

FEATURES INTERFERENCE ELECTROMYOGRAM RECTUS FEMORIS FOR SKILLED PLAYERS IN THE CONTEXT OF SPECIAL EXERCISES

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Annotation. The problems of improving physical fitness of skilled players were considered. The aim of the study is to determine the optimal position of the hip angle to the vertical plane for the manifestation of a maximum of bioelectric activity of the rectus femoris. In the experiment involved 15 players of FC "Metalist" (age 18 - 30 years). Has electromyogram muscle activity "hip flexion standing" on the mechanical simulator. Athletes performed around the maximum contraction of the muscle (musculus rectus femoris) for 5 seconds. Found that the angle of 70 degrees has minimal background for developing muscular force. It is established that the position of the straight leg on the same vertical axis with the body is the position of the largest overlap actinomyosinic filaments in muscle sarcomere.

Keywords: electromyography, angle, force, mechanical simulator, football, thigh muscle.

Introduction

Football is a dynamic kind of sports, in which sportsman himself is a moving object, who combines different forms of his segments' movement, such as bones and muscles. In this kind of sports there are a lot of technical elements, in context of which muscles, bending thigh, participate. High sport results to large extent depend on how perfectly football player uses them within the frames of rules for solution of certain tasks in variable conditions of match activity, with resistance of adversaries and, often, with progressing tiredness. Perfect technique – is an integral part of comprehensive training and harmonious development of football players (V.M. Khodukin, 1989; V.M. Shamardin, 2002; Yu.D. Zhelezniak, Yu.M. Portnov, V.P. Savin, A.V. Leksakov, 2004) [12, 14, 15].



Fig.1. Kicking ball in movement. (Yu.D. Zhelezniak, Yu.M. Portnov, V.P. Savin, A.V. Leksakov, 2004).

Systems of organism, which ensure transformation of chemical energy into mechanical, and it, in its turn, start muscle's contraction activity and as a result demonstration of force happens. Let us regard some methods of increasing of sports workability at the account of modification of sportsman organism's bio-chemical characteristics: effective application of force in more perfect way. A sportsman can have highly developed physiological systems, but if energy, Yu.D. Zhelezniak, Yu.M. Portnov, V.P. Savin, A.V. Leksakov, which is produced in his organism, is utilized incompletely, the level of sport workability will also be low.

That is why, the problem of first importance is determination of inter position of moving segments, in our case position of leg in respect to vertical plane, in which muscles can manifest their maximal bio-electrical activity and, as per researches of Gordon, Huxsley, Julian. (1966), V.M. Zatsiorskiy (1981), Luca de C. J. (1997) [3, 17, 20], can demonstrate maximal force.

Regarding the mentioned above factors of searching of new and improving of already known systems of training process's organization, we understood the need in applying of automatic systems of measurement and medical-biological information processing with the help of up-to-date program means. The obtained information will permit to understand the essence of muscular contraction in context of special exercise that envisages development of contracting abilities of segment, which constantly is used in context of specific activity.

Electric myography is an up-to-date method of diagnostics –i.e., the method of nervous-muscular system's examination with the help of registration of muscles' electric potentials. Electric myography permits not only to find the section of accentuated influence on certain contracting part, but also objectively appraise optimal angle of limb's position (in case of our research – position of thigh in respect to vertical plane, passing through torso and supporting leg). By determination of maximal bio-electrical activity; position of the highest closing of actinic-myosin filaments in sarcomere, according to angle of the applied force.

Sport training, at present stage of its development, is characterized by increasing physical and nervous loads;

the scope and intensity of training work reached critical values and further increasing of them is limited by biological possibilities of human organism as well as by social factors (V.N. Platonov, 1997) [9]. It completely concerns football, where constant increasing of football teams competition activity's tension results in reduction of scopes of basic preparation (V.M. Alekseyev, 1986; V.M. Khodukin, 1989; V.M. Shamardin, 2002.; V.M. Kostiukevych, 2007) [1,4,14,15]. These factors condition need in development of maximally effective training methods with complex optimization of all their main components.

Main methodic of electric myography include analysis of (surface, summarizing) electric myograms, as far as large size of surface electrode and its distant location from muscular tissue permit to register with its help only total muscular activity, that is an interference of actions of hundreds and even thousands of muscular filaments (S.G. Nikolayev, 2003, 2010; L. Vovkanych, B. Vynogradskiy, V. Tkachek, 2012) [2,6,7].

