

Assessment of the functional state and physical performance of young men aged 14-16 years in the process of orienteering training

YAROSLAV GALAN¹, YURII MOSEICHUK², IRYNA KUSHNIR³, LESIA LOHUSH⁴, LIDIYA DOTSYUK⁵, ANDRII KOSHURA⁶, VLADIMIR POTOPO⁷, OLENA YARMAK⁸

^{1,2,3,4,5,6} Yuriy Fedkovych Chernivtsi National University, Chernivtsi, UKRAINE

⁷ Ecological University of Bucharest, Bucharest, ROMANIA

⁸ Bila Tserkva National Agrarian University, Bila Tserkva, UKRAINE

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Abstract

The article presents the results of a pedagogical experiment, which lasted during 2017-2019 academic year. Altogether 69 young men aged 14-16 years (n=69) were involved in the study. According to the purpose of the study, the dynamics of the functional state and physical performance under the influence of orienteering training in the framework of the author's program of physical education classes was analysed.

Thus, the developed author's program for orienteering training in the system of extracurricular work has shown its high efficiency. In the course of the study, the set tasks were implemented, the goal of the study was achieved, and the hypothesis was confirmed.

Key words: orienteering training, functional state, physical performance, young men.

Introduction

As specific studies have shown, various kinds of motor activity have a different health-improving impact, and it depends not so much on the volume and intensity of the load performed, but on the emotional mood that accompanies the motor activity. The motor function is the most significant factor in maintaining the stability of the internal environment of the body, when it is deficient, the inhibitory effect on the vegetative systems of the body does not ensure its quick adaptation to changing conditions of existence. One of the ways to optimize the motor activity of students can be a combination of motor and mental activity, that is, active mental activity in the process of the motor one. Today orienteering training is the best means that has the necessary resources and gives extensive opportunities. This kind of sport is considered as one of the most accessible and mass types of health improvement that provides a large number of means for recreational activity. Orienteering training, as a form of active physical activity allows young people to satisfy lots of needs of an individual today: a combination of physical activity with mental activity, the need for outdoor activities, communication with nature, realization of the individual in orienteering training as a sport. Significant opportunities in orienteering training make it possible to determine the following main areas - orienteering training as a sport of the highest achievements, recreational activities, a healthy lifestyle (Tymoshenko, 2011; Kirihianen, 2011; Arefiev, 2013; Tomenko, 2017; Galan, 2018; Vaskan, 2019).

Many researchers addressed the issue of the influence of orienteering training on the body of schoolchildren and students and proved that training practice has a positive effect on indicators of the neuropsychic status of schoolchildren, improve the functioning of the functional systems of the body, promote the development of motor qualities, increase physical fitness and the level of tempering of the body of schoolchildren (Slonov, 2003; Berezovskyi, 2016; Galan, 2016; Blagii, 2018; Galan, 2019).

The questions of the effectiveness of the proposed recreational and health-improving programs with orienteering training tools that are aimed at improving the level of physical condition and correcting the psycho-emotional state of students.

Materials and Methods

The generalization and analysis of scientific and methodological literature made it possible to determine the research issue, to substantiate the relevance of the topic, to understand the essence of the process under study, to formulate a hypothesis, to define goals and objectives, and choose the most efficient research methods. To study the functional state of the cardiovascular and respiratory systems, the following direct measurements were performed: heart rate at rest (HR_{rest}), systolic blood pressure (SBP) and diastolic (DBP).

The technique which takes into account the anthropometric data of the young men and their principal functional indicators was used to determine systolic blood volume (Stroke Volume) (SV) and minute blood volume (Cardiac Output) (CO).

To assess the functional parameters of the respiratory system, in particular, to determine the vital capacity of the lungs (VC), we used the method of spirometry using a portable dry spirometer in compliance with all sanitary and hygienic standards.

To analyse the functioning of the respiratory system, we performed functional tests with breath-holding on inhalation (the Shtange test) and exhalation (the Genchi test). In both cases, the maximum possible breath-holding time was recorded. To assess the potential capabilities of the external respiration system, its resistance to hypoxia, and, to a certain extent, the level of compliance of activity with the circulatory system, we used the Skibinskyi index (SI). To determine the state of the oxygen transport system, namely the state of aerobic capabilities, the Robinson index was determined.

