

## Improvement of adolescents adaptation to the adverse meteorological situation by means of physical education

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**Abstract.** The research is devoted to the study and solving the problem of increasing the adaptive capacities of adolescents aged 11-16 years to unfavorable meteorological conditions by means of physical education with various forms of training in the system of physical education of students. Analysis of the impact of different physical exertion on physical capacity, on aerobic and anaerobic (lactic) capacity of muscles, quality parameters of physical fitness that have been registered in various meteorological situations, made it possible to identify the effective training regimens for improvement of the adaptive capacity of boys and girls. It was established that the best means of improving of the adaptive capabilities to adverse weather situation are athletics, swimming, basketball and rowing. The efficiency of the improvement of adolescents' adaptive capabilities to adverse meteorological situation by above-mentioned means is determined by the age and gender factors. Regardless of the gender, going in for athletics, swimming, rowing and basketball in adolescence contribute to effective improvement of the adaptive capabilities to adverse meteorological situation. Going in for boxing and weightlifting does not improve the adolescents adaptation to adverse meteorological situation based on the indicators of functional fitness and such indicator of physical fitness as the results in 1,500m race.

**Keywords:** adaptation, adolescents, functional and physical fitness, meteorological situation.

### Introduction

Human health is determined by the degree of adaptation to the impact of various factors that ensures support or restoration of stability of the internal environment/ milieu interieur (Gorshova, 2009). Specifically, the body's capability to adapt to various kinds of physical exertion may be considered as an objective health indicator. (Briskin, 2014; Karatnyk, 2015; Galan, 2016).

Research findings indicate a significant enhancement of human adaptive capability by means of regular physical training and proper dosage of physical exercises (Briskin, 2014; Ivani, 2016). Moreover, the effectiveness of physical training is significantly determined by the age factor (Khimenes, 2016). Physical training activities and going in for sports at young age are primarily aimed at improvement of motor skills, physical development and physical performance, preparedness for work, as well as the prevention of those diseases that can occur in older age. Application of physical training in order to enhance the adaptive capability of the organism is of prime importance in adolescence (Arefiev, 2014; Briskin, 2014; Andrieieva, 2017). Despite the fact that during this period of ontogenesis functional capacity of the body increases intensively, its ability to adapt to various kinds of physical exertion decreases (Arefiev, 2014; Briskin, 2014;). This phenomenon is accounted for by heterochronism of different systems development appearing at the background of hormonal changes in the body (Sitovskyy, 2008; Romanchyshyn, 2015; Briskin, 2015; Kmyta, 2015).

Adaptive abilities of a person are characterized by the quality of adaptation to different meteorological - climatic factors that define meteorological situation (weather type). Consequently, the adolescents ability to exhibit functional and physical fitness in an adverse meteorological situation may serve as an objective criteria for evaluating these capabilities.

Literary sources give evidence of achievements in the treatment and prevention of the meteorotropic response of meteosensitive people. For these people a limited regimen of physical activity is recommended, diet therapy and specific medicines (Gorbenko, 2005; Gorshova, 2009; Kmyta, 2016). At the same time, little attention is paid to prevention of the adverse meteorotropic reactions by means of physical exercise (Briskin, 2014; Karatnyk, 2015; Khimenes, 2015). In modern scientific literature there is limited information about the development of the united approaches to physical education of students concerning improvement of adaptation to adverse meteorological situation.

The orientation and content of physical education of secondary school students, whose physical education is regulated only by the state program with training lessons, do not provide full improvement of the adaptive capabilities of the body (Gorshova, 2009; Romanchyshyn, 2015).

Therefore, the study of the influence of various kinds of physical exertions during lessons and extracurricular activities aimed at the enhancement of adolescents adaptation to adverse meteorological situation, will help to expand the current conceptions of the possibilities of physical health improvement by means of physical education.

### Materials and Methods

To accomplish the objectives, the methods of theoretical analysis and synthesis were chosen. During the execution of the second and third tasks, the method of pedagogical testing of the functional and physical fitness of adolescents with different regimen of motor activity in different types of weather was used. In the course of the fourth task, the methods of analysis and synthesis of the results of summative experiment and method of pedagogical testing in the conditions of the I, II and III types of weather.

