CHARACTERIZATION OF THE INFLUENCE OF PHYSICAL REHABILITATION MEANS AND SPECIAL PHYSICAL EXERCISES OF ARCHERY ON THE SPORTS PERFORMANCE OF PARALYMPIC ATHLETES

ХАРАКТЕРИСТИКА ВПЛИВУ ЗАСОБІВ ФІЗИЧНОЇ РЕАБІЛІТАЦІЇ ТА СПЕЦІАЛЬНИХ ФІЗИЧНИХ ВПРАВ СТРІЛЬБИ З ЛУКА НА СПОРТИВНИЙ РЕЗУЛЬТАТ ПАРАЛІМПІЙЦІВ

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Abstract

Determining the effect of an individually selected complex of special physical exercises in archery and physical rehabilitation means on the functional state of the cardiovascular, neuromuscular, and sensory systems and sports achievements of Paralympic athletes. **Material.** To achieve the goal and solve the tasks of the study, the following methods were used: theoretical – search and bibliographic methods; empirical – medical-pedagogical and medical-biological research methods; methods of mathematical statistics. **Results.** The analysis of scientific and methodological literature on practically healthy archery athletes allowed us to establish the important role of the nervous, muscular, and sensory systems in the realization of the archer's sports results. Physical loads in archery are static and well-studied in practically healthy athletes, but in Paralympic athletes, they have not yet been studied sufficiently, and the effect of physical rehabilitation and special physical exercises in archery on recovery processes in the post-training and post-competition periods has not been studied, so a scientific study of Paralympic athletes was conducted. It was found that the Paralympians of the experimental and control groups at the firing line before and after the first training session of the first stage (background indicators) had no significant differences between all studied indicators. Significant differences between the first and second stages of the study and between the first and third stages of the study were determined only in the experimental group.

The positive influence of the use of a complex of special physical exercises in archery and physical rehabilitation means on increasing psycho-emotional stability and improving sports performance has been proved. It was proved that Paralympians of the experimental group were more stable in performing shots and outperformed Paralympians of the control group by the results of shots, which is also an argument for the application of the proposed changes to the plans of educational and training sessions. **Conclusions.** In order to improve and stabilize sports results, increase psycho-emotional stability in the preparatory part of training sessions of the preparatory and competitive periods, apply a set of special physical exercises in archery and in the final part of physical rehabilitation – back muscle massage, massage of the muscles of the shoulder girdle and upper extremities and, on a free day, recreational swimming.

Key words: Paralympic athletes, physical rehabilitation, special physical exercises, cardiovascular system, neuromuscular system, sensory system.

Мета. Визначення впливу індивідуально підібраного комплексу спеціальних фізичних вправ у стрільбі з лука та засобів фізичної реабілітації на функціональний стан серцево-судинної, нервово-м'язової та сенсорної систем і спортивні досягнення паралімпійців. **Матеріал.** Для досягнення мети та вирішення завдань дослідження використано: теоретичні – пошуково-бібліографічний метод; емпіричні – науково-педагогічні та медико-біологічні методи дослідження; методи математичної статистики. **Результати.** Аналіз науково-методичної літератури практично здорових спортсменів стрільців з лука дозволив встановити важливу роль нервової, м'язової і сенсорних систем у реалізації спортивного результату лучника. Фізичні навантаження у стрільбі з лука мають статичний характер

і добре вивчені у практично здорових спортсменів, але у паралімпійців вони ще недостатньо вивчені, також не вивчено вплив засобів фізичної реабілітації та спеціальних фізичних вправ зі стрільби з лука на процеси відновлення у післятренувальний та післязмагальний періоди, від того було проведено наукове дослідження паралімпійців. Установлено у паралімпійців експериментальної та контрольної групи на вогневому рубежі до та після першого навчально-тренувального заняття першого етапу (фонові показники) відсутність достовірних розбіжностей між всіма показниками, що вивчалися. Визначено достовірні відмінності паралімпійців між першим та другим і між першим та третім етапами дослідження лише у паралімпійців експериментальної групи. Доведено позитивний вплив використання комплексу спеціальних фізичних вправ зі стрільби з лука та засобів фізичної реабілітації на підвищення психоемоційної стійкості та покращення спортивного результату. Доведено, що паралімпійці експериментальної групи були більш стабільними у виконанні пострілів та переважали паралімпійців контрольної групи за результатами пострілів, що також є аргументом, щодо застосування запропонованих змін до планів навчально-тренувальних занять. **Висновки.** Для покращення і стабілізації спортивного результату, підвищення психоемоційної стійкості у підготовчій частині навчально-тренувальних занять підготовчого та змагального періодів застосовувати комплекс спеціальних фізичних вправ зі стрільби з лука та у заключній частині засоби фізичної реабілітації – масаж м'язів спини, масаж м'язів плечового пояса і верхніх кінцівок та у вільний від занять день оздоровче плавання.

