

Original Article

The effectiveness of the endogenous-hypoxic breathing in the physical training of skilled swimmers

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Abstract

The article analyses the effectiveness of the endogenous-hypoxic breathing in the physical training of skilled swimmers. The purpose of the study is to develop and substantiate the program of swimming activities in order to increase the physical fitness of swimmers at the stage of preliminary basic training. According to the results of the study, for the first time it was developed a program of swimming exercises with the application of the endogenous-hypoxic breathing technique in the preparatory period of the annual macrocycle, which improved the efficiency in the aerobic energy supply zone, the functional capabilities of the respiratory muscles, bronchial patency and the stability of the body of swimmers to hypoxia. For the first time quantitative characteristics of practice loads aimed at the development of swimmers speed were developed taking into account the individual abilities. The scientific information about the positive influence of trainings with application of the endogenous-hypoxic breathing technique on the physical fitness and acceleration of the restorative processes of swimmers was expanded at the stage of preliminary basic training. New information was added to the data on the possibility of improving the speed of swimmers taking into account age characteristics.

Keywords: swimmers, training, endogenous-hypoxic breathing, program, effectiveness.

Introduction

The dynamics of the results of winners and prize-winners of world-class competitions (Olympic Games, World and European Championships) in sporting swimming tends to grow steadily. Modern swimming is characterized by a significant increase of the age, in which the swimmers achieve the highest results and the duration of their performances at the highest level (Gruzevych, 2013; Ivashchenko, 2017; Melnyk, 2017). However, despite such world tendencies in achieving the highest sports results, the beginning of sports training and the duration of training of athletes are based on the program-normative frameworks of long-term training of swimmers which are currently in effect on the territory of Ukraine (Gruzevych, 2013; Herasymenko, 2016; Andrieieva, 2017; Gorshova, 2017).

Performing great amount of physical activity by adolescent athletes and especially in the area of anaerobic lactate energy supply, as V.M. Platonov states (2012), may negatively affect the dynamics of sports results increase. A number of scientists (Andrieieva, 2017; Bohuslavska, 2017; Galan, 2016; Gorshova, 2017; Melnyk, 2017) also point out that due to the intensive age-related reorganization of the body, the use of such exercises can disrupt the health of young athletes. In view of this, there is a need to find ways to increase the sports results of young athletes by optimizing the content of training sessions, taking into account age peculiarities, as well as by using additional means in the training process that contribute to increasing the threshold of sensitivity to hypoxia, the effectiveness of physical exercises and the preservation of functional reserves. (Galan, 2016). For this purpose, some scholars, along with traditional means of training, offer to apply the hypoxic training technique using special devices-hypoxicators in the process of training of adolescent athletes under normal atmospheric pressure (Furman, 2014; Bohuslavska, 2017). However, it should be noted that not all methods of hypoxic training are safe in the process of using them by adolescent athletes. According to the data of A. Z. Kolchynska (2003), the permissible reduction of oxygen concentration during hypoxic training in normobaric conditions is 12% for children. Taking this into account, we consider the safe and affordable method of hypoxic training in normobaric conditions in the process of working with young athletes, the endogenous-hypoxic breathing technique, because the oxygen content of the inhaled air is about 18% (Furman, 2014).

For this reason, the promising direction of tackling the question of modernization of the training process of swimmers at the stage of preliminary basic training is the scientific substantiation and integration into the training process of "the endogenous-hypoxic breathing technique".

Purpose of the research

To develop and scientifically substantiate the program of swimming practice for increasing the physical fitness of swimmers at the stage of preliminary basic training.

Materials and Methods

Theoretical analysis and generalization of data of literary sources on the subject of scientific research; Pedagogical observation; Pedagogical experiment (summative and formative); Physical fitness testing; Methods of mathematical statistics.

The research was conducted in the preparatory period of the annual macrocycle within 16 weeks based on the Children's and Youth Sports School number 2 and the Children's and Youth Sports School "Temp" in the city of Vinnytsia, as well as at the Chair of Biomedical Fundamentals of Physical Education and Physical Rehabilitation of the Vinnytsia State Pedagogical University named after Mykhailo Kotsiubynskyi.