The weather type was determined according to the classification of I.I. Grigoriev (1993) due to fluctuations magnitude of the main meteorological factors.

A survey was conducted in the city of Vinnytsia, located in a temperate climate zone. The I, II and III types of weather (meteorological situation) are recorded in this area. The type of weather was determined everyday during the survey. The data were compared with the information obtained from the consolidated weather report of Vinnytsia Regional Centre for Hydrometeorology. The potential movement of meteorological elements was taken from the Internet.

The cycloergometric test  $PWC_{170}$  has been performed for investigation of the functional fitness. This test meets broadly recognized requirements to the physical performance testing of children and adolescents in the laboratory conditions. According to the  $PWC_{170}$  rate it was determined an amount of maximum oxygen consumption ( $VO_2 \max$ ). To determine the anaerobic (lactate) capacity of the body it was used the method developed by A. Shögy, G. Cherebetin (1974), serving the purpose of determination of the index of the anaerobic (lactate) capacity of the body during the mass examination of athletes and sportsmen in terms of the maximum quantity of external mechanical work for 1 minute ( $kg \cdot \min^{-1} \cdot kg^{-1}$ ). (MQEMW).

For research and evaluation of physical fitness of students the complex tests were conducted, namely: general endurance (the result of running 1,500 meter race), speed (the result of running 60 m race), agility (based on "shuttle race"  $4 \times 9$  m), explosive force (based on the standing long jump), flexibility (based on trunk-bending forwards), dynamic power endurance (based on the test on push-up practice - flexion and extension of arms in front lying support on the floor (to failure)). At the same time it was determined static strength endurance of the extensor muscles of the back and gluteus muscles.

Empirical materials were processed by the methods of mathematical statistics. The probability of differences was determined by Student's t-test.

To achieve stated objectives 498 adolescents (280 boys and 218 girls) were examined. All subjects were divided into age groups - aged 11-12 years, aged 13-14 years and aged 15-16 years. The representatives of the above-mentioned groups were engaged in physical training during lessons and extracurricular (out-of-class and out-of-school) activities in the system of physical education of the students.

### Results

It has been proved that meteorological situation, which is caused by significant fluctuations of meteorological factors, can make influence on the physical performance ( $PWC_{170}$ ),  $VO_{2\max}$  and MQEMW of adolescents regardless of age, gender and physical activity orientation.

With the worsening of meteorological situation of favorable (I type) to relatively favorable (II type), adolescents aged 11 and 12 years, whose physical education was limited only by lessons and those who attended extracurricular classes in boxing, showed a reduction of physical capability and maximal oxygen consumption. The boys aged 11-12 years who were engaged in physical training only in physical education classes, the amount of relative indicator  $PWC_{170}$  decreased by 13.3% ( $p < 0.01$ ), and average amount of the relative indicator  $VO_2$  - only by 3.8% ( $p < 0.05$ ) compared with the average rates that were discovered under the conditions of the I (favorable) weather type.

Amount of the relative indicator  $PWC_{170}$  under the conditions of the II weather type of the 11-12-years-old boxers compared to the I weather type, decreased by 6.4% ( $p < 0.05$ ), and amount of the relative indicator of  $VO_{2\max}$  by 3.3% ( $p < 0.05$ ).

However, it should be noted that average amount of relative indicators  $PWC_{170}$ ,  $VO_{2\max}$  and MQEMW under the conditions of the II weather type of girls whose physical activity was limited to physical education classes, and of girls attending classes in athletics, swimming, basketball and rowing (extracurricular activities) in any age group, have not undergone any significant changes (see fig. 1).

Comparative analysis of adolescents functional fitness under the conditions of the III (unfavorable) weather type and of the I (favorable) weather type clearly demonstrated the dependence of the level of body

adaptation to meteorological changes on the physical training purposefulness. Regardless of gender, under the conditions of the adverse weather, covered adolescents of all age groups (11-12, 13-14, 15-16 years), whose physical education was limited only by lessons, significantly reduced their physical capability, aerobic and anaerobic (lactate) productivity/ capacity compared to the data of the I (favorable) weather type. As illustrated by Figure 1, the level of aerobic capacity of the body, according to the amount of relative indicator of maximum oxygen consumption ( $VO_{2max}$ ) of adolescents aged 11-16 years, whose physical education was limited to physical education lessons, under the conditions of the adverse meteorological situation was significantly lower than under the conditions of the favorable meteorological situation.

