

## *Sports training of physically impaired volleyball players: Russian experience and prospects for improvement*

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*The purpose of the study was to develop a protocol for the rational combination of rehabilitation-oriented physical exercises with the training process at the stage of sports improvement in volleyball players with locomotor system dysfunction. The research was conducted at the Regional Paralympic Training Center of Omsk, Russia. Seven physically impaired (PI) athletes displaying higher sportsmanship skills and having a 5-10-year experience in sitting volleyball were selected for the study. The assessment of the level of technical training of athletes' coordination abilities allowed developing a combined training methodology. As a result, the rehabilitation block involved a number of exercises aimed to improve posture, prevent contractures of the lower extremities and eliminate back and shoulder pain. These exercises were invariably carried out at the end of the training sessions. Each training session normally including coordination, speed-power and technical-tactical-centered exercises was expanded to include the rehabilitation block. The first experiments showed that the new technology allows improving playing skills of the PI volleyball players. The accuracy of a serve increased by 20-30% and the accuracy of offensive strikes – by 27-46%. Coordination and reaction demonstrated positive dynamics, the results of corresponding tests were improved by 13.3% and 30.27% respectively (with statistical significance,  $p < 0.05$ ). After experimental training, the heart rate recovery after loading significantly improved in all test subjects, which was confirmed by monitoring the heart rate and by a detailed analysis of the ECG signal.*

**Key words:** *physically impaired volleyball players, rehabilitation modules, training, adaptive sport*

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## *Introduction*

In modern society, one of the main tasks is the maximum adaptation of a person with health disorders to an independent life. The process of normal interaction of the physically challenged people in the society involves the formation of diverse social ties (Lewis & Sygall, 1997; Kalabekov, 2015). The long-term practice of experts from different countries shows that an effective method of integrating this contingent is rehabilitation by means of adaptive sports (Lape et al., 2018). Adapted sports are a method of therapeutic physical education in patients with long-term and persistent disability using elements of competition in combination with the submaximal physical exertion (Perrier et al., 2015; Skucas & Pokvytyte, 2017; Declerck et al., 2019; Diaz et al., 2019). Amputation of the lower extremities is a huge mental and physical trauma for a person, the consequences of which can manifest over a long period of time. Partial or complete loss of the lower limb causes restriction of motor functions, ability to work, self-service. With amputations of limbs, a disabled person begins a period of long-term restructuring associated with the adaptation of the body to new conditions of existence. Adaptive reactions are individual, they depend on the nature of the operation performed, the age, gender of the individual, his physical fitness, the quality of the prosthesis, the psychological status of the person, etc. Among the various sports used in working with amputees, the most popular in Russia is sitting volleyball, which was included in the program of the Paralympic Games in 1976 (Blauwet, 2007). The long-term sports training of physically impaired volleyball players in the Russian Federation includes the following stages: initial training, training, improvement of sportsmanship and higher sportsmanship (Briskin et al., 2010; Declerck et al., 2021). The “expert” stage of training implies not only demonstration of high sport results at international competitions, but also high socialization of the athlete and profound physical rehabilitation. Unfortunately, there is a lack of the training technologies for the people with the handicaps of locomotive system aimed simultaneously at the long-term advances in the sports skills, better rehabilitation and socialization, especially the ones having approved pedagogical effect (Briskin et al., 2010; Declerck et al., 2021; Maqhout-Juratli et al., 2010; Kocalevent et al., 2011; Bekker et al., 2020).

## Materials and Methods

Since the use of unified training loads allows accelerating the process of recovery of motor functions and corresponding skills necessary in everyday and competitive activities of disabled people, the development of scientifically substantiated technology of rational combination of training and rehabilitation exercises for volleyball players with PI seems to be very promising.

The purpose of this study is to develop a technology for the rational combination of rehabilitation-oriented physical exercises with the training process at the stage of sports improvement in volleyball players with locomotor system dysfunction. Organization and methods of the research: the prospective study has been conducted on the basis of the Department of Theory and Methodology of Adaptive Physical Culture of the Siberian State University of Physical Culture and the Regional Specialized Center for Paralympic and Deaflympic Training in Omsk, Russia. The biomedical research has been conducted in accordance with the ethical principles of the Helsinki Declaration of the World Medical Association (WMA) of 1964 (as amended in 2008). The inclusion of athletes in the study group has been carried out on the basis of a written signed and dated Informed Consent Form. The informed consent has been drawn up in accordance with the laws of the Russian Federation, the GCP rules and the principles of the Helsinki Declaration of the BMA.

