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FUNCTIONAL TESTING OF THE LOWER EXTREMITY MUSCLES

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Abstract. Functional testing of the lower extremity muscles. Sirenko P.O., Storozhenko I.P., Žīdens J., Zuša A., Yuzyk O.P., Lietuviete D., Kolesnyk T.V. *The purpose of the study was to increase the efficiency of diagnostics of the strength indicators of the lower extremity muscles by determining the optimal conditions for the mutual location of segments of kinematic links for the best implementation of contractile capabilities during functional testing. The main focus of the work was to determine the positions for the maximum overlaying of myofilaments in the sarcomeres of the investigated contractile areas of the movable segments of the lower extremities during power loads. 20 experienced football players, whose average age was 26.8±6.2 years, took part in the study. In order to fulfill the set goal, interference electromyography was performed on all athletes. The function of a separate group of muscles was considered in accordance with the endogenous ability to overcome external resistance in a given direction. Dependence of contractile manifestations was coordinated in accordance with the approach or distance of areas of attachment of muscles. The positions of the muscles were regulated by the ventral and sagittal planes, as well as by the average amplitude of rotation. On the basis of the ratio of maximum, average amplitudes and frequency, data regarding the maximum overlaying of myofilaments in sarcomeres (maximum bioelectric activity), in accordance with the position angle of the movable segment of the lower extremity were obtained. It was established that for conducting functional testing, the location of the trunk and lower extremities in the same plane of movement and axis were the optimal positions for the diarticular muscles of the thigh and lower leg; for monoarticular extensors of the lower leg - a position at a right angle between the lower leg and thigh; for rotators of the lower leg and foot - location of these segments in a plane parallel to the sagittal one. On the basis of the obtained data, the optimal conditions for the mutual location of the segments of the kinematic links for the realization of the contractile capabilities of the muscles of the lower extremities have been determined, a protocol for* *functional testing of the muscles of the lower extremities has been developed, it is presented in graphic form with the possibility of entering data from both limbs, while test points of rotator muscles of the thigh and lower leg have been added.*

Реферат. Функціональне тестування м'язів нижніх кінцівок. Сіренко П.О., Стороженко І.П., Жіденс Я., Зуша А., Юзик О.П., Лієтувієте Д., Колесник Т.В. *Метою дослідження було підвищення ефективності діагностики силових показників м'язів нижніх кінцівок шляхом визначення оптимальних умов взаємного розташування сегментів кінематичних ланок для найкращої реалізації контрактильних можливостей під час функціонального тестування. Основним у роботі було визначення положень для максимального перекриття міофіламентів у саркомерах досліджуваних контрактильних ділянок рухомих сегментів нижніх кінцівок під час силових навантажень. У дослідженні взяли участь 20 досвідчених футболістів, середній вік яких був 26,8±6,2 року. Для виконання поставленої мети всім спортсменам проводилась інтерференційна електроміографія. Розглядалась функція окремої групи м'язів відповідно до ендогенної здатності подолання зовнішньої протидії в заданому напрямку. Залежність контрактильних проявів узгоджувалась відповідно до зближення чи віддалення ділянок кріплення м'язів. Положення м'язів регламентувались вентральною та сагітальною площинами, а також середньою амплітудою обертання. На підставі співвідношення максимальної, середньої амплітуд та частоти було отримано дані щодо максимального перекриття міофіламентів у саркомерах (максимальної біоелектричної активності), відповідно до кута положення рухомого сегмента нижньої кінцівки. Установлено, що для проведення функціонального тестування оптимальними положеннями були для двосуглобових м'язів стегна та гомілки – розташування тулуба та нижніх кінцівок в одній площині руху та вісі; для односуглобових розгиначів гомілки – положення під прямим кутом гомілки та стегна; для ротаторів гомілки та стопи – розташування цих сегментів у площині, паралельній сагітальній. На основі отриманих даних визначені оптимальні умови взаємного розташування сегментів кінематичних ланок для реалізації контрактильних можливостей м'язів нижніх кінцівок, розроблено протокол функціонального тестування м'язів нижніх кінцівок, який представлено в графічній формі, з можливістю вносити дані обох кінцівок, при цьому додані пункти тестування м'язів – ротаторів стегна та гомілки.*

The practical activity of physical therapists, occupational therapists, and sports medicine specialists always involves an in-depth analysis of the essence of movement of kinematic links [1].

