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PRACA ORYGINALNA
ORIGINAL PAPER

Evaluation of correlation between functional shortening of hamstring and functional shortening of rectus femoris muscle in patients with anterior cruciate ligament (ACL) injury

Ocena korelacji między funkcjonalnym skróceniem mięśni kulszowo-goleniowych a funkcjonalnym skróceniem mięśnia prostego uda u pacjentów z uszkodzeniem więzadła krzyżowego przedniego (ACL)

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ABSTRACT

INTRODUCTION: The anterior cruciate ligament (ACL) is one of most important structures in the knee joint. It contains mechanoreceptors, that respond to mechanical pressure or distortion and enable one to feel the knee position and proprioreception. Injury of this structure can lead to changes in knee function. Issues which relate to knee translation and knee effusion are widely described in scientific literature but increasingly more attention is being paid to muscle function: strength and stiffness. ACL trauma is often accompanied by a sensation of instability and pain during knee load. This is accompanied by joint effusion, which gradually limits the knee range of motion, exacerbates the pain and secondarily has an impact on muscle function. Functional shortening of the hamstrings can be a symptom of inappropriate control in the knee joint.

MATERIAL AND METHODS: The study was carried out in a group of 46 men aged 18–46 years old, with a mean age of 25 years old (SD = 6) with an ACL injury, which was stated after 5–52 weeks from the injury, a mean of 20 weeks (SD = 15). The functional length of the hamstring and rectus femoris muscle were measured both passively and actively by a Saunders inclinometer which allows measurement with precision up to 1°.

RESULTS: Statistical analysis revealed a statistically significant negative correlation between functional shortening of the hamstring and rectus femoris muscle in the healthy extremity, in active and passive tests.

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CONCLUSION: With the increase in functional shortening of the hamstring, functional shortening of the rectus femoris muscle is diminished, both in active and passive tests in the healthy and ACL injured extremity.

KEY WORDS

muscle stiffness, hamstrings, rectus femoris, ACL

STRESZCZENIE

WSTĘP: Więzadło krzyżowe przednie jest jedną z ważniejszych struktur stawu kolanowego. Zawiera mechanoreceptory, które dzięki wrażliwości na ruch umożliwiają odczuwanie pozycji stawowej oraz kinestezji. Uszkodzenie powoduje zmiany w funkcji kolana. W literaturze szeroko opisywane są pozycje dotyczące translacji oraz wysięku, ale coraz większą uwagę zwraca się na funkcję mięśni: siłę i sztywność. Urazowi towarzyszą uczucie niestabilności kolana i ból przy obciążeniu kończyny urazowej. Występuje również wysięk, który stopniowo ogranicza zakres ruchu w stawie, wzmaga dolegliwości bólowe oraz wtórnie może wpłynąć na funkcje mięśni. Skrócenie funkcjonalne mięśni kulszowo-goleniowych może być objawem nieprawidłowej kontroli w obrębie stawu kolanowego.
MATERIAŁ I METODY: Badania zostały przeprowadzone na grupie 46 mężczyzn w wieku 18–46 lat (średnia wieku 25 lat; SD 6), u których stwierdzono zerwanie więzadła krzyżowego przedniego (*anterior cruciate ligament* – ACL) po 5–52 tygodniach od urazu (średnia 20 tygodni; SD 15). Dokonano pomiaru długości czynnościowej mięśni kulszowo-goleniowych oraz prostego uda zarówno w sposób bierny, jak i czynny. W tym celu użyto inklinometru Saundersa, który pozwala dokonać pomiaru do 1°.
WYNIKI: Analiza statystyczna wykazała istotną statystycznie ujemną korelację między skróceniem funkcjonalnym mięśni kulszowo-goleniowych a prostym uda w kończynie zdrowej w badaniu czynnym oraz biernym.
WNIOSKI: Wraz ze wzrostem funkcjonalnego skrócenia mięśni kulszowo-goleniowych zmniejsza się skrócenie funkcjonalne mięśnia prostego uda zarówno w badaniu czynnym, jak i biernym w kończynie zdrowej. Wzrostowi skrócenia funkcjonalnego mięśni kulszowo-goleniowych towarzyszy spadek skrócenia mięśnia prostego uda w kończynie z zerwanym ACL zarówno w badaniu czynnym, jak i biernym.

