

## Substantiation of the integrated physical rehabilitation program for the higher educational establishment students suffering from bronchial asthma

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### Abstract:

The article is devoted to the development and evaluation of the effectiveness of the integrated physical rehabilitation program for students suffering from bronchial asthma.

For patients with bronchial asthma (BA) it has been developed the integrated physical rehabilitation program, which includes therapeutic physical training (morning hygienic gymnastics, special breathing exercises, metered running and walking on the stadium's running track, action games, relay races, walking and running on stairs and walking through the hurdles), autogenous training, the endogenous-hypoxic breathing technique on the "Endogenic 01" apparatus, single dousing with cold water after a warm shower. It has been proved that its application results in the improvement of the external respiration apparatus function, the physical working capacity and aerobic productivity of the body, increasing the body's ability to adapt to hypoxia conditions, reducing the number of such symptoms of bronchial asthma, as coughing, chest tightness and suffocation.

**Key words:** bronchial asthma, hypoxia, physical rehabilitation, students.

### Introduction

Over the course of the past three decades, medical statistics have documented a steady increase in non-specific diseases (Herasyenko, 2016; Kmyta, 2015, 2016; Lazariya, 2017). One of them is the respiratory system diseases, which includes bronchial asthma (BA). Over the past century, the number of asthmatic patients in the world, depending on the region, has increased from 1 % to 15 % of the total population. The epidemiologists state the highest incidence in Ukraine in the Kyiv, Vinnytsia, Zaporizhzhia and Kharkiv regions. An increase in the number of patients with bronchial asthma in Ukraine is a significant problem, since this disease affects mainly young people, particularly student youth. In the Vinnytsia State Mykhailo Kotsiubynskyi Pedagogical University, 7 % of the students of the special medical group suffer from bronchial asthma, which not only restricts their physical, emotional and psychological activity, but also negatively affects the learning process of the educational material (Briskin, 2011; Furman, 2011; Gavrylova, 2011).

In the conditions of a higher educational establishment, the physical rehabilitation of students with bronchial asthma is carried out in accordance with the curriculum on physical education for special medical groups, which is developed and approved separately by each higher educational establishment. As experience shows, the content of such programs and their application methodology do not take into account the specific features of the course of a particular disease, therefore they do not contribute to solving the problem of improving the physical health of student youth.

To improve the condition of patients with bronchial asthma, there are applied various means of physical rehabilitation that reduce the need for the use of drugs: physiotherapy, speleotherapy, balneotherapy, ozone therapy, acupuncture, hydrotherapy, diet therapy, pelotherapy, aerophytotherapy, barotherapy, therapeutic physical training, massage, etc. (Briskin, 2015, 2016; Viktoriia, 2017). However, the application of such a wide range of therapeutic methods and means is not always effective for patients, and this is confirmed by the increase in the incidence rate among young people. At the same time, the abovementioned physical rehabilitation methods and techniques are used mainly in sanatorium-treatment and dispensary establishments, making them inaccessible to students during the training period for lack of time. The issue that arises then is search and development of new, close to the educational process, effective physical rehabilitation technologies for students suffering from bronchial asthma. To this end, in our view, in the rehabilitation of students with bronchial asthma, it would be advisable to apply more widely in combination with physical exertion the so-called hypoxic and hypercapnic training technique, which is applied to improve the functionality of the respiratory system in the process of athletes training (Onyshchuk, 2011; Pityn, 2017; Hruzevych, 2016; Sergiy, 2017). The use of hypoxia and hypercapnia in combination with physical exertion improves the adaptive capabilities of the

cardiorespiratory system and physical performance, increases the body's resistance to stressful situations (Bishop, 2002, Furman, 2011). It has been established that the creation in the body of the state of moderate hypoxia and produced hypercapnia by means of the application of the endogenous-hypoxic breathing technique in combination with the aerobic exercises helps to improve the passage of air in the small, medium and large bronchi (Gavrylova, 2011; Gorshova, 2017). Therefore, the development and scientific substantiation of such physical rehabilitation program, which included not only special therapeutic gymnastics, but also a technique for creating a state of normobaric hypoxia and hypercapnia in the body, is the perspective direction of the solution of the issue of treating patients with bronchial asthma in conditions close to the educational process, which determined the relevance of the chosen research topic.

