Peculiarities of neuromuscular apparatus and component composition of limbs of qualified divers

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Abstract. To achieve a high sports result in diving it is necessary to have a good development of neuromuscular apparatus. It is important to study the factors influencing its functional state. The article presents a correlation analysis of the relationship between the parameters reflecting the state of the neuromuscular apparatus and indicators of the component composition of the upper and lower limbs of qualified divers. It is shown that it is necessary to develop muscle mass and reduce the amount of adipose tissue to accelerate the conductivity of nerve impulse along the nerves, to increase the synchronization of activation of motor units in the muscles of upper and lower limbs. This will improve the speed and strength qualities of muscles necessary in the performance of technically complex diving.
Keywords: diving, nerve impulse conductivity, fat, muscle tissue

1 Introduction

Diving refers to a sport with complex coordination of dynamic movements close to the limit of human capabilities. In this case, the nervous system regulates multiple operational subsystems using a type of hierarchical control. To perform technically complex diving requires a good development of muscle strength, coordination and the ability to maintain body balance in space [1, 2].

The efficiency of diving performance is determined by various factors, one of which is the specificity of mobility of the joints of the lower limbs, especially in the knee and hip joints, as well as the strength of the muscles that provide movements in them [3, 4].

The efficiency of diving performance is also affected by the component composition of the body. The amount of muscle mass determines the ability to develop the explosive power required to perform an effective jump [5, 6].

The distribution of different tissue types in body segments influences the efficiency of the neuromuscular apparatus [7]. Conducting regular body composition assessment is essential in the training of a skilled vaulting athlete.

For this reason, the aim of the study was to investigate possible interrelationships

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between the component composition and peculiarities of neuromuscular apparatus functioning of the upper and lower limbs of qualified divers.

2 Materials and methods

The study was carried out in 30 qualified divers aged from 13 to 18 years old based on Voronezh State Academy of Sports.

The method of bioimpedanceometry is a simple and non-invasive method for assessing body composition [8, 9], which allows to promptly examine athletes in the dynamics of the training cycle. The study of segmental body composition of qualified divers was performed by bioimpedanceometry using a segmental body composition analyzer BC 418 MA at an ambient temperature of 22-24 °C between 08:00 and 09:00 am on an empty bladder and empty stomach. Segmental body composition was assessed by fat tissue content (FAT, kg, %), fat-free mass (FFM, kg), and relative muscle mass (RMM, kg) in the upper and lower limbs.

Functional features of the neuromuscular apparatus were studied by electroneuromyography using the neuromyoanalyzer NMA-4-01 "Neuromian". This method is effective in the study of physiological processes occurring in skeletal muscles and allows evaluating various aspects of human movement control [10].

We used the method of stimulation myography, including methods of recording the motor response (M-response), F-wave and H-reflex.

The M-response was studied using the method of stimulation electroneuromyography of the nerves Medianus, Ulnaris, and Tibialis. The M-response was recorded from the abductor pollicis brevis, abductor digiti minimi, and abductor hallucis muscles. The results of the study were evaluated using the following parameters: residual latency (RL, ms), terminal latency of motor reaction (Lat, ms), amplitude of M-response (A, mV), speed of nerve impulse conduction along the nerve (V, m/s).

For a more complete study of the state of the neuromuscular apparatus of the lower limbs, we carried out the technique of F-wave registration, which is a consequence of antidromic excitation of motor neurons of the spinal cord. The latency, amplitude of F-waves, percentage ratio of amplitudes of F-waves and M-responses, unrealized waves (blocks) were studied.

In order to assess the conductivity of the segmental arc, including sensory and motor fibers outside the spinal cord and its intraspinal part, as well as the level of motoneuron excitability, we recorded the H-reflex from the medial head of the Gastrocnemius muscle, which was induced according to the conventional method by stimulation of the Tibialis nerve through a unipolar electrode, with the active electrode located in the hamstring fossa.

The H-reflex was evaluated according to the following parameters: percentage of the maximum amplitude of the H-reflex to the maximum amplitude of the M-response (H/M, %), latent period (Lat, ms).

The obtained data were processed by the conventional methods of variation statistics with assessment of reliability of different empirical samples by Student's criterion. Correlation analysis between the studied parameters was performed with the help of Statistica 10 program

3 Results

To reveal a possible relationship between the functional features of the neuromuscular apparatus and the distribution of different types of tissues in the upper and lower limbs, a

correlation analysis was performed between the indices of stimulation electroneuromography and the amount of fat, fat-free, and relative muscle mass.

A strong positive correlation between the relative and absolute content of adipose tissue in the upper and lower limbs and the latency, as well as the resistive latency of the M-response was shown. A strong positive correlation was found between the above parameters of eletcroneuromyography and the amount of fat-free and relative muscle mass (Table 1).