Ключові слова: паралімпійці, фізична реабілітація, спеціальні фізичні вправи, серцево-судинна система, нервово-м'язова система, сенсорна система.

Introduction. The long-term practice of specialists working with the disabled shows that the most active methods of rehabilitation for this contingent are rehabilitation by means of physical education and sports. Systematic physical exercises not only increase the adaptation of disabled people to changed living conditions, expand their functional capabilities, helping to improve the body, but also contribute to the development of coordination in the activities of the musculoskeletal system, cardiovascular, respiratory, digestive, and excretory systems, have a beneficial effect on the psyche disabled people, stabilize their will, return people's sense of social fullness. Sports are of particular importance to the disabled. In connection with disabilities, a disabled person may develop an inferiority complex characterized by anxiety, loss of personal value, and confidence. Active participation in sports restores the mental balance of a disabled person and gives him the opportunity to return to life, despite physical disabilities. Ultimately, the goal of encouraging disabled people to play sports is to restore the lost contact with the environment and to create the conditions necessary for successful integration into socially helpful work.

The analysis of the scientific literature showed that the goal of archery training is the formation of stable, stable, controlled depending on the conditions of archery, and motor skills archery shooting [1, 3, 6, 7, 13]. Data on the mechanisms of the formation of motor activity – "shooting from a bow" can be used as a convenient model for the analysis of similar processes in other sports with a discrete nature of the result, a complex coordination structure of motor skills, in which the main mechanism for achieving the optimal result is a high muscle articular sensitivity of the upper limbs, a high capacity for afferent synthesis and decision-making in a micro-interval of time sufficient to maintain the "shooter-bow" system in a state that corresponds to hitting the top ten. The essence of the long-term training of archers can be reduced to a short work task: always shoot so as to hit the top ten [1, 2, 3, 6, 7]. On the way to the realization of this task, there are functional barriers in the form of natural variability of the functional state of the central nervous system (for example, the phase of alpha waves), different levels of excitability of the neuromuscular apparatus (motor units, neuromuscular synapses) of the heart – vascular and other systems that change their functional state during the repeated repetition of skills both during one day and during many weeks and months of training [2, 3, 4, 5, 6, 7, 9, 11]. Predicting the direction of these changes, their number, and their impact on the athlete's performance is one of the most important tasks of effective training.

As a result of many years of research on archers, scientists have come to conclusions that

show the role of improving the physiological functions of the nervous, muscular, and sensory systems in realizing the archer's sporting results [1, 6, 7, 10, 11, 12, 13, 14, 15]. Physical stress during archery is static in nature and is well-studied in archery athletes [1, 2, 4, 6, 7, 13, 15].

But Paralympic archers have not yet sufficiently studied how shooting loads and special archery exercises affect muscle sensitivity, and psychophysiological indicators, which are essential for physical rehabilitation and recovery after training and competitions Paralympians and sports dynamics. That is why we conducted a scientific study of Paralympic archers, members of the Medin sports club and the national team of Ukraine, who practice on the basis of the sports shooting range of the Department of Physical Education and Sports Medicine of the Danylo Halytsky Lviv National Medical University.

The aim of the study was to determine the effect of an individually selected complex of special physical exercises in archery and physical rehabilitation means on the functional state of the cardiovascular, neuromuscular, and sensory systems and sports achievements of Paralympic athletes.

Research material and methods. To achieve the goal and solve the research tasks, the following were used: theoretical – search and bibliographic methods; empirical – scientific-pedagogical and medical-biological research methods; methods of mathematical statistics.

