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Isokinetic Evaluation of Quadriceps Strength in Open and Closed Kinetic Chains in Patients with Anterior Cruciate Ligament Reconstruction

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Abstract

***Background*:** Strength of knee extension and squat were compared between anterior cruciate ligament reconstructed (ACLR) patients and healthy subjects.
***Materials and Methods*:** Twenty ACLR and twenty control subjects were participated in this non-exprimental study. Isokinetic peak strength of knee extension and squat in involved and uninvolved side of the ACLR patient and control group were measured.
***Results*:** Concentric and eccentric knee extension strength of the involved leg was decreased but squat strength showed no difference.
***Conclusion*:** In spite of return to sport activity and normal squat strength weakness of knee extensor muscles in the involved side of the ACLR patient was existed.

Introduction

Anterior cruciate ligament (ACL) rupture is one of the most common traumatic injuries in the young athletic population [1]. Anterior cruciate ligament reconstruction (ACLR) is one of the treatment procedures for these patients [2, 3]. After ACLR, one of the main objectives is to recover strength of the knee muscles in order to return the athletes to the pre-injury level of activation [4]. To determine the readiness of the ACLR patients to participate in their sport activities at the pre-injury level of activation, physical therapists should assess patients capabilities in tolerating physical demands [5]. Many researches and physical therapists use isokinetic dynamometry for assessing muscle strength which quantifies muscle deficits in a safe and controlled manner [5, 6]. Most isokinetic dynamometry assessments in ACLR patients were conducted on open kinetic chain, and there are few studies on closed kinetic chain in these patients [7, 8]. In order to find out any strength deficits in the involved side of the ACLR patients, the uninvolved side is used as a reference value. So, it is necessary to ensure that the surgery leg or the ACL rupture hasn't had an impact on the uninvolved side. For this purpose, the uninvolved side of the ACLR group was compared with control group. The purpose of this study was to compare the knee muscular strength of involved and uninvolved side, in open kinetic chain (OKC) and lower extremity extensor strength of closed kinetic chain (CKC) in ACLR patients and also compare these with the control subjects.

Materials and Methods

Forty athlete men aged 19 to 39 years (ACLR group, N=20; control group, N=20) participated in this non-exprimental study. All ACLR patients had undergone unilateral ACL reconstruction using the hamstring tendon auto-graft (semitendinosus and gracilis). Both groups were matched according to the age, weight and activity level. The ACLR group had no history of injuries in the contra-lateral knee. They were all 6 months after surgery. Each participant provided his informed consent be filling a form approved by the institutional ethics committee of Tehran University of Medical Sciences. All subjects were found free of pain and had full range of motion. Lachman test, anterior drawer sign and lateral pivot shift test were found negative. Knee muscle strength of OKC and lower extremity strength of CKC was measured.

OKC: Concentric and eccentric strength of the knee extensors and flexors were measured bilaterally using the Biodexmulti-joint system 3 isokinetic device (Biodex Medical Systems, Inc, Shirley, NY). The dynamometer was calibrated according to the manufacturer's protocol (Biodex Applications/operations, Biodex advantage software 4.0). Subjects were anchored to the chair at the chest, pelvis and thigh in a lying position. At this position, the dynamometer shaft was aligned with the assumed axis of rotation of the knee (lateral femoral condyle) and the shank was strapped to the dynamometer lever at the lower shank. Testing velocity was 60 °/sec and 180 °/sec and the range of motion was set to 90°-10° of knee flexion. A warm-up was provided before testing in order to familiarize the subjects with the general setup and the specific testing velocity.

CKC: All subjects were stand on the Isokinetic lift attachment. The lift handle of the accessory, which was designed for this purpose, was placed over the shoulders. This part included a T-shape rod with two horizontal bars covered by a soft material and completely fixed on thoracic by straps crossing it. Single legged squat range of motion at knee joint was sixty degree which was determined by a goniameter. The subject was instructed to perform single legged squat without flexing the trunk with 60 °/sec velocity (25.4 cm/s) vigorously. Three trials for each test were recorded.

Results

Analysis of variance and post hoc analysis demonstrated a significant difference in concentric and eccentric peak torque to body weight of the knee extensors at velocity 60 and 180 °/sec in OKC in involved and uninvolved sides with control group (Table 1, 2). Quadriceps muscle strengths were decreased in involved and uninvolved leg compare to control groups in both concentric and eccentric contraction ($p<0.05$). In CKC there were no significant differences in involved and uninvolved leg strength but significant differences was seen between involved leg with control group.

Table 1. One-way ANOVA between involved, uninvolved and control group's leg peak torque to body weight (Nm/kg) values in open and peak force to body weight (N/kg) closed kinetic chain (CKC)

Chain	Velocity°/sec	Variables	One-way ANOVA	*p*-Value
OKC	60	Concentric	Uninvolved	0.01
			Control	0.01
		Eccentric	Uninvolved	0.01
			Control	0.01
	180	Concentric	Uninvolved	0.01
			Control	0.01
		Eccentric	Uninvolved	0.01
			Control	0.01
CKC	60	Concentric	Uninvolved	0.37
			Control	0.01

Table 2. One-way ANOVA between uninvolved and control group's leg peak torque to body weight values at the open kinetic chain, and peak force to body weight closed kinetic chain (CKC)

Chain	Velocity°/sec	Variables	*p*-Value
OKC	60	Concentric	0.01
		Eccentric	0.05
	180	Concentric	0.12
		Eccentric	0.05
CKC	60	Concentric	0.03

Discussion

In OKC, the extensor strength of affected knee at two velocities of 60 and 180°/sec was lower than that of unaffected and control group. Also the extensor strength of unaffected knee (except concentric contraction at velocity 180°/sec) was lower than control group. Weakness of affected knee extensor torque may be related to weakness of quadriceps or increased in flexors co-contraction. Extensor torque system defect is one of the most common complications after ACL rupture, which is not eliminated even after surgery and rehabilitation program [9, 10]. This is to muscular atrophy or defect in afferent feedbacks from anterior cruciate ligament and gamma loop [11-14]. The strength deficits seen the knee extensors after ACLR when compared to control group are consistent with a persistent negative effect of ACLR on contralateral limb strength. The last may be attributed to motor activation cross-over inhibition, or insufficient reconditioning/de-conditioning [14].

Due to strength deficit of the unaffected knee, it could not be used as a reference to compare with the affected knee. Therefore, kinetic or electromyografic studies are suggested to compare both affected and contralateral ACLR limbs. In contrast to OKC, the CKC isokinetic dynamometer evaluation showed no differences between the involved and uninvolved side of the ACLR group during single leg squat. Single leg squat is a multi-joint exercise; therefore, movement at one joint will result in a motion at the other joints in the chain. In addition, CKC exercises gives opportunity to the weak link of the kinetic chain to be compensated by the stronger links of the chain, so the isolated specific deficits may be masked and undetectable. Salem et al. [15] reported reduced extensor effort at the knee and increased extensor effort at the hip in the involved side, which verifies a compensatory mechanism during squat in ACLR patients. The difference between the uninvolved side and the matched control subjects might suggest altered CNS programming of the ACLR patients [14].

The lack of difference between the involved and uninvolved side of ACLR patients could have two reasons. The ACLR patient's uninvolved side muscle strength has been changed or a compensatory mechanism has occurred on the involved side. Further investigations are needed to exactly identify the underlying mechanisms.

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Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

Conflict of Interest

The authors declare no conflict of interest.

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