Seven athletes with locomotor system dysfunction have been examined. The sports qualifications of the subjects are candidates for masters of sports. The experience of playing volleyball is from 5 to 10 years (Table 1).

**Table 1.**

*Distribution of volleyball players by age and level of lower limb amputation*

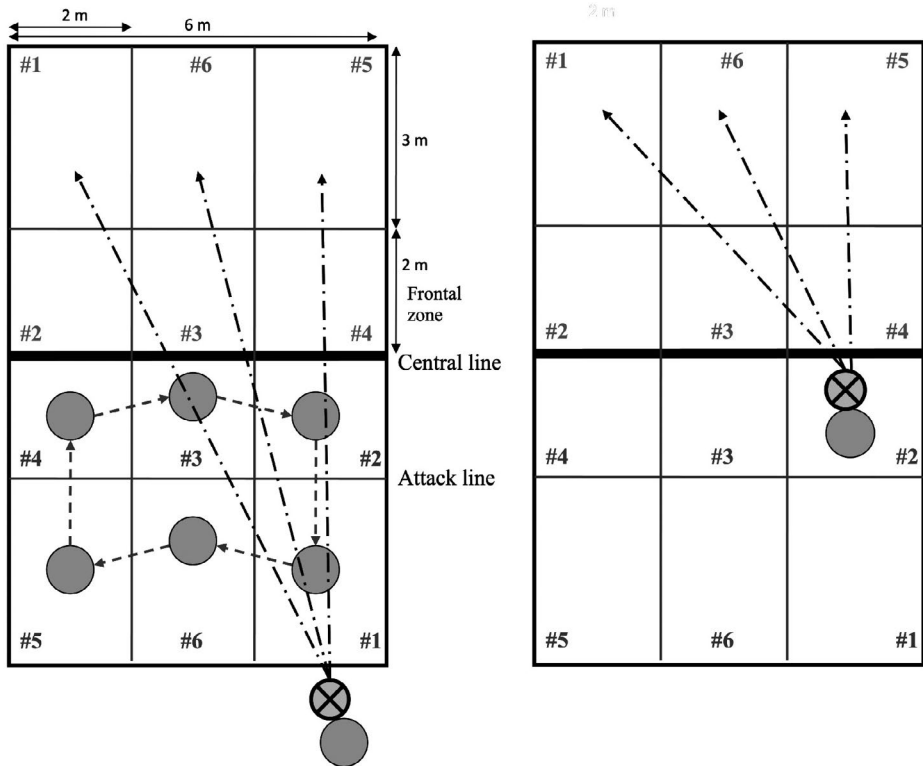
Age, years old	Level of amputees			Total
	Cnemis	Hip	Double-sided	
25 - 30	1	1	-	2
30 - 40	1	-	-	1
40 - 50	-	2	2	4

Testing the coordination abilities of sitting volleyball players has included an assessment of ability to orient in space and the ability to adapt to a changing situation using such tests as “Throwing the ball at the target”, “Catching the ruler”. These types of coordination abilities most strongly influence the achievement of high results when playing sitting volleyball.

Test “Throwing the ball at the target”. Equipment includes gymnastic hoop (diameter 80 cm), six balls for throws, measuring tape, rolling pin (length 60 cm). Testing scheme: a pendulum is mounted on the wall at a height of 230 cm, which consists of a rolling pin and a gymnastic hoop. The subject stands at the starting position, which is 300 cm away from the wall. The conductor raises the pendulum to a horizontal line and gives him the opportunity to perform a movement in one direction and back. When the pendulum moves, the subject must throw the ball into the middle of the hoop. Result: the hit is estimated in points (in the edge of the hoop – 1 point, in the middle – 2 points). The number of points scored out of 5 scoring attempts is calculated. The result “excellent” assumed a set of 9 points; “good” – 7 points; “satisfactory” – 4 points; “enough” – 2 points.

