BALANCE ALTERATIONS BEFORE ACL SURGERY AND AFTER REHABILITATION

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SUMMARY

Knee anterior cruciate ligament (ACL) is one of the most often injured knee anatomical structures. There are few studies about balance after ACL rupture, but all results are controversial [1, 2, 3].

Our primary aim was to determine the static and dynamic balance changes before ACL surgery and after rehabilitation.

Goals of the study: 1) to investigate and to compare static balance before ACL surgery and after rehabilitation; 2) to investigate and to compare dynamic balance before ACL surgery and after rehabilitation.

Ten untrained males participated in this study after ACL rupture (mean ± SD, age 28.4 ± 8.1 years, height – 179.8 ± 8.5 cm, weight – 76.0 ± 14.0 kg). The study was performed in the Lithuanian Academy of Physical Education in the Sports and Movements Science Centre. All subjects where tested before ACL surgery and after 3 months of rehabilitation. Two weeks after the surgery the following rehabilitation was applied: physiotherapy, massage and physiotherapy in the water (3 times per week, 16 times in total). Following these procedures rehabilitation was continued with muscle strength training exercises in a gym.

Balance was measured when participant stood on a KISTLER balance platform with open eyes, looking directly into the selected point 2 m away at the eye level, hands on hips. Balance within 20 s while standing on one leg and balance within 15 s after one leg hop for both healthy and ACL ruptured legs were measured.

The results showed that standing on ACL ruptured leg before surgery and after rehabilitation the oscillations were not significantly different, but standing on the healthy leg after rehabilitation significantly improved. Test results after one leg hop on ACL ruptured leg showed that oscillations were significantly greater after rehabilitation.

Conclusions:

1. After rehabilitation one leg static balance improved only in non-injured leg.
2. After rehabilitation one leg dynamic balance decreased in injured leg, but increased in non-injured leg.

Keywords: anterior cruciate ligament, rehabilitation, static balance, dynamic balance.

INTRODUCTION

Knee anterior cruciate ligament (ACL) is one of the most often injured knee anatomical structures. After ACL rupture, decreased neuromuscular and sensorimotor system control as well as muscle activation and muscle strength affects body imbalance and increases variability of muscle torque [4, 5]. There is no close relationship between static and dynamic body balance. Ability to maintain good static body balance does not ensure the ability to maintain dynamic body balance. There are few studies about body balance alteration after ACL, but research results are controversial. Some authors [1, 3] have found that after ACL, body sway is higher on injured leg compared to non-injured leg. But the others [2] have found that ACL rupture does not affect the body balance.

Aim of the research was to determine static and dynamic balance changes before ACL surgery and after 3 months of rehabilitation.

METHODS

The study was accomplished in accordance with the principles of the Declaration of Helsinki, concerning the ethics of experimenting with humans. Participants' inclusion criteria were as follows: 1) discharge after isolate ACL reconstruction; 2) no greater then I° cartilage damage during the surgery observed; 3) the other knee joint was not damaged; 4) the participants were not older than 35 years; 5) the period after ACL rupture till surgery was not longer than three months. Participants' exclusion criteria were as follows: 1) history of knee injuries or surgery; 2) diagnosed osteoarthritis, posterior cruciate ligament rupture, lateral or collateral ligament rupture, III° medial collateral ligament rupture; 3) greater then I° cartilage damage during the surgery observed.

All participants arrived at the Lithuanian Academy of Physical Education and they were familiarized with the research protocol, aim and methods and they were asked to fill in a questionnaire. Ten untrained men (mean ± SD, age 28.4 ± 8.1 years, height – 179.8 ± 8.5 cm, weight – 76.0 ± 14.0 kg), after ACL rupture surgery took a part in this study. Participants' static and dynamic body balance were measured on Kistler Force Platform (Kistler Instrument Company, Amherst, NY), force plate data were sampled at 100 Hz. During the test, all participants were asked to stand with their arms lying on hips, feet close together, eyes open and looking straight ahead at a visual reference 2 meters away.

1. To asses static body balance, we used ***one leg stance test***. During the test, all participants were

asked to stand quietly on one (first on non-injured, then on injured) 90° degrees bent leg and hold that position for 20 seconds.