### Materials and Methods

The following research methods were used in the work: theoretical analysis and generalization of literary sources on the topic of scientific research; questioning; pedagogical observation; pedagogical experiment; pedagogical testing using bicycle ergometry, pulsometry, chronometry, electrocardiography, sphygmomanometry, electronic spirometry with the analysis of the "flow-volume" loop; methods of mathematical statistics.

The pedagogical testing was used to determine the level of functional status of students with bronchial asthma. The function of external respiration was assessed by computer spirometry with the "flow-volume" loop analysis, which was performed with the help of the spirometer "CARDIO-SPIRO". In the study of the physical performance, a veloergometric PWC<sub>170</sub> test was used (Karpman B.L., et al., 1988). The maximum value of oxygen consumption  $VO_{2max}$  was calculated according to the PWC170 value. The electrocardiograph "EKSPChT-4" was used to register the bioelectrical activity of the heart. The determination of the blood pressure (BP) in a state of relative muscle rest was performed using a sphygmomanometer "LD-91". The ability of students suffering from bronchial asthma to withstand hypoxia and, to some extent, hypercapnia was determined with the help of the Shtange and Genchi functional tests.

The pedagogical observations were conducted using such methods of research as pulsometry, which was performed with the help of the heart rate monitor "TOPcom sports" and "SIGMA SPORT PS 4", and visual observation of external signs of fatigue.

The empirical materials were processed by methods of mathematical statistics. The probability of difference was determined in the formative experiment using the Student's t-test. The research work was carried out in the laboratory of the Department of Medical and Biological Principles of Physical Education and Physical Rehabilitation of the VSPU named after Mykhailo Kotsiubynskyi. The total number of students under study was 49, (of which 26 young women and 23 young men), who for health reasons belonged to the special medical group of the VSPU named after Mykhailo Kotsiubynskyi. All the students under study had bronchial asthma. 34 persons had predominantly the intermittent course of the disease and 15 students had the persistent mild degree of the disease.

Students were divided into four groups: two control groups (CG) - one group consisted of 12 young women and the second - of 11 young men; and two experimental groups (EG), which numbered 14 young women and 12 young men.

### Results

We have not revealed any significant differences in the average values of the parameters of the bioelectrical activity of the heart, the heart rate, systolic and diastolic blood pressure in a state of relative muscle rest in young men and women of the main and special medical groups.

It has been established that the average values of such parameters as minute breathing volume (MBV), vital capacity of lungs (VC), vital capacity of lungs on inspiration (IVC), vital capacity of lungs on exhalation (EVC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV) and the maximal voluntary ventilation of the lungs (MVV) in young men and young women with bronchial asthma were significantly lower than in the main group of students, which indicates the inadequate functionality of the respiratory muscles that provide lung ventilation.

At the same time, in the young men and young women of the special medical group we recorded low indices: the forced vital capacity of the lungs (FVC), the forced expiratory volume in the first second (FEV<sub>1</sub>), the forced expiratory volume in the first second in relation to the vital capacity of the lungs (FEV<sub>1</sub> / VC), the peak expiratory flow rate (PEF), the instantaneous volume velocity of air passing at the level of the large bronchi - forced expiratory flow or maximal expiratory flow (MEF<sub>25</sub>), the instantaneous volume velocity of air passing at the level of the medium bronchi - forced expiratory flow or maximal expiratory flow (MEF<sub>50</sub>), the instantaneous volume velocity of air passing at the level of the small bronchi - forced expiratory flow or maximal expiratory flow (MEF<sub>75</sub>), the average volume velocity of air passing at the level of the medium bronchi at the expiration of 25-75% of FVC (FEF<sub>25-75</sub>), the average volume velocity of air passing at the level of the small bronchi at the expiration of 75-85% of FVC (FEF<sub>75-85</sub>), which indicates obstructive disorders in the large, medium and small bronchi.

A study of the body's ability to withstand hypoxia caused by a breath holding during inhalation and exhalation showed that young men and young women with bronchial asthma have the lower ability to adapt to hypoxia than the students who do not suffer from this disease.

The basis for the development of the integrated physical rehabilitation program for students suffering from bronchial asthma was data from the scientific and methodological literature and the results of the study of the functional status of the cardiorespiratory system. The rehabilitation measures for students suffering from bronchial asthma were aimed at the development of their need and motivation for systematic exercise of the therapeutic physical training, improving the function of the cardiorespiratory system, normalizing the passage of air through the bronchi of different calibre, strengthening the evacuation function of the bronchi, improving the psychoemotional state and enhancing the overall performance of the organism.