The study involved 62 male swimmers aged 13-14 years (qualifications at the level of the second and third sport grades). As a result of the summative experiment, we identified the weaknesses of the physical preparedness of the swimmers during the preliminary basic training. 54 male athletes participated in the formative experiment, they were divided into one control ($n = 18$) and two main groups (the first main group was $n = 19$; the second main group was $n = 17$).

The program of trainings was developed and tested with the application of the endogenous-hypoxic breathing technique and the quantitative characteristics of training loads aimed at the speed development of swimmers, taking into account their individual abilities to improvement of the physical fitness of young swimmers in the preparatory period of the annual macrocycle.

Results

Based on the analysis of the literary sources, it was discovered that physical training at the stage of preliminary basic training requires that young swimmers maximize the mobilization of the body's reserves, which can negatively affect not only the dynamics of the sports result, but also the health of athletes (Furman, 2014; Briskin, 2016). In view of this, at this stage of preparation in training process of swimmers it is necessary to apply additional means and methods of preparation which promote enhancement of the physical exercises effectiveness and preservation of young athletes adaptation reserves. In addition, we found out that the content of swimmers training practices at the stage of preliminary basic training needs to be optimized taking into account sensitive periods of development of physical qualities, functional capabilities, as well as specific features of the construction of the training process in the puberty period (Gruzevych, 2013; Furman, 2014; Briskin, 2015).

In order to evaluate the physical fitness of swimmers, the following swimming tests were used: 800 m Freestyle swimming (characterizing endurance in the aerobic energy supply zone), 4x50m Freestyle relay (characterizing endurance in anaerobic lactate energy supply zone) and 25 m Freestyle swimming (characterizing endurance in the zone anaerobic alactatic power supply and high-speed quality). We have found out that the swimmers swam 800 m Freestyle in an average of 719.1 ± 8.7 seconds. For swimming of the first 50-meter relay during a test 4 x 50 m Freestyle relay with a rest interval in 15 seconds the swimmers spent on average 34.3 ± 0.6 seconds, for swimming of the second 50-meter relay - 38.7 ± 0.8 sec., the third 50-meter relay - 41.3 ± 1.1 sec., and the fourth - 42.3 ± 1.2 sec. To cover the 25 m Freestyle test distance swimmers spent 15.1 ± 1.5 sec. In the process of physical fitness testing of the swimmers, the greatest deviations were found in the results of swimming of 800 m Freestyle and 25 m Freestyle rounds compared with the range of differences in the results of a 4x50 m Freestyle swimming test, which in our opinion needs correction. In addition, the results of swimming of 25m Freestyle round indicate the need to focus on working with swimmers on the speed development, because the result of this test 15.1 ± 1.5 sec. corresponded to the grade "3" on the 5-point grading scale.

In the course of assessment of the functional conditions of the swimmers of all studied groups, low volumes of Shtange and Genchi breathing tests indices were established. The obtained results of the spiographic study indicate that the speed characteristics of the external breathing of swimmers are within the normal range.

During the analysis of volumetric indices of the external breathing apparatus, it was found that the tidal volume (VT), breathing rate (BR), vital capacity of the lungs (VC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV) and the ratio of maximum voluntary ventilation to the minute volume (MVV / MV) are normal, and the maximum voluntary ventilation (MVV) is below the established values. The reaction of the cardiovascular system of athletes on a metered physical load of 1 W and 2 W per 1 kg of body weight according to the arterial pressure corresponds to the normotonic type of reaction. Recovery of the heart rate after these loads occurred within three minutes.

During the study of capability in the area of aerobic energy supply with using cycle ergometric test PWC₁₇₀, it was established that the level of aerobic capability according to the criteria of Ya. P. Piarnat (1983) turned out to be mediocre.