2. To asses dynamic body balance, we used ***single hop-test*** [6, 7]. During the test, all participants were asked to stand on one (first on non-injured, then on injured) 90° degrees bent leg. After signal, participant were asked to jump on one leg and after landing on the same leg to hold position for 15 seconds.

The patients performed 2 trials, the second trial was used for the calculation of the results. In order to minimize the possibility of confounding effect of fatigue, rest periods between trials and tests were 60 s, signal discretization – 10 ms. Registered parameters were the centre of pressure (COP) coordinate displacement X and Y directions, where:

- Ax – mediolateral (ML) COP excursion, mm.
- Ay – anteroposterior (AP)COP oscillations, mm.
- Sp – ML and AL COP sway velocity, mm/s.

Tests were carried out two times: 1) before ACL surgery and 2) three months after rehabilitation. Rehabilitation was held in Lithuanian University of Health Sciences Kaunas Clinics.

Rehabilitation (16 times, 3 times per week) programme started 2 weeks after ACL surgery and consisted of physiotherapy (in a gym and a pool), massage, functional electrical stimulation. Physiotherapy procedure took 45 minutes and consisted of muscle strengthening, body balance, coordination, and range of motion improving exercises. Functional electrical stimulation procedure lasted 30 minutes; there we applied "Neuro Trac, Sport XL" at the intensity of 20 Hz. To reduce pain and swelling, the patients were recommended to use ice packages on the knee. After 16 procedures, muscle strengthening treatment was continued in the gym.

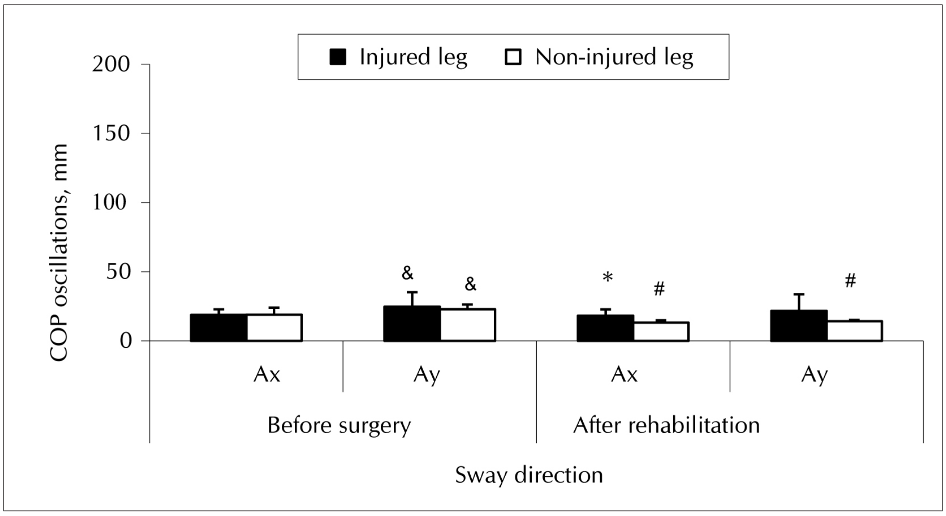
Mathematical statistics. The research data were processed employing Microsoft Excel 2007 software for mathematical statistical analysis. The data are reported as group mean values ± standard deviations (SD). Changes between the injury effect (injured and non-injured leg), time impact (before and after physiotherapy) were evaluated using Student's *t* test ($p < 0.05$ level of significance).

RESULTS

Balance during one leg stance

During one leg stance on *non-injured leg* (Figure 1) COP oscillation in Ax direction was greater ($p < 0.05$) before surgery (18.8 ± 5.04) than after rehabilitation (13.2 ± 1.73), and COP oscillation in Ay direction was greater ($p < 0.05$) before surgery (22.87 ± 3.47 mm) than after rehabilitation (24.69 ± 10.53 mm).

Before surgery, oscillation in Ay direction was greater ($p < 0.05$) than in Ax direction in non-injured and injured leg. However, we did not find any differences between oscillation in Ax and Ay directions after rehabilitation in both legs.



Note. * – p < 0.05 between injured and non-injured legs; # – p < 0.05 difference before surgery and after rehabilitation; & – p < 0.05 between Ax and Ay.