It was developed the integrated program for students of the experimental group, it included three periods of physical rehabilitation: introductory (5 weeks), basic (30 weeks) and final (5 weeks).

During the introductory rehabilitation period the students of the experimental group learned to regulate the duration of the phases of inspiration and expiration, mastered the technique of breathing exercises with pronouncing sounds on exhalation, the technique of diaphragmatic breathing, the endogenous-hypoxic breathing technique, and autogenic training according to the classic Schulz technique. In the morning the young men and girls did morning hygienic gymnastics on their own, after which they used a warm shower, which was completed with single-step dousing with cold water.

During the basic rehabilitation period along with the special breathing exercises, there were widely used such gymnastic exercises: flexion, extension, abduction, adduction and circumduction of limbs; extension, forward bending and lateral bending. During the exercises performance, the emphasis was placed on the slow prolonged exhalation. In autumn, in spring and in summer there were metered running and walking on the race track, high knees walking and running up the stairs and walking through hurdles. High knees running up the stairs and hurdling were carried out in the exhalation phase, which contributed to better removal of the residual air from the lungs. These exercises were performed at an average pace. In winter, action games and relay races were used. Along with this, during the whole period of the formative experiment, the students applied the endogenous-hypoxic breathing technique on the "Endogenik 01" apparatus.

In the final rehabilitation period, students continued to do morning hygienic gymnastics, single-step dousing with cold water after a warm shower and therapeutic gymnastics, which included special breathing exercises, metered running and walking on the race track, high knees walking and running up the stairs and hurdling, the autogenic training, the endogenous-hypoxic breathing technique.

The physical rehabilitation trainings of students with bronchial asthma were carried out according to the developed integrated program for ten calendar months.

The developed integrated program provided for such means of physical rehabilitation as therapeutic physical training, morning hygienic gymnastics, metered walking and running on the stadium's race track, single-step dousing with cold water after a warm shower, action games and relay races. In addition to the abovementioned means of physical rehabilitation, young men and women with bronchial asthma applied the autogenic training according the Schulz technique, high knees walking and running up the stairs and hurdling; as well as breathing through the apparatus "Endogenik 01", which ensured the creation in the body of the state of normobaric hypoxia and hypercapnia.

Each session of the therapeutic gymnastics, regardless of the rehabilitation period, consisted of three parts: preparatory, main and final. In the preparatory part of the training session students did special breathing exercises within 7-10 minutes. In the main part of the training session, alongside with special breathing exercises, there were used form building exercises. The duration of the main part of the session was 25-30 minutes. In the final part of the training session, there were used breathing exercises and muscle relaxation exercises. The final part lasted from 5 to 8 minutes. During the training period, the students were taught under the developed integrated program twice a week according to the schedule of physical education classes and additionally once a week during the extra-curricular time under the supervision of a physical rehabilitation specialist. For the training sessions under the developed integrated program a group method was used. The duration of the therapeutic training session was from 40 to 45 minutes. During the winter holidays (daily) and on weekends, students independently did morning hygienic gymnastics, single-step dousing with cold water after a warm shower, and also applied autogenous training according to the classical Schulz technique and the endogenous-hypoxic breathing technique on the "Endogenik 01" apparatus.

Taking into account the fact that the effective application of hypoxia for the prevention and even relief of asthma attacks is described in the special scientific sources, we investigated the rapid effect, that is, the effectiveness of a single application of the endogenous-hypoxic breathing in combination with a metered physical load on a bicycle ergometer with a power of 1W per 1 kg of body weight lasting 5 minutes, on the external respiration indicators of students with this disease (Onyshchuk, 2011; Kmyta, 2015; Hruzevych, 2017).