20 men, masters of sports and masters of sports of the international class, winners and prize-winners of the Ukrainian, European, and World Paralympic Games archery championships of different years, who were engaged in the Paralympic sport – archery in the shooting range of the Lviv National Medical University, took part in the research. Danylo Halytskyi University, aged 24 to 39 years. Paralympic archers were divided by diagnosis and groups of persons with disabilities (hereinafter – persons): 5 persons – diagnosis – cerebral palsy; 5 people – amputation of the right lower limb; 4 persons – congenital dislocation of the right hip; 6 people – consequences of injuries or spine fracture. All persons with disabilities moved in wheelchairs and had cars. During educational and training sessions and competitions, shooting was carried out from the position of sitting in a cart. By age, the disabled were divided into: 6 people 24–29 years old; 6 people aged 30-34; 8 people aged 35-39. Paralympians are divided into disability groups: I group – 4 people; II group – 8 people; Group III – 8 people. Taking into account the specifics of the contingent, the diagnoses of congenital and acquired diseases and injuries in Paralympic athletes, the conditions of conducting research and their sequence over many years, we used practically unchanged, accessible, simple, adequate, and tested scientific-pedagogical and medical-biological research methods [1, 2, 6, 7, 12, 13].

All Paralympic athletes agreed to participate in the study (pedagogical experiment) during training sessions in the preparatory period. To conduct the study, they were divided into two equal groups: an experimental group (EG) of 10 people and a control group (CG) of 10 people. The research was conducted for 12 weeks (48 training sessions) in 3 stages, each of which consisted of 4 weeks of 16 training sessions (hereinafter – NTW) and during the control competition, which took place on the 49th day of NTW.

Paralympic athletes (hereinafter – Paralympians) of the experimental group were offered to make changes to the plans of NTW with the performance in the preparatory part of each training session of an individually selected complex of special physical exercises in archery on a shooting simulator and increase, during the main part of the training session, the intensity of physical activity by the number of shots by 30–35 % and use in the final part after NTW and after competitive restorative means of physical rehabilitation, namely massage of muscles of the back. The Paralympians of the control group were offered to perform training sessions according to the established plans of NTW. Training sessions for the EG and CG were conducted under the same conditions, at the same time, 4 times a week, each for 90 minutes. Competitions were conducted on the 49th day of the NTW in a sports shooting range at a distance of 18 m. The 18 m

round (M3x2 exercise) consisted of 60 shots at a 40 cm triple target.

The study of indicators of cardiovascular, neuromuscular and sensory systems of Paralympic athletes in EG and CG was conducted before and after the first NTW of the first, second (day 17 of NTW) and third (day 33 of NTW) stages and before and after the control competition before and after NTW and before and after the control competition (day 49 of NTW). In Paralympians EG and CG the heart rate (HR) at the firing line was determined, which was recorded with the help of an electronic stopwatch for 10 s and recalculated for 1 min; the strength of the muscles of the right and left hands, which was determined by a hand dynamometer located with the arrow to the palm with the arm extended to the side and squeezing it with the hand; muscle sensitivity of the right and left hands was measured by a hand dynamometer by reproducing a force of 20 kG three times under visual control, and then three times by memory; the sense of time interval, which was carried out using an electronic stopwatch, first three times under visual control, a 5-s interval was reproduced with the right and left hands, and then – by memory, a 5-s interval was reproduced three times. During the study, the history of the Paralympic athletes and the results obtained were recorded in the study protocols. Mathematical and statistical processing of the results was performed using a personal computer.

Results of the research. The analysis of the obtained results in Paralympians of the experimental and control groups on a firing line before and after the first NTW of the first stage (background indicators) showed the absence of reliable differences ($p > 0,05$) practically between all indicators of the experimental and control groups (fig. 1, table 1). This most likely testifies to the low intensity of physical loads of training sessions in the post-competition period which did not influence physiological mechanisms which promote the increase of aerobic efficiency. The absence of tachycardia before the study indicated a low level of emotional stress in Paralympic athletes in the transitional post-competition period, which practically did not affect the heart rate response. However, at the following stages we found individual significantly ($p<0.05$) higher HR values in Paralympians of the control group before (78.7±2.1) and after (83.5±2.6) compared to EG before (72.2±1.1) and after (76.4±1, 5) NTW on the 17th day of the second stage and before NTW on the 33rd day of the third stage in Paralympians of the CG (87.6±2.4) compared to Paralympians of the EG 71.3±1.3, which indicated the advantage of the proposed changes to the plans of NTW by Paralympians of the experimental group.

The analysis of HR indices of the second, third stages and the fourth stage (before and after competitions) in Paralympic athletes of EG showed the absence of significant changes ($p>0.05$), which indicated the positive influence of the proposed changes in the plans of conducting NTW (fig. 1).