Consequently, the results of testing of the swimmers physical fitness indicate that there is a need to improve the efficiency in the zone of aerobic and anaerobic alactatic energy supply, as well as high-speed qualities of swimmers. Attention also needs to be directed to improving the functional capabilities of the young

swimmers respiratory system, whose activity have a significant effect on the sport performance in sport swimming.

In accordance with the curriculum on swimming, the week-long training regimen at the stage of preliminary basic training provides for performing of physical practice within 18 hours a week (6 training sessions per week, each lasting 135 minutes), that requires young sportsmen to maximize the mobilization of functional reserves of the body.

In this regard, when working with athletes of this age category, it is necessary to use additional means, which at the same time contribute to the preservation of the functional reserves of the organism for their use at the subsequent stages of multiyear preparation, and to increase the physical fitness of swimmers without increasing the external volumes of physical activity (Platonov, 2012). For this purpose, we introduced the endogenous-hypoxic breathing technique using the "Endohenik-01" apparatus into the training process of the first and second main groups (MG1, MG2) according to the so-called "route maps". This technique was used by the swimmers of the main groups MG1, MG2 at each training session in the preparatory part of the training session during the 16 weeks of the preparatory period in order to improve the functional capabilities of the body by improving the function of the breathing muscles and the bronchial permeability. This technique involves the gradual increase of water in the apparatus (to increase the resistance of air passage), increase the time of slowed exhalation to form an economic stereotype of breathing, as well as increase the training duration.

According to the authors-developers data (), due to the application of this technique, the vital capacity of the lungs increases, the functional capabilities of the muscles involved in the respiratory act increase, as well as massage of the organs of the abdominal cavity is carried out.

Analysis of the content of the curriculum on swimming provides grounds to assert that at the preliminary basic training stage, training practice under this program are mainly aimed at improving of the performance in the aerobic energy supply zone. At the same time, we discovered the problem connected with swimmers speed training at this multi-year preparation stage. Considering this problem, it can be asserted that there are many ways to improve the speed capabilities of adolescent swimmers. However, not all of them are adequate for the adolescent athletes, which is attributed to tension of the anaerobic function of the body and the central nervous system. Work performance in the area of anaerobic lactate energy supply is difficult for adolescents, which is attributable to a certain deficiency of enzymes that are responsible for anaerobic glycolysis. For that reason, when working with adolescent athletes, it is appropriate to use such physical activities that do not cause an increase of the body systems tension associated with an increase of the concentration of lactic acid. Such activities are anaerobic alactatic exercises that increase speed and speed strength. To enhance the anaerobic alactatic processes of energy supply, and hence speed, the exercises must be performed at the highest possible speed. In this case, the heart rate increases to 150-170 beats per minute⁻¹. If the heart rate exceeds the value of 170 beats per minute⁻¹ it indicates the transition of alactatic anaerobic metabolism to the lactate zone, which is a criterion for limiting the number of exercises repetitions. To improve the performance in the zone of anaerobic alactatic energy supply, we have developed quantitative characteristics of training loads in this zone, taking into account the individual possibilities of 11-12 years-aged swimmers, and determined the interval between training loads based on the control of the heart rate. Thus, through operational control, we ensured that the level of mobilization of young swimmers body met the individual requirements for the speed development, that not only ensures the effectiveness of work on improving this physical quality, but also prevents the overexertion. For this purpose, the athletes of the second main group, in addition to the practice with application of the endogenous hypoxic breathing technique, three times a week after warming up of the aerobic direction, swam series of 25m-long rounds with the maximum speed in different variations (different strokes with full coordination of motions and elements) from starting platform and with a push from the end wall of the pool. The rest interval between 25m-long rounds lasted 2-3 minutes. (Makarova, 2008). Between the swimming series athletes actively rested (5-10 min.). The pauses of the active rest were filled with compensatory swimming in the aerobic energy supply zone, which provided for the restoration of ATP (Adenosine Triphosphate) and CPK (Creatin Phosphokinase) stocks, the normalization of the ratio of processes of excitation and inhibition of the central nervous system, as well as the elimination of physics-chemical changes in the body that occurred during the runtime of the sprint series. This made it possible to perform the next sprint series after the 5-10 min. rest to increase speed capabilities. At one training session, athletes performed several series of such exercises. If, in comparison with previous series of races, it was reduced the number of swimming of 25m-long rounds within the heart rate 150-170 beats per minute⁻¹ zone, repetition of such series was stopped.

