ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Development of Strength Capacity of Students on the Basis of Static-Dynamic Exercises

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Abstract

Human health is an inexhaustible subject both for researchers of various scientific fields and for professionals whose professional activities are directly related to its preservation and improvement. Physical education tutors at higher educational institutions are to teach students to use various physical exercises to improve their own health and physical capacity. A very large group consists of exercises aimed at the development of strength capacity. They can be performed in different modes and the final result depends on this. A variety of exercises, aimed at the development of strength, and the modes of their performance provide various training effects: the increase or decrease in the muscle volume, the development of strength endurance or absolute strength, the reduction of fat, etc. The experimental data on the development of the strength capacity of students at academic physical education classes are presented in this article. The studies are carried out on the basis of various combinations of static-dynamic and dynamic exercises. The effectiveness of the application of the developed sets of exercises during academic physical education classes at a higher educational institution is proved.

Keywords: physical education, students of vocational school, static-dynamic exercises.

INTRODUCTION.

The problem of the development of strength, which is of great importance in sports activities, in professional and applied physical training and other types of activity, constantly attracts the attention not only of physiologists, biochemists and trainers, but also of physical education tutors and people independently engaged in physical education. When practicing physical education and sports, there can be a variety of external (exogenous) and internal (endogenous) factors, the effect of which requires the manifestation of strength and endurance. The strength is the ability of a person to overcome the external resistance or to resist it through muscular efforts [6]. The endurance in muscular activity characterizes the degree of efficiency and resistance of the organism to the development of fatigue [3, 10]. One of the varieties of general endurance is strength endurance, that is, the ability to resist the fatigue during quite steady loads of power nature. Strength endurance shows the ability of the muscles to create repeated efforts and the duration of such activity [2, 10].

The strength of the muscle is determined by the maximum stress developing under the conditions of isometric contraction, which corresponds to its maximum strength. The maximum muscle strength depends on the number of muscle fibers, constituting the given muscle, and on the thickness of these fibers [14, 16-17]. The ratio of the maximum strength of the muscle to its physiological diameter is called the absolute strength of the muscle. The increase in the muscle width as a result of muscle training is called working hypertrophy of the muscle. There are two main types of working hypertrophy – sarcoplasmic (noncontractile part of muscle fibers) and myofibrillar (the contractile apparatus of the muscle fibers).

According to the scientists involved in the physiological justification of strength development, a number of factors influence the cross-sectional area of muscles: the location of the muscle (upper or lower extremities), gender, age, the constitutional features of a person, and the level of his/her fitness or the degree of hypodynamia. The mass of the antigravitational muscles is twice as much as the mass of their antagonists due to the

force of gravity, which acts constantly, and the need to counteract it from the part of the extensor muscles of the lower limbs. The cross-sectional area of the skeletal muscles of males exceeds that of females by 60% or more. The hypertrophic strength training leads to an increase in the cross section of the muscles. In males, this indicator increases by 40-50%, in females – by 35% [4, 12, 14-15].

All muscle fibers are determined by their morphological and biochemical characteristics. The differences are in their strength and speed of contraction and endurance, that is, the muscle fibers in terms of physiology differ in slow-twitch muscle fibers (SMFs) and fast-twitch muscle fibers (FMFs) [9, 10, 13, 16].

FMFs, containing more contractile elements – myofibrils, have more strength than SMFs [15-16]. FMFs develop a much higher stress than SMFs. FMFs also have a faster contraction rate compared to SMFs.