This regards not only to directing, a patient to awareness of the content of his/her physical activity in everyday life during active recreation and doing sports [2, 3]. An important component is the construction of preventive measures for healthy people and the possibility of operational control of the effectiveness of the performed complexes of exercises for people who are at various stages of rehabilitation, with diseases of the locomotor system [4].

The selection of a system that will register the force characteristics of muscles in the specified initial positions is a priority task [5].

At present, the topic of functional testing (FT) in the most effective conditions for realizing contractile capabilities is not fully disclosed in the scientific and methodical literature. In the works of Sirenko PO (2015, 2022) [6,7] the relationship between the manifestation of bioelectrical activity and muscle strength which depends on the ratio of the proximal or distal part of the attachmentwas considered. Approaching or stretching of the area which contracts implies a change in the adjacent angles. For each of the kinematic links, there is a certain average position that is optimal for overlaying of myofilaments in the sarcomere and force. This provision is considered as the "rest length" [7].

Improving the known systems of organizing the activities of physical therapists and occupational therapists requires the search for new systems of measurement and processing of medical and biological information [8, 9]. Modern software tools make it possible to quickly and differentially assess the level of muscle ability to most effectively counteract external influences and realize contractile capabilities [6, 10]. Therefore, there is an urgent need to determine and scientifically substantiate the most optimal conditions for performing FT of the pelvic girdle muscles. This will make it possible to regulate the conduct of research and develop a unified testing protocol.

The purpose of the study: to increase the effectiveness of diagnostics of the strength indicators of the lower extremities muscles by determining the optimal conditions for the mutual location of segments of kinematic links for the best implementation of contractile capabilities during functional testing.

MATERIALS AND METHODS OF RESEARCH

The study involved 20 experienced football players (n=20). An average age of the participants was 26.8 (6.2) years. Written consent for participation and publishing the results of the study was obtained from all athletes. The study consisted of 8 blocks in accordance with various exercises directed at different muscle groups. But not all 20 participants were able to take part in each of the study blocks. Therefore, the volume of the sample population *n* in the blocks was different: in the exercises "thigh flexion standing" (TFS) *n*=20, "lower leg extension sitting" (LLES) *n*=10, "leg adduction standing" (LAS) *n*=17, "leg abduction standing" (LAabS) *n*=14, "lower leg flexion in prone position" (LLFPP) *n*=17, "thigh extension standing" (TES) *n*=17, flexed foot (FF) *n*=17, flexed lower leg (FLL) *n*=17 [6].

There were determined the positions of the extremities for the manifestation of the maximum bioelectric activity of the muscles of the anterior, posterior and median groups of the thigh, the posterior group of the lower leg and the gluteus maximus muscle. Separate initial positions and angles were determined for each of the studies. There was a maximum isometric resistance for 5 seconds on the lever of the simulator. Immediately before the diagnostic measures, preparatory exercises were conducted for 10 minutes. The regulation of preparatory exercises was determined separately for each of the studied areas.

The method of FT involved a direct (coaxial to the direction of force) isometric resistance during the exhalation phase for up to 10 seconds. The specialist conducting the test first of all fixed the unengaged extremity in the support. The extremity making counteraction moved in the given plane of movement to the limit of contractile capability [1]. Mechanisms of exercise influence for diarticular and monoarticular muscles were separated: for diarticular – the optimal ratio of the proximal and distal sections of the kinematic link [6, 7], for monoarticular ones – depending on the zone of emphasis of influence.

For each of the specified study blocks, the maximum amplitude of electrical impulses, their average amplitude and average frequency, considered as random values, were measured at different angles of the extremities.The comparative coefficient was also calculated – the ratio of the maximum amplitude to the frequency. Electromyographic (EMG) measurements were performed using a computerized electromyography device manufactured by research and development enterprise DX – "M-TEST" System (42 Tobolska str., Kharkiv, 61072, Ukraine), which is designed for recording and analyzing electromyograms.The active electrode was located in the innervation zone, and the reference electrode – in the area of the tendon part [6].

FT was performed using an E-LINK MyoMeter dynamometer;Hand Held Dynamometer (Biometrics Ltd. Newport, UK).The location of the sensor was on the part of the extremity in the axis and plane of the load. This component leveled the redistribution of force when the angle changed during the application of force.