For the formative experiment, three groups of athletes were formed by the technique of random sampling: control group (18 athletes), the first main group (19 athletes) and the second main group (17 athletes). Before conducting of the formative experiment, it was not established statistically reliable differences ($p > 0.05$) between the indices of physical fitness of athletes of all tested groups. To determine the significance of differences between statistical evaluations of those sample indicators, which corresponded to the normal distribution law, Student's criterion was used. For related samples, whose values did not match the normal distribution law, the significance of differences were determined by using Wilcoxon's non-parametric criterion. The difference was considered significant if the value of the Wilcoxon W-criterion was found in the zone of significance, which was

determined by the number of participants of the experiment. The significance was considered essential if it was 5% difference of significance ($p < 0.05$).

The developed programs have been integrated into the training process of swimmers in the preparatory period of the annual macro cycle. The structure of the preparatory period in the control and main groups did not differ.

Introduction of the endogenous-hypoxic breathing technique to the training process of swimmers of the first main group has positively influenced the physical fitness. The application of this technique during the 16-week formative experiment contributed to the probable increase of the speed of swimming of 800 m Freestyle round by 8.0 sec. (from 726.9 ± 8.2 sec. to 718.9 ± 5.1 sec.), indicating performance improvement in the aerobic energy supply zone (Fig. 1). Athletes of the second main group, who, besides the application of the endogenous-hypoxic breathing technique, used quantitative characteristics of training loads aimed at speed development in training practice, also improved the result of swimming of 800 m Freestyle round by 8.7 sec. (from 725.0 ± 8.6 sec. to 716.3 ± 5.3 sec.), (see Fig. 1).

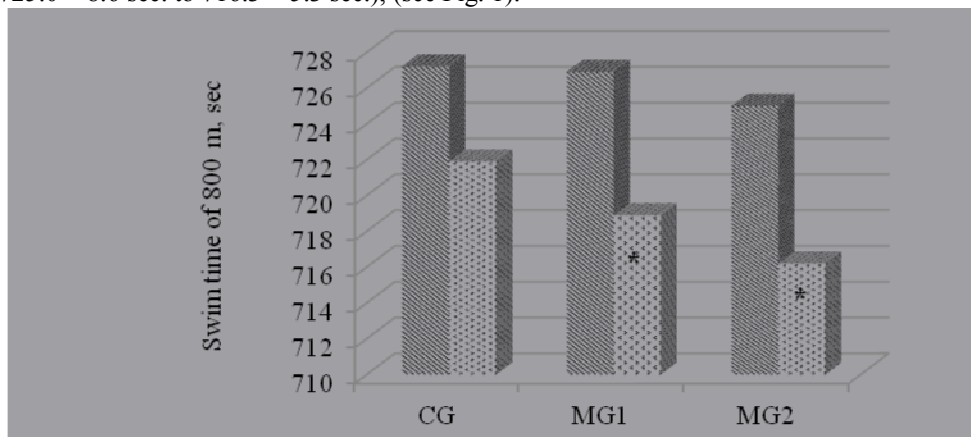


Fig.1. Dynamics of changes of the results on the 800 m Freestyle round of the swimmers before and after the pedagogical experiment:

CG - athletes of the control group; MG1 - athletes of the first main group; MG 2 - athletes of the second main group;

- Data recorded during the summative experiment;
- Data recorded at the end of the formative experiment (after 16 weeks);
- * - the differences are statistically significant at $p < 0.05$

It should be noted that after the completion of the formative experiment in the first and second main groups the range of individual differences in the 800 m Freestyle has declined, indicating the effectiveness of the impact of training under experimental work programs in the aerobic energy supply zone. During the formative experiment in the swimmers of the control group, which were training under the program for the Children's and Youth Sports School, a tendency towards improvement of the results of swimming of 800 m Freestyle round is noted, as indicated by a decrease in the time of the covering of this distance by 5.1 sec. (from 727.2 ± 8.9 sec. to 722.1 ± 8.6 sec.), (see Fig. 1). However, the positive dynamics of the results of swimming of 800 m Freestyle round by the athletes in the control group was not statistically significant ($p > 0.05$).