The 13-14- years-old and 15-16-years- old boys and girls who visited sections of track and field, swimming, basketball and rowing (as extracurricular activities), with worsening of meteorological situation up to the III weather type, parameters characterizing functional fitness of the body ( $PWC_{170}$ ,  $VO_{2max}$ , MQEMW) were unchanged that demonstrates the positive impact of the training of the abovementioned sports on the processes of improvement of adolescents adaptation.

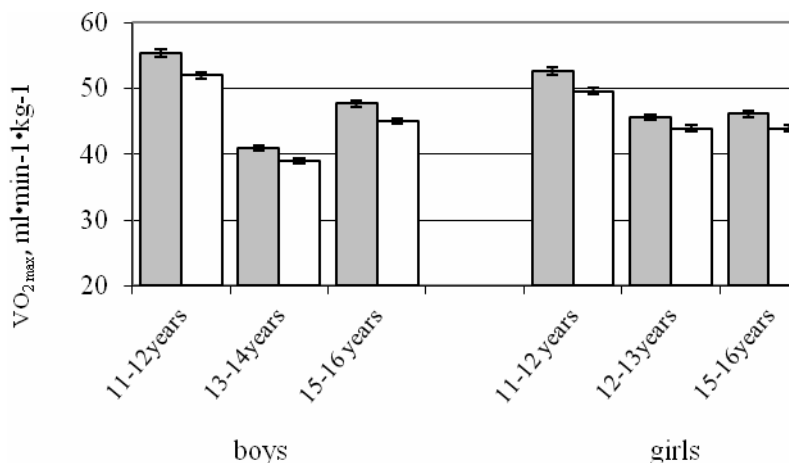


Fig. 1. The rate of the relative indicator of maximum oxygen consumption ( $VO_{2max}$ ) of non-sportive adolescents  
 ■ - the I weather type □ - the III weather type

In contrast to those who practiced the aforementioned sports, boxers and weightlifters of the same age under the conditions of the III weather type, reduce the physical performance, aerobic and anaerobic (lactate) productivity.

In adolescence the improvement capabilities of the adaptation to changes of meteorological situation by means of physical exercise are specified by age factor. Regardless of sports specialization, boys and girls in early puberty of the ontogeny (11-12 years) have much worse adaptation of the body to adverse meteorological situation than adolescents aged 13-14 and 15-16 years that is manifested in the decrease of the average values of absolute and relative indicators of the functional fitness, such as  $PWC_{170}$ ,  $VO_{2max}$  and MQEMW under the conditions of the III weather type, compared with the I weather type.

Indicators of bioelectrical activity of the heart, heart rate, systolic and diastolic blood pressure in a state of relative muscular rest of the adolescents of all surveyed age groups (11-12, 13-14, 15-16 years), regardless of gender and mode of motor activity under the conditions of the III weather type compared to the averages that have been registered under the conditions of the I weather type, are statistically unchanged.

Nevertheless, adolescents aged 15-16-years involved in after school athletics, swimming, rowing, basketball and boxing demonstrate probable decrease of the heart rate in a state of relative muscle rest and increase of the duration of all phases of the cardiac cycle, indicating the improved efficiency of the heart.

There are no significant changes in bioelectrical activity of the heart of adolescents-weightlifters that confirms the generally known scientific information about the absence of the impact of power training activities on the abovementioned parameters of the electrocardiogram.

The influence of meteorological situation on the ability to exhibit functional fitness by the adolescents of 11-12, 13-14 and 15-16 years with different modes of motor activity was investigated in different seasons (autumn, winter, spring). It is established that the impact of adverse meteorological situation on the indicators of physical performance, aerobic and anaerobic (lactate) productivity does not depend on seasons and transition periods between them.

The study found out that adolescents aged 11-12, 13-14 and 15-16 years, whose physical education is limited only by lessons, regardless of gender, have demonstrated deterioration of average endurance indicator according to the results of 1500-meter running under the conditions of the III weather type, compared with an average indicator fixed under the conditions of the I weather type.