SMFs, with a rich capillary network, receive a large amount of oxygen from the blood, and the increased content of myoglobin (an oxygen carrier) facilitates its transport inside the muscle cells to the mitochondria [14]. All this causes the use of more efficient aerobic, oxidative way of energy production by slower muscle fibers and determines their high endurance. According to Professor V.N. Seluyanov (2016), "the classification of muscle fibers can be performed by the mitochondrial enzymes, for example, by citrate synthetase. In this case, muscle fibers are divided into oxidative and glycolytic ones. In oxidative muscle fibers (OMFs) the mitochondria braid tightly the myofibrils, so the ratio of the mass of mitochondria to the mass of myofibrils is at the limit. The lactate is not formed in the OMFs; the fatty acids are the oxidation substrate. The mitochondria in glycolytic muscle fibers (GMFs) are so small that after their activation, glucose or glycogen, which are converted into lactic acid during the anaerobic glycolysis, are their oxidation substrate. The mass of mitochondria in GMFs can be increased, so it is possible to convert GMFs into OMFs" [13, p. 13]. Further, the author makes a very significant conclusion for teachers of physical education: "This means that the muscular composition of mitochondrial enzymes is not inherited, but it can be acquired in the course of training, and there is an intermediate stage of the state of muscle fibers, in which the amount of mitochondria is substantial, but not enough for complete processing of pyruvate, that is why it is partly converted into lactic acid. These muscle fibers are called intermediate muscle fibers (IMFs)" [13, p. 13].

FMFs have fewer capillaries than OMFs, they contain fewer mitochondria, myoglobin and fats; therefore, they have less preconditions for the intense and prolonged aerobic (oxidative) method of energy production. But FMFs have a high activity of glycolytic enzymes and a high content of glycogen, that is, they become glycolytic muscle fibers (GMFs). These fibers do not have a great endurance and are more suitable for powerful, but relatively short-term muscle contractions. The activity of the fibers of this type is of particular importance for performing the short-term work of high power, for example, the weightlifting, powerlifting, the running for short distances.

Two subtypes are distinguished among the FMFs, which differ in the force of contraction and endurance. The A subtype (conditionally) has a higher oxidative ability. The B subtype is characterized by the highest glycolytic activity among all muscle fibers. The A subtype is called the IMFs. The percentage ratio of the three types of muscle fibers and their average sizes (cross-sectional areas) are given in Table 1 [16].

The analysis of the data presented in the table shows the following. The cross-sectional area in males aged 20 to 30 years in all groups of muscle fibers is higher than in young males: in OMFs by 9%, IMFs by 11%, GMFs by 14%. This is probably due to higher motor activity. Females have slightly different values; the area for all muscle fiber groups is much lower: in OMFs by 9%, IMFs by 16%, GMFs by 43%. In females during the considered age period, the muscle fibers lose myofibrils, therefore, they become thinner. At the same time, GMFs undergo more intensive hypotrophy; the decrease is equal to 43%. This is associated with a decrease in motor activity and, especially, with a decrease in intense muscle activity, which requires the active participation of this type of muscle fibers. At the same time, it is necessary to pay attention to the fact that the number of GMFs in percentage terms is much less than that of OMFs (14% vs. 52%). GMFs correspond to FMFs, while OMFs are slow-twitch. The ratio of the cross-sectional area of FMFs and the SMFs in different muscles may differ, but it must be taken into account that SMFs can influence the growth of the body's strength capacity.

Table 1. The percentage and the cross-sectional areas of the three muscle fiber species of the four-headed muscle in males and females of different ages (according to B. Saltin, 1977 [16])

Fiber type	Fiber percentage	Cross-sectional area (micron²)			
		Males		Females	
		16 years	20-30 years	16 years	20-30 years
Oxidative muscle fibers (OMFs)	52	4880	5310	4310	3948
Intermediate muscle fibers (IMFs)	33	5500	6110	4310	3637
Glycolytic muscle fibers (GMFs)	14	4900	5600	3920	2235

METHODS AND ORGANIZATION OF THE STUDY

In classical power work with maximum weights, slow-twitch and fast-twitch fibers are used, but only fast-twitch ones are trained. The data given in the table show that in order to increase the strength capacity it is necessary to use both IMFs and OMFs. Without the necessary knowledge in the field of physiology, it is impossible to solve the task.

The success of human motor activity largely depends on the level of the development of strength endurance. Strength endurance is a complex physical quality and it is defined both by the level of vegetative functions, ensuring the required oxygen regime of the body, and the state of the neuromuscular system. When working with the circumscribed (submaximal) muscular efforts, the level of its development is determined primarily by the maximum force. With a decrease in the magnitude of the work effort, the role of vegetative maintenance factors increases. The limit of the transition of the work with the predominance of "power" and "vegetative" factors is considered to be the load with the force of 30% of the individual maximum [2].