Unlike the athletes of the control group and the first main group, in the athletes from the second main group, training sessions contributed to improving the results not only of the swimming of 800 m Freestyle round, but also of the 25 m Freestyle round. Thus, the swim time of a 25 m long distance was likely to decrease by 1.3 sec. (from 14.9 ± 1.3 sec. to 13.5 ± 0.9 sec.). Also, the range of individual differences in the second main group also decreased as a result of swim time 25 m Freestyle round.

Analysing the data obtained after a 16-week training cycle, it was established that the rate of development of the swimming speed of the swimmers of the second main group has increased and corresponds to the assessment of "5" on the 5-point scale. In addition, the athletes of the second main group increased the number of swimming of 25m-long rounds with a maximum speed in the area of anaerobic alactatic energy supply from three to five, while in the athletes of the control and the first main groups the number of such 25m-long rounds did not exceed three throughout the whole experiment period (Table 1). Such results testify to the effectiveness of the influence of training sessions on swimming under the program with application of the endogenous-hypoxic breathing technique and the quantitative characteristics of training loads aimed at the development of swimmers' speed, taking into account their individual abilities to improve physical performance in the zone of anaerobic alactatic energy supply.

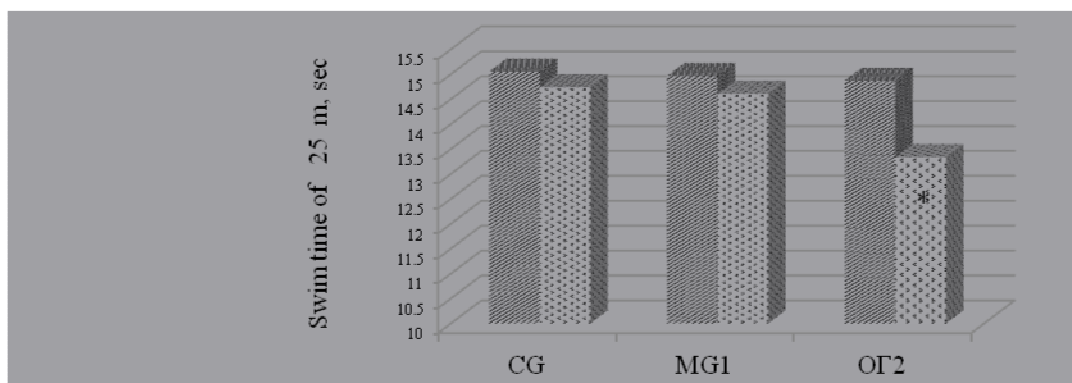


Fig.2 Dynamics of changes in the results of swimming of 25 m Freestyle round before and after the pedagogical experiment:

CG - athletes of the control group; MG 1 - athletes of the first main group; MG 2 - athletes of the second main group;



–Data recorded during the summative experiment;

–Data registered at the end of the formative experiment (after 16 weeks);

* – the differences are statistically significant if $p < 0.05$

After a sixteen-week training cycle, in the swimmers of the first and second main groups physical performance in the aerobic energy supply zone has been significantly improved, as evidenced by the growth of both absolute and relative values for the PWC_{170} test. So, for example, in the swimmers of the first main group, the value of absolute index PWC_{170} exceeded the baseline by 12.1% ($p < 0.05$), and of relative - by 11.9% ($p < 0.05$). In the swimmers of the second main group, the value of absolute index PWC_{170} increased by 13.7% ($p < 0.05$), and of relative - by 11.4% ($p < 0.05$).