Assessment of physical performance was carried out based on Yuriy Fedkovych Chernivtsi National University, Faculty of Physical Culture and Human Health. Bicycle ergometry studies were carried out according to the recommendations of WHO together with a medical professional. Functional test PWC170 was used to determine the physical performance of young men. The test was performed on a standard stationary bicycle ergometer: the duration of pedalling is at least 3 minutes. Cadence (pedalling speed) 60 rpm. The heart rate was measured over the last 15 seconds of each 3-minute step. The initial load was set as follows: 1 W per 1 kg of body weight of the subject. With such a load, the tested person spins the pedals of the bicycle ergometer for the first 3 minutes (the first step of the test). After measuring the heart rate, the next load was 1.5 W per 1 kg of body weight of the subject, and at the third stage, there was 2 W per 1 kg of body weight. Note: if the heart rate at the end of the first stage of the test (at the end of the 3rd minute) exceeded 155 beats min⁻¹, the test stopped. It was repeated the other day, reducing the load of the first degree of the test.

The maximum oxygen consumption (VO_{2 max}) was calculated by the formula:

$$VO_2 \max = 1.7 PWC_{170} + 1240$$

Legend:

W1 - the power of the first load; W2 - the power of the second load; W3 - the power of the third load;

f1 - heart rate during the first load; f2 - heart rate during the second load;

f3 - heart rate during the third load.

Dynamic coordination was studied using a finger test (the recipient was asked to touch the tip of the nose with the index finger). Uncertain recipient movements accompanied by trembling hands indicate a particular violation of dynamic coordination.

The vestibular analyser was determined using the Yarotskyi test. The recipient carried out a rotational movement of the head in one direction at a pace of 2 turns in 1 second. The time was fixed until the first signs of a violation of coordination appeared. Assessment of equilibrium maintaining: 35 seconds - excellent, 20 seconds - good, 16 seconds - satisfactory.

The study was carried out based on Chernivtsi Specialized School of I-III stages of physical and mathematical profile No. 6. Altogether 69 young men of 14-16 years old were involved in the study. All of them are systematically engaged in orienteering training according to the author's program for orienteering groups ().

Results

The pedagogical experiment was carried out during the 2017-2019 academic years with young people of 14-16 years who are engaged in the author's program in the orienteering section in extracurricular time. Training sessions were held three times a week; the duration of the practice was 2 hours. The structure, intensity and power characteristics were selected for the comprehensive development of young men aged 14-16 years, taking into account the principles of regularity, comprehensiveness, graduality and affordability. When developing a training program, we took into account the anatomical and morphological parameters and parameters of physiological functions. Middle and senior school age is characterized by growth and development, which are accompanied by the changes in the morpho-physiological status and functional state of the body systems. Physiological functions are directly subject to the process of enlargement of organs and muscles.

The principal attention in the analysis of the obtained data focused on studying the influence of orienteering training on indicators of the functional state of the body and the physical performance of the young men. A comparative analysis, shown in table 1, characterizes the dynamics of the functional state of the cardiovascular and respiratory systems of young men under the influence of orienteering training.

When comparing the average results of heart rate at rest between the young men of 14 and 15 years old, there is a significant ($p < 0.05$) improvement of this indicator by 9.2 % in the young men aged 15 years old, the average result decreased by 7.3 beats per minute. Compared with the young men of 14 years, the average statistical result of heart rate at rest in the young men of 16 years is lower by 14.6 % ($p < 0.01$). The average systolic blood pressure in the young men of 15 years old grew by 3.9 % ($p < 0.05$) and in the young men aged 16 years - by 7.0 % ($p < 0.01$) as compared with the young men of 14 years old. Slight changes ($p > 0.05$) are observed in the average results of diastolic blood pressure between the boys aged 14 and 15 years. Significant (p

<0.01) changes are observed only between the young men of 14 and 16 years; in the young men of 16 years old diastolic blood pressure is higher by 7.1 %. Analysis of the minute blood volume (Cardiac Output) (CO) and systolic blood volume (Stroke Volume) (SV) also testifies to the positive changes and the presence of a statistically significant difference ($p < 0.05$) between the young men of 14 and 16 years old. So, the average result of the minute blood volume in the young men aged 16 years is 15.1 % lower than in the young men of 14 years.

The analysis of indicators characterizing the functioning of the respiratory system indicates the presence of reliable ($p < 0.05$; $p < 0.01$) changes between the young men aged 14-16 years. So, in the young men of 15 years, the average VC result increased by 27.2 % ($p < 0.01$), and in the young men of 16 years old - by 37.3 % ($p < 0.01$) compared with the young men of 14 years. That is, under the influence of orienteering classes during two years, the average VC result increased in total by 1,267.2 ml. It is significant to mention that this indicator characterizes the functional capabilities of the organ of external respiration and not of its functional state. In our research, we used functional tests. The use of functioning tests is very important during the analysis of the functional level of any physiological system. Using them, the researchers study the character of the reaction of the specified system to a particular action from the outside. The results obtained enable the specialists in the field of physical education to assess such qualities of a physiological system as its lability or, on the contrary, stability, system reaction rate, potential capabilities and the like.

