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PHYSIOLOGICAL AND BIOMECHANICAL CHARACTERISTICS OF LOWER EXTREMITIES' MUSCLES IN FEMALE BOXERS DURING THE MAXIMUM LOAD TEST OF BOSCO REPEATED JUMPS

S.V. Nopin
FSBI NCFSCC of the FMBA of Russia, Essentuki, Russia

Key words: biomechanics, electromyography, boxers, adaptation, functional capabilities, sports and pedagogical testing.

Annotation. The aim of the work was to study the electrophysiological and biomechanical characteristics of the lower extremities' muscles in athletes when performing the maximum load test of Bosco repeated jumps. For biomechanical and electrophysiological analysis of movements and test exercises of athletes for the BTS SMART-Clinic software, a computer program was developed – the Bosco repeated jump test (Certificate of registration of the computer program № 202161987918, 18.06.2021). The study of indicators of muscles' electric activity during the performance of the sports load test of Bosco repeated jumps was carried out in a group of women, Masters of Sports in boxing. The results of the study showed that the highest biomechanical parameters of the repeated jumps test in the 1st period of the test load (1-15 s) are due to high tension, and, consequently, the activation and synchronization of motor units, primarily the rectus femoris muscle. In the 3rd (31-45 s) and 4th (46-60 s) period of the test the tension of the biceps femoris increases, which stabilizes the body when landing and pushing off. This, as well as an increase in the electric activity of the muscles of the left leg and a decrease in physical parameters by the end of the test, indicates the development of first compensated and then uncompensated fatigue. The dynamics of indicators of the electric activity of the lower extremities' leading muscles, providing jumping movements during the multiple jump test, allows one to characterize the local physiological processes that determine the manifestation of functional capabilities and the state of fatigue.

Introduction. The electroneuromyography (ENMG) is the only technology, using which an objective study of functional capabilities of the neuromuscular system in the state of norm and pathology can be conducted, including sports activity when performing sports movement. Scientists in the sports field actively use the surface ENMG method, some hardware and software complexes include the use of wireless sensors for this method [1]. Performing vertical jumps is defined by a

complex interaction of several factors, including maximal strength, speed of strength's development, muscle coordination [2-3]. The main role is played by strength endurance in case of performing multiple jumps. Researchers, when studying neuromuscular mechanisms that define these motor abilities, examined characteristics of different jump movements with the wireless surface ENMG [4]. They revealed features of muscle work coordination in athletes of different sports [5]. However, there are no studies considering the bioelectric muscle activity when performing multiple jumps and maximum load jump tests with the simultaneous registration of biomechanical parameters.

The purpose of this work was to study the electrophysiological and biomechanical characteristics of the lower extremities' muscles in athletes when performing the maximum load test of Bosco repeated jumps.

Methods and organization. The biomechanical control over movements was carried out using the SMART BTS Motion System. The SMART BTS Motion System (made by BTS Bioengineering, Italy) is the video analysis system that works with EMG-devices and force plates, which allows receiving the extended results of the analysis.

In order to biomechanically analyze movements and test exercises of athletes, a computer program called the Bosco repeated jumps test was developed for the BTS SMART-Clinic software (Certificate of the computer program registration № 2021619879, 18.06.2021) [6]. The study was conducted in the Center for biomedical Technologies of the FSBI NCFSCC of the FMBA of Russia located in Kislovodsk during training camps. The study of the electric muscle activity indicator when performing the sports load test of Bosco repeated jumps [7] was conducted in the group of women, who engage in boxing (n=11), with the Master of Sports qualification.

The statistical data processing was carried out using the Statistica 13.0 software. In order to characterize the examined indicators, the arithmetic mean value of the selected amount was calculated (M). The error of representation (m) served as an indicator of varying the obtained results. We also used the Spearman test when evaluating correlations between indicators.

Results and discussion. According to the obtained results, the fatigue index was 1,67±0,37 N, the average maximal force before jumping (the force of pushing off) – 1973±734 N. When comparing, the fatigue index in female track-and-field athletes was 2,2±0,3 N, the maximal force before jumping – 1436,9±67,5 N [8]. Therefore, women, who engage in boxing, have lower indicators of the maximal strength in comparison with female track-and-field athletes, but higher indicators of strength endurance.

The data analysis has shown, that the highest indicators of the maximal power, mean and maximal height of the jump made by the right leg were registered during the 1st period of the test (1-15 s), the highest electric activity of following muscles was also revealed: rectus femoris, peroneus longus and musculus gastrocnemius (Table 1). It indicates the maximal activation and synchronizing of motor units (MU) of the right leg's muscles. At the end of the test, values of these indicators decreased, possibly because of fatigue's development. The electric activity of the left musculus biceps femoris significantly increased during the 3rd period of the test (31-45 s), which is possibly related to a necessity to increase the body stabilization.