In Paralympians of the control group, the index of heart rate obtained after NTW of the first stage significantly increased in comparison with the index which was fixed after the control competition (fig. 1; tab. 1), which, in our opinion, indicates insufficient physical fitness and functional readiness of cardiovascular, neuromuscular and sensory systems of Paralympians of the control group to perform intensive shooting loads of competitions and is an important argument, for the use in the final part after NTW and after competitive physical rehabilitation, namely back muscle massage, massage of the shoulder girdle and upper extremities and on a day free from NTW, 1 session per week, 45 minutes, recreational swimming, which were used by EG Paralympians.

The obtained data before and after NTW on the 17th day of the second stage of the study allowed stating significant differences between the indicators of the neuromuscular and sensory systems of Paralympic athletes of the experimental and control groups (table 1) in the vast majority of them.

There were no significant differences between 6 indicators of Paralympic athletes of the experimental and control groups, namely the results of measuring the strength of the right hand squeezing muscles after NTW, the left hand before and after NTW, the muscle sensitivity of

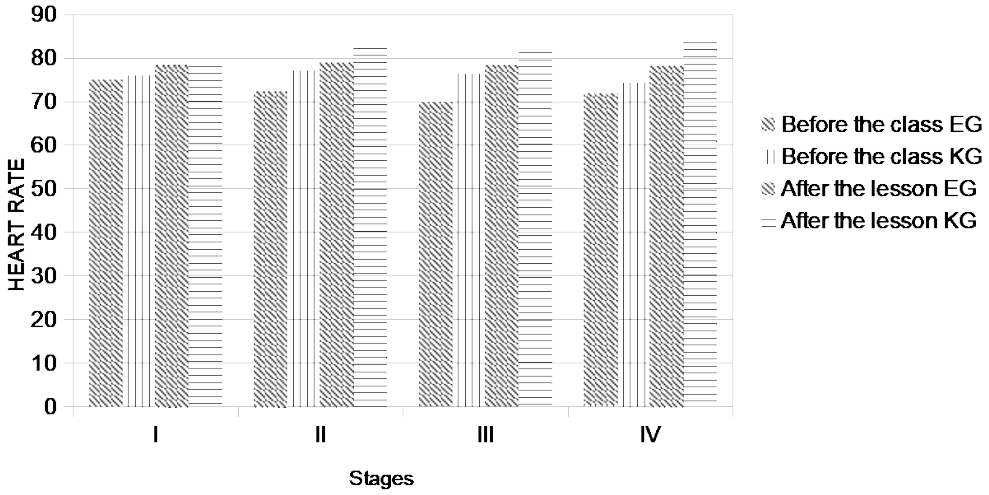

Fig. 1. Indicators of heart rate in Paralympic athletes at the stages of the pedagogical experiment before and after classes and before and after competitions

the right hand before and after NTW and the left hand after training sessions (table 1).

So the results of the research before and after NTW of the 33rd day of the third stage of measuring indicators of the neuromuscular and sensory system showed the same tendency which testified to the presence of reliable differences between the studied indicators of Paralympians of the experimental group who were engaged in the plans of educational and training classes developed by us, and Paralympians of the control group who continued to conduct educational and training classes according to the established plans of the preparatory period.

At this stage, there were no reliable differences between the three indicators of Paralympians of the experimental and control groups, namely by results of measuring of muscular sensitivity of the right hand before and after NTW and of the right hand before educational and training sessions (table 1).

There were no significant differences between 6 indicators of Paralympic athletes of the experimental and control groups, namely the results of measuring the strength of the right hand squeezing muscles after NTW, the left hand before and after NTW, the muscle sensitivity of the right hand before and after NTW and the left hand after training sessions (table 1).

Thus, the results of the study before and after NTW on the 33rd day of the third stage of measuring the indicators of the neuromuscular and sensory systems showed the same tendency, which testified to the presence of significant differences between the studied indicators of the Paralympic athletes of the experimental group, who were engaged in the plans of training sessions developed by us, and the Paralympic athletes of the control group, who continued to conduct training sessions according to the established plans of the preparatory period.

At this stage, there were no significant differences between the three indicators of Paralympians of the experimental and control groups, namely by results of measuring muscle sensitivity of the right hand before and after NTW and of the right hand before educational and training sessions (table 1). Compared with the second stage at the third stage (48th day of NTW) we did not establish significant ($p>0, 05$) differences between 3 indicators of Paralympians of the experimental and control groups and there were changes in the reproduction of weight of a hand dynamometer between the left and right hands (table 1).