Statistical processing of the research results was carried out using packages of standard free statistical programs with open source (GNU PSPP (https://www.gnu.org/software/pspp/), GNU Octave https://octave.org/ and Fityk (https://fityk.nieto.pl/). The level of statistical significance was $p<0.05$. The homogeneity of the sample was ensured by approximately the same physical condition, gender, and age of the study participants. The Irwin test undermined the hypothesis of the homogeneity of the sample. Subordination of the obtained values to the normal distribution law was performed using the Shapiro-Wilk agreement test. All random variables were found to be normally distributed. Therefore, this made it possible to use powerful estimators and parametric criteria for normally distributed random variables. In the work, the estimation of mathematical expectation, variance of random variables, two-factor analysis of variance and regression analysis were performed (polynomial regression was estimated by the method of least squares and its adequacy was checked by the F-criterion). Quantitative data are presented in the M(SD) format, where M is the arithmetic mean, SD is the root mean square deviation [6].

The study was conducted in accordance with the principles of bioethics set forth in the Declaration of Helsinki "Ethical Principles of Medical Research Involving Human Subjects" and the "Universal Declaration of Bioethics and Human Rights (UNESCO)". Protocol of the Bioethics Commission No. 24 of the Latvian Academy of Sports Education.

RESULTS AND DISCUSSION

To identify the dependence of the measured random variables on the angle of the extremities and individual characteristics of the participants, a two-factor variance analysis was performed using the F-test. The dependence of all random variables was statistically significant both on variations between individual participants of the study and on the angle of extremity position. The value of the criterion for the variation of participants was approximately equal to the critical one, while the value of the criterion for the angle is 10-15 times higher than the critical value. The exception is the impulse frequency, the dependence of which on the angle for different exercises and muscles turned out to be ambiguous. For example, in the TES exercise for *m.biceps femoris*, the criterion value was equal to 36.6 and 25.9 for the right and left extremity, respectively, and for *m.semitendinosus* – 0.83 and 1.69, respectively. The critical value of the criterion is 2.52. That is, the influence of the angle on the impulse frequency of *m.biceps femoris* is statistically significant, and on *m.semitendinosus* it is insignificant. For most exercises and muscles, the criteria values of impulse frequency and variation of participants are approximately equal.

For the "leg abduction" exercise, the dependence of the oscillation frequency on the angle turned out to be statistically insignificant [6]. Therefore, the maximum and average amplitudes of electrical impulses depend significantly on the angle. These dependencies are much stronger than the influence of individual characteristics. As for the impulse frequency, the results turned out to be ambiguous and require clarification.

In order to find the optimum angles of the extremities, regression equations in the form of polynomial of the third order were found. All regression equations are generally adequate. The worst consistency between theoretical and experimental values was found for the dependence of the maximum amplitude of impulses of the muscle that stretches the broad fascia in the LLAbS exercise with a coefficient of determination of 0.67 (value of the F-criterion F=8.1) and 0.72 (F=10,3) for the right and left extremities, respectively. The critical value of the criterion is 7.7.That is, even in the worst case, the regression equation is generally adequate. For all other regression equations, the coefficient of determination was not less than 0.85. All regression curves have some consistency. The angles of the maximum amplitude of impulses are the angles of the minimum of their frequency. There was no local extremum in the regression dependence in the interval from 125 to 180 degrees in the LLFPP exercise with the foot flexed and unbent [6].

The angles of maximum and average amplitudes of electrical impulses were found by regression equations. In connection with the limited volume of samples, the optimal angles were found visually by graphs of regression equations, taking into account the consistency of all parameters - the maximum and average amplitude of electric impulses, their frequency and comparative coefficient. Figure 1 shows an example of regression curves for the maximum and average amplitude of impulses.

