Publication date: 01.12.2021
DOI: 10.51871/2588-0500_2021_05_04_7
UDC 612.741

FUNCTIONAL STATE OF THE NEUROMUSCULAR APPARATUS AND HEMODYNAMICS OF THE LOWER LIMBS OF TRACK-AND-FIELD ATHLETES

A.Sh. Abutalimov
FSBI "North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency", Essentuki, Russia

Key words: functional state, track-and-field athletes, neuromuscular apparatus, peripheral hemodynamics, electroneuromyography, rheovasography.

Annotation. The aim of the work was to study the functional state of the neuromuscular apparatus and hemodynamics of the lower extremities in elite athletes. It was found that in the process of sports training there are specific changes in the functional state of the neuromuscular apparatus and hemodynamics of the lower extremities in elite athletes. The data obtained as a result of electroneuromyographic studies indicate a large number of muscle fibers involved in contraction during stimulation of the peroneal nerve, and high muscle coordination. In addition, a high velocity of electric pulse conduction along the nerve fiber was recorded. We also noted compensatory changes in the peripheral hemodynamics of the lower extremities in response to systematic physical loads. The data obtained will be used in the future to develop criteria for assessing the functional state of the neuromuscular apparatus and peripheral hemodynamics in elite athletes, as well as to create recovery programs for athletes when intense physical loads are applied.

Introduction. Adaptive rearrangements in the athlete's organism that form under the effect of systematic physical loads aimed at the development of certain athletic qualities are shown in changes of the functional state of the neuromuscular apparatus and hemodynamics of an athlete [1-2]. It is well-known that within a long-term training process, athletic prowess improves and functional capabilities of an athlete significantly increase [3]. In addition, both functional and structural changes occur in the neuromuscular apparatus and hemodynamics of an athlete [4-5].

The aim of the work was to study the functional state of the neuromuscular apparatus and hemodynamics of the lower extremities in elite athletes.

Methods and organization. The study was carried out in the Rehabilitation Center and in the Center for Biomedical Technologies of the FSBI "North-Caucasian

Federal Research-Clinical Center of FMBA of Russia" located in Kislovodsk. It included 34 track-and-field athletes of the Candidate Master of Sports – Master of Sports of International Class qualifications. Among them, there were 19 female athletes and 15 male athletes. Average age of athletes is 24,1±5,8 years. Study of hemodynamics of the lower extremities was carried out using the rheograph (Rheograph Valenta, LLC "Company Neo", Saint Petersburg). The stimulation electroneuromyography (ENMG) was carried out using the 4-channel hardware and software complex Neuro-MVP ("Neurosoft", Ivanovo). We examined a registration of motor responses (M-responses) from the extensor digitorum brevis muscle, innervated by the common perineal nerve. The statistical data processing was conducted using the non-parametric Mann-Whitney test and the Statistica 6.0. software.

Results and discussion. According to the ENMG data of the peroneus nerve of elite athletes (table) in the "tarsus" stimulation point, we received following results: latency at right was 4,2±0,69 ms, at left – 4,2±0,70 ms; M-response amplitude at right was 6,22±2,72 mV, at left – 6,98±2,79 mV; M-response duration at right was 6,47±0,81 ms, at left – 6,26±0,96 ms; M-response spread at right was 20,67±9,23 mV×ms, at left – 21,53±7,30 mV×ms; residual latency at right was 2,78±0,65 ms, at left – 2,84±0,67 ms.

Study of M-response indicators in the "head of fibula" stimulation point revealed the following: latency at right was 11,2±1,5 ms, at left – 11,2±1,6 ms; M-response amplitude at right was 6,4±2,7 mV, at left – 6,1±2,8 mV; M-response duration at right was 7,1±1,0 ms, at left – 6,8±1,1 ms; M-response spread at right was 22,0±9,0 mV×ms, at left – 19,9±7,9 21,53±7,30 mV×ms; velocity of pulse conduction along the nerve at right was 51,0±5,1 m/s, at left – 50,4±5,1 m/s.

Following M-response indicators were registered in the "popliteal fossa" stimulation point: latency at right was 12,7±1,5 ms, at left – 12,7±1,7 ms; amplitude at right was 6,5±2,6 mV, at left – 6,5±2,6 mV; duration at right was 6,9±0,9 ms, at left – 6,7±1,2 ms; spread at right was 22,7±9,5 mV×ms, at left – 21,4±7,9 mV×ms; velocity of pulse conduction along the nerve at right was 55,5±6,3 m/s, at left – 57,5±8,4 m/s.

Studying parameters of the neuromuscular transition revealed a high value of the M-response amplitude in case of its small duration in the "tarsus", "head of fibula" and "popliteal fossa" stimulation points. Moreover, values of the M-response duration in the proximal point of stimulation are higher than 7% in comparison to the distal point. For healthy people who do not engage in sports, this difference does not exceed 15%. Values of the M-response spread among track-and-field athletes practically do not change in case of stimulating proximal and distal projection points of the peroneus nerve. The residual latency indicator did not exceed the limits of standard values at both sides. Values of the velocity of pulse conduction along the nerve were high both in the "tarsus – head of fibula" area and the "head of fibula – popliteal fossa" area.

Thus, the analysis of indicators of amplitude, duration and spread of M-response shows a large number of muscle fibers involved in contraction during stimulation of the peroneal nerve, and high muscle coordination. Low latency values, high velocity of electric pulse conduction along the nerve allow considering a high myelination of the nerve fiber. Moreover, there is a short period of time needed to conduct the pulse along the axon terminals that do not have the myelin shealth.

