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Quadriceps femoris strength and knee functions in soccer players after anterior cruciate ligament reconstruction: six month follow-up

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Research Report

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Purpose: The purpose of this study was to examine the relationship among isokinetic knee extensor strength in 60°/sec, hop and vertical jump strength tests, and to determine differences between the involved and uninvolved leg in soccer players after anterior cruciate ligament (ACL) reconstruction. **Materials and methods:** Thirty-seven soccer players (mean age: 25.16±6.5 years) who had undergone arthroscopic ACL reconstruction using bone-patellar tendon-bone at a 6 month follow-up participated into isokinetic measurement in 60°/sec (CYBEX 6000), hop and vertical jump (VJ) strength tests including involved and uninvolved leg. Mean time for testing was 26 weeks following surgery. **Results:** Uninvolved leg test results were better then involved leg results ($p<0.05$). Correlation coefficients between 60°/sec extensor peak torque (PT) and hop test results with involved and uninvolved legs were $r= .38$ ($p<0.05$), $r=0.60$ ($p<0.01$), respectively. Correlation coefficients between 60°/sec extensor PT and VJ test results with involved and uninvolved legs were $r=0.22$ ($p>0.05$), $r=0.15$ ($p>0.05$), respectively. The mean quadriceps muscle strength of the injured side was 75 % of that of the uninjured side. **Conclusion:** The results of this study suggested that knee extensor strength and hop tests of both sides were effective in the functional performance of the lower limb following ACL reconstruction. Knee functions tests were suggested as a reference guide for the outcome of rehabilitation program.

Key words: Anterior cruciate ligament, Muscle strength, Function.

Futbolcularda ön çapraz bağ tamirinden sonra Quadriceps femoris kuvveti ve diz fonksiyonları: altı aylık takip

Amaç: Bu çalışmanın amacı futbol oyuncularında ön çapraz bağ (ÖÇB) tamirini takiben 60°/sn hızda izokinetik diz ekstansör kuvveti, atlama ve dikey sıçrama kuvvet testleri arasındaki ilişkiyi değerlendirmek ve etkilenmiş ve etkilenmemiş bacakla arasındaki farklılığı belirlemekti. **Gereç ve yöntem:** Kemik-patellar-tendon-kemik kullanılarak artroskopik ÖÇB tamiri yapılan 37 futbolcu (ortalama yaş: 25.16±6.5 yıl) 6 aylık takipte etkilenmiş ve etkilenmemiş bacakla 60°/sn hızda izokinetik ölçüm (CYBEX 6000), atlama ve dikey sıçrama kuvvet testlerine katıldı. Ölçüm için ortalama zaman cerrahiyi takiben 26 haftaydı. **Sonuçlar:** Etkilenmemiş bacak sonuçları, etkilenmiş bacak sonuçlarından daha iyiydi ($p<0.05$). Etkilenmiş ve etkilenmemiş bacakların 60°/sn ekstansör zirve tork ve atlama testi sonuçları arasındaki ilişki sırası ile $r=0.38$ ($p<0.05$) ve $r=0.60$ ($p<0.01$) idi. Etkilenmiş ve etkilenmemiş bacakların 60°/sec ekstansör zirve tork ve dikey sıçrama testi sonuçları arasındaki ilişki sırası ile $r=0.22$ ($p>0.05$) ve $r=0.15$ ($p>0.05$) idi. Yaralanmış tarafın ortalama quadriceps kas kuvveti yaralanmamış tarafın % 75 idi. **Tartışma:** Çalışmanın sonucu her iki taraf diz ekstansör kuvvet ve atlama testlerinin ÖÇB cerrahisini takiben alt bacağın fonksiyonel performansını değerlendirebileceğini desteklemektedir. Diz fonksiyon testleri rehabilitasyon programının sonucunda bir referans olarak önerilebilir.

Anahtar kelimeler: Ön çapraz bağ, Kas kuvveti, Fonksiyon.