Meanwhile, in the 3rd (31-45 s) and the 4th (46-60 c) periods of the test, increase of electric tension in all examined muscles of the left leg was registered. Thus, in the course of the fatigue development in the leading extremity (the right leg), the non-leading extremity (the left leg) takes all loads due to higher tension in order to maintain the required power level and the amount of repeats (it even increases in the 3rd period). It is a sign of the physiological effect of the compensated fatigue.

Nonetheless, despite the aforementioned facts, following biomechanical parameters are minimal in the 4th period of the test: height and amount of jumps. It means that the uncompensated fatigue takes place. Taking into account the decrease of physical and electrophysiological parameters during 1-minute high intensity work, the energy fatigue (fatigue theory), metabolite accumulation (metabolite intoxication theory) and disturbance in the neuromuscular transfer take place [9-10].

The Spearman correlation analysis of physical and electrophysiological indicators in different periods of the maximal load test of Bosco repeated jumps confirmed the revealed features. During the 1st period of the test, statistically significant correlations between parameters of jump's power and height with electric tension of the rectus femoris (Fig. 1).

During the 2nd period of the test, significant correlations between following parameters were found: average jump height and electric tension of the right musculus biceps femoris, maximal jump height and electric tension of the left musculus peroneus longus, amount of jumps and electric tension of the left musculus gastrocnemius (Fig. 2).

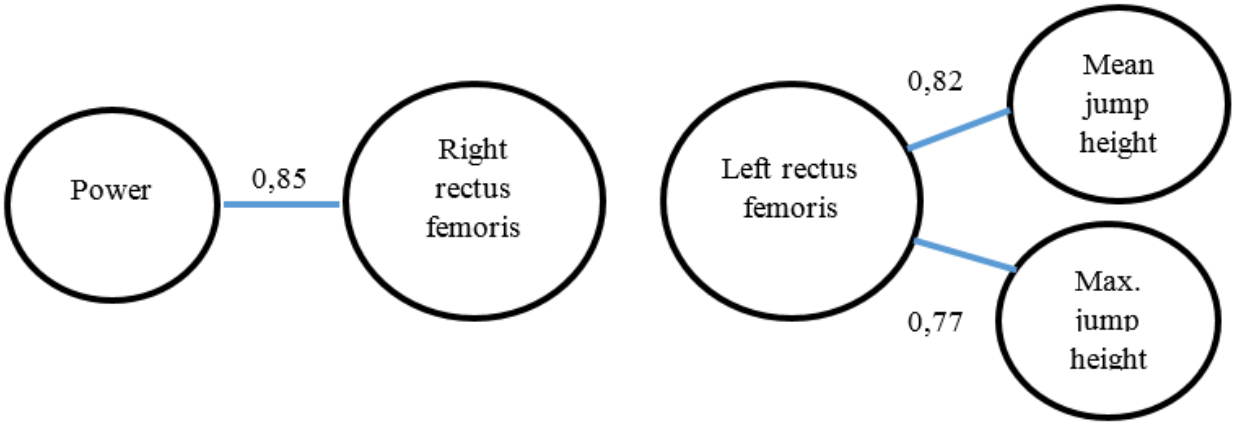

Fig. 1. Significant correlations of physical and electrophysiological indicators of the first period (first 15 s) of the maximal load test of Bosco repeated jumps