SŁOWA KLUCZOWE

sztywność mięśniowa, kulszowo-goleniowe, prosty uda, ACL

INTRODUCTION

The anterior cruciate ligament (ACL) is one of the most important structures of the knee joint. It is inserted in the anterior intercondylar area between two menisci. It originates from the medial aspect of the lateral femoris condyle. It follows an oblique course and inserts in the anterior intercondylar area of the tibia. Its primal function apart from knee joint stabilization to cause a sliding movement between the knee articulation surfaces. The ACL contains mechanoreceptors that respond to mechanical pressure or distortion and enable one to feel the knee position and proprioception. This enables one to make feedback to the hamstring and rectus femoris muscle, which control knee position. The hamstrings are responsible for knee stabilization – strengthening of this group of muscles can result in a lower incidence of ACL injury. The hamstrings play an essential role in ACL protection as well as for the whole knee. It seems that increased hamstring stiffening prevents further knee damage and concomitantly the same findings appear in the healthy extremity as a stabilization compensation [1].

It is believed that the shortening of hamstrings is a symptom of inappropriate neuromuscular control of the knee joint, hence patients with a ligament insufficiency can compensate that inappropriate biomechanics of the joint with a functionally shortened hamstring. A similar observation was noted in a group of patients with impaired control of the sacroiliac joint, where also as above, functional stiffness of the hamstrings was increased [2]. ACL injury is one of the most common knee injuries occurring at a rate of 1:3500. It typically occurs during landing, stopping after running or changing direction of movement combined with internal rotating of the knee while the calf is stabilized [2].

This kind of trauma is often accompanied by a sensation of instability and pain during knee load. This is accompanied by joint effusion, which gradually limits the knee range of motion and exacerbates the pain. One of the symptoms of ACL injury is the ability to move the tibia in relation to the femur like a drawer. (the anterior drawer test). A completely torn ACL is accompanied by a typical crashing sound [3,4].

This study was carried out to discover whether after ACL injury functional shortening of the hamstring is correlated somehow with the functional length of the rectus femoris muscle both in the healthy and ACL injured extremity.

MATERIAL AND METHODS

The study was carried out in a group of 46 men aged 18–46 years old, with a mean of 25 years old (SD = 6) and an ACL injury, which was stated after 5–52 weeks from the injury, a mean of 20 weeks (SD = 15). The diagnosis was based on a physical examination and MRI scan. The inclusion criteria were: 1. ACL injury confirmed by medical examination and MRI scan. 2. Painless range of motion of knee above 90° and above 100° in the hip joint. 3. No joint effusion and patellar ballottement sign – negative. Meniscus injury tests – negative. 4. Patient's mobility did not require crutches.
During the examination the Saunders inclinometer was used, which allowed measurements to be made with precision up to 1° [6].
The information about the research group is presented in Table I.

Table I. Characteristics of study group
Tabela I. Charakterystyka grupy badanej

Variable	Age	Height [cm]	Body weight [kg]
Min	18	164	58
Max	46	189	111
Mean	25	178	79
SD	7	6	11

Firstly the functional length of the selected groups of muscles were measured both in an active (ballistic) and passive (classic) way. In the passive measurement, the movement was established by the researcher, whereas in the active (ballistic) way the movement was established by the patient himself, who was asked to make a move in the opposite direction to the analyzed muscle group i.e. for hamstring-knee extension. In both methods, the patient was asked to focus on his feelings during the examination. The examination was stopped when the patient reported a slight feeling of tissue resistance or a pulling sensation in the examined muscle group. During the measurements none of the patients reported knee joint pain. Every measurement was conducted twice and in the case of substantial differences in the results between the first and second attempt (> 5°) a third measurement was conducted and the most varying one was rejected.

Evaluation of Functional Shortening of selected groups of muscles

1. Hamstring muscles

The patient in the supine position with lower extremity in the triple-flexed position and stabilized pelvis. The hip on a tested side was in the 90° position. During the passive examination the "lacking-angle" test was performed, which was an angle included between the long axle of the thigh and the horizontal axle of the body [1]. In this test the investigator extended the limb passively until significant hard-elastic resistance appeared or the patient reported a feeling of discomfort in this area. In the active (ballistic) test, extension of the lower extremity was performed by the patient himself and the test was limited by the same terms as in the passive test for the final movement criteria. In both tests the inclinometer was applied each time to the tibia (zero was set in the vertical tibia position so the measured angle meant a difference to reach 0° in the knee joint). The described test is illustrated in Figure 1.

Fig. 1. Method for measuring shortening of hamstring muscles ("lacking-angle" test).
Ryc. 1. Metoda pomiaru skrócenia mięśni kulszowo-goleniowych (test dopełnienia kąta).

