

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Increasing Students' Functional Capabilities during the Academic Lessons in Physical Education.

Larisa Vladimirovna Byankina^{1*}, Irina Mikhailovna Vorotilkina², Vladimir Vasilyevich Byankin³, Aya Petrovna Bugaeva⁴, and Maria Mikhaylovna Prokopyeva⁵.

¹Far Eastern State Academy of Physical Culture Russian Federation, 680028, Khabarovsk, Amursky boulevard,1.

²Sholom-Aleichem Priamursky State University, Russian Federation, 679015, Birobidzhan, Shirokaya Street, 70a

³Far Eastern State Transport University, Russian Federation, 680021, Khabarovsk, Seryisheva str., 47

⁴Federal Autonomous Institution of Higher Professional Education "The North-Eastern Federal University named after M. K. Ammosov" Russian Federation, 677000, Yakutsk, Belinskogo str., 58

⁵Federal Autonomous Institution of Higher Professional Education "The North-Eastern Federal University named after M. K. Ammosov" Russian Federation, 677000, Yakutsk, Belinskogo str., 58

ABSTRACT

Physical education in the system of higher education is included in colleges' study plans of all specializations as a mandatory discipline and is currently conducted on the basis of the complex program for higher education institutions. The main forms of its actualization are the lessons, which are aimed at versatile physical conditioning of students, health strengthening and increase of physical development, fitness and performance levels. The article presents the data about the levels of vital lung capacity and wrist dynamometry characteristics in students, who participate and do not participate in sports. We also provide a validation of large-scale measurements of maximal oxygen uptake; as an example we present the data of pedagogic experiment for increasing the maximal oxygen uptake (VO_2 max) by using the high-intensity intermittent training, which facilitate students' aerobic capacities development without long running exercise, in the educational-training process.

Keywords: students of professional school, functional capabilities, physical education, maximal oxygen uptake.

**Corresponding author*

INTRODUCTION

Physical education in professional school is currently one of the most researched problems in the Russian science. A strong confirmation of this fact lies in constant defenses of doctoral theses about the problems of students' physical education. The research addresses the questions of physical education in students from special medical groups, the issues of sport education, differentiation and individualization of physical education in dependence from multiple various parameters. In the 90th of the XX century the scientific schools, which study the development of a personality's physical culture, began to form [16, 6]. The research focused not only on the mechanisms of attracting to physical culture or learning its reach potential, but also of acquiring its axiological and essential components, which stimulates towards the constant independent exercise life-long [19, 7]. At the same time, according to the scientists [17], physical activity of Russian population, including studying youth, remains on a rather low level.

Therefore, we consider that the most significant problems of the practical lessons are: explaining the essence of the performed physical exercise, explaining the main principles of independent training and understanding the changes, which happen in the body after the workout in the proposed conditions on the basis of changing functional characteristics parameters. The connection between a body's aerobic capacities and health condition was first discovered by an American doctor Cooper [5]. He demonstrated that people, who have the maximal oxygen uptake characteristics of 42 ml/min/kg in mean and 35 ml/min/kg in women, or higher, do not suffer from chronic diseases and have normal arterial blood pressure. Thus, the VO_2 max is one of the most informative parameters for diagnosing a person's health condition.

METHODS

The studies, which results are presented in this article, were conducted in several stages. During the first stage we studied the characteristics of vital lung capacity (VLC) and wrist dynamometry in both female and male students, who do and do not perform athletic activity. We selected these characteristics upon the following parameters: they are simple to measure, dynamic in development and related to the physical development level in general. Participants of this stage of the study were 890 people – 619 women and 271 male. As people, who are involved in sport, we considered those participants, whose volume of special physical activity was not less than six hours a week and who had an athletic qualification. We considered non-athletes to be the participants, who are included in the main medical health group, who attend the lessons and do not exercise additionally.

Due to the fact that the study had the goal of increasing functional capabilities in non-athlete students, during the second stage of the study we also studied the maximal oxygen uptake, in addition to VLC and dynamometry characteristics. In order to measure this characteristic we conducted multiple-years studies [2], which allowed replacing traditional tests for VO_2 max level measurement in students and simplifying the procedures of measurements conduction. The study included over two thousands of students; we analyzed over eight thousands results. First, we defined and verified the coefficient of running disciplines compatibility, then we established the connection between various tests of VO_2 max measurement in young men and women, including the correlations with their weight; we also studied the VO_2 max characteristics from the Astrand-Ryhming test [12]. The results of the studies were presented as a table of VO_2 max measurement on various distances [2], as well as the tables of VO_2 max establishment by the heart rate during the step-test exercise in young men and women.