Table1. Swimming of 25m-long round in the zone of anaerobic alactatic energy supply

Group	The average value of the number of swims, times					
	before the beginning of the trainings		8 weeks from the beginning of the trainings		16 weeks from the beginning of the trainings	
	\bar{x}	S	\bar{x}	S	\bar{x}	S
CG	2,7	0,1	2,8	0,1	3,0	0,2
MG1	2,6	0,1	2,7	0,1	3,1	0,1
MG2	2,9	0,2	4,0	0,2	5,1*	0,1

Notes: * - the differences are statistically significant relatively to the initial data at $p < 0.05$; MG 1 - the first main group; MG 2 - the second main group

On the basis of the conducted researches it was established that the training sessions of swimmers of the second main group under the swimming program with application of the endogenous-hypoxic breathing technique and the quantitative characteristics of the training loads aimed at the development of swimmers speed, taking into account their individual abilities, also contribute to improving of physical performance in the zone of anaerobic alactatic energy supply, as evidenced by an increase of the absolute index of the maximum amount of external mechanical work for 10 sec (MAEMW10) by 15.2% ($p < 0.05$).

Unlike the training exercises of the swimmers of the control group, swimming practice under the programme with application of the endogenous hypoxic breathing techniques and the quantitative characteristics of training loads aimed at the development of swimmers speed, taking into account their individual abilities, contribute to a possible increase of the indices of Shtange and Genchi functional tests. In comparison with the initial data, the value of the Shtange test indices in the swimmers of the first main group has increased by 79.1% ($p < 0.05$), and value of Genchi test indices - by 34.4% ($p < 0.05$). In the swimmers of the second main group, the value of Shtange test indices has increased by 82.2% ($p < 0.05$), while the value of Genchi test indices - by 39.8% ($p < 0.05$).

It was established that after introducing into the training process of the programs we have developed, the functional capabilities of the respiratory system of the swimmers of the first and second main groups were improved, while the training sessions of the swimmers of the control group did not affect the probable increase of the values of the parameters of the external respiration. After 16 weeks of the application of the endogenous-hypoxic breathing technique by the swimmers of the main groups, their respiratory muscles functional capabilities were increased, as it was indicated by the increase of the value of the index of maximum lung ventilation (MLV). In addition, such trainings have increased the vital capacity of the lungs (VC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV) functional residual lung capacity (FRC), indicating an

increase of the respiratory surface of the lungs (Table 2).

Table 2. Indicators of the external breathing function of the swimmers at different stages of the study

Indicators	Group	Indicators volume				t
		before the beginning of the trainings		16 weeks from the beginning of the trainings		
		\bar{x}	S	\bar{x}	S	
MLVI/min ⁻¹	MG1(n=19)	137,1	3,3	153,1*	4,4	2,9
	MG 2(n=17)	139,6	4,7	158,9*	5,2	2,7
VC, l	MG 1(n=19)	4,8	0,6	5,1*	0,5	3,5
	MG 2(n=17)	4,9	0,5	5,1*	0,5	2,8
IRV, l	MG 1(n=19)	2,6	0,4	2,8*	0,4	2,4
	MG 2(n=17)	2,5	0,3	2,6*	0,3	2,2
ERV, l	MG 1(n=19)	1,5	0,2	2,2*	0,4	2,4
	MG 2(n=17)	1,7	0,2	2,1*	0,2	3,3
FRC,l	MG 1(n=19)	2,2	0,3	2,3*	0,3	4,0
	MG 2(n=17)	2,4	0,5	2,5*	0,4	2,5

Notes: * - the differences are statistically significant relatively to the initial data at $p < 0.05$; MG1 - the first main group; MG2 - the second main group