With the help of this method it is possible to study structure and functions of neuro-motor system, which includes functional elements – mobile units (MU), consisting of motor-neuron and group of innervated by it muscular filaments. Muscular MU – is a combination of motor-neuron and group of innervated by it muscular filaments. (V.M. Smirnov, 2001) [13]. For example, if stretched muscle is two times longer than in rest, force producing will practically equal to zero (D. L. Costill, W. J. Fink, M. Flynn, J. Kirwan., 1987) [18]. However, it is necessary to consider that strength of muscular filaments will depend of quantity of transversal bridges, which are in contact with actinic filaments. With overstretching of muscular filaments, distance between actinic and myosin filaments still increases. Reduction of area of these filaments' closing shortens the quantity of transversal bridges, which are required for producing of force (Gollnick P.D., Hodson D.R., 1986) [19]. With reducing or increasing of muscular length, the value of closing changes and force reduces (I.P. Ratov, 1972; V.M. Zatsiorskiy, 1981) [3,10]. In our case, directing of right leg's movement from below – upward makes closer proximal and distal fastening areas, thus making closer myofilaments in sarcomere; in the process of bending – levels (the higher leg's position - the shorter muscle is and, correspondingly, quantity of transversal bridges is less) their bio-electrical and, consequently, contraction ability.

Bending of thigh happens owing to bi-articulate musculus rectus femoris and mono articular musculus iliopsoas, musculus sartorius, musculustensor fasciae latae, musculus pectineus) (F. Netter, 2003) [5]. Gordon, Huxsley, Julian (1966) [17] Studied interconnection between force, which is manifested by contraction components, and the length of muscle, considering the fact that it is the biggest in certain average length. It was found that with simultaneous registration of sarcomere's length, driving force and closing of actinic-myosin filaments in sarcomere, the force of contraction components is maximal with the largest closing of these areas. Certain average length, in which contraction muscle's components can manifest the highest force is called "length of rest" (V.M. Zatsiorskiy, 1981) [3].

With bio-mechanical analysis of human movements, the muscles' nomenclature, adopted ion anatomy, is not always sufficient. Different parts of muscles (not only separate heads) can differ by their functions. Morecki A., Ekiel J., Fidelus K. (1971) [21] offered to introduce concept "acton". Acton – is a part of muscle, filaments of which are located so that created by them force moments in respect to joint always coincide by direction.

Control of bi-articulate muscles was always a matter of interest. It was not clear, how brain control activity of muscles, creating force moments in respect to two joints simultaneously. As it was shown by electric myography researches (I.P. Ratov (1972), S.G. Nikolayev, 2003) [6,10], some bi-articulate muscles, which have pinnate structure, for example rectus muscle of thigh,, can contract independently by their proximal and distal ends. Anatomical data by F. Netter, 2003 et al., [5], confirm such ability. Separate contraction of different parts of bi-articulate muscles can be observed only in laboratory, creating too little moments of muscles' driving force (Basmadjan, 1978; Luca de C. J., 1997) [16,20]. It is necessary to consider also probable limitation of amplitude of thigh bending movement owing to limited stretching ability of its bi-articulate muscles-antagonists. The higher foot of leg moves from vertical axis the bigger muscles, executing opposite function, stretch (P.O. Sirenko, 2012) [11].

As on to-day, the topic of straight leg's position in respect to torso axis, for demonstration of maximal force in bending element, has not been elucidated sufficiently. Detail description of bio-electrical activity of rectus muscle of thigh in structure of isometric contraction permits to determine optimal angle of highest actinic-myosin filaments' closing, to optimize content of technical-tactic actions on the base of more effective realization of special physical training.

Purpose, tasks of the work, material and methods

The purpose of the work is experimental determination of thigh position's optimal angle in respect to vertical plane for manifestation of maximal bio-electrical activity of musculus rectus femoris in exercise "bending of thigh in standing position" on mechanical simulator.

15 players of main and backup staff of 18-30 years old from SC "Metalist" took part in the research. The research were conducted on training base of SC "Metalist" in first half of day with the help of computer electric neuro-myograph, produced by DX – Systems "M-TEST", that complies with technical specifications TYV33.1-30428373-004-2004, and is designed for registration and analyzing of EMG. We used electrodes Ag/AgCL Skintact easitabs RT34 with adhesive base. As per data by S.G. Nikolayev (2003, 2010) [6,7] we used electrodes with free inter-electrode distance: active electrode was fixed in zone of innervations – area of middle one third of musculus rectus femoris (along the muscle, in projection of mobile zone), referential electrode was fixed at proximal part of sinew area.