During the third stage we created control and experimental groups of second- and fourth-year female students, who participate in general physical conditioning training. In the second-year groups the VO_2 max was measured by the Astrand-Ryhming test (stepping up on a stair 33 cm high during five minutes with a pace of 22.5 times per minute). Upon the end of the stepping the students measured the heart rate, and, based on that pulse, the individual VO_2 max (according to the tables, which were specified during the second stage of the study). Physical conditioning level in the fourth-year groups was measured upon the results of endurance running (1000 m). Students' results of the 1000 m running test were compared at the end of third and fourth years. Experimental factor on the third stage were training exercise of the Tabata system [13, 14]. In order to establish the efficiency of the proposed program we conducted a pedagogic experiment, which was the main research method. Students of the control groups performed the exercise according to the conventional method (constant-paced distance running method for not less than 10 minutes). The experimental group performed

high-intensity intermittent training (squats with maximal pace during 20 seconds with 10 seconds rest). In total the round consisted of 8 rounds, and the time of its performance did not exceed 4 minutes. During the implementation of high-intensity intermittent training we used the method of gradual increase of training load. In the beginning of the semester the squats were performed with the pace of 15 squats per 15 seconds with 15-seconds rest. With each following lesson the load increased by 1 squat and the rest decreased by 1 second. Finally, we reached the required level – 20 squats in 20 seconds with 10-seconds rest for 8 rounds. After performing the intensive workout, we measured the pulse in order to establish a body’s reaction for the proposed load. The efficiency of this system during the lessons with students was verified by two parameters – aerobic capacity and functional fitness level (running 1000 m).

RESULTS AND DISCUSSION

During the first stage of the studies we analyzed the vital lung capacity and dynamometry characteristics in athletes and non-athletes. Levels of these characteristics development were analyzed according to the norms, created for the Russian Far East [10]. It was previously demonstrated that the Far-Eastern region has a certain effect on physical development in young people. Among the male participants of the study, 78.8% of athletes have high level of vital lung capacity and 15% have the level above average (see table 1). None of the male athletes has low or below-average level, whereas the characteristics of male non-athletes were distributed relatively equally on the levels of vital lung capacity – each level has a sufficient amount of the results. For both right and left hands there are no male athlete students in the low-level category, as well as no non-athlete students in the high-level category. The majority of the assessed students belong in the average level. Student athletes present a shift towards high and above-average levels, whereas the results of student non-athletes shift towards below-average and low levels. Generally, it can be noted that wrist dynamometry characteristics, as well as VLC, reflect the supposed tendency of characteristics growth in dependence from participating in sports.

Table 1 Distribution of male students upon the vital lung capacity and dynamometry characteristics

Functional characteristic/ Level of development		Low	Below average	Average	Above average	High
VLC	Students-athletes	-	-	6,2%	15%	78,8%
	Students-non-athletes	5%	20%	35%	25%	15%
Left wrist dynamometry	Students-athletes	-	4,2%	63,1%	27,1%	5,6%
	Students-non-athletes	10%	15%	70%	5%	-
Right wrist dynamometry	Students-athletes	-	1,4%	61,6%	22,3%	14,7%
	Students-non-athletes	10%	20%	65%	5%	-

Table 2 Distribution of female students upon the vital lung capacity and dynamometry characteristics

Functional characteristic/ Level of development		Low	Below average	Average	Above average	High
VLC	Students-athletes	-	-	14,8%	18,5%	66,7%
	Students-non-athletes	2%	9,3%	72,1%	12,6%	4%
Left wrist dynamometry	Students-athletes	-	2,5%	37,1%	41,9%	18,5%
	Students-non-athletes	9%	40,3%	49,4%	-	1,3%
Right wrist dynamometry	Students-athletes	-	2,5%	33,5%	46,8%	17,2%
	Students-non-athletes	12,2%	21,1%	62,3%	3,8%	0,6%

Results of the females were also analyzed with regard to the levels, calculated for the Far East (table 2). Firstly, the majority of female athletes have high vital lung capacity levels, similar to the male athletes. Vital lung capacity characteristic is more flexible, and, compared to the people, who do not do sports, athletes have a major advantage. The comparison of dynamometry characteristics in females reveals a similar tendency to

the results of males: the majority of the results of the assessed female athletes belong to the above-average level for both right and left wrists. The majority of the results for female non-athletes belong to the average level with a shift towards the below-average level, whereas the highest percentage of the assessed female athletes presents the characteristics of the above-average level.

Relatively high percentage of assessed female athletes has high-level results – almost each fifth athlete. In regard of conventional average age dynamometry characteristics (26.24 kg), 90% of the female athletes met this criterion, whereas in the female non-athletes this criterion was reached only by one fifth of the participants.

Average age dynamometry norms in the males were reached by 79% of student athletes and by only 60% of student non-athletes. Thus, we can make a general conclusion that female athletes, in contrast with male athletes, have bigger strength capacities, compared to the non-athlete females.