Therefore, the development of strength endurance should be conducted in a comprehensive manner, on the basis of parallel improvement of the vegetative systems and strength capacity. The main method of the development of strength endurance is the method of off-peak efforts with the maximum number of repetitions [7, 11].

The training aimed at the development and improvement of strength endurance can be organized both in the form of a consistent application of the series of each selected exercise and in the form of circular training, as well as in other combinations; in this study the Isoton system, created in 1992 in Russia in the Problem Research Laboratory of the State Central Institute of Physical Culture [9], was used by the authors.

According to the idea of the authors, the Isoton system as well as other wellness systems, includes a combination of physical exercises of a certain direction performed in certain modes, including the means of psychological correction, the means of physiotherapeutic influence, the hygienic measures, rational nutrition and control over the physical and functional state, applied both at the beginning of the classes and for the purpose of correction of the load in the process.

The exercises themselves – the isotonic, the static-dynamic and the static ones – are the peculiarity of the system. These exercises, according to their creators, are designed to solve the following tasks: to increase or decrease the volume of muscles, "to change their strength and endurance; to improve the endocrine mechanisms that respond to stressful effects; to reduce the amount of fat; to create a common, so-called "anabolic" background, to facilitate the positive changes in the body, the reflective and mechanical influence on internal organs aimed at the normalization of their work; to train the vascular reactions and to improve the nutrition of the tissue; to improve the trophism of the intervertebral discs and to reduce the hypertension of deep spine muscles, creating a "muscle corset" to prevent any damage to it, etc." [9, pp. 10-11]. Also, the system of physical exercises includes aerobic training, stretching, asanas and breathing exercises.

The principles of construction of the Isoton system: the principle of minimizing the growth of systolic blood pressure; the principle of extreme stress intenseness, the principle of the continuity of the training process and nutrition. The principle of extreme stress intenseness requires the following: the intensity of muscle activation is 30-70%, the exercises are performed in the static-dynamic mode, it is forbidden to hold the breath, the duration of the exercise is minimum 30 and maximum 60 s, the exercise is performed until a strong pain sensation – stress, the exercises for one muscle group are combined into a supersession [9, p. 67].

Let us consider the proposed principles in more detail. The Isoton system was created as a health-improving exercise system for people of mature and older age. First of all, the Isoton exercises are performed in a way that does not increase blood pressure so that there is no delay in breathing. Holding the breath necessarily increases blood pressure, and this causes an increased flow of blood.

This condition can be normal for young people, but for people of age, almost guaranteed to have certain deposits on the walls of blood vessels, the increased blood flow can lead to the rupture of atherosclerotic plaques by the blood flow. A thrombus, carried by blood, reaches a narrow site and clogs it. If this happens in the heart or brain region, then heart attacks and strokes are quite likely. Exercises in the Isoton system have no such negative consequences for the following reason.

The exercises in the analyzed system are performed in a static-dynamic manner. This method of exercises was invented with the direct participation of Professor V.N. Seluyanov. The essence of it is as follows: the movements are performed within very small amplitude of motion – 10-15 degrees. For example, the squats in the range of 10-15 degrees from the right angle in the knee joints. The movement is performed in a time range of 30-60 seconds. During this time, it is necessary to achieve a strong burning sensation bordering on pain. After this, the exercises are stopped, i.e. it is necessary to choose such burdens to achieve such a feeling, when performing a movement, without any straining and holding the breath.

The severe burning causes a mental action – a mental stress. The mental stress is a prerequisite for the release of anabolic hormones into the blood. Getting into the blood, hormones (testosterone, growth hormone) are transferred with blood flow to the muscles that have worked, penetrate into them, causing the muscle growth. But, at the same time, blood-borne hormones are able to penetrate the cholesterol plaques on the walls of blood vessels. Inside these plaques, hormones split the cholesterol into fatty acids, which are subsequently released into the bloodstream and used by the body, and the atherosclerotic plaque disappears.