It has been established that in most of the subjects, speed indices of the external respiration, which characterize the passage of air through the large and medium bronchi, have significantly improved, namely: FVC, FEV<sub>1</sub>, FEV<sub>1</sub> / VC, PEF, MEF<sub>25</sub>, MEF<sub>50</sub>, FEF<sub>25-75</sub>. In 80 % of boys and 60 % of girls, the FVC score

improved. In 60 % of the young men and in 80 % of the young women, there was an increase in the FEV<sub>1</sub> index reflecting the tone of the large bronchi. In particular, 80 % of the young men and 70 % of girls improved their FEV<sub>1</sub> / VC and PEF. The increase in 70 % of young men and 70 % of girls of MEF<sub>25</sub> and MEF<sub>50</sub> is a confirmation of the positive impact of the moderate hypoxia and pronounced hypercapnia in combination with metered physical load (power - 1 W per 1 kg of body weight, duration - 5 min), on the condition of bronchi. This fact indicates a decrease in obstruction in the large and medium bronchi. A decrease in the tonus of the large and medium bronchi according to the rate of FEF<sub>25-75</sub> in 80 % of young men and 70 % of girls is a confirmation of such changes.

Taking into account that in persons with bronchial asthma the functional capacity of the organism worsens mainly due to the decrease in the function of the external respiration and cardiovascular system, we have investigated the impact of the trainings under the developed program on the parameters of spirometry, aerobic capacity of the organism, bioelectrical activity of the heart, blood pressure. There are also literary data that patients with bronchial asthma are worse adapted to the conditions of hypoxia than healthy individuals. Therefore, we investigated the ability of this contingent of students to resist hypoxia, for this purpose there were used the Shtange and Genchi breath holding tests.

Based on the conducted studies, it was established that trainings under the developed integrated program contributed to the improvement of most of the parameters of external respiration in the young men of the experimental group. In the students of the control group, the application of a standard physical rehabilitation program for patients with bronchial asthma for the period of 10, 20 and 30 weeks did not cause significant changes in the studied parameters of the external respiration. Only 40 weeks later, the boys of this group had a significant decrease in the respiration rate (RR) by 5.86 %. In the young men of the experimental group in 20 weeks after the beginning of the trainings there were observed significant decrease of the external respiration functions indicators: RR - by 7.25 % and MV - by 6 %, which gives grounds to assert about the economization of the function of the external respiration apparatus. In 30 weeks, the students of this group significantly increased such indicators: IVC - by 3.71 %, IRV - by 3.73 %, maximal voluntary ventilation of the lungs in relation to the minute volume of respiration (MVV / MV) - by 12.32 %. After the completion of the 40-week cycle of physical rehabilitation, we have registered not only a significant decrease the external respiration function indicators, such as RR (by 11.56 %,  $p < 0.02$ ) and MV (by 6.95 %,  $p < 0.02$ ), but also an increase in IVC (by 4.34 %,  $p < 0.02$ ), IRV (by 3.94 %,  $p < 0.05$ ); MVV/ MV (by 16.4 %,  $p < 0.02$ ), the ratio of the duration of exhalation to inspiration ( $T_{exp/insp}$ ) (by 4.31 %,  $p < 0.05$ ) EVC (by 5.75 %,  $p < 0.02$ ), ERV (by 5.9 %,  $p < 0.05$ ), VC (by 4.46 %,  $p < 0.05$ ); MVV (by 9.76 %,  $p < 0.05$ ); residual volume (RV) (by 2.08 %,  $p < 0.05$ ).

It has been established that after 30 weeks of training under the developed program, in the young men of the experimental group there was a significant increase of such indicator as MEF<sub>75</sub> by 13.45 %, which characterizes the tonus of the small bronchi. After 40 weeks of the trainings under the developed program in the students of this group, we have recorded a significant increase not only of the above-mentioned index, but also of such indicators as: FVC (by 5.5 %,  $p < 0.05$ ), FEV<sub>1</sub> (by 7.4 %,  $p < 0.05$ ), PEF (by 4.10 %,  $p < 0.05$ ), MEF<sub>25</sub> (by 4.06 %,  $p < 0.05$ ), MEF<sub>50</sub> (by 13.02 %,  $p < 0.05$ ), FEF<sub>25-75</sub> (by 6.87 %,  $p < 0.05$ ), FEF<sub>75-85</sub> (by 12.2 %,  $p < 0.05$ ). The recorded changes in the spirometry results indicate a decrease in bronchial obstruction in the airways. The average value of MEF<sub>75</sub> increased by 14.61 % ( $p < 0.02$ ) in 40 weeks after the beginning of studies. The ratio of FEV<sub>1</sub> / VC has remained unchanged.