The second stage of the study addressed the development of simple methods of VO_2 max measurement in students as a characteristic of aerobic capabilities and physical health, in general. Health is not only the absence of diseases but also a certain level of fitness and functional state of the body. The main criterion of the human health should be his energy potential, i.e. the capability to consume the energy from the environment, store it and mobilize it for supporting physiological functions [1]. The more energy the body is able to store, and the more efficient its usage is, the higher the level of a person's health. Due to the fact that the ratio of aerobic (with oxygen) energy production is predominant in the total energy metabolism, the maximal level of a body's aerobic capabilities is the main criterion of physical health and viability. It is known from the physiology that the main characteristic of body's aerobic capabilities is the amount of consumed oxygen per time unit. Therefore, the higher the VO_2 max, the better health a person has. The maximal oxygen uptake characteristic reflects aerobic capabilities of the body [4, 5].

Currently, twelve-minute running is proposed as a method of establishing the fitness level during physical education classes. However, the practical experience shows that the implementation of this test presents certain difficulties. Knowing that *there is a linear dependence between running speed and oxygen consumption*, we concluded that aerobic capabilities might be established also on other long distances. In order to confirm our hypothesis we conducted the studies. During the development of assessment scales for running disciplines we analyzed the athletic ranks norms in track and field and the tables of results evaluation in this sport [15], and as a result we revealed that all distances are related to each other with robust coefficients (coefficients of compatibility), which reflect the compatibility of the time of running various distances. The most optimal coefficients of compatibility lie in the range from 0.94 to 1.00. Analysis of various systems of results evaluation in endurance running, as well as the results of running tests in general physical conditioning groups, which had lessons for three years, showed that the most optimal coefficients of compatibility between distances range from 0.94 to 0.98.

As a result of using the coefficient of compatibility and of establishing the VO_2 max by the twelve-minute test [5], we developed a plot, which provides the opportunity to find out the VO_2 max from the time of running the distances from 1500 to 3000 meters. This plot was validated on over a thousand students, whose VO_2 max level was established by various methods. As a result of the conducted studies we revealed a correlation between running disciplines and VO_2 max characteristics. We established, that higher result of the testing is related to higher VO_2 max level [2].

Then we explored, to which extent our results correspond with the results of the testing with other methods, particularly with PWC170 test. The characteristic of physical capacity, during which the heart rate equals 170 bpm, was calculated with a formula developed by V.L. Karpman and colleagues [3]. Participants in our study were 36 students from two groups of general conditioning training. During two lessons we established the students' aerobic capabilities by the VO_2 max level with the PWC170 test. After that we conducted comparative analysis to reveal the correlation between the students' VO_2 max levels, established through running tests and PWC170 test. The results of the test were included in a table with the previous results of those students in running 1.5 mile and VO_2 max evaluation by the timing of running various distances. We revealed that VO_2 max characteristics in the same students, which were obtained as a result of using various methods, have no significant differences, i.e. during large-sample studies of fitness level evaluation, PWC170 test requires significantly more time than running disciplines, as well as additional equipment.

One of the most preferable methods is the Astrand-Ryhming nomogram; although, considering the corrections, it presents deviations from the data of direct VO_2 max establishment, but these deviations do not exceed 10-15% [12]. In order to establish VO_2 max with the Astrand-Ryhming monogram, the heart rate of the last minute of the standard test with 22.5 step-ups per minute for 5 minutes (the stair height is 40 cm for men and 33 cm for women) is taken in account. Then, using the scales of subject's heart rate and weight on the nomogram, it is possible to calculate oxygen consumption per minute, and after that the relative amount of oxygen consumption is calculated [3]. In order to establish students' aerobic capacity we conducted a study, which lasted for four months. Participants in the study were 198 males and 179 females from various groups. The mean relative VO_2 max level in males was 44.53 ml/min/kg and in females it was 36.2 ml/min/kg. Both in males and in females the VO_2 max corresponded with the threshold level. Mathematical analysis of the study results showed that relative VO_2 max level can be defined only by the heart rate after the test exercise without using the Astrand-Ryhming nomogram. During the analysis of protocols (376 results) we revealed that the relative VO_2 max levels with equal heart rate, regardless of the subjects' weight, are almost the same. Based on the conducted studies and the analysis results, we developed tables for males and females, using which it becomes possible to establish the VO_2 max in ml/min/kg through the heart rate measured after the step-exercise. The main conclusion of the second stage of the conducted studies was the developed tables for establishing maximal oxygen uptake in a large-sample study [2].

During the third stage of the studies we set the goals of increasing maximal oxygen uptake during physical education lessons in college. According to the researchers [20], these lessons in particular possess the functions of increasing students' physical activity and their fitness. In this case, the lessons content and the quality of their conduction have the primary significance.