Earth electrode is located on distal part of opposite limb. It is to be connected with appropriate terminal of electric myograph. This electrode short circuits capacity difference of potentials between body of the tested and earth (S.G. Nikolayev, 2003) [7].

The research was carried out on mechanical simulator “bending of thigh in standing position”, with possible adjustment of counter-action lever’s angle (reducing the angle of thigh position in respect to torso axis), with right and left legs alternatively owing to weight that prohibits to move lever under angles (see figs. 3, 6 – 15 degrees; figs. 4,7 -0 degrees; figs. 5,8 – 20 degrees; figs. 9,12 – 40 degrees; figs 10,13 – 50 degrees; figs. 11,14 – 70 degrees), but envisages manifestation of force, close to maximal by the tested. This simulator we regard as “bending of thigh” as far as in initial position leg is straight and locomotion occurs only owing to movement in knee joint (P.O. Sirenko, 2012) [11]. Additional support on simulator of shoulder girdle is an element of priority (as element of balance keeping and maintaining of final position), of torso axis and supporting leg’s keeping in one vertical plane. Location of counter-acting lever in lower one third of thigh, but higher than referential electrode is fixed, conditions minimizing of mono articulate musculus vastus medialis, musculus vastus lateralis, musculus vastus intermedius’ functions, which acts only for keeping of shin position in one axis with thigh. With locating of counter-acting lever lower than knee joint, simultaneously arm of force increases and above mentioned muscles will act for counter acting to bending of shin, creating additional bio electrical “noise”– muscle cross talk (Basmadjan J. V., 1978) [16]. Regulating of applied force’s angle and distance of rotation axis from counter acting lever are conditioned by structural specificities of simulator and was standard for all tested. Besides, possibility to adjust position of supporting leg on simulator (upward-downward), depending on the leg’s length of the tested, permits to locate knee joint’s and simulator’s rotation axes in one plane (P.O. Sirenko, 2012) [11]. In our research, as far as shin is located on one axis with thigh, distal part of musculus rectus femoris is in certain fixed position, being maximally close to proximal area of fastening. That means: for reaching of “length of rest” we should determine certain optimal correlation of straight leg’s and torso’s positions owing to movement only in knee joint.

Determination of angle between thigh and vertical plane (combines axes of torso and supporting leg) was fulfilled with the help of photo-goniometric examination. Point “0” of angle change (axis of angle-meter’s rotation) was fixed at the level of big swivel: one branch is on thigh axis the other – of side of torso.

The following indicators were determined: maximal amplitude (mcV) – maximal amplitude, observed at given area of interferential myogram; average amplitude (mcV) – average amplitude of given area of interferential myogram’s analysis; average frequency – average frequency of given area of interferential myogram’s analysis; comparative coefficient – relation of average amplitude to average frequency given area of interferential myogram’s analysis. The closer to zero this indicator is the less asymmetry between compared channels exists.

In table, there is presented average indicator calculated on the base of 15 tested results; minimal and maximal indicators were considered as erroneous and were not considered in system of calculation. In our research we set the speed of “tape” within 200 m.sec. p. cm, amplification (reflected amplitude) of signal – 5 mV p.cm, with current value of responses’ speed up to 40 m.sec p.cm and current amplification of responses up to 0.9 mV p.cm. (See fig.2). The obtained indicators were analyzed with statistical methods with the help of program Microsoft Excel 2007.

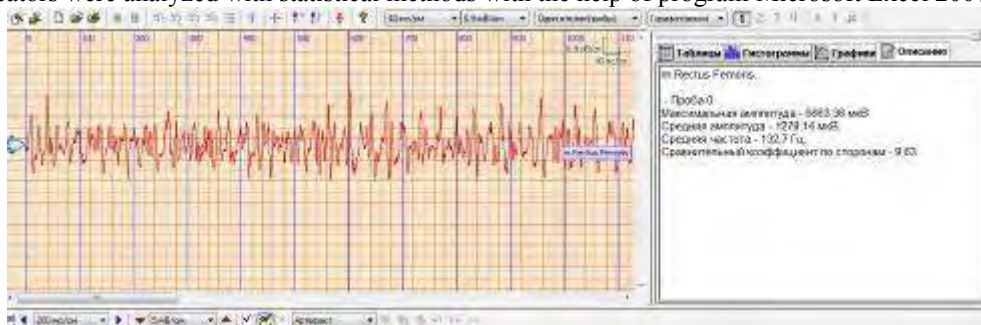


Fig.2. Fragment of interferential myogram of musculus rectus femoris’s bio electrical activity at angle of 15 degrees.