The 11-12- years-old boys' results of 1500-meter running declined by 9.7% ( $p < 0.001$ ), and the girls - by 8.1% ( $p < 0.01$ ); 13-14-years-old boys - by 8.0% ( $p < 0.05$ ) and girls of the same age - 7.3% ( $p < 0.05$ ); 15-16-years-old boys and girls in accordance with their peers by 7.3% ( $p < 0.05$ ) and 6.0% ( $p < 0.05$ ).

Regardless of the orientation of physical training, average amounts of such quality parameters of physical fitness as speed, explosive power, agility, flexibility, strength static and dynamic endurance of non-sporting adolescents of all age groups studied under the conditions of the III weather type, remained unchanged.

Regardless of specialization, general endurance of the 11-12- years-old boys and girls who were training at sports sections during extracurricular (out-of-class and out-of-school) activities, according to the results of 1500-meter running under the conditions of the III type of weather compared with I type of weather, also significantly reduced.

Though, average amounts of qualitative indicators of physical fitness that characterize speed, explosive power, agility, flexibility, strength static and dynamic endurance, remained unchanged are not subject to any alteration are not affected

Regardless of gender, the adolescents aged 13-14 year and aged 15-16-year who were going in for athletics, swimming, basketball and rowing during extracurricular (out-of-class and out-of-school) activities, such qualitative indicators of physical fitness as overall endurance, speed, explosive strength, agility, flexibility, strength static and dynamic endurance under the conditions of adverse meteorological situation, significantly do not change.

In the adolescents who are engaged in boxing and weightlifting of all studied age groups, it was revealed a significant deterioration of overall endurance according to the results of 1500-meter running under the conditions of the III weather type Other indicators of the qualitative parameters of physical fitness in boxers and weightlifters under adverse meteorological situation apparently were not changed.

In 16 weeks from the beginning of the experiment it was found significant increase of physical performance, aerobic and anaerobic (lactate) productivity of boys (tests carried out under favorable meteorological conditions) (Table. 1). The girls who were training in accordance with the developed program in 16 weeks also demonstrated improvement of the abovementioned indicators of functional and physical fitness except indicator MQEMW (tab. 2), which describes the anaerobic (lactate) productivity, coinciding with the assertion of some researchers about the disability of the female body to improve capacity of aerobic processes of energy supply under the influence of physical training.

Table 1. Relative values of physical performance aerobic and anaerobic (lactate) productivity of 15-16-years-old boys who were training in accordance with the developed program under the conditions of various meteorological situations (n=12)

Indicators	Average amount M+m		
	I weather type	II weather type	III weather type
Before the beginning of the experiment			
PWC <sub>170</sub> (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	15.9±0.31	15.7±0.28	14.5±0.32▲▲
VO <sub>2max</sub> (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	46.8±0.56	46.4±0.58	44.8±0.61▲▲
MQEMW (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	32.7±0.35	32.0±0.35	31.1±0.32▲▲
In 16 weeks			
PWC <sub>170</sub> (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	17.4±0.33	16.7±0.31	16.6±0.30▲▲
VO <sub>2max</sub> (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	51.3±0.52	49.1±0.61	48.9±0.58▲▲
MQEMW (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	35.3±0.35	34.8±0.35	33.2±0.34▲▲
In 32 weeks			
PWC <sub>170</sub> (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	18.5±0.33	18.3±0.31	18.1±0.35
VO <sub>2max</sub> (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	52.1±0.52	51.9±0.61	51.4±0.58
MQEMW (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	36.5±0.34	36.2±0.33	36.0±0.35

Note. Probability of the differences related to the values, registered under the I weather type

▲▲ –  $p < 0.01$

During this period physical fitness was improved for such indicators as 1,500- meters running, the standing long jump, “shuttle race 4×9 m”, flexion and extension of arms in front lying support on the floor (to failure). Continuation of the trainings for the next 16 weeks did not contribute to further improvement of the abovementioned parameters.