In the girls of the experimental group training under the developed physical rehabilitation program also contributed to the improvement of volumetric and speed parameters of external respiration. After 20-week-period a spirometric examination showed a significant decrease of the RR index by 4.8 %. Continuation of trainings over the next 10 weeks contributed to a decrease of RR (by 6.9 %,  $p < 0.02$ ), and an increase in RV (by 3.18 %,  $p < 0.05$ ), IVC (by 4.25 %  $p < 0.05$ ), EVC (by 4.34 %,  $p < 0.05$ ), IRV (by 5.37 %,  $p < 0.02$ ), ERV (by 4.5 %,  $p < 0.05$ ), VC (by 5.13 %,  $p < 0.02$ ). After 40 weeks of training under the developed integrated program, we registered a significant increase in such indicators as MV (by 5.31 %,  $p < 0.02$ ),  $T_{exp/insp}$  (by 5.69 %,  $p < 0.05$ ), MVV by 6.9 %,  $p < 0.05$ ), RV (by 1.92 %,  $p < 0.05$ ), MVV / MV (by 11.25 %,  $p < 0.05$ ). During this period of training, it was significantly improved the average values of such parameters as: RR (by 7.4 %,  $p < 0.02$ ), RV (by 4.02 %,  $p < 0.05$ ), IVC (by 4.93 %,  $p < 0.05$ ), EVC (by 4.87 %,  $p < 0.05$ ), IRV (4.28 %,  $p < 0.05$ ), ERV (by 4.6 %,  $p < 0.05$ ), VC (by 4.71 %,  $p < 0.02$ ).

After 30 weeks of training under the developed program, the girls of the experimental group had an increase in such speed indicators as FVC (by 4.35 %,  $p < 0.05$ ), FEV<sub>1</sub> (by 6.3 %,  $p < 0.05$ ), PEF (by 3.21 %,  $p < 0.05$ ), MEF<sub>50</sub> (by 9.21 %,  $p < 0.05$ ), MEF<sub>75</sub> (by 9.1 %,  $p < 0.05$ ), FEF<sub>25-75</sub> (by 4.16 %,  $p < 0.05$ ). After completion of the physical rehabilitation course, the girls of the experimental group increased the average values of FEV<sub>1</sub> / VC (by 4.47 %,  $p < 0.05$ ), MEF<sub>25</sub> (by 3.5 %,  $p < 0.05$ ) and FEF<sub>75-85</sub> (by 11.32 %,  $p < 0.05$ ), that characterize the tonus of the large and small bronchi. Compared to the baseline, there were significantly increased the average values of such parameters as: FVC (by 4.5 %,  $p < 0.02$ ), FEV<sub>1</sub> (by 6.5 %,  $p < 0.02$ ), PEF (by 3.12 %,  $p < 0.02$ ), MEF<sub>50</sub> (by 9.6 %,  $p < 0.05$ ), MEF<sub>75</sub> (by 9.0 %,  $p < 0.05$ ), FEF<sub>25-75</sub> (by 5.1 %,  $p < 0.05$ ). Unlike the female students of the experimental group, the girls of the control group did not demonstrate the

significant changes in the studied parameters after 40-week training under the typical physical rehabilitation program for patients with bronchial asthma.

It was found out that in the young men of the experimental group the whole forty-week period of application of the developed program did not contribute to the improvement of the absolute and relative indices of the aerobic productivity of the organism. In our opinion, the ineffectiveness of the impact of such trainings on the absolute and relative indices of the PWC<sub>170</sub> and VO<sub>2</sub> of the young men of the experimental group is due to the insufficient amount of running loads (Furman, 2011; Gavrylova, 2011; Kmyta, 2015; Briskin, 2016). According to the calculations, the maximum allowed value of energy consumption (E<sub>max</sub>) of running loads for one training session was 554.9 kcal for young men, and the minimum (threshold) energy consumption (E<sub>min</sub>) was 244.15 kcal, which is 44 % of E<sub>max</sub>. That is, to increase the aerobic performance of the young men's body, the internal volume of the running loads should have been in the range 244.15 kcal - 554.9 kcal. The amount of running load per one training session in the students of the experimental group was less than the threshold value and averaged 204 kcal (36.8 % of E<sub>max</sub>).