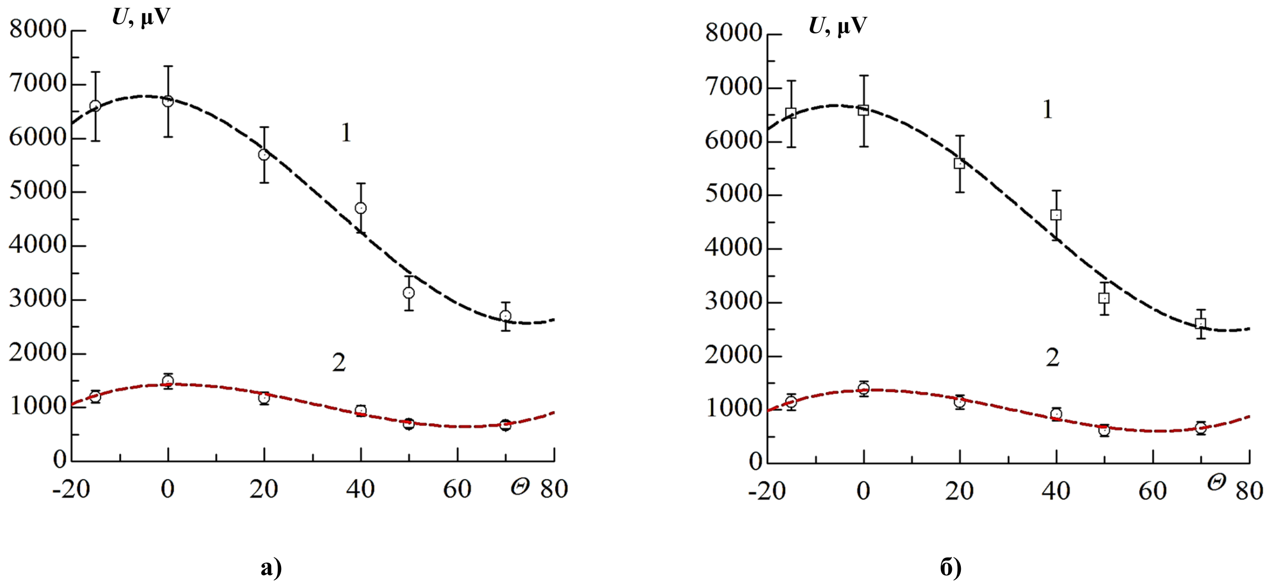


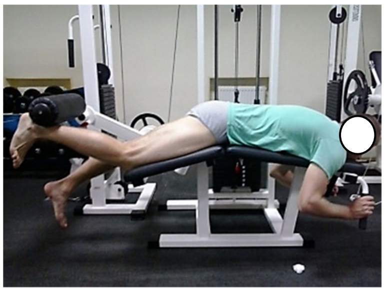
Fig. 1. Regression dependence between the values of the amplitude of the electromyogram of *m.rectus femoris* and the angle in the hip joint for the right (a) and left extremity (b) (n=20) (regression lines with experimental points are presented):
1– maximum voltage amplitude;
2 – average value of voltage amplitude;
U – amplitude in EMG, µV;
Θ – angle in the hip joint (degrees)[6]

According to the results of the assessment of the regression dependence, the optimal positions of the trunk and lower extremities were obtained, which are given in the Table 1. So, in the LLES and LLFPP exercises, the "length of rest" was set on the horizontal axis passing through the knee joint and accepted in the counting system as 180° (straight leg); in exercises TES, TFS – on the horizontal axis passing through the hip joint in the ventral plane and accepted in the counting system as 0° (vertical orientation of the extremity); in LAS, LLAbS exercises - on the horizontal axis passing through the hip joint in the sagittal plane and accepted in the counting system as 0° (vertical orientation of the extremity).

Table 1

Position of the utmost overlaying of myofilaments of the study area of hip girdle muscles (p<0.05)

No.	Exercise	Content	Engaged muscles	Angle
1		**Thigh flexion standing(n=20)**	***m.rectus femoris***	**0°**
2		**Leg extension sitting (n=10)**	***m. vastus medialis, m. vastus lateralis, m. rectus femoris***	**90°**
3		**Leg adduction standing (n=17)**	***m. adductor magnus, m. adductor longus, m. gracilis***	**0°**

No.	Exercise	Content	Engaged muscles	Angle
4		**Leg abduction standing (n=14)**	***m. tensor fasciae latae***	**0°**
5		**Leg flexion in prone position(17)**	***m. biceps femoris, m. semitendinosus, m. semimembranosus***	**180°(in thigh position 0°)**
6		**Thigh extension standing (n=17)**	***m. biceps femoris, m. semitendinosus, m. semimembranosus***	**0°**
7		**Leg flexion in prone position (flexed foot) (n=17)**	***m. gastrocnemius (caput mediale, caput laterale)***	**180°**

No.	Exercise	Content	Engaged muscles	Angle
8		**Thigh extension standing (flexed leg) (n=17)**	***m. gluteusmaximus***	**90°**

Notes: exercise – preparatory position; content– performance of motor action; engaged muscles – area of distribution of the main load; angle – optimum angle to achieve "length of rest" for muscles making counteraction.