Thus, the release of hormones due to the exercises makes it possible to get rid of atherosclerosis. For 3-4 months of continuous training, the vessels are able to purify themselves completely of atherosclerosis (subject to the correct, in terms of hormone release, performing of the

exercises), while atherosclerosis is the cause of mortality. The Isoton system is able to cure completely of the atherosclerosis of the vessels in a short time (3-4 months), i.e. to halve the chance of dying. And although the production of anabolic hormones decreases with age, nevertheless, regular performance of the static-dynamic exercises within the Isoton system can significantly increase their production and stimulate their release into the bloodstream for health-care activities.

The main form of implementation of the analyzed system are academic classes aimed at comprehensive physical training of the students, strengthening their health, increasing the level of physical development, physical fitness and working capacity.

Practical importance: the proposed organization of the training process at physical education classes contributes to the improvement of the physical condition of students. The exercises of the Isoton system significantly influence the increase in the body's strength capacity. The Isoton system was created as a health-improving exercise system. The performance of the exercises can be carried out both during the physical education classes and at home.

The objectives of the study.

1. To determine the level of strength preparedness of female students using the control standards at the beginning and end of the semester.
2. To conduct a comparative analysis of strength preparedness at the beginning and at the end of the study.
3. To determine the capacity of the proposed methodology of training aimed at developing physical preparedness.

The study was carried out as follows. The female students of the reference group were engaged in the physical education program during the classes. The female students of the experimental group took exercised on an indoor track and in the shaping room. On the indoor track, the female students performed physical exercises by the method of circular training. The amount and composition of the exercises in the "circle", as well as the number of "circles", depended on the level of preparedness of the students and the training purposes. The "circular training" is most effective at the stage of basic (general physical) training. The subjects consistently performed a series of exercises, consisting of: flexion and extension of the arms in the plank position, lifting of the straight legs in the prone position and rope jumping. The load was recorded in the working protocols and subjected to mathematical processing in order to identify the student rankings affecting the overall assessment of the physical education [1]. Thus, the student, in carrying out the training load offered in the class, was additionally motivated to complete the task. The exercises were performed dynamically during a two-week cycle.

In the shaping room, the exercises aimed at developing the strength of the shoulder and abdominal muscles were carried out in a static-dynamic mode. The method of using the static-dynamic exercises was as follows. At the beginning of the experiment, the exercises were performed during 30 seconds in a slow mode, after which the 30-second rest followed. The exercises were performed in three series. Gradually, with the increase in the level of exercise, the exercise time increased: 40-50 seconds of work, 40-50 seconds of rest, the number of episodes at the end of the experiment increased to four. This study was conducted in groups of young females engaged in general physical training. The testing included: the measurement of maximum oxygen consumption (MOC) according to the Astrand-Rimming technique, the flexion-extension of the arms in the plank position from the bench of not more than 25 cm high, lifting the trunk from the prone position a number of times per one minute. The results of passing the control standards for general physical training were subjected to statistical processing to determine the effectiveness of the method of conduct of the physical education classes.

RESULTS

To determine the effectiveness of the proposed program, a pedagogical experiment was conducted, which was the main method of study. The effectiveness of the proposed effects in addition to the test exercises themselves (Table 3), which in this case acted as training exercises, was assessed using the MOC indicator by the Astrand-Rimming method (Table 2). The MOC is the main indicator reflecting the aerobic capabilities of the body, which are interrelated with health in general, and also reflect the current functional state in a representative manner [5, 8, 18-19].

The analysis shows that the results of the experimental group significantly exceed the results of the reference group, which indicates not only an increase in the indicator of the functional readiness of the female students, but also an increase in their health reserves.

According to the table, the use of the Isoton training system at physical education classes in the form of the exercise of flexion and extension of the arms in the plank position, which, as we have said, is the test one in the determining of the strength abilities of the students, proved to be more effective. The average results in the experimental group in comparison with the reference group were higher by 53%.

The differences between the average arithmetic values obtained in the experiment in lifting the trunk from the prone position proved to be unreliable. Consequently, the use of the Isoton training system at the physical education lessons in lifting the trunk from the prone position was not very effective in the development of strength endurance. The average results in the experimental group are greater than in the reference group by 7%.