Unlike the young men, in girls of the experimental group, trainings under the developed program caused the growth of absolute and relative average indices of the physical working capacity and aerobic productivity of the organism. In 30 weeks after the beginning of the training, the absolute PWC<sub>170</sub> index exceeded the initial level by 8.5 % (p < 0.05), and the relative index by 8.12 % (p < 0.05). Absolute and relative parameters of VO<sub>2</sub> increased by 5.61 % (p < 0.02) and by 5.76 % (p < 0.05), respectively. Continuation of the training under the developed program for the next 10 weeks in the girls of the experimental group contributed to further improvement of the physical fitness and aerobic performance. Thus, the average absolute value of PWC<sub>170</sub> increased by 11.8 % (p < 0.02), and the relative value - by 5.13 % (p < 0.02). The absolute value of VO<sub>2</sub> improved by 6.9 % (p < 0.02), and the relative value - by 7.53 % (p < 0.02). The obtained positive results are due to the fact that the girls of the experimental group spent for the running load the amount of energy that was in the zone of the optimal energy consumption range. According to the calculations, the maximum allowed energy consumption (E<sub>max</sub>) of the race loads for girls on average should be about 543.2 kcal per one training session, and the minimum (threshold) energy consumption (E<sub>min</sub>) is 239 kcal, which is 44% of E<sub>max</sub>. The girls of the experimental group performed running loads, the volume of which was in the required range of the energy consumption - on average it took 267.7 kcal per one training session, which was 49.17 % of E<sub>max</sub>.

We found that trainings under the developed program did not cause negative changes in the bioelectrical activity of the heart in young men and women. At the same time, a positive aspect is a reliable reduction in the heart rate, indicating the economization of the cardiac activity of the subjects in the state of relative muscle rest.

After 40 weeks of training under the developed integrated program, compared to the data recorded before the beginning of the formative experiment, in comparison with the control group, in the students of the experimental group the average values of the maximum breath holding time on inspiration significantly increased: in young men - by 19.58 %, and in girls - by 24.18 %, as well as the maximum duration of the breath holding time on expiration: in young men - by 24.4 % and in girls - by 30.37 %.

An analysis of the results of the questionnaire showed that after 20 weeks, the number of painful symptoms, such as coughing, chest tightness, and suffocation attacks, significantly decreased under the influence of training under the developed integrated physical rehabilitation program for students of experimental groups, regardless of gender. In young men and women who used a standard program of physical rehabilitation, there was a significant decrease only in the number of coughing attacks.

## Discussion

The conducted surveys confirm the literature data that the functional state of students suffering from bronchial asthma is significantly lower in comparison with the functional condition of peers who do not have chronic diseases. Regardless of the gender of the students of the special medical group, the average values of the parameters of the function of the external respiration, physical performance and maximum consumption of oxygen and the body's ability to resist hypoxia were significantly lower than the average values of the students in the main group.

In the young men of special medical group suffering from bronchial asthma, the relative value of PWC<sub>170</sub> is lower by 40.5 % (p < 0.02), and in girls - by 30.6 % (p < 0.02) compared with the students of the main group. The average value of the relative VO<sub>2</sub> index of such students is also notably lower in comparison with the values registered in the students of the main medical group, in boys - by 22.12 % (p < 0.02), and in girls - by 14.9 % (p < 0, 02). Among the indicators of the external respiration in the students with bronchial asthma, compared with the students of the main group, there were significantly lower such indicators as: MEF<sub>25</sub> - by 30.89% in young men and by 27.92 % in girls; MEF<sub>50</sub> - by 40.74 % in young men and by 50.32 % in girls; FEF<sub>25-75</sub> - by 15.08 % in young men and by 49.59 % in girls; MEF<sub>75</sub> - by 37.54 % in young men and by 39.32 % in girls; FEF<sub>75-85</sub> - by 6,74 % in young men and by 9,9 % in young women. The average values of the maximum duration of the breath holding time on the inspiration in young men with bronchial asthma are significantly lower than in the main group - by 14.7 %, and in girls - by 17.93 %. The maximum duration of the breath holding time

on expiration was lower by 17.56 % and 23.11 %, respectively. In students of special and basic medical groups, regardless of gender, there are no reliable differences in the parameters of bioelectrical activity of the heart, systolic and diastolic blood pressure, heart rate in a state of relative muscle rest.

