Effect of magnetic muscles stimulation on the biomechanical structure of sambo throws

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Abstract

Objective of the study was to improvement of the biomechanical structure of throws in sambo when using magnetic stimulation of the quadriceps muscles of the thighs of athletes in the isokinetic mode of their functioning.

Methods and structure of the study. Four wrestlers of the 1st category, three candidates for the master of sports and three masters of sports participated in the experiment. The average age of the subjects was 18.5±3.5 years. All subjects are students of Russian State University of Physical Education, Sports, Youth and Tourism, active athletes. The methodology of the experiment was as follows: against the background of planned training work, the subjects were exposed to magnetic stimulation in the mode for 10 consecutive days. Stimulation was given when performing an oscillatory movement of the lower leg in the isokinetic mode on Biodex.

Results and conclusions. The conducted cycle of magnetic stimulation led to a predominant shift of the characteristic frequencies of the spectrum of the integrated electromyogram to a higher frequency part of the spectrum. An analysis of the phase composition of throws in wrestlers subjected to magnetic stimulation showed that after the experiment, the time of the second phase decreased and the total time for performing each of the throws decreased. Quantitative values of the parameters of dynamograms, such as the maximum repulsion force, the rate of increase in force during the vertical jump showed a significant increase in their values ($p<0.05$ and $p<0.01$) in wrestlers who underwent a course of magnetic stimulation. They also showed a significant ($p<0.05$) decrease in the time to reach the maximum force.

Keywords: *sambo wrestling, magnetic stimulation, quadriceps femoris, isokinetic mode, electromyogram spectrum, speed-strength indicators, phase composition, biomechanical parameters.*

Introduction. In the types of wrestling, throws are essential technical actions. They are quite diverse, but there are some common biomechanical patterns. Naturally, the search for ways to improve throws in wrestling is an urgent task.

Throws in their structure have a three-phase division [2]. The technical actions that an athlete must carry out are distributed in such a way that the second phase of the throws is the leading one [2].

The approaches to the research that we have chosen are connected with the inclusion of new methods and means of influencing the neuromuscular apparatus of athletes into the training process of wrestlers. Such means with good reason include magnetic stimulation. Technical means for conducting magnetic stimulation were developed and entered the medical services market [1, 3].

Objective of the study was to improvement of the biomechanical structure of throws in sambo when using magnetic stimulation of the quadriceps muscles of the thighs of athletes in the isokinetic mode of their functioning.

Methods and structure of the study. The following equipment was used in the study: Magstim Rapid 2 magnetic stimulator (Magstim Company Ltd Spring Gardens, UK), Biodex System Pro-4 inertial dynamometer (Biodex Medical Systems, NY, USA), ME6000 professional 16-channel electromyograph (MEGA Electronics Ltd, Kuopio, Finland), AMTI BF 1200 1200 dynamometer platform (AMTI Force Plate, NY, USA), Qualisys eight-chamber optoelectronic system, Ag/AgCl electrodes, self-adhesive Sensor type, diameter 50 mm (Pirrone and Co, Milano, Italy). To conduct magnetic stimulation, it is necessary to set the frequency of the electromagnetic signal that affects the muscles on the stimulator coil. To do this, it is necessary to obtain an interference electromyogram of a working muscle, and then conduct a spectral analysis on it in order to identify the existing maxima in the spectrum corresponding to the excitation of various motor units. It is at the frequency of one of these maxima that the electromagnetic signal should be applied.

Measurement technique. Magnetic stimulation of the quadriceps muscles of the thighs was carried out on an electronic Biodex dynamometer, when the subjects in the sitting position of one of the legs overcame the resistance created by the device. The coil of the magnetic stimulator was installed on the thigh in such a way that at least two heads of the quadriceps muscle were captured by the magnetic flux. The bipolar skin electrodes were positioned in such a way that edge-to-edge lead-off electrodes were placed on the muscle abdomen. The ground electrode was located distal to the study site. Self-adhesive electrodes, which did not require additional fixation with an adhesive plaster, were installed after treating the skin with a special abrasive paste for cleaning the skin EVERY (Kendall Meditec, Mirandola (MO), Italy). At the experimenter's command, the subject performed oscillatory movements of the lower leg in the isokinetic mode, and at that moment a magnetic signal was applied. The exposure duration was 10 s. The maximum moment of forces was fixed on Biodex with the specified method of muscle activation. Measurements were taken for the right and left legs. The power spectrum was calculated from the interference EMG.