The comparative analysis of indicators concerning differences in the obtained results of the experimental and control groups between

Table 1

Indicators of the neuromuscular and sensory systems in Paralympic athletes at the stages of the pedagogical experiment (x±m)

Stages	Groups	Hand	Hand muscle strength, kG		Muscle sensitivity		Sense of time (5 s)	
			Before the class	After the lesson	Before the class	After the lesson	Before the class	After the lesson
I	Experimental group (n-10)	Ave.	38, 7±2, 1	38, 1±1, 9	19, 0±1, 1	18, 8±0, 9	4, 8±0, 04	4, 7±0, 09
		left.	37, 4±2, 5	35, 6±2, 2	18, 0±1, 4	17, 6±1, 3	4, 6±0, 06	4, 5±0, 06
	Control group (n-10)	Ave.	38, 2±2, 2	38, 9±2, 3	18, 02±1, 7	18, 3±1, 9	4, 7±0, 04	4, 6±0, 05
		left.	36, 1±2, 1	34±2, 7	17, 9±1, 4	17, 8±1, 5	4, 5±0, 07	4, 6±0, 09
II	Experimental group (n-10)	Ave.	43, 0±1, 1*	39, 8±1, 4	19, 8±0, 9	20, 2±0, 6	4, 9±0, 07*	4, 9±0, 06*
		left.	39, 4±1, 0	34, 3±1, 7	20, 3±1, 1*	19, 6±1, 1	4, 8± 0, 03* ***	4, 7±0, 09*
	Control group (n-10)	Ave.	37, 6±1, 7	36, 9±1, 5	18, 6±1, 4	17, 8±1, 4	4, 6±0, 08	4, 4±0, 09
		left.	33, 1±1, 9	32, 2±1, 4	16, 8±1, 5	16, 7±1, 8	4, 4±0, 09	4, 3±0, 07
II	Experimental group (n-10)	Ave.	45, 2±1, 2* **	42, 7±1, 4* **	20, 1±0, 9	20, 2±0, 8	5, 0±0, 08* **	5, 1±0, 04* **
		left.	42, 4±1, 1*	40, 7±1, 5*	19, 7±1, 0	19, 8±0, 7*	5, 0±0, 07* **	4, 9± 0, 03* **
	Control group (n-10)	Ave.	37, 9±1, 1	36, 6±1, 4	18, 1±1, 3	17, 5±1, 2	4, 4±0, 09	4, 3±0, 06
		left.	35, 1±1, 7	33, 6±1, 4	17, 4±1, 1	16, 8±1, 3	4, 0±0, 07	4, 2±0, 04
IV	Experimental group (n-10)	Ave.	45, 5±1, 4* ***	43, 9±2, 1** ***	20, 0±1, 3	20, 4±0, 7**	5, 0±0, 03*	5, 1±0, 09** ***
		left.	43, 5±2, 3* ***	42, 6±1, 7** ***	19, 8±0, 5* **	19, 6±0, 9**	4, 9±0, 06*	5, 0±0, 07** ***
	Control group (n-10)	Ave.	39, 2±2, 4	36±2, 8	18, 2±2, 1	17, 0±1, 7	5, 0±0, 03*	5, 1±0, 09** ***
		left.	34, 1±1, 6	33, 9±1, 8	17, 1±1, 3	16, 5±1, 6	4, 9±0, 06*	5, 0±0, 07** ***

Notes: significant differences ($p<0.05$) between the experimental and control groups before the start of the stage*; between the stages of the study in the groups and after the fourth stage (after the competition)**; between the fourth (competition) and the first stage in the experimental and control groups**.

stages of the research within each group allowed revealing reliable (p<0, 05) differences only in Paralympians of the experimental group between the first and the second and between the first and the third stages (table 1).

At this stage, there were no significant differences between the three indicators of Paralympians of the experimental and control groups, namely by results of measuring muscle sensitivity of the right hand before and after NTW and of the right hand before educational and training sessions (table 1).

Compared with the second stage at the third stage (48th day of NTW) we did not establish significant (p>0, 05) differences between 3 indicators of Paralympians of the experimental and control groups and there were changes in the reproduction of weight of a hand dynamometer between the left and right hands (table 1).

The comparative analysis of indicators concerning differences in the obtained results of the experimental and control groups between stages of the research within each group allowed revealing reliable (p < 0, 05) differences only in Paralympians of the experimental group between the first and the second and between the first and the third stages (table 1).