Based on the analysis of the special literature and the results of the summative experiment for students with bronchial asthma, it was developed and tested a physical rehabilitation program which contained a set of therapeutic physical exercises, morning hygienic gymnastics, a single-step dousing with cold water after a warm shower, the autogenic training according to the Schulz technique, metered running and walking the on the race track, high knees walking up the stairs and hurdling, action games and relay races. The peculiarity of the developed program is the fact that, in combination with these means of the student's physical rehabilitation it was created a hypoxic-hypercapnic state by breathing through the "Endogenik 01" apparatus. The use of the developed program can be carried out in conditions close to the educational process, and does not require its cessation.

The results of the study confirm that the physical rehabilitation trainings using such means as traditional therapeutic gymnastics, a single-step dousing with cold water after a warm shower, morning hygienic gymnastics, autogenic training according to the Schulz technique, have the positive impact on the respiratory system of patients with bronchial asthma (Furman, 2011; Kmyta, 2016).

It has been confirmed that the functional state of students suffering from bronchial asthma is significantly worse than in peers who do not have chronic diseases, as well as the scientists' conclusions about the effective use of hypoxia for the prevention and relief of asthma attacks.

There were supplemented the scientific data (Gavrylova, 2011; Briskin, 2015) that simultaneous creation in the body of a state of moderate hypoxia and pronounced hypercapnia contributes to the improvement of bronchial air permeability in the area of the large, medium and small bronchi, as well as to the strengthening of the drainage function of the bronchi .

For the first time it was developed the integrated physical rehabilitation program for students with bronchial asthma, which, in addition to the traditional therapeutic gymnastics, includes the endogenous-hypoxic breathing technique, the autogenous training, a single-step dousing with cold water after a warm shower and is aimed at improvement of the function of the external respiration apparatus, physical work capacity and aerobic performance of the body; increasing the ability of the body to adapt to the conditions of hypoxia; reducing the number of symptoms of the disease.

## Conclusions

The trainings under the developed program, which included the endogenous-hypoxic breathing technique, contributed to a significant increase in such volumetric indicators as MV - by 6.95% in young men and by 5.31 % - in girls; ERV - by 5.9 % in young men and by 4.6 % in young women; VC - by 4.46 % in young men and by 4.71 % in young women; MVV – by 9.76 % in young men and by 6.9% in young women; RV - by 2.08 % in young men and by 1.92 % in young women. During the formative experiment, the students of experimental groups significantly increased the average values of such speed indicators as FVC - in young men by 3.5 %, and in girls by 4.5 %; FEV<sub>1</sub> - in young men by 7.4 %, and in young women - by 6.5 %; PEF – in young men by 4.1 %, and in girls by 3.21 %. Unlike the young men, the young women improved their ratio FEV<sub>1</sub> /VC by 4.47 %. The significant changes of these indicators bear evidence of a decrease in obstruction, which, in its turn, requires strengthening of the work of the respiratory muscles during exhalation. A confirmation of the reduction of the respiratory obstruction in the large, medium and small bronchi is the fact that in 40 weeks after the beginning of the training under the developed program there was a considerable improvement of indicators MEF<sub>25</sub> (both in young men - by 4.06 % and in girls - by 3.5 %), MEF<sub>50</sub> (in young men - by 13.02 %, and in young women - by 9.6 %), MEF<sub>75</sub> (both in young men - by 14.61 %, and in girls - by 9.0%). Such gender differences in the impact of the trainings under the developed program are explained by the fact that for girls the inside of the running loads exceeded the threshold level (44 % of E<sub>max</sub>), while in the young men it was below this level. Therefore, it is advisable to increase the amount of running loads for every young man at the training sessions under the developed program to a value corresponding or exceeding the threshold level.

Regardless of gender, the students of the experimental and control groups did not have meaningful changes in the systolic and diastolic blood pressure in the state of relative muscle rest during the whole period of the experiment. The bioelectrical activity of the heart in young men and women of control groups was not notably different before and after the experiment. At the same time, the students of the experimental groups experienced a significant increase in the R-R interval: in boys - by 3.79 % and in girls - by 3.25 %. Such changes in the bioelectrical heart activity indicate an increase in the economization of cardiac function.

The effectiveness of the impact of the trainings under the developed physical rehabilitation program on the functional capabilities of the body of students with bronchial asthma was also the improvement of the ability of the body of young people with this ailment to withstand hypoxia. In forty weeks after the beginning of the experimental program, the average values of the maximum duration of breath holding became significantly

higher: on inspiration - by 19.58 % in young men and by 24.18 % in girls, and on expiration -by 24.4 % in young men and by 30,37 % in girls (p <0.05).

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