TFS exercise (Table 1, exercise No. 1). In 20 subjects, we examined the position of the thigh at angles of force application of 20°, 0°, 40°, 60°, 70°. In the position of the kinematic link at an angle of 0°, the maximum bioelectric manifestations in the muscle were established; *m. rectus femoris*, which indirectly indicates the maximum overlaying of myofilaments. A decrease in indicators of bioelectric activity was observed with a corresponding decrease in the attachment areas stretching to 20° and approaching 70°.

LLES exercise (Table 1; exercise No. 2). In 10 subjects, the positions of the lower leg were examined at angles of application of force of 80°, 90°, 105°, 120°, 130°, 140° (Fig. 2). The position of the kinematic link at an angle of 90° provided the maximum bioelectric manifestations in *m. vastus medialis, m. vastus lateralis, m. rectus femoris*, which indirectly indicates the maximum overlaying of myofilaments. A decrease in indicators of bioelectric activity was observed in the attachment areas stretching to 80° and approaching 140°.

LAS exercise (Table 1, exercise No. 3). In 17 subjects, the muscles of the medial group of the thigh were examined at abduction angles of 45°, 35°, 20°, 0° and 20°.

The position of the kinematic link at an angle of 0° provided the maximum bioelectric manifestations in *adductor magnus*, *adductor longus*, and *m.gracilis* muscles, which indirectly indicates the maximum overlaying of myofilaments [6]. A decrease in indicators of bioelectric activity was observed in the attachment areas stretching to 45° and approaching 20°.

LAbS exercise (Table 1, exercise No. 4). In 14 subjects, the muscles of the medial thigh group were examined at abduction angles of 40°, 30°, 20°, 10°, 0°, 20°. The position of the kinematic link at an angle of 0° provided the maximum bioelectric manifestations in the *fasciae latae* muscles, which indirectly indicates the maximum overlaying of myofilaments [6]. A decrease in indicators was observed in the attachment areas stretching to 20° and approching 40°.

LLFPP exercise (Table 1, exercise No. 5). In 17 subjects, the muscles of the posterior group of the thigh were examined at angles of force application of 180°, 165°, 145° and 125°. The position of the kinematic link at an angle of 180° provided the maximum bioelectric manifestations in *biceps femoris*, *m.semitendinosus*, *m.semimembranosus* muscles,which indirectly indicates the maximum overlaying of myofilaments [7]. A decrease in the indicators was observed in the attachment areas approaching 125°. A change in bioelectrical activity depending on the ratio of the hip and knee joints was observed as well.

TES exercise (Table 1, exercise No. 6). In 17 subjects, the muscles of the posterior group of the thigh were examined at angles of force application of 15°, 0°, 20°, 40°, 70°. The position of the kinematic link at an angle of 0° provided the maximum bioelectric manifestations in *m.biceps femoris*, *m.semitendinosus* and *m.semimembranosus*, which indirectly indicates the maximum overlaying of myofilaments. A decrease in indicators of bioelectric activity was observed in the attachment areas stretching to 70° and approaching 15°.

LLFPP exercise with a flexd foot (Table 1, exercise No. 7). In 17 subjects, the calf muscle was examined at angles of force application of 180°, 165°, 145°and 125°.The position of the kinematic link at an angle of 180° provided maximum bioelectric manifestations in *m.gastrocnemius (caput mediale, caput laterale)*, which indirectly indicates the maximum overlaying of myofilaments. A decrease in the indicators was observed in the attachment areas approaching 125°.

TES exercise with a flexed lower leg (Table 1, exercise No. 8). In 17 subjects, the *gluteus maximus muscle* was examined at sub-angles of force application of 15°, 0°, 20°, 40°, 70° and 90°. The position of the kinematic link at an angle of 90° provided the maximum bioelectric manifestations in *gluteus maximus muscle*, which indirectly indicates the maximum overlaying of myofilaments [6]. A decrease in indicators was observed in the attachment areas approaching 15°.