Four wrestlers of the 1st category, three candidates for the master of sports and three masters of sports participated in the experiment. The average age of the subjects was 18.5±3.5 years. All subjects are students of Russian State University of Physical Education, Sports, Youth and Tourism, active athletes. Informed consent was obtained from all subjects. The program of experiments was submitted to the Ethics Commission of Russian State University of Physical Education, Sports, Youth and Tourism and approved. Before the start of the stimulation cycle and at the end of it, biomechanical testing of athletes was carried out in the jump up test with two legs, hands on the belt. The jump was carried out on a dynamographic platform from the starting position with an angle in the knee joint of 90 degrees. The biomechanical characteristics of the wrestlers' motor actions were calculated from the recordings of the dummy athletes' throwing movements obtained using the Qualisys system.

Experimental technique. Against the background of planned training work, the subjects were exposed to magnetic stimulation for ten days in a row in the following mode: 10 sets of 10 seconds, with a minute interval for each of the legs. Stimulation was given when performing an oscillatory movement of the lower leg in the isokinetic mode on Biodex. The angular velocity of oscillatory movements of the lower leg was 150 deg/s. When testing (background and final), the wrestlers made throws of a dummy, the weight of which was 32.4 kg.

Results of the study and their discussion. During muscle contraction, the order of recruitment of motor units is important, which is generally predetermined [4]. The gradual increase in strength to perform a motor task is based on the gradual recruitment of large motor units. However, the size of a motor unit does not strictly increase with its type. Therefore, there

Table 1. *The frequency of magnetic stimulation and the magnitude of the maximum in the spectrum before and after the experiment*

Test subject	Left leg			Right leg		
	Maximum in the spectrum		Stimulation frequency	Maximum in the spectrum		Stimulation frequency
	Before	After		Before	After	
Bi-or	42, 50	42, 76	40	52, 61	42, 62	50
Ko-in	50, 62	56, 67	60	54, 77	53, 77	50
Sv-ov	37, 67	57, 67	50	37, 61	47, 66	50
Pa-ov	37, 82	38, 80	40	37, 72	38, 78	40
Ma-yan	33, 78	41, 106	50	46, 80	64, 92	50
Gl-ov	52, 72	57, 76	50	66, 90	62, 87	60
Sm-ov	27, 61	41, 73	50	56, 66	67, 73	60
Sm-ov	53, 67	57, 80	60	41, 56	43, 80	50

Table 2. *The time of execution of the phases of throws and throws in general for the members of the experimental group before and after the experiment*

t, c	Through the thigh X±σ		p	Through the back X±σ		p	Through the chest X±σ		p
	Before	After		Before	After		Before	After	
First phase	0,46±0,09	0,43±0,1	>0,11	0,50±0,09	0,50±0,13	>0,26	0,62±0,14	0,55±0,1	<0,02
Second phase	0,52±0,07	0,40±0,09	<0,05	0,52±0,08	0,40±0,07	<0,05	0,52±0,1	0,41±0,09	<0,05
Third phase	0,58±0,09	0,58±0,06	>0,89	0,58±0,1	0,58±0,08	>0,55	0,61±0,04	0,61±0,05	>0,64
General	1,56±0,17	1,42±0,21	<0,01	1,60±0,19	1,47±0,22	<0,05	1,73±0,18	1,57±0,18	<0,05

is some mutual "overlap" between type S and FR and type FR and FF in terms of the size and order of recruitment. That is why it is impossible to selectively activate slow- or fast-twitch motor units. When the frequency of electromagnetic impact on the muscle through the "coil" of the magnetic stimulator was set at the level of the frequency S of the motor unit, this not only affected the amplitude of this unit, but also led to an increase in the amplitude and frequency of the spectral component of the FR unit, and vice versa. This fact is reflected in Table 1. The frequency of spectral maxima of motor units S and FR increased in more than 80% of cases after a cycle of stimulation. An individual reaction of individual subjects was also observed, when the frequencies of spectral types practically did not change or even decreased. This is typical mainly for type S motor units.