Table 1. The indicators of the cardiovascular and respiratory system of the young men aged 14-16 years engaged in orienteering training (n = 69)

Indicators under study	14 years (n=26)		15 years (n=25)		16 years (n=18)	
	\bar{X}	S	\bar{X}	S	\bar{X}	S
HR _{rest} , beats /min ⁻¹	86.4	10.11	79.1	8.29	75.4	4.28
SBP, mmHg	110.1	12.36	114.6	7.51	118.4	6.24
DBP, mmHg	70.2	8.76	71.4	7.26	75.2	4.38
Systolic blood volume (SV), ml	72.4	5.63	72.1	4.22	71.1	2.15
Minute blood volume (CO), ml·min ⁻¹	6.1	0.61	5.8	1.12	5.3	0.52
VC, l	2130.6	35.12	2928.5	321.4	3397.8	212.4
Shtange test, sec	42.2	5.81	52.6	10.06	55.8	8.54
Genchi test, sec	24.6	1.96	25.7	1.24	28.4	1.03
Skibinskyi index, nominal units	842.4	112.42	954.8	89.45	1275.8	96.12
Robinson index, nominal units	89.4	9.34	84.3	7.54	78.7	6.92

The analysis of the average statistical results of breath-holding tests indicates a statistically significant difference ($p < 0.05$; $p < 0.01$) between the young men aged 14-16 years. During the two-year period of orienteering training, the indicators of the Shtange test increased by 13.6 seconds, that is 24.4 %, and the indicators of the Genchi test - by 3.8 seconds, that is 13.4 %. The Skibinskyi index indicator in total increased by 433.4 nominal units that is 34.0 %, and the Robinson index indicator decreased by 13.6 %. The results indicate a significant positive impact of orienteering on the functional state of the respiratory system of young people aged 14-16. The next stage of the research was a comparison of the central nervous system and physical performance of young men aged 14-16, which are presented in table 2.

Table 2. The indicators of the central nervous system and physical performance of the young men aged 14-16 who are engaged in orienteering training (n = 69)

Indicators under study	14 years (n=26)		15 years (n=25)		16 years (n=18)	
	\bar{X}	S	\bar{X}	S	\bar{X}	S
Yarotskyi test, second	19.9	2.11	25.8	2.04	39.9	1.25
Dynamic coordination	Nothing abnormal detected		Nothing abnormal detected		Nothing abnormal detected	
Sharpened Romberg test, second	7.3	1.34	15.6	0.97	19.4	0.75
PWC ₁₇₀ , kg · min ⁻¹ · kg ⁻¹	679.4	91.21	743.9	80.31	841.7	32.11
PWC ₁₇₀ , kg·min ⁻¹ ·kg ⁻¹	11.2	1.32	12.1	1.06	13.8	0.54
VO _{2 max} , ml kg ⁻¹	2,151.4	153.2	2,246.7	142.45	2,598.7	121.17
VO _{2 max} , ml·min ⁻¹ ·kg ⁻¹	34.6	3.26	37.8	1.48	40.2	1.26

When conducting a study of dynamic coordination, it was found out that nothing abnormal was detected in the young men aged 14-16 years during the test through the entire period of the pedagogical experiment.

There is a close relationship between the perception of one's own body and the environment, due to the common neurophysiological mechanisms. In violation of some structures of the central nervous system, the perception of space and one's own body is simultaneously disturbed. Assessing the vestibular analyser, which provides the central nervous system about all changes in the direction of movement of the body, its acceleration, rotational movements, and vibrations, they concluded that, under the influence of orienteering training, the result improves significantly with age. In two years of training of orienteering, the total increase of the average statistical result of the Yarotskyi test is 20.0 seconds, that is 50.1 % ($p < 0.01$).