Based on the results of the regression analysis, the work systematized the preparatory positions for the FT of the pelvic girdle muscles (Table 2).

Table 2

Preparatory positions for the functional testing of the pelvic girdle muscles

No.	Positions	Content	OMR	Focus of influence
1		Thigh flexion.	In supine position, hands down in support; the leg is straight, the foot is flexed; the free leg is flexed in support. The axis of counteraction is at a right angle to the lower third of the thigh.	Upper third of the muscles of the anterior group of thigh
2		Thigh flexion (modified exercise; thigh and lower leg are flexed at a right angle).	In supine position, hands down in support; the leg is straight, the foot is extended; the free leg is flexed in support. The axis of counteraction is at a right angle to the lower third of the thigh.	Upper third of the muscles of the anterior group of thigh
3		Thigh flexion, lower leg is flexed.	In supine position, hands down in support; the thigh is flexed at a right angle, the lower leg is flexed; the free leg is straight. The axis of counteraction is at a right angle to the lower third of the thigh.	Synergists of the muscles of the anterior group of thigh

No.	Positions	Content	OMR	Focus of influence
4		Low leg extension (thigh and lower leg are flexed at a right angle).	Forarm support; the leg is flexed in support at a right angle, the foot is extended; the free leg is straight. The axis of counteraction is at a right angle to the lower third of the lower leg.	Lower third of the muscles of the anterior group of thigh
5		Foot flexion.	In supine position, hands down in support; the leg is straight, the foot is extended;the free leg is flexed in he support. The axis of counteraction is at a right angle to the arch of the foot.	Diarticular flexors of foot
6		Foot extension	In supine position, hands down in support; the leg is straight; the free leg is flexed in the support. The axis of counteraction is at a right angle to the arch of the foot.	Extensors of foot
7		External rotation of the thigh	In supine position, hands down in support; thigh, lower leg are flexed at a right angle, foot is extended; a free leg is straight. The thigh is fixed. The axis of counteraction is at a right angle to the lower third of the lower leg.	Supinators of thigh

No.	Positions	Content	OMR	Focus of influence
8		Internal rotation of the thigh	In supine position, hands down in support; thigh, lower leg are flexed at a right angle, foot is extended; a free leg is straight. The thigh is fixed. The axis of counteraction is at a right angle to the lower third of the lower leg	Pronators of thigh
9		Leg adduction	In side-lying position; the leg is straight, the foot is parallel to the support; a free leg is flexed in the support. The axis of counteraction is at a right angle to the lower third of the lower leg	Medial group of thigh muscles.
10		Leg abduction	In side-lying position;leg is flexed; a free leg is straight (parallel to the support in the plane of the trunk). The axis of counteraction is at a right angle to the lower third of the thigh	External muscles of the hip girdle.
11		Foot flexion (lower leg is flexed)	In prone position,arms to breast; the lower leg is flexed at a right angle, the foot is extended. The axis of counteraction is at a right angle to the arch of the foot	Monoarticular flexors of foot

No.	Positions	Content	OMR	Focus of influence
12		Internal rotation of the thigh	In prone position; lower leg is flexed at a right angle, the foot is extended; a free leg is straight. The axis of counteraction is at a right angle to the lower third of the lower leg	Pronators of thigh
13		External rotation of the thigh	In prone position; the lower leg is flexed at a right angle, the foot is extended; the free leg is straight. The axis of counteraction is at a right angle to the lower third of the lower leg	Supinators of thigh
14		External rotation of the lower leg	In prone position; the lower leg is flexed at a right angle, the foot is extended; the free leg is straight. The axis of counteraction is at a right angle to the distal part of the external lateral column	Supinators of lower leg

No.	Positions	Content	OMR	Focus of influence
15		Internal rotation of the lower leg	In prone position; the lower leg is flexed at a right angle, the foot is extended; the free leg is straight. The axis of counteraction is at a right angle to the distal part of the inner lateral column.	Pronators of lower leg