Figure 1. **COP sway oscillations in mediolateral (Ax) and anteroposterior (Ay) directions during one leg stance**

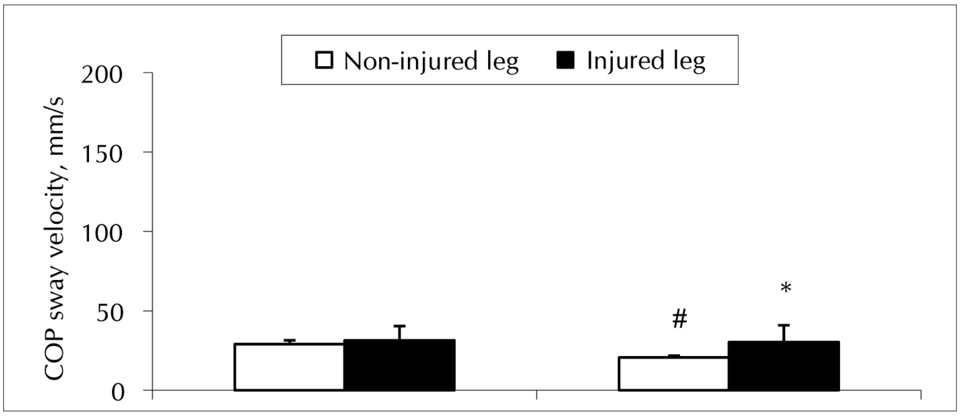
Comparing results between injured and non-injured leg, we found that after rehabilitation, COP oscillation in Ax direction was greater ($p < 0.05$) in injured leg (mm) than in non-injured leg (mm).

Non-injured leg *COP sway velocity* (Figure 2) was less ($p < 0.05$) after rehabilitation than before surgery. Comparing results between injured and non-injured leg, we found that after rehabilitation COP sway velocity was greater ($p < 0.05$) in injured leg (mm) than in non-injured leg (mm).

Balance after one leg hop test. During one leg hop test on *non-injured leg* (Figure 3), COP oscillation in Ax direction was greater ($p < 0.05$) before surgery (61.95 ± 15.53 mm) than after rehabilitation (40.5 ± 12.4 mm).

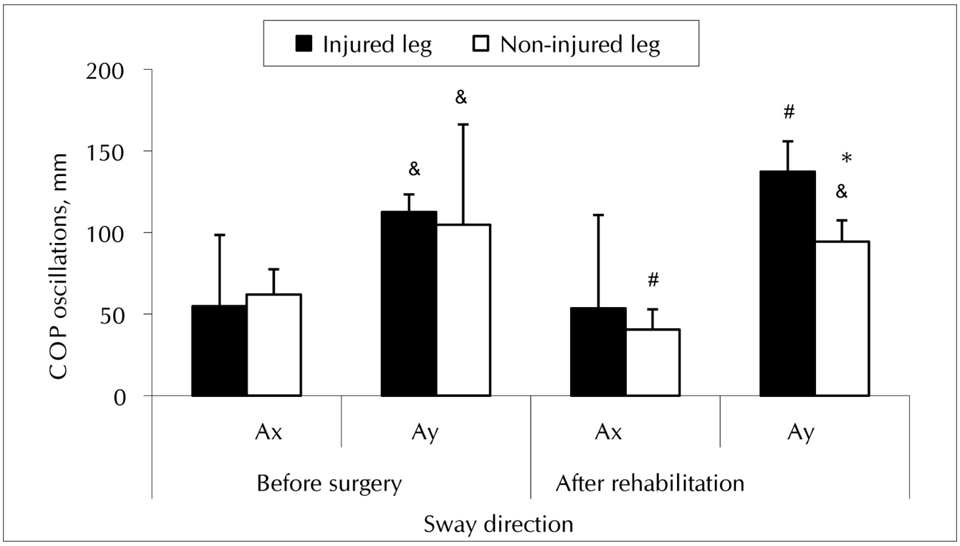
After one leg hop test on *injured leg* (Figure 3) COP oscillation in Ay direction was greater ($p < 0.05$) after rehabilitation (137.26 ± 18.62 mm) than before surgery (112.52 ± 10.79 mm).

Before surgery oscillation in Ay direction was greater ($p < 0.5$) than in Ax direction in non-injured and injured leg. After rehabilitation oscillation in Ay direction was greater ($p < 0.05$) than in Ax direction in non-injured leg.