The main factor that provides the strength of voluntary contraction of skeletal muscles is the recruitment of fast motor units and an increase in the frequency of their impulses. These motor units have a high threshold of excitability. And because these motor units contain a large number of muscle fibers, they contribute more to muscle tension than other, low-threshold (slow) units. By analogy with electrical stimulation, motor units under the action of magnetic stimulation will be activated with a slight stimulation, which means that high-threshold motor units will be involved in contraction, as well as low-threshold ones. Their activity provides an additional increase in the strength capabilities of the muscles, which will have a trace physiological effect.The results of biomechanical measurements and test tests at the beginning and at the end of the experiment are presented in tables 2, 3, 4. The phase composition of the dummy throws is presented in table 2.

The results of the time of the phases of throws and throws in general before and after the experiment in the members of the experimental group were compared by the nonparametric Wilcoxon T-test. At a significance level of 0.05, the following phase parameters improved: the time to complete the first phase of a chest throw, the time to complete the second phase of all throws, and the total time to complete all throws. There is one very important point - the execution time of the second phase for all types of throws has significantly decreased. Since it is in the second phases of the throws that the main power actions of the confrontation take place, which determine the result of the throw, reducing the duration of the second phase is very important. The wrestler conducting the throw must deprive the opponent of the opportunity to counter the attack. And this is possible when the enemy has less time to carry out counterattacks. A significant decrease in the total time of all throws also works for this.

The experiment showed the following:

1 Increasing the speed-strength indicators of the quadriceps muscles of the thighs. In tests on "Biodex" with instructions to achieve the maximum peak torque, the subjects showed large peaks after the end of the experiment (Table 3). This indicates that, as a result of magnetic stimulation, it was possible to achieve greater activation of the FR muscle fibers during the motor action.

2 The analysis of dynamograms in the biomechanical jump test revealed positive trends in the growth of the main indicators that are used in sports biome-

Table 3. *Peak values of the moments of force of the anterior surface of the thighs in the members of the experimental group before and after the experiment*

Indicator	Right leg		p<	Left leg		p<
(Peak torque N*M)	Before	After		Before	After	
	284,1±66,7	351,4±55,5	0,05	318±73,5	392,5±64,5	0,05

Table 4. *Calculated values of the parameters of dynamometers when performing a vertical jump by members of the experimental group before and after the experiment*

Parameter	Before	After	p<
	X±σ		
Maximum repulsion force, H	2105±85	2925±92	0,05
Time to reach maximum strength, s	0,539±0,09	0,410±0,08	0,05
Force increase rate, H/s	3905±171	7134,1±194	0,01

chanics for the analysis of dynamograms (Table 4). All gains are valid.

Conclusions. The frequency of the spectral maxima of the S and FR motor units after a cycle of stimulation in the isokinetic mode of muscle work increases in more than 80% of cases, regardless of whether magnetic stimulation is performed at the frequency of the spectral peak maximum corresponding to the S motor unit or the spectral maximum corresponding to the motor unit FR.

The conducted cycle of magnetic stimulation leads to a preferential shift of the characteristic frequencies of the spectrum of the integrated electromyogram to a higher frequency part of the spectrum.

An analysis of the phase composition of throws in wrestlers subjected to magnetic stimulation showed that after the experiment, the time of the second phase decreased and the total time for performing each of the throws decreased.

Quantitative values of the parameters of dynamograms, such as the maximum repulsion force, the rate of increase in force during the vertical jump showed a significant increase in their values ($p<0.05$ and $p<0.01$) in wrestlers who underwent a course of magnetic stimulation. They also showed a significant ($p<0.05$) decrease in the time to reach the maximum force.

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