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Comparison of the postural control between football players following ACL reconstruction and healthy subjects

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Abstract

Background: Rupture of the Anterior Cruciate Ligment (ACL) is a common knee injury. The purpose of this study was to determine the balance control in football players with and without ACL reconstruction in posture of injury.

Methods: Sway of the center of gravity of 15 patients with ACL reconstruction was compared with 15 healthy, age and sex-matched subjects as the control group. All tests were done unilaterally in the posture of injury, using a kistler force plate with the open and -closed eye conditions.

Results: The knee of the operated side of the case group showed more displacement of the center of gravity when compared to the non-operated side in the same subject for all variables of the force plate. The operated side of the case group showed more displacement of the center of gravity for all variables of the force plate in comparison with the dominant side of knees in control group. There were significant differences between the non-operated side in the case group and the dominant side of the control group.

Conclusion: All together, postural control in the operated side of the case group was weaker than the non-operated side of the same group and the dominant limb of the control group, which might have resulted from poor proprioception. The postural control was even weaker in the non-operated side of the case group as compared with the dominant limb of the control group, which can justify the hypo mobility of limb for several months after the surgery.

Keywords: Anterior cruciate ligament, Postural control, Reconstruction.

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Introduction

Anterior Cruciate ligament (ACL) sprains are one of the most common knee injuries. In the United States, 100000 to 200000 of these injuries are reported annually which makes them the most common ligament injury in the country (1- 4). This number continues to rise in both the general population and athletes (4). Football players comprise the greatest number of ACL injuries (53% of the total) and skiers and gymnasts are also at a high risk (4). For the past twenty years, surgical techniques for Anterior Cruciate Ligament Reconstruction (ACLR) and post-operative rehabilitation have become highly developed, which enables the patients to resume sports activities at the pre-operative levels (5). However, a long time is still needed for full recovery and gaining the previous activity level (5, 6). The recovery period imposes mental, physical, and economic burdens on the pa-

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tient. Thus, injury prevention has received attention in the past years (7).

The risk factors for the ACL injury have been analyzed from the standpoints of the environmental, anatomical, hormonal, and biomechanical factors (7).

Previous studies indicate that gender and anatomical features such as the width of the intercondylar notch are related to the ACL injury. However, both the gender and anatomical features are non-modifiable risk factors (7).

Furthermore, according to video observational analysis studies, most of the ACL injuries are caused by a noncontact mechanism, suggesting that the dynamic knee valgus is one of the highest risk injury mechanisms (7). Other biomechanical studies also suggest knee valgus, slightly bent knee and internal or external rotation of the knee as a risk factor for anterior cruciate ligament injury (7, 8).

The ACL is a critical component of the knee joint. Although there is disagreement about the significance of its role, evidence suggests that ACL injury can lead to the impairment of the postural control during upright stance in both double- and single-leg stance positions and on either the injured or the uninjured leg (9). Moreover, these changes have also been observed in individuals with ACL reconstruction (10). One possible explanation is that with ACL injury, sensory stimuli from the injured leg that signal position and movement of this leg are decreased and as a result, a larger body sway is perceived. Thus, the ACL is more than a mechanical constrainer of the knee joint and can be defined as an important sensorimotor component for the postural control (9, 10).

The reconstruction surgery is typically recommended following ACL rupture to restore the mechanical stability for the knee and to subsequently resume the normal function, including sports participation (11). Previous researches have indeed shown excellent restoration of knee joint stability and function following ACL reconstruction surgery. However, there are controversial results regarding the restoration of sensory function following ACL reconstruction surgery. A growing body of literature supports the recovery of postural control following ACL reconstruction surgery. However, the extent to which postural control is restored and the mechanism of the restoration of the postural control following surgery are yet to be fully elucidated (11).

The purpose of this study was to determine the sway of the center for gravity in football players with and without ACL reconstruction seven months after the surgery.

Methods

This was a cross-section study in which the postural stability evaluated in 15 football players after a single ACLR (mean± S.D. age: 23.13±0.99 years; height: 176.88±1.82 cm; weight: 76.76±1.69 kg) and a control group consisting of 15 age- and activity-matched subjects (age: 23± 1.06 years; height: 175.4±2.32 cm; weight: 75.62± 2.1 kg). The sample size was determined based on the significance level, power, and magnitude of the difference(effect size) of previous studies (9, 10, 12 - 15) by G power software (16).