2. Rectus femoris muscle

The patient in the prone position with the untested lower extremity on the ground beside the medical couch perpendicular to the ground with knee slightly flexed and the whole foot placed on the ground. This secured the pelvis from anteversion during the examination [5]. The pelvis was additionally stabilized by the researcher. In the passive test the researcher flexed the limb passively until significant hard-elastic resistance appeared or the patient reported a feeling of discomfort in this area. In the active (ballistic) test the flexion of the lower extremity was performed by the patient himself and the test was limited by the same terms as in the passive test for the final movement criteria. In both tests the inclinometer was applied each time to the tibia distally to the tibia tuberosity (0 was set in the vertical tibia position so the measured angle meant a difference to reach 0° in the knee joint). The described test is illustrated in Figure 2.

Fig. 2. Method of testing shortening of rectus femoris muscle (prone knee bend test).
Ryc. 2. Metoda badania skrócenia mięśnia prostego uda (test Mackiewicza).

Statistical analysis

The values analyzed for the experimental data are expressed as mean ± SE, while for descriptive statistical analysis for the study group were expressed as mean ± SD. All the analyses were performed using Statistica 13.1 (Dell, US). Correlation analysis was performed using Pearson's or Spearman's correlation depending on the normal distribution of the variables at the 5% level ($P \leq 0.05$) of significance. The strength of correlation was assessed according to Mukaka (2012).

RESULTS

Descriptive statistics for the angle values in the tests for the rectus femoris muscle and hamstring, both for the active and passive tests, healthy and ACL injured extremities are listed in Table II.
Statistical analysis revealed a statistically significant negative correlation between functional shortening of the hamstring and rectus femoris muscle in the healthy extremity, in both active (r = -0.24) and passive (r = -0.38) tests.
The analysis also revealed a statistically significant negative correlation between functional shortening of the hamstring and rectus femoris muscle in the ACL injured extremity in both active (r = -0.31) and passive (r = -0.25) tests.

Table II. Angle values of tests for hamstrings and rectus femoris in healthy limb and limb with ACL injury – active and passive examination
Tabela II. Wartości kątowe testów dla mięśni kulszowo-goleniowych oraz prostych uda w kończynie zdrowej oraz chorej – badanie czynne i bierne

Test	Lacking-angle test (hamstring)				Prone knee bend test (rectus femoris)			
Extremity	healthy extremity		ACL injured extremity		healthy extremity		ACL injured extremity	
Type of examination	active	passive	active	passive	active	passive	active	passive
Min	0	0	0	0	85	60	83	85
Max	39	44	46	44	146	158	150	173
Mean	11	16	19	15	123	133	113	124
SD	13	12	12	13	12	20	15	19

CONCLUSIONS

1. With the increased functional shortening of the hamstring, shortening of the rectus femoris muscle is diminished, both in the active and passive tests in the healthy extremity.
2. With the increased functional shortening of the hamstring, shortening of the rectus femoris muscle is diminished, both in the active and passive tests in the ACL injured extremity.

DISCUSSION

A traumatically torn ACL is very common in sport active people. It seems like without appropriate rehabilitation aimed at restoring knee joint function, full recovery is impossible. Therefore great emphasis is placed on sensorimotor re-education by working on the lower extremity, especially with the knee. Regaining stabilization, control of position and appropriate knee feeling are the goals of the rehabilitation. The effect is achieved by systematic proprioception and sensorimotor training performed in both active and passive ways. SET (Sling-Exercise Therapy) based training performed in a closed kinematic chain activates deeper stabilization of the muscles which tends to decrease stiffness of the hamstrings [7,8,9,10].

The test results clearly indicate the negative correlation between functional shortening of the hamstring and the rectus femoris muscle in both in the healthy and ACL injured extremity [11,12,13,14].

Solomonow et al. [15] and Bencke et al. [16] in their studies made a supposition that the hamstrings are crucial for ACL protection – significantly increased stiffness of the hamstring can prevent ACL injury. The ACL takes significant part in movement of the tibia vs. the femur while the hamstrings are the effectors of that movement. The aim of this system is to protect the knee joint during in open-chain movement [15,16]. What is more, hamstring shortening is present in more than half of the human population, even though they have never experienced an ACL injury. It is explained by the fact that these muscles are biarticular and are stretched during hip flexion and knee extension. Nowadays due to the sedentary lifestyle the shortening is so common in the human population [15,16].

Author's contribution

Study design – W. Likus, M. Szlęzak
Data collection – K. Ficek
Data interpretation – K. Ficek
Statistical analysis – M. Wasilewska
Manuscript preparation – D. Czerwik, K. Baryluk
Literature research – M. Wasilewska

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