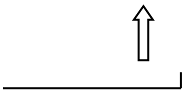
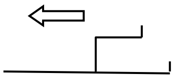
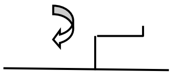
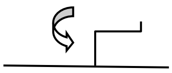
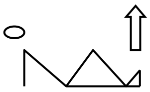
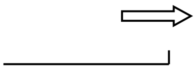
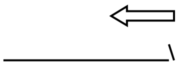
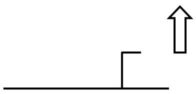
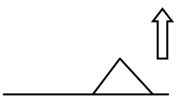
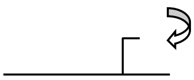
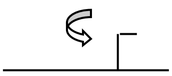
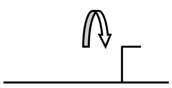
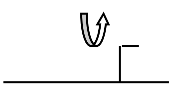
Notes: position – preparatory position; content – performance of motor action; OMR – organizational-methodical recommendations; focus of influence – area of muscles making counteractions.

The positions defined in the previous Table are systematized in the FT protocol for the hip girdle (Table 3). It does not need a detailed description of individual elements of the movement. The points of registration of the right and left extremities determine the dynamics of the ratio of the manifestation of strength characteristics of different segments. In order to strictly regulate the conditions for using diagnostic measures for the rotator muscles of the hip and lower leg, we choose certain average positions in the main planes of motion.

Restrictions on the application of the FT protocol for the muscles of the pelvic girdle. We do not recommend using this protocol (Table 3) as a control of the maximum strength capabilities of professional athletes, as its diagnostic characteristics are limited. Application of the maximum force during compression to the sensor will predict its likely displacement or a change in the position of the moving extremity. In previous studies, Garrett J. et al. (2019) [4], Sirenko PO (2015, 2022) [6,7] by means of interference electromyography, bioelectric activity, angle ratio and applied force of individual contractile links were determined. The studies were considered local, without compliance with the optimal provisions for the implementation of generalized reduction opportunities. Also, in their studies, Kendall F.P., et al. (1993) [11] described the performance of muscle FT without the dependence of approach or distance of attachment areas. For example: for the *gluteus maximus muscle*, it is suggested to perform the exercise "lower leg flexion in prone position". This is the position of the maximum approach of the attachment areas of this segment and its possibilities for contraction will be minimal. We have supplemented and expanded the data on performing FT of skeletal muscles. From the entire array of obtained data, there were separated components of distribution of the emphasis of the load on the motor area for the maximum overlaying of myofilaments, the manifestation of static force for the muscles of the pelvic girdle.

Table 3

Protocol of FT of the hip girdle muscles

No.	Date of study: ____________	Element under study	Right leg	Left leg
1.		Thigh flexion (straight leg)		
2.		Thigh flexion (leg flexed at a right angle)		
3.		External rotation of the thigh		
4.		Internal rotation of the thigh		
5.		Lower leg extension (leg flexed in support at a right angle)		
6.		Foot flexion		
7.		Foot extension		
8.		Foot flexion (leg flexed)		
8.		Leg flexion		
9.		Abduction		
10.		Adduction		
11.		External rotation of the lower leg		
12.		Internal rotation of the lower leg		
13.		External rotation of the thigh		
14.		Internal rotation of the thigh		

Notes: element of study – direction of motion of kinematic link (indicated by additional arrows); right, left leg – necessity to study each of the extremity.

CONCLUSIONS

1. The optimal starting positions for the implementation of contractile capabilities for functional testing of the lower extremity muscles are determined.
2. The conditions for diagnosing the strength capabilities of the pelvic girdle muscles have been proven and regulated.
3. It has been proven that in abduction, adduction, thigh extension, leg and foot flexion, the optimal position for carrying out diagnostic measures is the location of the straight leg and the trunk in the same plane and axis.
4. It has been proven that in leg extension, the optimum position is a right angle between the trunk, thigh and leg.
5. The conditions for diagnostic testing of the rotator muscles of the thigh and lower leg in a plane parallel to the sagittal one have been defined and regulated.

The prospect of further research consists in the creation of a functional testing protocol for the muscles of the shoulder girdle.

The proposed diagnostic methods and their regulation can be recommended for the practice of sports doctors, physical therapists, occupational therapists, physical therapy instructors, and rehabilitation specialists.

Contributors:

Sirenko P.O., Žīdens J. – conceptualization, methodology;

Storozhenko I.P. – statistical processing of study results, biophysical interpretation;

Zuša A., Yuzyk O.P., Lietuviete D., Kolesnyk T.V. – research, resources, data monitoring.

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