Physical performance (PWC_{170}) and maximum energy potential, expressed as the maximum oxygen consumption ($VO_{2\max}$), is considered as a principal indicator of physical health. The evidence is the numerous data confirming the relationship between the general level of physical performance and its aerobic components with the degree of development of functional reserves, morbidity, and mortality. Among physiological tests ascertaining the aerobic capacity of a body, the most special consideration is given to the conduct of measurements of the maximum oxygen consumption ($VO_{2\max}$). It is an integral indicator of the degree of perfection of vegetative systems in the body, and it reflects the level of physical performance (PWC_{170}). $VO_{2\max}$ is an extremely variable indicator: it depends on lifestyle, profession, climatic - geographical and environmental conditions. Studying the aerobic potential in young people aged 14-16, we can conclude that between PWC_{170} and $VO_{2\max}$ there is a direct correlation between work power, oxygen consumption and heart rate. It should be noted that a low level of $VO_{2\max}$ is also observed in the young men of 14 years old, it can be due to many factors, including the instability of the relationship between organs and systems in the puberty period. The total increase in the result of PWC_{170} for two years of classes is $162.3 \text{ kgm} \cdot \text{min}^{-1}$, that is 19.3 % ($p < 0.01$) and corresponds to the average level of physical performance. The total increase in the result of the $VO_{2\max}$ for two years of orienteering training is $5.6 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$, that is 13.9 % ($p < 0.01$).

In our study, we used the Ruffier functional test to determine the response of the cardiovascular system to a dosed dynamic load, the results are presented in Table 3. Functional tests characterize the activity of the organism as a whole, but they can be used to assess the response of a particular system of the subjects. This will reveal the peculiarities of the adaptation of the body of the young men aged 14-16. In this case, the most informative parameters of functional systems are used to determine the individual impact, and the features of the course of recovery processes after the termination of loads are studied.

Table 3. The level of the Ruffier index in the boys aged 14-16 years engaged in orienteering training

Level of the Ruffier index	14 years (n=26)	15 years (n=25)	16 years (n=18)
High	-	8.0	22.2
Good	11.5	24.0	33.3
Average	20.8	36.0	45.5
Satisfactory	67.7	32.0	-
Bad	-	-	-

The percentage of test results according to the age groups indicates that a satisfactory level of physical performance prevails among the young men of 14 years old, and a high level is generally absent. In the young men aged 16 years, a high percentage of pupils have an average level of physical performance, and only 8.0 % of young men have a high level. The highest percentage of a high level of physical performance (22.2 %) is observed among the young men aged 16 years old. It should be noted that under the influence of two-year training in orienteering, the young men significantly ($p < 0.01$) improved the physical performance.

Discussion

In modern society, the theory and practice of a healthy lifestyle are actively formed, and now we can state that it could be reasonable to introduce the recreational and health-improving programs into out-of-school work. The main task of recreational and health-improving work with schoolchildren is to increase the reserves of the cardiovascular, respiratory systems and the body's resistance to adverse environmental factors. Orienteering enable forming in the most efficient way the specified properties of the body. As a form of active leisure, orienteering is an affordable means of physical activity for various age categories. Moreover, we should pay attention to the variety of types of orientation and a wide range of skills that are formed as a result of training in this sport. Orienteering training is accompanied by physical work of medium, high and submaximal intensity. The work of high power contributes to the efficient formation of mechanisms for urgent adaptation, and the work of submaximal power contributes to the long-term adaptation. During the systematic orienteering training, the results are improved not only in running but also in the speed of determining at each control point a rational route for further movement. It is due, on the one hand, to the increased resistance of the body to adverse changes in the environment, and on the other hand, the ability to perform efficient mental activity even with the sharp changes in physiological functions (Rattray, 2012; Rosen, 2018).

We can affirm that as a result of the pedagogical experiment, groups of data were obtained that confirm

the results of research of many scientists that the means of orienteering positively affect the development and formation of the central functional systems of the body (Kolomiets, 2008; 2009; Voronov, 2012; Honcharova, 2015; Khimenes, 2016; Selcuk, 2017; Sirakov, 2018;).

The data on the positive effect of orienteering on the central nervous system of schoolchildren and youth (), on increasing the level of physical performance (Creagh, 1997; Kolomiets, 2009; Korol, 2013; Korol, 2015; Celestino, 2015) are supplemented.

Conclusions

As a result of the formative pedagogical experiment, the effectiveness of the author's program based on orienteering tools was scientifically substantiated. The obtained results of the functional state of the cardiovascular system indicate a significant positive dynamics of the principal studied indicators. So, in the boys aged 15 and 16 years, the average statistical results of heart rate at rest and blood pressure improved significantly ($p < 0.05$; $p < 0.01$) during two years of orienteering training. Significantly ($p < 0.05$; $p < 0.01$), positive changes also occurred in the rate of the respiratory and central nervous system. Under the influence of orienteering classes, the level of physical performance increased significantly ($p < 0.01$).

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