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CHARACTERISTICS OF STIMULATION AND SURFACE ELECTROMYOGRAPHY OF ELITE WEIGHTLIFTERS AT REST AND WITH SPECIFIC SPORTS LOADS

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Key words: athletes, neuromuscular apparatus, stimulation electromyography, surface electromyography, bioelectric activity of muscles, weightlifting.

Annotation. Aim of this work was to study the functional features of the neuromuscular apparatus of weightlifters according to the data of stimulation and surface electromyography at rest and in case when specific sports loads are applied. The study of the parameters of the M-response in weightlifters revealed low values of latency and residual latency, as well as the M-response’s duration. High values of the amplitude, area of the motor response and the spread of excitation velocity along the nerve were noted. The data obtained indicate a substantially high level of the functional state of the neuromuscular apparatus of athletes specialized in weightlifting. Indicators of bioelectrical activity of the trapezius muscles when performing the snatch reflect the phase nature and a high level of neuromuscular coordination, contributing to the timely activation of muscle fibers and regulation of muscle tension during the development of efforts. The obtained data can be used to assess the functional state of the neuromuscular apparatus of weightlifters at various stages of the training process.

Introduction. Systematic influence of specific physical loads on the athlete’s body is shown through adaptive rearrangements aimed at optimizing the work of the neuromuscular apparatus (NMA). These processes occur more clearly in athletes of power sports, weightlifters in particular [1-2]. The electromyography method (EMG) is a study of bioelectric activity of muscles and parameters of neuromuscular transmission. It allows obtaining objective data on the functional state of the NMA of athletes at rest, as well as study its morphofunctional changes when physical loads are applied [3]. There are different methods of conducting the EMG study. Stimulation and surface methods are used the most frequently [4-5]. Moreover, the stimulation EMG is better to use at rest for evaluating the NMA’s functional state, the surface EMG – in case of performing motor actions [6-7]. Development of diagnostics methods that includes implementing both ways of conducting the EMG gives the researcher a possibility to study features of mechanisms of urgent and long-term adaptation of the NMA of athletes to physical loads [8-9].

The aim of our work was to study the functional features of the neuromuscular apparatus of weightlifters according to the data of stimulation and surface EMG at rest and in case when specific sports loads are applied.

Methods and organization. The study was carried out in the Center for Biomedical Technologies of the North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency and included 53 weightlifters (31 male athletes, 22 – female athletes). Sports qualification of athletes – Candidate Master of Sports, Master of Sports, Master of Sports of International Class. Average age of participants was 21±3,6 years.

The surface EMG was carried out using the wireless sensors of the BTS Motion System (BTS Bioengineering, Italy) that were attached to trapezius muscles. The stimulation EMG was made through registration of motor responses from the extensor digitorum brevis muscle, innervated by the peroneus nerve using the 4-channel hardware and software complex Neuro-MVP (Neurosoft, Ivanovo). The data processing was made using the Microsoft Office and Statistica 6.0 programs (Wilcoxon’s nonparametric test).

Results and discussion. The study of parameters of the neuromuscular transmission in weightlifters at rest are presented in the table 1.

Table 1

M-response parameters, registered from the extensor digitorum brevis muscle when stimulating the peroneus nerve in the “tarsus”, “head of fibula” and “popliteal fossa” points

Stimulation EMG indicators	Right leg	Left leg	Standard values
“Tarsus” stimulation point			
Latency, ms	3,81±0,31	3,83±0,22	-
M-response amplitude, mV	6,99±1,34	6,92±1,27	not less than 3 mV
M-response duration, ms	5,81±0,51	5,86±0,34	-
M-response spread, mV×ms	24,72±3,41	23,32±3,62	-
Residual latency, ms	2,58±0,31	2,51±0,24	less than 4 m
“Head of fibula” stimulation point			
Latency, ms	11,2±0,18	11,12±0,11	-
M-response amplitude, mV	6,14±0,58	6,36±0,74	lot less than 3 mV
M-response duration, ms	6,32±0,41	6,27±0,33	-
M-response spread, mV×ms	21,6±3,02	22,3±3,14	-
Velocity of excitation spread, m/s	55,11±2,13	54,95±1,71	not less than 40 m/s

Table 1 (continued)

“Popliteal fossa” stimulation point			
Latency, ms	12,1±0,31	12,1±0,19	-
M-response amplitude, mV	5,98±1,58	6,21±1,44	lot less than 3 mV
M-response duration, ms	6,75±0,53	6,14±0,65	-
M-response spread, mV×ms	20,01±2,50	20,56±2,14	-
Velocity of excitation spread, m/s	54,31±4,01	53,26±2,98	not less than 40 m/s

Surveying M-response parameters in weightlifters revealed low values of latency and residual latency, as well as the M-response duration. Moreover, there are high values of amplitude, M-response spread and velocity of excitation spread along the nerve. The data obtained not only fit within limits of standard values of healthy people who do not engage in sports, but also indicate a substantially high level of the NMA’s functional state of weightlifters.