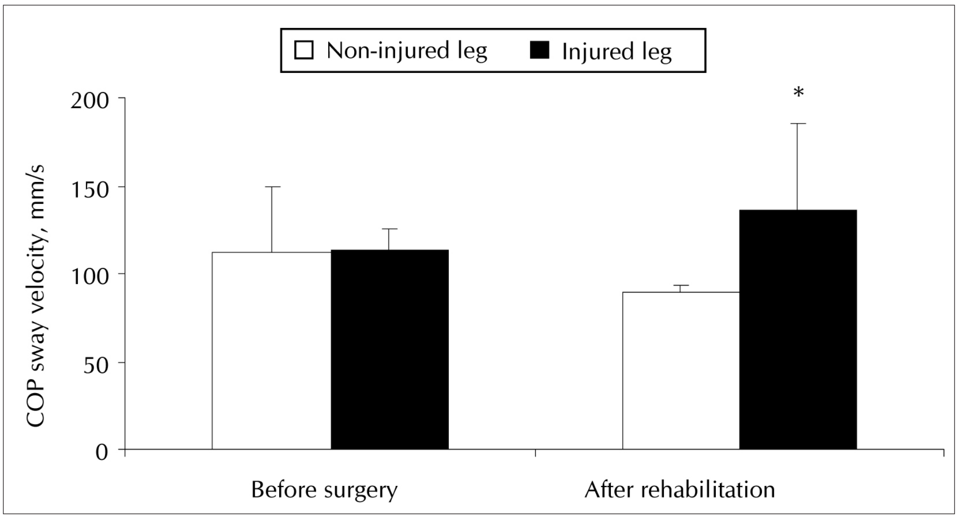
Note. * – p < 0.05 between injured and non-injured legs; # – p < 0.05 difference before surgery and after rehabilitation.

Figure 2. **COP sway velocity during one leg stance**



Note. * – p < 0.05 between injured and non-injured legs; # – p < 0.05 difference before surgery and after rehabilitation; & – p < 0.05 between Ax and Ay.

Figure 3. **COP sway oscillations in mediolateral (Ax) and anteroposterior (Ay) directions after one leg hop test**



Note. * – p < 0.05 between injured and non-injured leg.

Figure 4. **COP sway velocity after one leg hop test**

Comparing results between injured and non-injured leg, we found that after rehabilitation COP oscillation in Ay direction was greater ($p < 0.05$) in injured leg (137.26 ± 18.62 mm) than in non-injured leg (94.39 ± 13.04 mm).

After rehabilitation, COP sway velocity (Figure 4) was greater ($p < 0.05$) in injured leg (mm) than in non-injured leg (mm).

DISCUSION

We established that after rehabilitation static and dynamic body balance on non-injured leg improved and dynamic body balance decreased standing on injured leg.

Balance during one leg stance. After one leg stance test, we found, that body sway on non-injured leg improved and there were no statistically significant differences of body sway in injured leg. It is known that during the injury mechanoreceptors from skin, tendons, muscles and joints are disrupted, and this disturbs optimal afferent impulse emanation to CNS. After ACL surgery decreased body balance on injured leg may be influenced by disturbed afferent impulses to CNS [2]. During the surgery disrupted mechanoreceptors influences decreased body position comprehension and increased body sway on injured leg [8].

We established that ACL rupture did not influence COP sway on injured leg before surgery and after rehabilitation. Our results are similar to those of Harrison and co-authors' [2] research results. They established that there was no statistically significant difference between injured and non-injured leg during one leg stance test with open eyes. However, other authors' results are controversial, they established statistically significant difference between injured and non-injured leg during one leg stance test with open eyes [1]. Harrison with co-authors [2] states that one leg stance test with open eyes is not accurate to assay body balance after ACL rupture.

Balance after one leg hop test. We found that after one leg hop test COP sway was greater on injured leg compared to non-injured leg. After one leg hop test on injured leg COP sway in Ay direction and sway velocity were greater after rehabilitation then before surgery. After rehabilitation, COP sway in Ay direction was greater in injured leg compared to non-injured leg. We established that ACL rupture influenced greater COP sway in Ay than in Ax direction. One leg hop test is applied to assay knee function after ACL rupture, surgery and rehabilitation. It is well known that one leg hop requires higher knee muscle work compared to walking or running [7]. Shelbourne and co-authors [9] established that for 50% of patients with ACL rupture, one leg hop test result was statistically significantly different between injured and non–injured leg.