In the swimmers of the main groups, statistically significant changes were found in the forced vital capacity of the lungs (FVCL) and its components that show an improvement in the bronchial permeability. The value of FVCL of the swimmers of the first main group relatively to the initial data increased by 5.5% ($p < 0.05$), while the swimmers of the second main group - by 3.2% ($p < 0.05$). The value of the indicator of forced expiratory volume for 1 sec. (FEV1), indicator of the peak volume velocity of air passing through the respiratory tract during exhalation (Peak expiratory flow) (PEF) and the instantaneous volume velocity of air passing at the level of middle bronchi (IVV₅₀) in the swimmers of the first main group have increased by 3.7%, 3.2% and 7% respectively. In the swimmers of the second main group, the value of the FEV1 indicator increased by 4.9% ($p < 0.05$), the value of the PEF indicator -by 2.7% ($p < 0.05$), and the value of the IVV₅₀ - by 7.8% ($p < 0.05$)

Training sessions on swimming during the 16 weeks of the preparatory period of the annual macrocycle accelerated the restoration of the blood pressure after performing physical work on a bicycle ergometer of 1W and 2W per 1 kg of body weight.

Training sessions of the swimmers of the control group affected only the acceleration of the restoration of systolic blood pressure. In the representatives of the main groups, training sessions under the developed training programs have probably accelerated the recovery of both systolic and diastolic blood pressure after dosed physical activity on a bicycle ergometer of 1 W and 2 W per 1 kg of body weight. Unlike the athletes of the control group, after 16 weeks of the formative experiment, the athletes of main groups also accelerated the recovery of the heart rate after the metered physical load on a bicycle ergometer with a power of 1 W per kg of body weight.

Discussion

Analysis of special scientific and methodological literature convincingly suggests the expediency of using in the systemic training of young athlete's special means that improve the adaptation of the body to hypoxia of physical activity. For this purpose various techniques of artificial hypoxic training are used. However, not all methods can be used when working with adolescent athletes due to the threat of a violation of the fitness shape of the body. Therefore, in the process of working with young athletes, some scientists recommend application of safe and accessible methods of the hypoxic training in conditions of normal atmospheric pressure.

The endogenous-hypoxic breathing technique corresponds to such requirements, its application in combination with physical exercises constructively affects the dynamics of improvement of the physical fitness of young swimmers, accelerates recovery processes and increases the effectiveness of work performed by athletes under hypoxia. Individual quantitative characteristics of training loads that are aimed at the speed development of young swimmers, as well as the determination of optimal rest intervals between loads of such orientation, require the refinement and development.

In the swimmers who are at the stage of preliminary basic training it was found that: the result of swimming 25 m Freestyle round, at which the speed is estimated, corresponds to the grade of "3" according to the 5-point -grading scale; the range of individual differences in swim time of 800 m and 25 m Freestyle - high; The level of aerobic performance of swimmers - mediocre; The value of the indicators of the Shtange and Genchi functional tests indicate a reduced level of resistance of the body to hypoxia; The indicator of maximum lung ventilation indicates reduced functional capacity of the respiratory muscles; The reaction of the cardiovascular system of swimmers on the metered physical load by the indicator of blood pressure and the recovery of the heart rate is consistent with the established norm.

Based on the obtained results, a program of training sessions with application of the endogenous-hypoxic

breathing technique with the use of the "Endohenik-01" apparatus was developed; it is aimed at increasing of physical performance in the aerobic energy supply zone, improving functional capabilities of the respiratory muscles, the bronchial permeability and resistance to hypoxia. It was used before each training session in the preparatory part during the 16 weeks of the preparatory period of the annual macro cycles. For the purpose of increasing speed capabilities of the swimmers, it was used the method of quantitative characteristics of training loads in the anaerobic alactatic energy supply zone, taking into account the individual capabilities of the organism on the basis of operational control of the heart rate. The swimmers covered series of 25m-long rounds at the heart rate of 150-170 beats per min⁻¹. The interval of active rest between the exercises was 2-3 minutes, and between the series - 5-10 minutes. The criterion for limiting the number of swimming of 25-meter distances in one series was the excess of the heart rate of 170 beats per min⁻¹. If, in comparison with previous series of races, it was reduced the number of swimming of 25m distances within the heart rate 150-170 beats per minute⁻¹ zone, repetition of such series was stopped.