Anterior cruciate ligament (ACL) injuries are common especially in soccer players and result in mechanical and functional dysfunction. Athletes often find it difficult to return to the sport activities after ACL injury, and ACL reconstructive surgery is frequently indicated in soccer players.[1,2] Joint stability is the primary goal of the reconstructive surgery. It has been indicated that, after surgery, the ability to perform sport activities and balance may be decreased.[3] Evaluation of the knee stability, such as strength, laxity and range of motion, is very important following ACL reconstruction but more importantly, functional evaluations has been used as the primary tool to assess patient's functional strength, readiness to proceed to a higher functional level, and return to sports.[4,5] Isokinetic measurements and functional tests are often used to assess functional level following anterior cruciate ligament (ACL) reconstruction using the opposite leg as a control.[6]

Follow up studies in ACL reconstructed patients demonstrated that the level of functional outcome according to the self reports of the patients has a positive correlation with strength measurements.[7,8] Single leg hop test which involves balancing on one leg after landing from a maximal hop incorporates functionally relevant challenges. Although this test is common in the evaluation of patients after ACL reconstruction,[9] the use of vertical jump (VJ) test on one leg is less common.[6] The purposes of this study, therefore, were to examine the relationship among isokinetic knee extensor strength in 60°/sec, hop and VJ strength tests, and to determine differences between the involved and uninvolved leg in soccer players after ACL reconstruction.

MATERIAL AND METHODS

Thirty-seven male soccer players (age=25.05±7.3 years, height=178.59±7.68 cm, weight=73.18±10.68 kg) treated with arthroscopic ACL reconstruction using bone-patellar tendon-bone graft participated into isokinetic quadriceps strength measurement in 60°/sec, one-legged hop test and VJ test including involved and uninvolved leg. Mean time for testing was 26 weeks following surgery. The patients were selected if they met the following criteria: had only one surgery for a tear of the ACL that did not include a multiligament injury, no history of surgery or traumatic injury to the contralateral knee and ankle joint on the reconstructed side and hip joint, no history of a medical problem that limited activities within the 6 weeks before testing.

Isokinetic testing

Strength testing was performed for knee at 60°/sec on the Cybex 6000 isokinetic dynamometer (Cybex, Inc., Ronkonkoma, NY, USA) in the seated position. Subjects were seated on the dynamometer and stabilized with chest and leg hook and loop straps according to the manufacturer's guidelines[10]. The axis of rotation of the Cybex 6000 was adjusted so as to align with the margin of the knee. The distal pad of the dynamometer arm was placed proximal to the malleoli. Before testing, we asked to the patient to extend their leg and the weight of the leg was recorded and patients performed five practice repetitions at 75% of subjective maximal effort. After warm up phase, a 2-minute rest was given. The evaluation phase was consisted of five repetitions of maximal concentric and eccentric contractions for each leg. We asked patients "to push or pull as hard and fast as they can" against the resistance of the dynamometer. A 5-minute resting period was given to the patients before the opposite leg was tested. Peak torque values were used as the dependent measure of muscle strength.

Functional testing

1. One-legged hop test

One-legged hop for distance is a commonly used functional test after ACL reconstruction. It is very important in functional measurement of both strength and confidence of the tested leg. Test was performed three times with each leg. Patients were asked to hop as far as possible with a maximal effort from a predetermined line and to floor on the same leg. The best distance of the three repetitions was recorded in centimeters.[1]

2. Vertical jump test

Vertical jump test is not as common as one-legged hop test after ACL reconstruction, but it is well known and reliable test in the measurement of the function in knee problems.[11] Patients had to

Table 1. Analysis of the test results for involved and uninvolved leg.

	Involved leg (N=37) X±SD	Uninvolved leg (N=37) X±SD	
One-legged hop test (cm)	156±33.66	172.91±36.37	*
Vertical jump test (cm)	25.32±11.97	29.21±11.14	*
60°/sec extansor peak torque (Nm)	114.41±37.26	146.71±44.2	*

* p<0.05.

stand on one leg and perform VJs and were required to land on the same leg. A measuring tape was placed to the wall and three trials were performed. The highest value among three trials was recorded.[11]

Testing procedure

Prior to any testing, informed consent forms were signed by all patients. One-legged hop test and VJ test data for each patient were applied by the same physiotherapist. Functional tests and the isokinetic test were separated by at least 48 hours of rest.