The analysis of indicators of the electroneuromyographic study revealed a higher velocity of electric pulse conduction through the nerve fiber in women in the "head of fibula" stimulation point. Moreover, in the "tarsus" point at right, the "head of fibula" point at left and the "popliteal fossa" point at both sides have lower latency values among female athletes. However, it is reasonable to note that latency values depend on a distance between the stimulating and pick-up electrode. Therefore, height of a test subject plays a key role in calculating this indicator. Other indicators did not have any significant differences.

Table

Parameters of the rheovasographic study of the lower extremities in elite athletes

Indicators	Right leg	Left leg	Standard values
Sole			
RI	1,83±0,9	1,8±0,9	0,9-1,3
Qa	0,32±0,06	0,29±0,03	0,25-0,27
alpha	0,17±0,06	0,17±0,05	0,08-0,12
alpha2	0,12±0,05	0,12±0,04	0,05-0,07
EM	18,2±7,23	18,0±7,1	11-16%
VO	32,4±14,7	35,5±11,8	0-20%
DCI	0,40±0,25	0,48±0,4	0,4-0,6
DSI	0,42±0,25	0,35±0,4	0,30-0,55
AC	36,8±17,1	36,8±17,1	0-20%
Lower leg			
RI	2,1±1,5	2,4±1,9	0,90-1,25
Qa	0,26±0,02	0,30±0,1	0,23-0,26
alpha	0,16±0,05	0,17±0,06	0,08-0,12
alpha2	0,11±0,04	0,11±0,05	0,05-0,06
EM	17,0±5,7	17,3±6,8	11-15%
VO	30,9±16,6	31,0±11,0	0-20%
DCI	0,60±0,32	0,44±0,31	0,4-0,6
DSI	0,44±0,31	0,49±0,29	0,45-0,75
AC	40,3±15,4	41,2±15,0	0-20%

Note: RI – rheographic index; Qa – time of spread of rheographic waves; alpha – time of maximal content of vessels; alpha2 – time of slow content of vessels; EM – elastic modulus; VO – venous outflow; DCI – dicrotic index; DSI – diastolic index; AC – asymmetry coefficient

Parameters of rheovasographic study of the lower extremities of athletes specializing in track-and-field are presented in a table above. Study of arterial blood content of vessels in the "sole" segment revealed an increase in following indicators: rheographic index, time of spread of rheographic waves, time of maximum content of vessels, time of slow content of vessels. Besides that, the venous outflow indicator also exceeds the reference interval. However, microcirculation indicators did not exceed limits of standard values.

High values of following indicators were also registered in the "lower leg" segment: rheographic index, time of spread of rheographic waves, time of maximum content of vessels, time of slow content of vessels, venous outflow, elastic modulus and asymmetry coefficient. Microcirculation indicators remained normal.

Comparison of rheovasographic indicators of the lower extremities in male and female track-and-field athletes did not reveal any significant differences.

Therefore, the obtained data correspond with earlier studies and show that great physical loads increase venous elasticity of the lower extremities and do not cause changes of viscoelastic characteristics of the deep vein wall, which serves as a response to an increasing volume of circulating blood and an increase of arterial inflow as a result of systematic aerobic training sessions [6-8].

Conclusion. Consequently, it was found that in the process of sports training there are specific changes in the functional state of the neuromuscular apparatus and hemodynamics of the lower extremities in elite athletes. The most significant are an improvement of the neuromuscular coordination that allows developing speed-power and coordination abilities, as well as compensatory changes in peripheral hemodynamics that develop as a response to a high motor activity.

The data obtained will be used in the future to develop criteria for assessing the functional state of the neuromuscular apparatus and peripheral hemodynamics in elite athletes, as well as to create recovery programs for athletes when intense physical loads are applied.

References

1. Lanskaya O.V. Electromyographic study of muscle activity in students of a physical culture university specializing in various sports / O.V. Lanskaya, E.V. Lanskaya // New Research. – 2017. – № 1. – P. 50-64.

2. Vojnova S.E. Features of electric activation of muscles in running of track-and-field athletes of different qualifications / S.E. Vojnova, A.A. Shimanskij, E.N. Medvedev // Scientific Notes of the P.F. Lesgaft University. – 2021. – № 6. – P. 72-77.

3. Krasnoperova T.V. Control of the functional state of athletes of various nosological groups at the initial stage of sports training / T.V. Krasnoperova,

N.B. Kotelevskaya // Scientific Notes of the P.F. Lesgaft University. – 2020. – № 11(189). – P. 270-274.

4. Koryagina Yu.V. The use of electroneuromyography in sports medicine / Yu.V. Koryagina, L.G. Roguleva // Modern Issues of Biomedicine. – 2018. – Vol. 2. – № 12. – P. 31-43.

5. Nikolaeva T.M. Features of peripheral hemodynamics and cognitive abilities of a person in case of dynamic physical loads with increasing power / T.M. Nikolaeva, E.K. Golubeva // Modern Issues of Science and Education. – 2020. – № 6. – P. 147-153.

6. Kozlov V.I. Microcirculation during muscle activity / V.I. Kozlov, I.O. Tupitsyn // Physical Culture and Sport. – M. – 1982. – 135 p.

7. Popova I. E. Features of regional hemodynamics in middle-distance runners / I.E. Popova, G.N. Germanov, E.G. Tsukanova // Scientific Notes of the P.F. Lesgaft University. – 2010. – № 2(60). – P. 104-112.

8. Kudrya O.N. Features of peripheral hemodynamics of athletes during adaptation to loads of various direction / O.N. Kudrya, M.A. Kiryanova, L.V. Kapilevich // Bulletin of Siberian Medicine. – 2012. – Vol. 11. – № 3. – P. 48-53.

Information about the authors: Ali Shamil’evich Abutalimov – Trauma Orthopaedist of Medical Centre “Yunost”, branch of the FSBI “North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency”, Essentuki, e-mail: abutalimov05@mail.ru.