**Figure 1.**

- (a) Training precision of the serve into zones No. 1, 6, 5  
 (b) Training offensive strikes from zone 2 to zones No. 1, 6, 5



The “Catching the ruler” test. Testing scheme: the subject bends his right arm at the elbow joint to an angle of 90 degrees, palm inward, fingers straightened. The experimenter sets a ruler 40 cm long at a distance of 1-2 cm from the palm parallel to its plane. The zero mark of the ruler is at the level of the lower (outer) edge of the palm. Without a signal, the experimenter releases the ruler. The subject must catch it as quickly as possible. The distance in centimeters from the zero mark to the lower edge of the palm is measured. One trial attempt and three credits are given. The average value of three attempts is calculated.

The level of technical and tactical readiness of PI athletes are the basic elements to achieve the highest sports results in their chosen sports. Testing of specific skills in the technique of the game “sitting volleyball” involves a serve in the 1st, 5th, 6th zone from the starting position – sitting behind the front line and an offensive strike to zones No. 1, 5, 6 from the starting position of the saddle in zone No. 2, then No. 4. The number of accurate hits in the zone of five attempts has been taken into account.

The assessment of the health status of athletes has been carried out on the basis of the results of functional tests. To assess the functional state of the cardiovascular system, we have developed test tasks similar in nature to the Martinet-Kushelevsky test (20 push-ups from the floor with the trunk resting on a gymnastic bench at the hip joint level in 30 seconds). The following indicators have been taken into account: heart rate at the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> minutes of the recovery period. The type of reaction to physical activity has been evaluated (Perrier et al., 2015). To assess the adaptive capabilities of athletes with locomotor system dysfunction, the study of the vegetative functions has been conducted using the POLY-SPECTRUM computer system (Poly-Spectrum, 2022). A short-term recording of a cardiogram in the state of relative rest has been marked. During the examination the factors leading to emotional arousal have been eliminated. The following indicators have been analyzed (Blauwet et al., 2007):

- TR is the power of the low-frequency component of the spectrum (fluctuations in the range of 0.04-0.15 Hz), characterizing the influence of the sympathetic nervous system on the heart rate;
- %VLF is the power of an extremely low-frequency component of the spectrum (fluctuations in the range of 0.003-0.04 Hz), characterizing the influence of various humoral factors on the heart rate;

- %LF is the power of the low-frequency component of the spectrum (fluctuations in the range of 0.04-0.15 Hz), characterizing the influence of the sympathetic nervous system on the heart rate;
- %HF is the power of the high-frequency component of the spectrum (fluctuations in the range of 0.15-0.4 Hz), characterizing the influence of the parasympathetic nervous system on the heart rate;
- IN, cu (voltage index of regulatory systems)- reflects the degree of centralization of heart rate management.

For statistical calculations and plotting, Statistica-6 (statistical analysis package), the General Discriminant Analysis Models module has been used. The reliability of the study results has been assessed using nonparametric criteria: Wilcoxon for connected samples and Mann-Whitney for comparing quantitative characteristics of two independent populations.

## *Results*

The results of testing the technical and tactical readiness of the volleyball players have revealed the highest accuracy of the serve into zones No. 1 and No. 5 ( $3.5 \pm 0,9$  and  $3.7 \pm 0.4$  points respectively), and the lowest (3.1 points) – for the accuracy of the offensive strike into zones No. 1 and No. 5 and the serve into zone No. 6. Most of all, the results have been reduced with an offensive strike into zone No. 6 ( $2.8 \pm 0.9$  points). This indicates the lack of readiness of the players for active attacks, and a firmly formed dynamic stereotype of ball delivery. For volleyball players with locomotor system dysfunction, the greatest difficulty has been caused by the accuracy of hitting the ball into zone No. 6 (both the offensive strike and the ball delivery), which indirectly indicates the lack of differentiation of efforts which is necessary for a certain angle of rotation of the body.

When analyzing the results of testing coordination abilities, it has been revealed that all the athletes have shown an average level of ability to adapt to a changing situation (reactivity). In the “Throwing the ball at the target” test, 28.5% of the subjects’ indicators correspond to a good ability to orient in space, and in 71.5% – satisfactory (Table 2). The average group indicator in the “Catching the ruler” test has been  $13.1 \pm 2.04$  cm; “Throwing the ball at the target” –  $6 \pm 0.82$  points.