All recruited patients had undergone the same type of ACLR (arthroscopically-assisted central bone-patellar tendon–bone graft) and had returned to competitive activities (after an average time interval of 7 months ± 2 weeks). The study protocol was approved by the ethics committee of Tehran University of Medical Sciences. All subjects signed written informed consent to participate in this study.

The subjects were selected to participate based on the following inclusion criteria:

I. Only one surgical intervention for a torn ACL, with no concomitant tear of the posterior cruciate ligament or other ligaments of both knees.
II. Unilateral knee ACLR (right leg).
III. No evidence of collateral ligament repair at the time of surgery.
IV. No history of surgery or traumatic in-

jury to the contralateral knee.
V. No history of surgery or traumatic injury to the ankle or hip joints on the either side.
VI. No history of a medical problem that limited activities within the 6 weeks prior to testing.
VII. Full return to the previous competitive level.
VIII. No complaints concerning instability.
IX. All reconstructions done by the same surgeon after acute ACL injury.
X. Physical therapy intervention done completely (7 months).

Exclusion criteria were subjects with previous knee injuries on the target side, neurological disease, sprain of other knee ligaments, bilateral ACL sprains, instability or pain at rest in the knee, sprain of the non-dominant or the left dominant limb.

Test procedures

Subjects were asked to take part in a testing session. The test order for the postural stability and single-leg stance tests were randomized to avoid learning or fatigue effects.

All tests were done in unilateral standing on the bare foot on each side. Three trials were carried out with open and closed eyes. When the eyes were open, the subjects' glance aimed at a fixed point at a 1-m distance on the front wall. The test duration was 30 seconds while keeping the arms along the body. The 100Hz frequency was chosen to obtain a better detection of the movements on the center of pressure by kistler force platform. On unilateral standing, the stance foot was at the center of the zero reference of the platform and the testing leg had contact with the opposite leg. Static unilateral standing tests began with the non-ACLR side or ACLR side randomly. The knee was positioned in the 20 degree angle of flexion, valgus and internal rotation (posture of injury). One minute rest was provided between every test repetition. Three studied parameters were: mediolateral axis (distance X) and an anterior–posterior axis (distance Y) movement distance of the center of pressure and the velocity of center of pressure sway.

The data were collected over a five month period and analyzed using SPSS software version 17. Normal distribution was evaluated using Kolmogrov Smirnov test. Paired t-test was used for comparing the data of the right and the left lower limbs of the case group. The independent test-t was used to compare variables between the cases and the controls.

Result

The two groups were matched for age, height, and weight.

The operated side (OS) of the case group showed more displacement of the COG for all variables of the force plate as compared to the nonoperated side (NOS) (Table 1).

The OS of the case group presented more displacement of the COG for all variables of the force plate in comparison with the dominant limb of the control group (Table 2).

There was a significant difference between the NOS of the case group and the dominant side of the control group (Table 3).

Table 1. The COG displacement of the case group (operated and nonoperated side)

	Variables	Mean difference ± SD	95% confidence interval of the difference		p
			lower	upper	
Open eyes	Displacement around ant.-post. axis(cm)	6.63±1.05	4.37	8.88	0.001
	Displacement around med.-lat. axis(cm)	2.75±1.39	-0.25	5.75	0.001
	Total velocity(cm/sec)	0.82±0.27	0.24	1.38	0.009
Close eyes	Displacement around ant.-post. axis(cm)	6.44±1.17	3.93	8.95	0.001
	Displacement around med.-lat. axis(cm)	0.67±0.08	-1.14	2.49	0.04
	Total velocity(cm/sec)	0.61±0.25	0.07	1.15	0.03

Table 2. The COG displacement of the control group and case group (operated side)

	Variables	Mean difference ± SD	95% confidence interval of the difference		p
			lower	upper	
Open eyes	Displacement around ant.-post. axis(cm)	6.66±1.22	9.17	4.16	0.001
	Displacement around med.-lat. axis(cm)	5.38±1.16	7.76	2.98	0.001
	Total velocity(cm/sec)	1.72±0.26	2.27	1.16	0.001
Close eyes	Displacement around ant.-post. axis(cm)	7.06±1.18	9.47	4.63	0.001
	Displacement around med.-lat. axis(cm)	4.15±0.8	5.81	2.51	0.001
	Total velocity(cm/sec)	1.33±0.18	1.72	0.96	0.001