Statistical analyses

Means±standard deviations, paired sample t test for the differences between involved and uninvolved leg and Pearson product moment correlations for delineation of isokinetic test, hop test and vertical jump test variable relationships were performed using SPSS version 11.5 software (SPSS Science, Chicago, IL). The level of significance was set at $p<0.05$ for statistical analysis.

RESULTS

Differences between involved and uninvolved leg test results were shown at Table 1. Uninvolved leg test results were better then involved leg results ($p<0.05$). Pearson product moment correlation coefficients between 60°/sec extensor peak torque and hop test results with involved and uninvolved legs were $r=0.38$ ($p<0.05$), $r=0.60$ ($p<0.01$), respectively. Pearson product moment correlation coefficients between 60°/sec extensor peak torque and VJ test results with involved and uninvolved legs were $r=0.22$ ($p>0.05$) and $r=0.15$ ($p>0.05$), respectively (Table 2). The mean quadriceps muscle strength of the injured side was 75 % of that of the uninjured side.

Table 2. Correlation between peak torque and One-legged hop and vertical jump tests.

	Peak torque Involved r	Uninvolved r
One-legged hop test (cm)		
Involved	0.38*	-
Uninvolved	-	0.60**
Vertical jump test (cm)		
Involved	0.22	-
Uninvolved	-	0.15

r: Pearson product moment correlation coefficient.
* : p<0.05, ** : p<0.01.

DISCUSSION

In this study, differences between the involved and uninvolved legs were determined and relationship among isokinetic knee extensor strength in 60°/sec, hop test and VJ test was examined in soccer players after ACL reconstruction.

In the literature, a limb symmetry index of less than 90% was considered inadequate for peak torque.[12] The limb symmetry index represents the involved leg's performance as a percentage of that of the uninvolved leg and 85% limb-symmetry index has been recommended as a standard for normal function.[4] In our study, the limb symmetry

index was 75% of that of the uninjured side. Shelbourne and Foulk reported in their study that 50% of the patients had achieved 80% quadriceps muscle strength at the speed 180°/sec, 4 months postoperatively.[13] Petschnig et al found 54.7% limb symmetry 13 weeks after ACL reconstructive surgery and 87.2% limb symmetry 54 weeks postoperatively at the speed 90°/sec.[6] The differences between two studies may be related to a faster velocity (180°/sec) used by Shelbourne and Foulk.

At the same time, moderately strong and statistically significant correlations were noted between the involved leg hop test and quadriceps muscle strength and uninvolved leg hop test and quadriceps muscle strength in our study. The ability to perform a single leg hop depends on the strength of the quadriceps muscle.

The VJ test was found to be a beneficial measurement to develop standards for the evaluation of lower extremity functional strength.[6] There was a significant correlation between uninvolved leg vertical jump test and peak torque but no significant correlation was not found between involved leg VJ test and peak torque performed at 60°/sec. Our findings did not support those of Petschnig et al, who found significant correlation between the height of the involved one-legged vertical jump and peak torque performed at a slow speed.[6] The differences may be related to the testing time postoperatively, differences in testing procedure and differences of patients' sports participation.

Knee extensor strength of both sides might be affected functional performance of the lower limb following ACL reconstruction. The function of standing, walking, and running are governed by the biomechanics of a closed kinetic chain, and isolated muscle testing does not give enough information about a patient's functional ability. Isokinetic strength testing alone may provide insufficient data for the assessment of athlete's functional level. Therefore, if functional tests are used to measure function of the player additional to the isokinetic strength test, a better presentation of the ability of a soccer player can be indicated. In this way, functional tests appear to be valuable as general assessments.[5,14] At the same time these tests can be a reference guide for the outcome of rehabilitation program. According to the results of this study we conclude, regardless of dominance, the uninvolved leg can serve as a control and can be used as an outcome measure from rehabilitation.

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