Table 2. The indicators of functional preparedness of female students during the experiment

Test indicators	Experimental group (EG)(n=13)		Reference group (RG) (n=14)		Difference in increase in EG-RG		t	P
	Before the exp. M1 ± m	After the exp. M2 ± m	Before the exp. M3 ± m	After the exp. M4 ± m	In units	%		
MOC, the Astrand-Rimming test (ml/min/kg)	39.40± 1.15	46.73±2,15	40.90±1.38	42.50±1.57	5.65	12.0	3.01	<0.01

Table 3. The indicators of physical preparedness after the experiment

Test indicators	Experimental group (EG) 2 (n=13) M1 ± m	Reference group (RF) 2 (n=14) M3 ± m	Difference in increase in EG-RG		t	P
			In units	%		
Flexion and extension of the arms in a plank position (times)	21.6±1.48	14.1±1.35	7.5	53	3.78	<0.01
Lifting the trunk from a prone position (times)	44.3±1.58	41.2±2.09	3.1	7	1.28	>0.05

DISCUSSION

The results were achieved due to the fulfillment of certain conditions. First of all, they should be attributed to the principles of construction of classes, as well as the features of the methodology used.

In this study, the following principles of construction of sports training were used at the physical education classes [7, 11]:

– the focus on the greatest possible achievements;

– the unity of general and special training;

– the continuity of the training process;

– the unity of graduality and boundedness in the buildup of training loads;

– the wave-like dynamics of loads;

– the cyclicity of the training process.

In classical strength work with maximum weights, both slow-twitch and fast-twitch fibers are used, but only the fast-twitch ones are trained. As noted above, SMFs are not less than FMFs, but they are not trained in a dynamic mode of operation. Therefore, there are some reserves of strength development, if you train SMFs. Let us consider the influence of the Isoton system on the development of the strength of SMFs.

If the exercise is performed in a dynamic mode, then in SMFs practically no lactic acid is formed; therefore, there is no acidification. In the static-dynamic mode of operation, the muscle is strained, muscle fibers squeeze the capillaries and the blood ceases to flow into the muscle through them. After a few seconds, hypoxia begins; therefore, in all cells, including in oxidative muscle fibers, the anaerobic glycolysis begins, the lactic acid is formed. After such training, the hypertrophy of SMFs occurs. It happens first imperceptibly, as the density of the myofibrils grows due to the appearance of the new ones, then the diameter grows, when the mitochondria appear around the new myofibrils. But the mitochondria occupy only 10% of the total muscle volume. The main growth is due to the myofibrils. The main sign of hypertrophy is the increase in strength due to the increase in the strength of SMFs, and the strength of FMFs remains the same. But the most useful is that due to this, the oxygen consumption is increasing.

According to the concept of V.N. Seluyanov, SMFs and FMFs should be trained through different exercises and different methods. FMFs are trained in a dynamic mode, while SMFs are trained in a static mode. Naturally, a certain group of muscles is trained at a different time.

At the same time, the analysis of the experimental data and the application of the method in the development of the strength of the abdominal muscles showed the following. The training for the development of the strength of abdominal muscles (press) in a dynamic mode was performed in two ways: the development of the upper part of the press (lifting the trunk from a prone position) was performed at one class; the lower part of the press was trained (lifting the legs from the prone position) at the second class. The upper part of the press is checked (lifting the trunk from the prone position) when testing the strength of the abdominal muscles. Consequently, the training of FMFs of the abdominal muscles occurs 1 time during four classes. That is, the training is not developing, but tonic (supportive). Thus, the development of the strength capacity of the abdominal muscles occurred only in SMFs, through the static-dynamic exercises in the shaping hall, i.e. the increase in strength was only due to SMFs.

CONCLUSION

The pedagogical experiment showed the effectiveness of the proposed methods of conducting the classes. The results of testing the level of strength preparedness in groups according to the proposed method turned out to be high. The use of the Isoton training system at physical education classes in push-ups in the plank position proved to be more effective in the development of strength capacity ($P < 0.01$). The average results in the group increased by 53%.

Although the test results turned out to be inaccurate for the liftings of the trunk from the prone position ($P > 0.05$), the observed trend indicates that the increase in strength occurred only at the expense of SMFs by 7%, that is, it can be concluded that the training of SMFs improves the strength capacity of the muscles.

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