Table 1

Data of interferential myogram of musculus rectus femoris

m. rectus femoris	-15 degrees		0 degrees		20 degrees	
	Right leg	Left leg	Right leg	Left leg	Right leg	Left leg
Amplitude max. (mcV)	6592.36± 638.2	6518.34± 621.4	6688.24± 657.1	6572.89± 664.3	5693.76± 521.4	5587.23± 530.5
Amplitude av. (mcV)	1200.21± 111.3	1140.34± 114.4	1491.36± 138.7	1392.98± 129.8	1171.76± 110.8	1143.81± 115.5
Frequency av. (Hz)	127.5± 11.7	120.4± 11.6	138.6± 13.4	131.43± 13.8	129.1± 11.8	125.9± 12.3

Comparative coefficient	9.44± 0.81	9.5± 0.87	10.76± 0.97	10.59± 0.98	9.07± 0.84	9.14± 0.79
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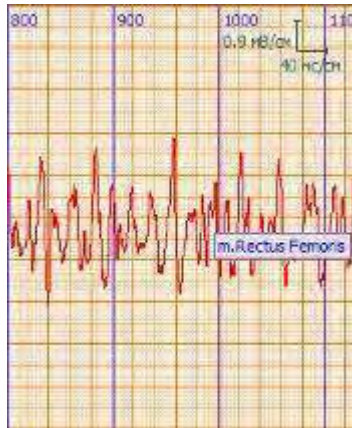


Fig.3 Fragment of interferential myogram (angle 15 degrees)

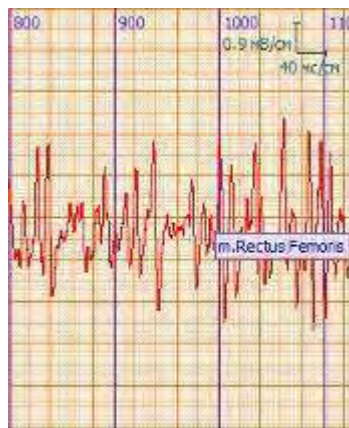


Fig.4 Fragment of interferential myogram (angle 0 degrees)

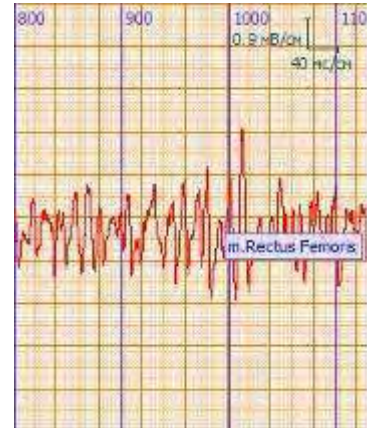


Fig.5 Fragment of interferential myogram (angle 20 degrees)



Fig.6 Photo-goniometry (angle – 15 degrees)



Fig.7 Photo-goniometry (angle – 0 degrees)



Fig.8 Photo-goniometry (angle – 20 degrees)

Table 2

Data of interferential myogram of musculus rectus femoris

m. rectus femoris	40 degrees		50 degrees		70 degrees	
	Right leg	Left leg	Right leg	Left leg	Right leg	Left leg
Amplitude max. (mcV)	4707.84± 458.7	4628.38± 463.2	3123.84± 320.7	3075.75± 307.5	2689.92± 264.4	2601.05± 270.8
Amplitude av. (mcV)	937.93± 94.0	919.53± 92.6	696.9± 67.7	614.3± 63.3	675.16± 66.8	661.99± 67.4
Frequency av. (Hz)	133.3± 12.7	125.6± 13.1	176.6± 18.4	168.2± 17.1	212.7± 20.8	208.2± 21.4
Comparative coefficient	7.04± 0.65	7.35± 0.7	3.95± 0.41	3.65± 0.37	3.17± 0.29	3.18± 0.30