Despite the fact that the training by the author's programs in 16 weeks of the experiment led to plausible improvement of the functional and physical fitness of the study participants, the level of adaptation to the adverse meteorological situation by the indicators of functional preparedness for this period was not increased, as evidenced by the study results presented in Tables 1, 2. The trainings in the regimen of the proposed integrated programs increased adaptive capabilities of boys and girls to adverse meteorological situation in 32 weeks from the beginning of the pedagogical experiment by the indicators of functional fitness (PWC<sub>170</sub>, VO<sub>2max</sub>, MQEMW (see. Table.1, 2) and of physical fitness (the result of 1,500-meter running).

Table 2. Relative values of physical performance, aerobic and anaerobic (lactate ) capacity of 15-16 years-old girls who were training in accordance with the developed programs under the conditions of different meteorological situations (n = 13)

Indicators	Average amount M+m		
	I weather type	II weather type	III weather type
Before the beginning of the experiment			
PWC <sub>170</sub> (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	13.8±0.32	13.4±0.35	12.6±0.34 ▲
VO <sub>2 max</sub> (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	46.8±0.58	46.4±0.63	44.6±0.50 ▲▲
MQEMW (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	27.0±0.30	27.6±0.33	25.4±0.32 ▲▲
In 16 weeks			
PWC <sub>170</sub> (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	15.8±0.30	15.5±0.33	14.3±0.32 ▲▲
VO <sub>2 max</sub> (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	50.2±0.61	49.9±0.62	47.7±0.58 ▲▲
MQEMW (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	27.6±0.31	26.4±0.30	26.1±0.31 ▲▲
In 32 weeks			
PWC <sub>170</sub> (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	15.9±0.31	15.8±0.33	15.5±0.35
VO <sub>2 max</sub> (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	50.3±0.61	50.3±0.60	49.9±0.59
MQEMW (kgf·m·min <sup>-1</sup> ·kg <sup>-1</sup> )	27.4±0.31	27.3±0.29	27.1±0.30

Note. Probability of the differences comparatively to values, registered under the I weather type

- 1) ▲ – p < 0.05;
- 2) ▲▲ – p < 0.01

## Discussion

The ability to perform work in aerobic and anaerobic regimen of energy supply under the influence of adverse meteorological situation, can serve as an objective criteria for assessing of adaptive capabilities In the scientific and methodological literature there are no reasonable recommendations for the use of means of physical education of adolescents for the purpose of improvement of the mechanism of adaptation to adverse meteorological conditions.

The ability of adolescents aged 11-16 years to adapt to the adverse meteorological situation is specified by the purposefulness of motor activity and can be evaluated according to the level of functional and physical fitness. In this case a significant role is played by gender and age factors. To improve the adolescents adaptation to adverse meteorological situation it is appropriate to practice trainings in athletics, swimming, basketball in the form of extracurricular activities, and in rowing in the form of after-school activity. Boxing and weightlifting as after-school activity do not contribute to effective improvement of the adaptive capacities of the body.

The obtained data testify that trainings according to the developed programs, three times a week, which included classes in athletics, swimming, basketball in some days of microcycles and were conducted as extracurricular forms of activities, in 16 weeks of the beginning of the experiment, contributed to the apparent increase of physical performance, aerobic and anaerobic (lactate) productivity of boys (testing was carried out in favorable meteorological conditions). Also, the received results indicate that the adolescents ability to perform physical activity in aerobic and anaerobic regimen of energy supply under the adverse meteorological situation, can serve as the indicator of the adolescents adaptive capabilities as well as an indicator of physical health.

The study confirmed scientific evidence that improvement of human organism resistance to adverse meteorological situation can be realized by practicing various types of physical activities. The new scientific information was added on the negative impact of low motor activity of young people on the ability to adapt to adverse meteorological situation. Our study results prove that in adolescence, regardless of the gender, trainings in athletics, swimming, rowing and basketball contribute effectively to improvement of adaptive capacities to adverse meteorological situation. Boxing and weightlifting do not assist in improvement of adolescents adaptation to adverse meteorological situation according to indicators of functional fitness and according to such indicator of physical fitness as a result of 1,500-meter running.

Training period of 16 weeks is insufficient to adapt the adolescents to adverse meteorological situation. Regardless of gender, the period of improving adaptation of adolescents aged 15-16 years to adverse meteorological situation under the influence of workouts in which are included classes in athletics, swimming and basketball on separate days of the week micro cycle, is about 32 weeks.