Table 2

Surface EMG parameters of the right trapezius muscle when performing the snatch

Snatch phases	EMG indicators				
	Mean amplitude	Max amplitude	Peak frequency	Mean frequency	Median frequency
1.1	0,171±0,084	1,448±0,784	44,7±16,4	62,1±13,2	54,3±13,1
1.2	0,445±0,199	1,911±0,812	49,9±13,2	66,7±13,4	62,8±15,3
2.1	0,365±0,198	1,412±0,792	59,6±18,4	75,2±19,6	63,1±20,8
2.2	0,411±0,224	1,416±0,690	67,3±16,9	79,1±15,2	64,5±13,9
3.1	0,546±0,214	2,560±0,911	56,4±23,6	72,3±14,1	63,4±15,4
3.2	0,677±0,299	2,847±1,112	44,6±21,1	74,2±9,8	60,1±10,1
4	0,491±0,234	2,498±1,012	57,1±17,4	71,2±14,1	61,2±11,8

Note: 1.1 – Pull’s first phase; 1.2 – Pull’s second phase; 2.1 – Snatch’s first phase; 2.2 – Snatch’s second phase; 3.1 – Squat’s first phase; 3.2 – Squat’s second phase; 4 – Recovery phase

Table 3

Surface EMG parameters of the left trapezius muscle when performing the snatch

Snatch phases	EMG indicators				
	Mean amplitude	Max amplitude	Peak frequency	Mean frequency	Median frequency
1.1	0,164±0,13	1,441±0,714	44,6±14,2	61,8±15,4	53,1±15,4
1.2	0,489±0,223	1,865±0,895	51,3±23,4	69,2±20,1	55,6±21,1
2.1	0,464±0,312	1,587±0,799	72,8±38,6	79,8±19,8	65,8±30,2
2.2	0,436±0,184	1,595±0,548	74,6±27,1	84,1±17,9	71,9±26,8
3.1	0,568±0,241	2,314±0,745	71,4±28,3	77,1±18,3	69,3±19,9
3.2	0,651±0,321	2,654±0,954	60,2±19,8	75,6±15,7	64,1±14,8
4	0,454±0,286	2,323±1,041	47,3±14,1	73,9±12,6	60,9±12,9

Note: 1.1 – Pull’s first phase; 1.2 – Pull’s second phase; 2.1 – Snatch’s first phase; 2.2 – Snatch’s second phase; 3.1 – Squat’s first phase; 3.2 – Squat’s second phase; 4 – Recovery phase

To study mechanisms of urgent adaptation of the NMA of weightlifters to physical loads, we use the surface EMG of trapezius muscles when the weightlifting snatch is being performed. The data on bioelectric activity of the right and left trapezius muscles are presented in tables 2,3.

The analysis of indicators of mean and maximal amplitude of the right and left trapezius muscles (tables 2, 3) demonstrated that minimal tension developed by muscles is registered in the Pull's first phase, minimal – in the Squat's second phase (differences between minimal and maximal indicators in the Pull 1.1 and Squat 3.2 phases: mean amplitude at left is $p \leqslant 0{,}003$, mean amplitude at right – $p \leqslant 0{,}004$, maximal amplitude at left – $p \leqslant 0{,}003$, maximal amplitude at right – $p \leqslant 0{,}0002$). Moreover, frequency-based activity of motor neurons is also minimal in the Pull's first phase, but it increases and reaches its maximum in the Snatch's second phase. At the same time, it recruits additional muscle fibers in the contraction and slightly decreases by the end of the exercise (differences between minimal and maximal indicators in the Pull 1.1 and Snatch 2.2 phases: peak frequency at left is $p \leqslant 0{,}0003$, peak frequency at right – $p \leqslant 0{,}002$, mean frequency at left – $p \leqslant 0{,}0006$, mean frequency at right – $p \leqslant 0{,}0003$, median frequency at left – $p \leqslant 0{,}001$, median frequency at right – $p \leqslant 0{,}008$).

The received data on bioelectric activity of trapezius muscles when performing the snatch show a phase-based nature and a high level of neuromuscular coordination that contributes to a timely activation of muscle fibers by regulating a degree of muscle tension when developing effort and saving energy resources. In its turn, this is a result of urgent adaptation of the athletes' NMA to physical loads.

Conclusion. In consequence of the conducted study, we noted an influence of a long-term training process on the functional state of the neuromuscular apparatus of weightlifters. Moreover, conducting the stimulation EMG at rest allows examining mechanisms of long-term adaptation, i.e. high values of amplitude, M-response spread, velocity of excitation spread, low values of M-response duration, latency, residual latency, which, when combined, indicate a substantially high level of the NMA's functional state of weightlifters. Conducting the surface EMG, while the exercise is being performed, allowed evaluating urgent mechanisms of the NMA's adaptation to physical loads, i.e. an increase of amplitude and frequency indicators in phases of maximal and explosive power, as well as their fast decrease in the following phases, show a high level of the neuromuscular coordination that contributes to a timely adaptation of muscle fibers and saves energy resources.

The data obtained can be used for evaluating the functional state of the NMA of weightlifters at different stages of the training process.

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