**Table 2.**

*The results of the development level of coordination abilities in athletes with locomotor system dysfunction in comparison with the normative indicators*

Test	Grading of the results for the healthy subjects	Athletes with locomotor system dysfunction (number; % of all)
Catching the-ruler	“exceptional” level, 0 cm	-
	“above average” level, 0-9 cm	-
	“average” level, 10-19 cm	13.1±2.04 (7; 100%)
	“below average” level, 20-29 cm	-
	“low” level, 30 cm and more	-
Throwing the ball at the target	“excellent”, 9 points	-
	“good”, 7 points	2; 28,5%
	“satisfactory”, 4 points	5; 71,5%
	“just enough”, 2 points	-

**Table 3.**

*The reaction of the cardiovascular system of volleyball players with locomotor system dysfunction to a functional test in comparison with normative indicators*

Conditions	Average for healthy athletes (16)	Physically impaired (PI) athletes Before experimental training	Physically impaired (PI) athletes After experimental training	
Rate at rest	69.5±13.4	average: 71.2±4.6	68.7±4.4*	
Rate after loading	increase, 30-48	average: 37±5.9	37.0±5.2	
Pulse rate, min <sup>-1</sup>	To normal after 1 min of recovery	Excellent adaptation	28,5% of subjects	43% of subjects
	To normal after 2 min of recovery	Good adaptation	57% of subjects	57% of subjects
	To normal after 3 min of recovery	Satisfactory	14.5% of subjects	0% of subjects

The functional tests have shown the presence of a small number of athletes with excellent recovery (Table 3). The results of cardiorythmography have indicated a decrease in adaptive capabilities in athletes with locomotor system dysfunction. This is confirmed by a high voltage index (IN) and low indicators of the total power of the spectrum (TR) (Analysis of medical documents showed that 29% of athletes have posture disorders, 14% have contractures of the joints of the lower extremities, 14% have back pain and 43% have pain in the joints of the upper extremities. The results of

the questionnaire using the method “Well-being, Activity, Mood” have disclosed a decrease in the indicators of well-being (up to 3.8 points) and mood (up to 4.5 points). At the same time, the activity index has been within the normal range (5.4 points).

**Table 4.**

*Indicators of the heart rate variability of volleyball players with locomotor system dysfunction in comparison with standard indicators*

ECG spectrum parameter	Test subjects (physically impaired (PI) athletes) Before experimental training	Test subjects (physically impaired (PI) athletes) After experimental training	General for athletes (17): average (Q25; Q75)
IP, arb. Units	3064±1826.4	3474,4±904,4*	8743 (2104; 18001)*
VLF	33.7±7.22	31,1±6,5	36.7 (27.3; 45.5)
LF	31.3±4.98	32,5±6,3	31.1 (24.0; 33.2)
HF	36.0±5.84	34,6±8,2	32.7 (24.8; 39.8)
LF/HF	1.12±1.256	0,9±1,2	0.94 (0.69; 1.21)
RSTI, arb. Units	161±46.6	128±21,2*	90±42,2*

(\*) sufficient level of significance  $P < 0.05$  for the difference between healthy and PI athletes.

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Based on the conducted preliminary research we have developed a technology for the rational combination of physical exercises of a rehabilitation orientation with the training process at the stage of the highest sportsmanship among volleyball players with locomotor system dysfunction. The main structural form of the organization of the training process of athletes is the macrocycle of preparation, i.e. the period between the beginning of preparation for the main competitions of one year and the beginning of preparation for similar competitions of another year. Each macrocycle includes the following periods:

- the *preparatory stage* - the stage of preparation of volleyball players, solving the tasks of restoring and improving general and special physical and functional readiness, restoring and improving technical readiness, restoring tactical and game readiness;
- the *competitive stage* - the stage of preparation of volleyball players, solving the tasks of maintaining a level of physical and functional readiness, improving technical and tactical skills, game and



- competitive training, and most importantly, successful participation in the main competitions;
- *the transitional stage* - the stage of preparation of volleyball players, solving the tasks of active recreation, preventive treatment of athletes.