The force of a squeeze of the right hand before and after competitions (49 NTW) in comparison with the index before the first NTW of the first stage, which was 37, 4±2, 5 kG, reliably increased on 8, 1 kG and was equal to 45, 5±1, 4 kG and the left hand it also increased on 5, 2 kG and was equal to 37, 4±2, 5 kG and 42, 6±1, 7 kG accordingly (table 1). It is the right hand that pulls a bowstring and the growth of force from stages of NTW to competitions is a sign of the positive reliable influence of inclusion in the preparatory part of educational and training classes of the individually selected complex of special physical exercises in archery on a shooting simulator.

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In Paralympians of the group, there was no significant increase in the index of the force of compression of the right and left hand obtained before and after competitions (49th day of NTW) in comparison with the index before and after the first first, second and third stages of NTW (table 1), which, in our opinion, indicates insufficient physical fitness of Paralympians of the control group who used small and medium physical loads during three stages of the research according to the established plans, which testified to insufficient power endurance of muscles of the right and left hand, insufficient readiness to perform intensive shooting loads of competitions, which were held according to the rules of official competitions, in a short period of time with a fixed period of time. This is another important argument in favor of justifying the need to use special physical exercises in archery, which should be aimed at improving the strength indicators of the left hand.

Muscular sensitivity of Paralympians of the experimental group improved from a stage to a stage and in time of competitions (49 NTW) and was within 19, 0±1, 1 kG for the right hand and 18, 8±0, 9 kG for the left hand before and after the first NTW of the first stage (background indicators) and reached the reliable changes for the left hand 19, 8±0. 4 kG before the competition for the right hand 20.4±0.7 and the left hand 19.6±0.9, and practically did not differ in the indicators of the right and left hands, in contrast to the indicators of Paralympians of the control group. The same applies to the indicators of the strength of the right and left-hand compression muscles and indicators of time perception (table 1).

The obtained results on the measurement of the index of the feeling of the time of the right and left hands indicate that Paralympians of the

control group (table 1), who conducted training sessions according to the constant curricula, decreased from stage to stage of the research and reached the lowest level before competitions for the left hand and after competitions for the right and left hands and significantly ($p<0.05$) differed from indicators obtained after the first NTW of the first stage, which testifies to the reduced peripheral muscular properties and their central mechanisms. Therefore, the use of complexes of special physical exercises in archery, which were used for Paralympians of the experimental group, in our opinion, should improve not only the state of the muscles of the right and left hands and their nervous mechanisms, but also contribute to the improvement of the psycho-emotional state of the Paralympian, and, as a result, improve the result of the overall sport.

The analysis of the protocols of competitions (49th day of NTW) of Paralympians of EG and CG of 18 m round showed that Paralympians of the experimental group were more stable in performing shots on two attempts of exercise M3x2 and surpassed Paralympians of the control group by results of shots, and the top ten by results of competitions included 8 Paralympians of EG and only two of CG, which is also a weighty argument for the application of the offered changes to plans of educational and training classes.

Thus, it is possible to state that under the influence of the performance of shooting loads of low and average intensity during all stages of training sessions of the preparatory period and loads of competitions Paralympic archers of the control group, in comparison with Paralympic archers of the experimental group, established significantly worse indicators of heart rate, reduced indicators of the force of compression of the right and left hand, muscle sensitivity, accelerated sense of time.

Thus, to improve the functional characteristics of the muscles of the right and left hands in Paralympic athletes of the control group, it is necessary to use individually selected complexes of special physical exercises in archery in the preparatory part of training sessions for the development of strength of the muscles of the hands, the sensitivity of the hands, sense of time and to create a competitive atmosphere for increasing psycho-emotional stability.

Conclusions.

1. The improvement of the strength of muscles of the right and left hands, muscular sensitivity, and sense of time of Paralympic sportsmen in the preparatory part of educational and training sessions of the preparatory and competitive periods takes place at the application of the individually selected complex of special physical exercises in archery with the use of the shooting simulator and the increase of volume and intensity of physical activity during educational and training sessions.

2. The improvement of the sports result of Paralympic athletes is due to the use of physical rehabilitation means in the final part of training sessions of the preparatory and competitive periods – back muscle massage, massage of the muscles of the shoulder girdle and upper extremities, and recreational swimming on a free day.

Prospects for further research will be aimed at the use of a complex of special physical exercises in archery in the individual plans of training sessions of Paralympic athletes, the formation of the volume and intensity of physical activity, the use of individually selected means of physical rehabilitation of persons with disabilities of different nosologies and disability groups.

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