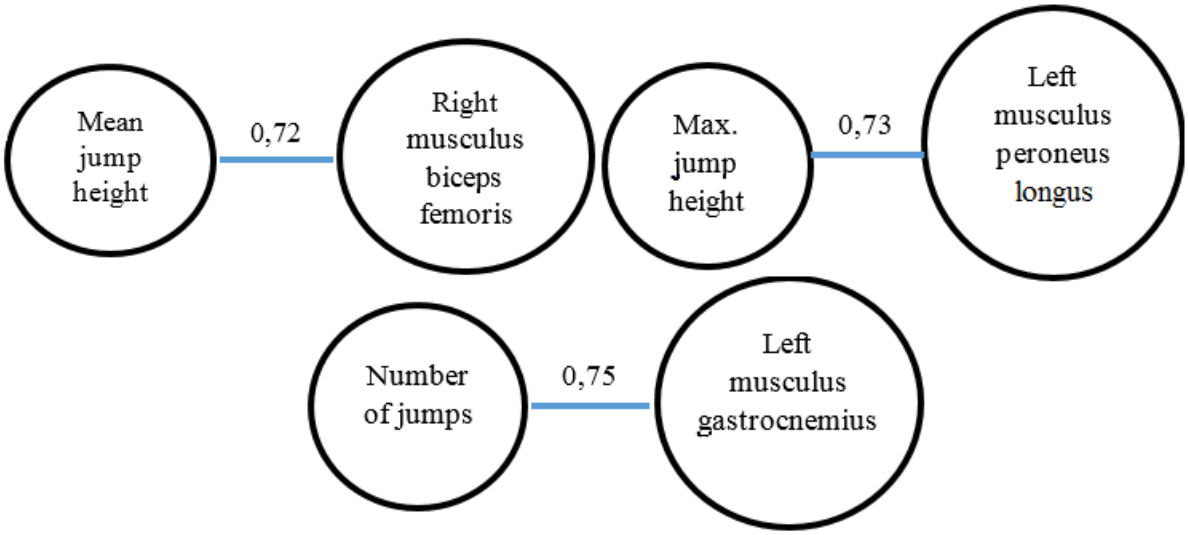

Fig. 2. Significant correlations of physical and electrophysiological indicators of the second period (16-30 s of the test) of the maximal load test of Bosco repeated jumps

The third period of the test revealed significant correlations between parameters of power, jump heights and electric activity of the left musculus gastrocnemius (Fig. 3).

In the fourth period of the test, statistically significant interactions between all physical parameters of the test and electric activity of the musculus biceps femoris were revealed (Fig. 4).

Table 1

Physical and electrophysiological indicators of the maximal load test of Bosco repeated jumps

Test indicators, according to 15 s periods	Test indicators				Average values of electric activity, mV							
					Rectus femoris		Musculus biceps femoris		Musculus peroneus longus		Musculus gastrocnemius	
	Power, W/kg	Average jump height, m	Maximal jump height, m	Number of jumps	Right	Left	Right	Left	Right	Left	Right	Left
1 period	13,5±3,1	0,17±0,04	0,20±0,05	13±1	1,46± 0,59	1,10± 0,29	0,71± 0,40	1,15± 0,36	1,10± 0,35	1,06± 0,35	1,05± 0,47	1,11± 0,38
2 period	11,9±3,9	0,14±0,05	0,17±0,05	13±2	1,39± 0,55	0,65± 0,33	0,61± 0,30	0,62± 0,35	1,08± 0,36	0,59± 0,35	1,00± 0,48	0,54± 0,24
3 period	11,0±4,4	0,12±0,05	0,15±0,05	14±4	1,16± 0,54	1,24± 0,29	0,58± 0,32	1,17± 0,35	1,05± 0,38	1,20± 0,33	0,94± 0,42	1,22± 0,37
4 period	9,5±3,5	0,11±0,04	0,13±0,05	12±3	1,30± 0,48	1,25± 0,59	0,57± 0,31	1,31± 0,64	1,09± 0,49	1,27± 0,66	0,95± 0,41	1,23± 0,76