Table 3. The COG displacement in control and case group (nonoperated side)

	Variables	Mean difference ± SD	95% confidence interval of the difference		p
			lower	upper	
Open eyes	Displacement around ant.-post. axis(cm)	-0.03±0.84	-1.77	1.71	0.96
	Displacement around med.-lat. axis(cm)	-2.62±1.13	-4.94	-0.3	0.03
	Total velocity(cm/sec)	-0.9±0.12	-1.15	-0.63	0.001
Close eyes	Displacement around ant.-post. axis(cm)	-0.61±0.96	-2.58	1.35	0.53
	Displacement around med.-lat. axis(cm)	-3.49±0.97	-5.49	-1.47	0.001
	Total velocity(cm/sec)	-0.73±0.13	-1.01	-0.45	0.001

Discussion

The operated side of the case group versus the dominant side of the control group:

In our study, the OS of the case group was higher in all variables of the force plate (total velocity, displacement at the anterior-posterior axis and medial- lateral axis) in open- and closed-eyes conditions as compared to the dominant side of the control group. According to these results, one leg standing balance of the case group knees was significantly weaker than the dominant side of the control group.

Many studies suggest that the ACL receptors and the receptors in other knee structures have a fundamental role in maintaining the dynamic joint stability based on the existing neuronal reflex pathways between the knee and the thigh muscle systems (11). The ACL's proprioceptive neurophysiological function has been considered to be as important as its biomechanical role in maintaining joint stability(10). However, after ACLR, the ACL function of will not restore fully. One can infer that ACL reconstruction does not restore motor control deficits associated with the original injury (9, 17).

The non-operated leg of the case group versus the dominant leg of the control group: According to our findings, the NOS of the case group showed more displacement of the center of gravity and less stability when compared to the dominant side of the control group regarding total velocity, and medio- lateral displacement variables of the force plate in open- and closed-eyes conditions but it did not have significant different in terms of displacement at the anterior- posterior axis in open- and closed-eyes conditions. According to these results, one leg standing balance of NOS of the case group was more impaired when compared to the dominant side of the control group.

One speculative explanation for the aforementioned phenomena is that individuals with ACL injury may overload the contralateral (the uninjured ACL) leg. In such a case, the uninjured leg might be overstressed and fatigued leading to a decrease in performance compared to the control group (9). Another possible explanation might be reduction of neural signal transmission in the injured leg because of the ACL lesion; leading to malfunctioning of, the motor control system would have difficulties in controlling two limbs with different sensory input properties and, also to avoid such an asymmetric control, the performance of the uninjured leg (18).

Operated leg versus NOS of the case group: Based on our findings, the OS of the case group was higher when compared to

the declined NOS for all variables of the force plate in open- and closed eyed condition. According to these results, one-leg standing balance of the subject with ACLR knees was significantly impaired versus the non-operated side.

These results are not congruent with some of the previous investigations (15.17) probably due to: 1) Individuals with ACL injury have reduced sensory inputs for position sense and movement detection from the knee joint after reconstruction surgery and this reduction seems to contribute to the observed larger body sway (9). 2) The interval between the surgery and the date when the evaluation was performed and 3) different postures of evaluation.

For the first time, in these study confounding factors such as age, height, weight, surgeon, type of surgery, preoperative level of actuality, type of activity and gender which involved in the assessment of postural control were excluded from the study.

The limitations of this study: A) Lack of a sufficient number of female for comparing gender effects on postural control subjects after anterior cruciate ligament reconstruction surgery. B) Assessing of functional status has been more dynamic than static state. These can be examined in future studies.

Conclusion

Altogether, it can be concluded that the postural control in the operated limb of the case group was weaker than the non-operated limb of the same group and the dominant limb of the control group, due to the poor proprioception. The postural control ability of the non-operated limb of the case group was even weaker than the dominant limb of the control group, which can be related to months of the hypo mobility in limb after the surgery.

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Conflict of Interests

There is not any conflict of interest between the coauthors.

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