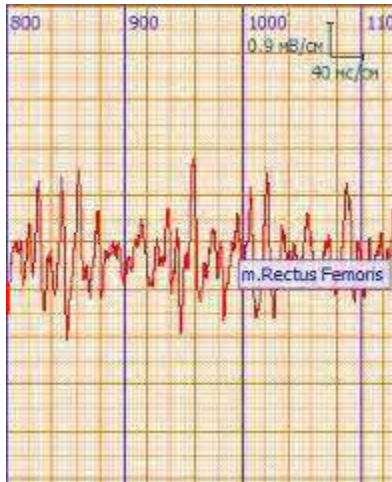


Fig.9. Fragment of interferential myogram (angle 40 degrees)

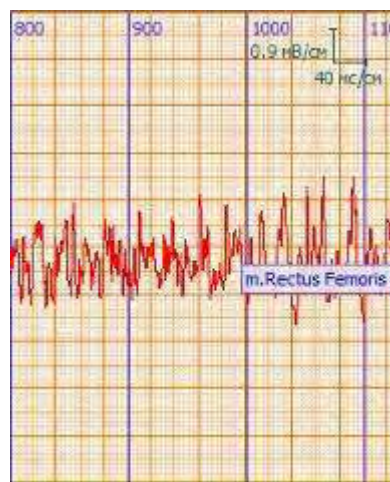


Fig.10. Fragment of interferential myogram (angle 50 degrees)

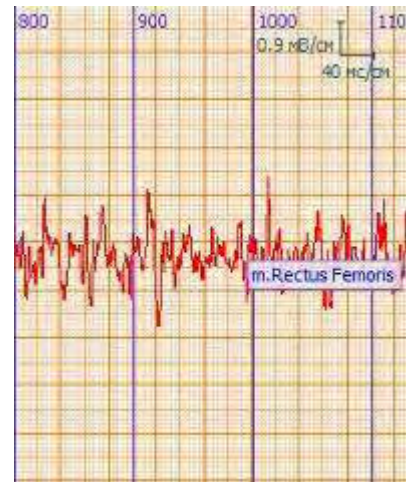


Fig.11. Fragment of interferential myogram (angle 70 degrees)



Fig.12. Photo-goniometry (angle - 40 degrees)



Fig.13. Photo-goniometry (angle - 50 degrees)



Fig.14. Photo-goniometry (angle - 70 degrees)

Summary

There has been carried out experimental determination of optimal thigh position angle in respect to torso axis for manifestation of maximal bio-electrical activity of musculus rectus femoris.

Having analyzed IEMG of musculus rectus femoris in exercise “thigh bending in standing position” on mechanical simulator, we can make conclusions that, basing on regarded by us principles, correlation of straight leg and torso axis in one vertical plane has the best pre-conditions for manifestation of muscular strength as far as indicators of the lowers average and maximal (mcV) amplitudes witness about the highest closing of actinic-myosin filaments in sarcomere with the highest comparative coefficient. (See figs. 4,7; table 1) and correspond to theory of Gordon, Huxsley, Julian (1966) and V.M. Zatsiorskiy, (1981), which we regarded above as well as have optimal preconditions for manifestation of muscular strength.

In the process of thigh bending (shin is unbent) these indicators reduce and reach their minimum with the lowest comparative coefficient with position to vertical plane at angle of 70 degrees (see figs. 11;14; table 2) and it witnesses that this very angle (from all studied by us) reflects position of least closing of actinic-myosin filaments in sarcomere of м'язу *musculus rectus femoris*.

The prospects of further researches imply further study of bi-articulate musculus rectus femoris IEMG with thigh bending and simultaneous bending of shin in standing posture; study of re-distribution of bio-electrical thigh muscles' activity (front and medial groups) with counter-acting on immovable lever by supine or pronated leg. Conducting of these researches will permit to optimize training process of qualified football players with the help of determination of optimal influence of movable segment.

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Cite this article as: Sirenko P.O., Korolinska S.V., Sirenko Y.P. Features interference electromyogram rectus femoris for skilled players in the context of special exercises. *Pedagogics, psychology, medical-biological problems of physical training and sports*. 2013, vol 8, pp. 92-98. doi:10.6084/m9.figshare.747479

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Received: 03.06.2013

Published: 30.08.2013