The received scientific data increase the opportunities to create the new integrated programs for physical education, the use of which will effectively improve the adolescents adaptation to the influence of various environmental factors.

## Conclusions

Average values of the absolute and relative indicators of physical capability and maximal oxygen consumption under the conditions of the II weather type, compared with the I weather type, are apparently reduced only in the 11-12- years old boys who were engaged in physical training only in physical education lessons, and boys engaged in boxing. For girls, regardless of age, physical activity orientation and form of workouts, abovementioned indicators do not undergo significant changes. The anaerobic (lactate) capabilities of adolescents aged 11-16 years, regardless of gender, orientation and forms of workouts under the conditions of the II weather type are not significantly changed.

Regardless of gender, averages of indicators specifying the functional fitness (physical performance, aerobic and anaerobic lactate productivity) and overall endurance (according to the result of 1,500-meter running) in adolescents aged 11-16 years whose physical education was limited only by physical education lessons, are reduced under the conditions of the III weather type, compared with the I weather type. Average indicators of physical fitness such as speed, agility, explosive power, flexibility, strength static and dynamic endurance of non-sportive adolescents under the conditions of the III weather type, do not undergo significant changes.

Under the conditions of the III weather type, there is a decrease of the average values of absolute and relative indicators of physical performance, maximum oxygen consumption and the maximum number of external mechanical work for 1 min, in adolescents aged 11-12-years, regardless of gender and orientation of physical training, as well as in adolescents aged 13-16 years engaged in boxing and weightlifting. In the adolescents aged 13-16 years attending workout in athletics, swimming, basketball and rowing, regardless of gender, deterioration of meteorological situation do not change the abovementioned values.

The indicators of physical fitness of adolescents aged 11-16 years who are engaged in athletics, swimming, basketball and rowing, under the conditions of the III weather type, deteriorate only in 11-12-years-old boys and girls in terms of general endurance ( $p < 0.05$ ). In this case such indicators of physical fitness as speed, agility, explosive power, flexibility, strength static and dynamic endurance, are statistically unchanged. In the 11-16 year old boys engaged in boxing and 13-16 years-old weightlifters it was revealed the deterioration of the overall endurance under the conditions of adverse meteorological situation.

Practicing the developed integrated programs for 15-16-year-olds adolescents, which included workouts in athletics, swimming and basketball, stimulate aerobic and anaerobic energy supply processes. In 16 weeks from the beginning of the experiment (regardless of gender), aerobic capacity level is improved. The relative value of maximal oxygen consumption during the aforementioned period increased by 4.9% in boys ( $p < 0.01$ ), and in girls - by 5.7% ( $p < 0.05$ ). During the same period the boys' anaerobic lactate productivity is apparently improved. The value of the absolute indicator of the maximum quantity of external mechanical work for 1 minute for the entire period of the study, trainings increased by 9.9% ( $p < 0.001$ ) and relative by 6.5% ( $p < 0.001$ ). The girls' lessons in this mode will not affect the girls anaerobic lactate performance.

Physical training classes based on the developed programs, improve the value of such indicators of total physical fitness as endurance, explosive strength, agility and dynamic strength endurance, the optimal level of growth of which was recorded after 16 weeks of the experiment. Average time of overcoming the distance in the race for 1,500 meters in boys decreased by 5.4% ( $p < 0.001$ ) and in girls - by 5.1% ( $p < 0.01$ ). Average value of the standing long jump in boys increased by 4.3% ( $p < 0.01$ ), and in girls - by 5.8% ( $p < 0.001$ ). The time taken to perform the test "shuttle run 4×9 m" reduced in the boys by 4.1% ( $p < 0.01$ ), and in girls by 2.7% ( $p < 0.05$ ).

The number of flexion and extension of arms in lying support is increasing in boys by 16.7% ( $p < 0.05$ ), and in girls - 23.4% ( $p < 0.05$ ). Practicing physical activity for the next 16 weeks in this mode does not promote the growth of physical fitness.

Applying of physical loads in such mode during next 16 weeks did not contribute to further improvement of the physical fitness.

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