The technology is focused on the preparatory period of the training process of athletes who are at the stage of sports improvement. The main objectives are to increase the total amount of training equipment, general preparatory exercises and partially special preparatory ones that develop physical qualities and contribute to the improvement of technical and tactical training – to correct concomitant disorders and deviations in the state of health. The structure of the lesson has consisted of four blocks of exercises. The coordination block has involved exercises aimed to improve the reactivity and differentiate the efforts. The speed-power unit has been aimed to improve special endurance, explosive strength of the muscles of the arms and shoulder girdle, speed of individual movements. The technical and tactical block has included a set of exercises to improve the technique of offensive strikes, ball delivery for accuracy and strength. In addition to the standard components of the training process (Kalabekov, 2015), we have added the fourth block of exercises – rehabilitation block that has been aimed to correct posture disorders, prevent contractures of the lower extremities and increase the functionality of the cardiovascular system of athletes. The ratio of funds in the training and rehabilitation session is presented in Table 5.

**Table 5.**

*The ratio of funds at the rehabilitation and training session for volleyball players with locomotor system dysfunction in the preparatory period, %*

Type of exercises	Time spent
General physical training	26%
Special physical training	21%
Technique training	31%
Tactics training	11%
Rehabilitation	11%

The results of the comparative pedagogical experiment showed some positive changes in both physical fitness and the functional state of the cardiovascular system and outlined an increase in the adaptive capabilities of the body of athletes with locomotor system dysfunction. When testing the ball delivery and the forward strike, the increase in the number of hits

in all zones was revealed. However, the increase in indicators in zones No. 1 and No. 5 did not reach statistically evident differences; the increase was at a statistically significant level and in zone No. 6 (Table 6). Testing of the coordination abilities showed a significant increase in indicators in the “Throwing the ball at the target” and “Catching the ruler” samples (Figure 2).

**Table 6.**

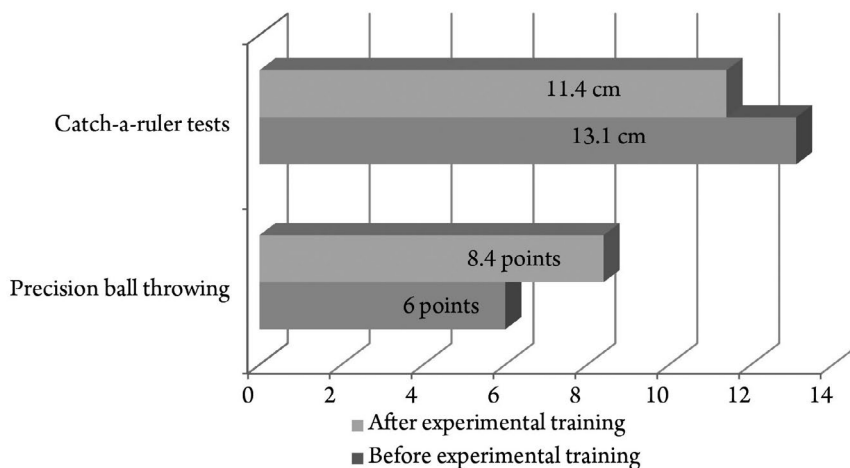
*Results of the study of the level of mastery of the technical elements of sitting volleyball in athletes with locomotor system dysfunction*

Tests		Before experimental training	After experimental training	Significance	Improvement, %
Serve into zones Nr. :	№1	3.57±0.97	4.43±0.53	P≥0.05	21.5%
	№5	3.71±0.49	4,57±0.53	P≥0.05	20.8%
	№6	3.14±0.69	4,28±0.75	P<0.05	30.7%
Offensive strike into zones Nr. :	№1	3.14±1.21	4,14±0.69	P≥0.05	27.5%
	№5	3.14±0,9	4.71±0.49	P≥0.05	40%
	№6	2.86±0,9	4.57±0.53	P<0.05	46%

The improvement in the state of adaptive capabilities is confirmed by a decrease in the voltage index (IN 128±21.2 conl. units) and an increase in the total power of the spectrum (TR 3474.4±904.4 mc) (p<0,05).