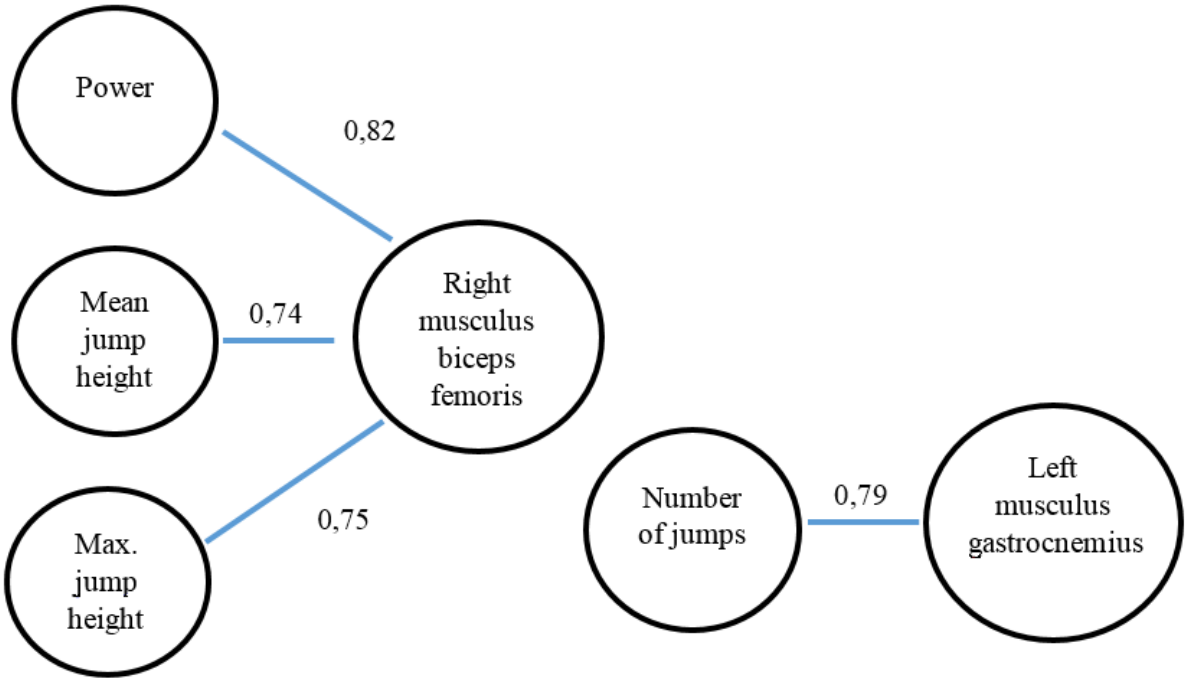

Fig. 3. Significant correlation of physical and electrophysiological indicators of the third period (31-45 s of the test) of the maximal load test of Bosco repeated jumps

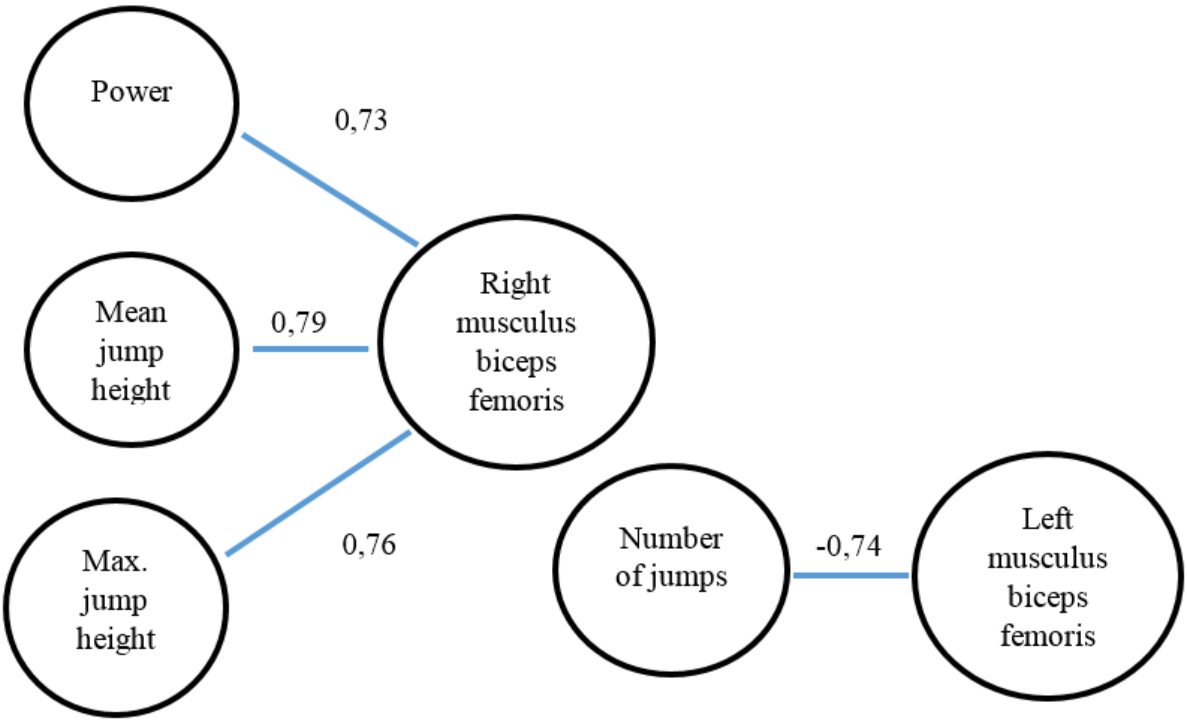

Fig. 4. Significant correlations of physical and electrophysiological indicators of the second period (46-60 s of the test) of the maximal load test of Bosco repeated jumps

Conclusion. The highest biomechanical parameters of the repeated jumps test during the 1st period of the test load are due to high tension and, consequently, activation and synchronization of the rectus femoris MU. During the 3rd and the 4th period of the test, tension of the musculus biceps femoris increases, which supports

the body stabilization when landing and pushing off. This, as well as the increase of the left leg's muscles and the decrease of physical parameters by the end of the test indicates the development of compensated and then uncompensated fatigue.

Dynamics of indicators of electric activity of lower extremities' leading muscles supporting jump moves when performing the multiple jumps test allows describing local physiological processes and determining manifestation of functional capabilities and the state of fatigue.

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Information about the authors: Sergej Victorovich Nopin – Candidate of Technical Sciences, Leading Researcher of the Biomedical Technologies Center of the FSBI "NCFSCC of the FMBA of Russia", Essentuki, e-mail: work800@yandex.ru.