According to the results of the study, for the first time a program of swimming exercises with application of the endogenous-hypoxic breathing technique in the preparatory period of the annual macrocycle has been developed, which improved the physical performance in the aerobic energy supply zone, functional capabilities of the respiratory muscles, the bronchial permeability and resistance of the swimmers organism to hypoxia; For the first time, it was developed the quantitative characteristics of training loads aimed at the development of swimmers speed, taking into account their individual abilities; it was expanded scientific information about the positive influence of trainings with the application of the endogenous-hypoxic breathing technique on the physical preparedness and acceleration of restorative processes of swimmers at the stage of preliminary basic training; it was supplemented the data on the possibility of improving the speed of swimmers, taking into account the age characteristics.

The practical significance of the obtained results is the development of swimming programs with application of the endogenous-hypoxic breathing technique and quantitative characteristics of training loads aimed at the development of swimmers' speed, taking into account their individual capabilities, and the implementation of these programs in the training process of swimmers in the preparatory period of the annual macrocycle. The obtained data can be used in the training process of swimmers in the preparatory period of the annual macrocycle at the stage of preliminary basic training in order to increase the physical fitness of the swimmers.

Conclusions

1. The application of the endogenous-hypoxic breathing techniques in the training exercises of swimmers during 16 weeks contributes to a possible improvement of physical fitness. Such classes have improved the result of swimming of the 800 m Freestyle round by 8,0 sec. (from 726.9 ± 8.2 sec. to 718.9 ± 5.1 sec.), which indicates an increase of the performance in the aerobic energy supply zone. Applying of this program in the training process of swimmers contributes to increasing of the level of functional preparedness not only in terms of performance in the aerobic energy supply zone, but also external respiration, Shtange and Genchi functional tests of, as well as the rate of recovery of the cardiovascular system after metered physical loads;

2. Training under the program on swimming for sports schools of different levels and under the program, which includes the application of the endogenous hypoxic breathing technique, doesn't sufficiently effectively influence the dynamics of increasing of swimmers speed and efficiency in the area of anaerobic alactatic energy supply. The ineffectiveness of the influence of such programs is indicated by the absence of probable changes of the results of swimming of 25-m Freestyle round, the maximum number of swimming of 25m- long rounds at a heart rate of 150-170 beats per min⁻¹, and the results of WAnT10test (the maximum quantity of external mechanical work for 10 seconds).

3. The training of swimmers using the endogenous hypoxic breathing technique and quantitative characteristics of training loads aimed at the speed development of 11-12 years ages swimmers, taking into account their individual abilities, during the 16 weeks is likely to improve physical fitness not only as a result of 800m Freestyle test round by 8.7 sec. (from 725.0 ± 8.6 sec. to 716.3 ± 5.3 sec.), but also as a result of swimming the 25 m Freestyle round by 1,3 sec. (from 14.9 ± 1.3 sec. to 13.5 ± 0.9 sec). The athletes of this group who trained under the program indicated a decrease in the range of individual differences in the swimming of distances of 800 m and 25 m Freestyle. After 16 weeks of the formative experiment, the rate of speed development increased from the grade "3" to the grade "5" according to the 5-point-grade scale. An indication of the positive impact of the program is also an increase from three to five in the number of 25mswimming rounds in Freestyle with a maximum speed within the heart rate of 150 to 170 beats per min⁻¹, which indicates an increase in the capacity for work in anaerobic alactatic energy supply zone. The effectiveness of the influence of swimming activities is confirmed by the probable improvement not only of the performance indicators in the aerobic energy supply zone, the functions of external respiration, the Shtange and Genchi functional tests, the speed of restoring the function of the cardiovascular system after metered physical activity, but also performance indicators in the zone of anaerobic alactatic energy supply, which increased by 15.2% ($p < 0.05$). The results of the WAnT10 test are confirmed by the test results of swimming 25 m rounds in Freestyle, which indicates the effectiveness of the impact of the trainings

under this program for improvement of the physical performance in the area of anaerobic alactatic energy supply.

Competing Interests

The authors declare that they have no competing interests.

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