**Figure 2.**

*Comparison of the results of the coordination and reaction tests average for all test subjects (PI volleyball players) before and after experimental training*



## *Conclusions*

The results obtained in the course of this study significantly expand the field of scientific knowledge related to the sports training of qualified volleyball players with locomotor system dysfunction. Previous research demonstrates that practicing adaptive sports has a positive effect on the physical and functional condition of physically impaired people. At the same time, there is a limited number of research papers devoted to the problem of studying the conditions of adaptive abilities of the body of Paralympians, which, certainly, regulate the physical performance of athletes and affect their health. Thus, when building the training process, besides physical and tactical training, it is necessary to take into account the state of health of athletes with locomotor system dysfunction. In this regard, the objective of the current research is to develop a technology for the rational combination of rehabilitation-oriented physical exercises with the training process at the stage of sports improvement in volleyball players with locomotor system dysfunction. The assessment of intermediate results, including assessments of the levels of technical and tactical training, coordination abilities of athletes, their adaptive capabilities, allow us to further improve the training methodology and adjust it individually. As a result, we included exercises in the rehabilitation module aimed at improving posture, preventing contractures of the lower limbs and eliminating back and shoulder pain. These exercises were invariably performed at the end of the workout. Each training session was expanded from the traditional three modules with coordination, speed-strength and technical-tactical exercises to the fourth, recovery module. The new technology for training athletes with locomotor system dysfunction was proposed, which was previously tested on a small group of seven physically impaired (PI) athletes. In our experiments, this technology clearly demonstrated its high potential, but further experiments with larger groups of subjects are necessary to prove its effectiveness. Nevertheless, even the first experiments showed that the new technology makes it possible to improve the playing skills of the PI volleyball players. The accuracy of the serve increased by 20-30%, and the accuracy of offensive strikes – by 27-46%. Coordination and reaction showed positive dynamics, the results of the corresponding tests improved by 13.3 and 30.27%, respectively (with statistical significance,  $p < 0.05$ ). After the experimental training, the recovery of the heart rate after exercise was significantly improved in all subjects, which was confirmed by monitoring the heart rate and a detailed analysis of the ECG signal.

Based on the experience gained, we intend to continue using the new technology of training with athletes with locomotor system dysfunction, hoping to expand the range of subjects in our further research and achieve higher athletic results and improve the well-being of athletes with musculoskeletal disorders. At the same time, preliminary results of using the technology on volleyball players with PI indicated that the balanced inclusion of active rehabilitation modules at the end of an athlete's training can benefit athletes with other types of disorders.

### *Conflict of Interest*

There are no conflicts of interest.

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## SPORTSKI TRENINZI ZA ODBOJKAŠE SA FIZIČKIM OŠTEĆENJIMA: ISKUSTVA IZ RUSIJE I PROSPEKTI ZA UNAPREĐENJE

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### Sažetak

Svrha ovog istraživanja je da se razvije protokol za racionalno kombinovanje fizičkih vežbi u cilju rehabilitacije i trenažnog procesa u fazi sportskog usavršavanja odbojkaša koji imaju disfunkciju lokomotornog sistema. Istraživanje je sprovedeno u Regionalnom Paraolimpijskom Trening Centru u Omsku u Rusiji. Sedam sportista sa fizičkim oštećenjima koji pokazuju više sportske veštine i koji imaju od pet do 10 godina iskustva u sedećoj odbojci su izabrani za istraživanje. Procena nivoa tehničke obučenosti koordinacionih mogućnosti sportista je omogućila razvoj kombinovane mogućnosti treninga. Kao rezultat toga, rehabilitacioni blok je uključivao određeni broj vežbi koji je imao za cilj da se poboljša držanje tela, spreče kontrakture donjih ekstremiteta i da se otkloni bol u ramenima i leđima. Ove vežbe su se uvek izvodile na kraju treninga. Svaki trening koji se uobičajeno sastoji od vežbi koordinacije, vežbi brzine i snage i tehničko-taktičko-centriranih vežbi je proširen tako da je sadržao i rehabilitacioni blok. Prvi eksperimenti su pokazali da nova tehnologija omogućava poboljšanje igračkih sposobnosti odbojkaša sa fizičkim oštećenjima. Preciznost servisa je povećana za 20-30%, a preciznost ofanzivnih udaraca za 27-36%. Koordinacija i reakcija su pokazale pozitivnu dinamiku, rezultati odgovarajućih testova su samim tim poboljšani za 13.3% i 30.27% (sa statističkom značajnošću  $p < 0.05$ ). Nakon eksperimentalnog treninga, oporavak otkucaja srca nakon opterećenja značajno je poboljšan kod svih ispitanika što je potvrđeno praćenjem pulsa i detaljnom analizom EKG signala.

**Ključne reči:** odbojkaši sa fizičkim oštećenjima, rehabilitacioni moduli, trening, adaptivni sport