Table 1. Correlation coefficients between the content of different tissues and M-response parameters of the muscles of upper and lower limbs of qualified divers

	Lat, m/s	**RL**	**A, mV**	**V, m/s**
Medianus				
FAT mass, kg	0.9	0.9	-0.8	-0.8
FAT, %	0.9	0.9	-0.8	-0.8
FFM, kg	-1.0	-1.0	0.9	0.9
PPM, kg	-1.0	-1.0	0.9	0.9
Ulnaris				
FAT mass, kg	0.9	0.9	-0.8	-0.8
FAT, %	0.9	0.9	-0.8	-0.8
FFM, kg	-0.9	-0.9	0.9	0.9
PPM, kg	-1.0	-1.0	0.9	0.9
Tibialis				
FAT mass, kg	0.9	0.9	-0.8	-0.8
FAT, %	0.9	0.9	-0.8	-0.8
FFM, kg	-1.0	-1.0	0.9	0.9
PPM, kg	-1.0	-1.0	0.9	0.9

A strong negative correlation was revealed between the amount of fat mass and M-response amplitude, as well as the speed of nerve impulse conduction along the Medianus, Ulnaris, Tibialis nerves. The increase in the values of the amplitude and speed of motor response of the indicated muscles is determined by the increase in the amount of fat-free and relative muscle mass in the limbs (Table 1).

A comprehensive assessment of the neuromuscular apparatus is possible with a combination of basic techniques of F-wave study. Analysis of this phenomenon is an auxiliary but integral indicator of the state of practically all departments of the neuromuscular system [9].

It is known that the ratio of the average F-wave amplitude to the M-response amplitude, not exceeding 5%, is considered diagnostically significant. Correlation analysis showed a moderate negative correlation between such body composition parameters as relative and absolute content of fat, fat-free and relative muscle mass in the lower limbs. A weak positive correlation relationship was found between the above body composition parameters and such F-wave parameters as speed and blocks (Table 2).

Table 2. Correlation coefficients between the content of various tissues and F-wave indices of the lower limbs of qualified divers

F-wave	**V, v/c**	**A, F/M, %**	**Blocks F, %**
FAT mass, kg	0.3	-0.3	0.2
FAT, %	0.3	-0.3	0.2
FFM, kg	0.4	-0.4	0.1
PPM, kg	0.4	-0.4	0.1

The H-reflex, reflecting the state of various departments of the nervous system, makes it possible to clarify some subtle mechanisms of functioning of the nociceptive and antinociceptive systems. The ratio of the maximum amplitude of the H-reflex to the maximum amplitude of the M-response is used as the main index characterizing the functional state of the segmental apparatus. The correlation analysis revealed a strong negative relationship between the H/M parameter and the amount of fat mass in the lower limbs, as well as a strong positive relationship between this H-reflex parameter and the amount of fat-free and relative muscle mass. Weak positive correlations were found between the parameters determining the amount of different tissue types in the lower limbs and the latency of the n-reflex (Table 3).

Table 3. Correlation coefficients between the content of different tissues and the H-reflex parameters of the lower limbs of qualified divers

H-reflex	H/M, %	Lat Hmax, ms
FAT mass, kg	-1	0.1
FAT, %	-1	0.2
FFM, kg	1	0.1
PPM, kg	1	0.1

4 Discussion

Motor response is the total potential of muscle fibers arising from stimulation of the nerve innervating the muscle. Correlation analysis showed that the time of impulse conductivity along axon terminals, the speed of nerve impulse conductivity along Medianus, Ulnaris, Tibialis nerve fibers, as well as the synchrony of activation of motor units in the muscles of upper and lower limbs increase with the increase in the amount of relative muscle and fat-free tissue, and decrease with the increase in fat mass. That is, the efficiency of functioning of the neuromuscular apparatus of the limbs increases with decreasing fat and increasing muscle tissue. Our findings are consistent with the results of Clemente-Suarez et al. studies, according to which body weight restriction is recommended for divers [11].

Correlation analysis of F-wave parameters and tissue composition of the upper limbs showed that the ratio of fat and relative muscle mass does not significantly affect the ability of lower limb motoneurons to generate a return response.

Using the technique of H-reflex conduction it was found that the greater the amount of relative muscle and fat-free tissue and less fat mass, the higher the number and degree of synchronization of motor units involved in excitation, determined by the number of motoneurons responding to afferent stimulation and the number of type Ia fibers conducting it. This contributes to the improvement of the neuromuscular apparatus of the lower limbs.

The component composition of the lower limbs does not affect the latency of the H-reflex, which is a relatively constant value and is not subject to pronounced changes.

5 Conclusion

As a result of the correlation analysis between the indicators of tissue composition and functioning of the neuromuscular apparatus of the upper and lower limbs, it is shown that to accelerate the passage of the nerve impulse along the nerves, to increase the synchronization of activation of motor units in the muscles of the upper and lower limbs it is necessary to develop muscle mass and reduce the amount of adipose tissue. This will improve the speed and strength qualities of the muscles necessary in performing technically

demanding diving. However, it is important to control the level of adipose tissue so that it does not reach critically low values.

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