Aerobic capabilities develop efficiently during the performance of long continuous exercise, such as cross-country running or skiing and swimming [18]. It is also possible to use sport games for this goal. Aerobic capabilities are relatively non-specific and are not strongly dependent of the exercise type. Therefore, if a person was able to increase his aerobic capabilities in running or swimming, this improvement would manifest in the performance of other exercise as well. The lower the performed work load, the less its efficiency depends on the proficiency of the motor skill and more – on aerobic capabilities. Moreover, functional capabilities of a body's vegetative systems will be high during the performance of any aerobic-type exercise. Due to this, endurance for such type of work gains general nature and, therefore, it is called general endurance.

In order to improve the endurance in cyclic motions of aerobic nature (running, swimming, cross-country skiing, etc.) the athletes are suggested to use intermittent and distance (constant and changing) methods [8]. During the training, which is aimed at endurance development, vital organ systems undergo reorganization [9, 11]. First of all, working capacity of cardiovascular system increases.

The Tabata Protocol is well-known worldwide high-intensity intermittent training [13, 14]. Tabata training was introduced by Doctor Izumi Tabata and a team of researchers from the National Institute of Fitness and Sport in Tokyo. They discovered that such training provides significantly better results in comparison with the usual aerobic exercise. Interval trainings are the most efficient both for fat burning and for building lean muscle. This is an excellent training program, which is used by athletes of almost all sports and which leads to fast fat burning, endurance increase and muscle growth. The specific trait of the training is the fact that the exercises are performed with the highest possible intensity, i.e. the focus is not on the duration, but on the quantity of the repetitions. A cycle consists of 8 rounds of 20 seconds each; the rounds are interrupted by 10-seconds rest intervals. It is necessary to point out once more that during those 20 seconds a person has to repeat the exercise as many times as possible – this is the essence of this training method.

We studied the possibility of using Tabata interval trainings in the system of physical education in college. We established the efficiency of high-intensity intermittent training during the aerobic capabilities development without using long-duration cyclic exercise (running) (see tables 3, 4). Simultaneously we conducted the monitoring in the fourth-year groups in order to reveal the endurance development through the control 1000 m running at the end of the experiment. In the control group the endurance was developed through long-duration running, and in the experimental group – through high-intensity intermittent training.

Table 3 Fitness characteristics during the experiment, according to the results of running test

Test characteristics	Control group 1 (n=12)		Experimental group 2 (n=11)		Difference in the increase EG-CG		t	P
	Before the exp. M1 ± m	After the exp. M2 ± m	Before the exp. M3 ± m	After the exp. M4 ± m	In units	%		
Running 1000 m (sec.)	301,1± 4,80	301,7± 5,53	326,7±5,79	302,3±4,06	23,2	8,0	3,45	<0,01

Table 4 Fitness characteristics during the experiment, according to the VO₂ max levels

Test characteristics	Control group 1 (n=12)		Experimental group 2 (n=11)		Difference in the increase EG-CG		t	P
	Before the exp. M1 ± m	After the exp. M2 ± m	Before the exp. M3 ± m	After the exp. M4 ± m	In units	%		
Astrand-Ryhming test	39,40± 1,15	46,73±2,15	40,90±1,38	42,50±1,57	5,65	12,0	3,01	<0,01

The pedagogic experiment demonstrated the efficiency of the proposed method of lessons conduction. The results of fitness level testing in the experimental groups, which had lessons with the proposed method, were significantly higher than in the control groups, which had the lessons with traditional conventional method. This was confirmed by the results of mathematical-statistical analysis of the study results. During the training with the new method the maximal oxygen uptake level increased by 12% on average, while in the group, which trained according to the standard plan (i.e., several fold more), the same characteristic increased by 3.9%.

During endurance testing with 1000 m running in females, the results in the experimental group were significantly higher than in the control group – 8% vs 0.002% (P<0.05). The highest increase in the results occurred in females with the low level of fitness. For the students with good fitness level this method was not so efficient.

CONCLUSION

Students, who participate in athletic activities, more frequently have high levels of functional skills development. Furthermore, young women, who do sports, have a bigger tendency of building strength, as opposed to young men.

Development of simple tests for VO₂ max establishment is a guarantee of large-sample studies; modernization of Astrand-Ryhming test is one of the first steps towards simplifying the VO₂ max evaluation. Knowledge of one’s own VO₂ max level allows a student to establish the fitness level and decide on the prospective program of its increase (if he is the “risk” zone) or maintenance on a certain level of his physical conditions.

Using the Tabata Protocol during physical education lessons allows increasing the functional capabilities level in students, which is confirmed both with the results of 1000 m running and VO₂ max characteristics, which show a high level of students’ aerobic capabilities and physical health.

ACKNOWLEDGEMENTS

we would like to thank the students, who participated in our study. Their active and responsible attitude allowed gathering extended material and obtaining valid information about functional capabilities development.

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