the competitive period covering the stages of early competitions and basic competitions. Following the end of the six-week hypoxic training program, we have tested the competitors in both groups again by cardio-pulmonary test up to refusal for defining the changes.

The competitors are between 18 and 28 years of age, weight 61-71 kg and height of 167-183. We have acquainted each competitor participating in the scientific project with the coming procedures and entered into the list according to his own wish, signing informative agreement. We have planned the scientific project into three stages of complex studies: 1) incoming, 2) final and 3) post-experimental studies. The procedure of the study covers: complete blood test, anthropometry, electrocardiography, cardio-pulmonary test up to refusal and lactate recovery. All tests are made into the Scientific and Applied Activity in Sport Center to "Vassil Levski" National Academy of Sport. Oxycon- Jaeger и Treadmill-Cosmos hp, Germany is the trade mark of the gas analysis apparatus. The system is calibrated prior the test start. The cardio-pulmonary test up to refusal protocol is according to prof. I.Iliev's methodology. It starts with initial speed of 6 km/h, the duration of each step is a minute and a half, the speed of running is increased by 1,2 km/h without changing the inclination, the test goes on up to the individual refusal of the persons under study. We have acquainted each competitor individually with the test prior the testing while during the testing itself they were informed about the time reached and the basic functional indicators. The normobaric training was conducted through mountain air generator Higer-Peak, 2015 year of manufacture USA.

We have statistically processed the average values and the standard deviations by the Paired- Sample t-test, at a level of importance $p = 0,05$.

Analysis of the results

Comparative analysis of the cardio-pulmonary test results corresponding to aerobe threshold level (AeT):

- The comparative analysis of the changes for the Oxygen Consumption indicator measured

at aerobic threshold level (VO_2 ml. /kg. /min.) shows increase (14%) in the experimental group training with artificial hypoxia while in the control group the increase is by 1, 9% (fig.1). The increase of the VO_2 is related to the high levels of the aerobic abilities of the competitor in sports where endurance is a basic quality. The difference between the two groups proves the effect of the offered training methodology combined with artificial hypoxia.

Fig.1 Percentage increase of VO_2 ml/kg/min on the level of Aerobic threshold

- Utilization ($F_{et}O_2$) measured at aerobic threshold level (AeT), following a six-week artificial hypoxia.

The experimental group shows increase of all persons under study while the average increase is 5, 7 %. Considerable change is not observed in the control group (fig.2). The changes under study are measured at mouth level at intensity corresponding to the aerobic threshold. Values of a complete step of intensity corresponding to the aerobe zone of workability are entered for the calculation.

Fig.2 Percent increase utilization of oxygen after 6 week normobaric hypoxia in Experimental and Control group

- Oxygen heart rate (HR/O_2 ml.) measured at aerobe threshold level. This indicator is a derivative one and its calculation is based on the

maximal oxygen consumption and the frequency of the cardiac contractions. The experimental group shows an increase by 10, 2 %, for the control group the increase is by 4, 2% (fig.3). During the post hypoxic study, a decrease of the frequency of the cardiac contractions is established for the group training with hypoxia. The decrease is individual for the various persons under study and varies from three to eight contractions. There is no change for the cardiac contractions frequency indicator for the control group.

Fig.3 Percentage changes in O₂/HR achieved on the level of Aerobic Threshold

- Speed of running achieved at Aerobic threshold level. Fig.4 shows the comparison between the speed of running at aerobe threshold level prior the start of the experiment and immediately after its end as well as the percentage improvement of both groups (experimental and control ones).

Fig.4 Percentage increase of running velocity achieved on the level Aerobic threshold

The experimental group having trained under artificial hypoxia shows increase of the speed of running by 19 % and decrease of the cardiac contractions frequency at the level of intensity studied. These changes show improved economy and effectiveness in the function of the respiratory mechanisms while providing the energy needs of the organism. For the control group the increase of the speed of running corresponding to the level of the aerobe energy exchange is 3, 5 %. Both groups have increased

the speed of running registered at aerobe threshold level while the percentage increase is definitely greater in the experimental group.

- Pulmonary ventilation (VE l. /min.) at aerobic threshold level. The group having trained under hypoxia shows decrease of the minute respiratory volume at a level corresponding to the aerobe energy exchange while in the control group there is no such a tendency (Fig.5) I.e. an improvement of the economy in the work of the aerobic mechanisms is again observed.

Fig. 5 Pulmonary ventilation on equal level to Aerobic Threshold

Comparative analysis of functional indicators at Ventilation threshold intensity level (RER1)

- We executed the post experimental study on the first day following the hypoxic training program. The experimental group shows prolonged time for reaching the Ventilation threshold (RER1), i.e. the ventilation threshold moves to the right side towards higher speed of running, which shows that the competitors have been running for a longer time at an aerobic and mixed regime of energy supply. The control group does not change substantially the time for reaching the ventilation threshold.
- Distinctive difference between both groups experimental and control one is registered for the equivalent of the oxygen indicator at a ventilation threshold level (RER1). The experimental group marks a decrease of the values for all persons under study while the control group registers a slight increase (Fig.6). The measured indicator bears information about the economy and effectiveness in the work of the respiratory system and shows how many liters of air should be ventilated in order to use one liter of oxygen.

Fig. 6 Equivalent of oxygen on level of Ventilatory threshold (RER1)

- Comparative analysis of the changes for the Maximal Oxygen Consumption (VO₂max.) indicator measured at Ventilation threshold level (фиг.7).

Fig.7 Percentage increase of VO₂ ml/kg/min on level Ventilatory threshold (RER1)

Experimental group show increase maximal oxygen consumption of 8, 2% in investigated level but control group – slight decrease.

Conclusions:

The training within an artificially created hypoxic conditions is an effective method for improving the functional economy in the activity of the energy mechanisms of the organism.

This basic conclusion is confirmed by the following results of the studies and analysis effected:

- The comparison of the functional indicators at aerobic threshold level shows that the experimental group has increased the VO₂ max. indicator, which is related to the high levels of the aerobic abilities of the competitors practicing sports where endurance is a basic quality.
- The experimental group shows statistically reliable increase of the lung utilization (FetO₂) indicator measured at aerobic threshold level, the zone of intensity studied corresponds to a stable steady-state.

- Following the experiment, the speed of running at aerobic threshold level is increased for the experimental group. These changes show improved economy and effectiveness in the functioning of the respiratory mechanisms while providing the energy needs of the organism.

- The experimental group having trained with hypoxia shows increase of the minute respiratory volume (VE 1.) at a level corresponding to the aerobic energy exchange, there is no such a tendency for the control group.

- The comparison of the functional indicators at anaerobic threshold level shows that the experimental group has increased the VO₂ max. indicator, the control group does not increase the values of the indicator mentioned.

- The equivalent of oxygen (EqVO₂) functional indicator measured at ventilation threshold (RER1) level notes a decrease of the values for all persons under study from the experimental group, while the control group registers slight increase.

- The post experimental study executed on the first day following the hypoxic training program registers prolonged time to reaching the Ventilation threshold (RER1) i.e. the ventilation threshold moves to the right side towards higher speed of running.

- The cardio-pulmonary test up to refusal covers the whole range of the training intensities of load and can be an objective means for establishing the effected changes in the organism of the competitors.

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