Noyes and co-authors [6] investigated 67 patients after ACL surgery. They established that one leg hop test results depended on quadriceps femoris muscle strength. During the dynamic movement, the main quadriceps femoris function is to stabilize knee joint. Lower function of this muscle influences decreased knee join function [10]. Dynamic body balance depends on femur and calf muscle function. If knee joint stabilizing muscles are week, and tarsus joint stabilizing muscles are strong, dynamic body balance is not impaired [11]. It was established that during the dynamic leg movements patients with ACL rupture try to stabilize knee joints involving dorsal flexion muscles [7]. We suppose that one leg hop test is not enough sensitive to assay body balance after ACL rupture. We think that one leg hop test might be used with other body balance test for accurate body balance assay after ACL rupture.

CONCLUSIONS

1. After rehabilitation one leg static balance improved only in non-injured leg.
2. After rehabilitation one leg dynamic balance decreased in injured leg, but balance increased in non-injured leg.

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PUSIAUSVYROS POKYČIAI PRIEŠ PRIEKINIO KRYŽMINIO RAIŠČIO OPERACIJĄ IR PO REABILITACIJOS

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SANTRAUKA

Kelio sąnario priekiniai kryžminiai raiščiai (PKR) – gana dažnai pažeidžiama kelio sąnario struktūra. Yra atlikta keletas pusiausvyros po PKR tyrimų, tačiau gauti rezultatai skiriasi [1, 2, 3].

Tyrimo tikslas – ištirti statinės ir dinaminės pusiausvyros pokyčius prieš PKR operaciją ir po reabilitacijos. Uždaviniai: 1) ištirti ir palyginti statinės pusiausvyros pokyčius prieš operaciją ir po reabilitacijos; 2) ištirti ir palyginti dinaminės pusiausvyros pokyčius prieš operaciją ir po reabilitacijos.

Buvo tiriama 10 fiziškai aktyvių netreniruotų vyrų, kuriems diagnozuotas kelio sąnario PKR plyšimas. Tiriamųjų amžiaus vidurkis – 30,1 ± 9,7 metų, svoris – 94,4 ± 11,8 kg, ūgis – 183,9 ± 8,8 cm. Tyrimas atliktas Lietuvos kūno kultūros akademijos Sporto judesių ir mokslo centre. Tiriamieji testuoti du kartus: prieš PKR rekonstruojamąją operaciją ir po 3 mėnesių reabilitacijos. Praėjus dviem savaitėms po operacijos, buvo pradėta reabilitacija, kurią sudarė: kineziterapija, fizioterapija, masažas, pratybos baseine (3 k./sav., iš viso 16 kartų.). Šešiolika kartų atlikus visas gydomąsias procedūras, reabilitacija toliau buvo tęsiama raumenų jėgos ugdymo pratimais treniruoklių salėje.

Pusiausvyra buvo matuojama, kai tiriamasis stovi ant KISTLER tenzoplatformos atsimerkęs, žiūri tiesiai į akių lygiu pažymėtą tašką, esantį už 2 m, rankos prie šonų. Buvo matuojama pusiausvyra stovint ant sveikos ir pažeistos kojos (20 s) ir pusiausvyros išlaikymas po šuolio ant sveikos ir pažeistos kojos (15 s).

Tiriamajam stovint ant pažeistos kojos prieš operaciją ir po reabilitacijos svyravimai statistiškai reikšmingai nesiskyrė, tačiau stovint ant sveikos kojos po reabilitacijos pusiausvyra statistiškai reikšmingai pagerėjo. Šuolio ant pažeistos kojos testo rezultatai parodė, kad po reabilitacijos svyruojama buvo labiau.

Išvados:

1. Po reabilitacijos sveikos kojos statinė pusiausvyra reikšmingai pagerėjo, tačiau pažeistos kojos nepakito.
2. Po reabilitacijos po šuolio ant pažeistos kojos buvo svyruojama labiau ($p < 0,05$) nei prieš operaciją.

Raktažodžiai: priekinis kryžminis raištis, reabilitacija, statinė pusiausvyra, dinaminė pusiausvyra.