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The Effects of Functional Knee Brace on Postural Control in Patients Who Underwent Anterior Cruciate Ligament Reconstruction

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Abstract

Background: The current study aimed to evaluate the postural control in patients underwent anterior cruciate ligament reconstruction pre and post wearing functional knee brace.
Methods: Eighteen athletes undergone unilateral anterior cruciate ligament reconstruction included in the study. They had unilateral anterior cruciate ligament reconstruction at least six months before session test. Postural control was assessed pre and post wearing custom-fit functional knee brace using a posturographic platform prokin 254. The balance tests included: 1) standing on prokin platform with eyes open/closed on anterior cruciate ligament reconstruction limb, 2) standing on prokin platform with eyes open/closed on both limbs. The standard deviation (SD) of body sway along the anteroposterior (AP) and mediolateral (ML) axis, mean velocity of center of pressure (COP) along AP/ ML axis and the area ellipse (measured in 2 mm) were calculated.
Results: Results of the paired T-test revealed a significant effect on selected postural control variables for the brace conditions especially in low challengeable conditions (double leg, eyes open test situations) ($P < 0.05$). But in high challengeable conditions this effect was not significant.
Conclusions: Functional knee brace improved postural control in the simple balancing task in the subjects with anterior cruciate ligament reconstruction. But this improvement in more difficult balancing task was limited.

Keywords: Knee Bracing, Anterior Cruciate Ligament, Reconstruction, Postural Balance

1. Background

Anterior cruciate ligament (ACL) sprain or tear is a common injury of knee ligaments (1). ACL injury often occurs during sports. Anterior cruciate ligament injury is common in high demand sports such as soccer, football and basketball (2). The primary role of ACL ligament is a mechanical restraint against anterior tibial translation (3). ACL deficiency reduces mechanical stability of knee (1). In addition to mechanical instability, ACL rupture inescapably displays reduced knee proprioception due to disruption of mechanoreceptors within the ligament (4). Disruption to both the sensory feedback and mechanical restraint role of the intact ACL following ACL rupture may result in impaired lower limb function and impaired postural control (5).

ACL-reconstruction can recover mechanical stability of knee but amendment of somatosensory function remains debatable (1). Literature suggests that in the first year after ACL-reconstruction, athletes may challenge with great risks of later injuries (3, 6).

Adding external stabilization of the knee by knee braces reduced likelihood of subsequent injury (7, 8). Although literature reported that compressive sleeves improve knee proprioception and single-limb standing balance in subjects with ACL-reconstruction, but research on the effects of knee brace on dynamic balance is limited (9, 10).

Although braces and sleeves may enhance proprioception acuity in non-weight bearing positions, generalization of this type of improvement to dynamic activities is questioned (11). Tasks that challenge the control of standing balance, by altering support surfaces and stance positions, are reported to provide predictable changes in performance and suggested to evaluate the postural control (5). Disturbance of dynamic postural control, between the two limbs of ACL-reconstructed group and between the ACL-reconstructed subjects and control group are reported (1, 5).

Assessing the postural control is frequently done by manipulation of size support area and perturbations of the base of support. Perturbation of supporting surface is a popular approach for the dynamic balance test. The dynamic postural tests showed considerably better accuracy than the static tests to predict injury during sport and functional activities (12). In the previous research less attention was paid to dynamic postural control tests and challenging tasks in the subjects who underwent ACL-reconstruction (5).

2. Objectives

The current study aimed to evaluate the effects a functional knee brace has on measures of dynamic postural control assessed using testing situations that including differing sensory inputs and limb support that challenged postural control to various degrees.

3. Methods

The participants of the study consisted of 18 athletes with a unilateral ACL injury who had ACL-reconstruction at least six months before testing, using semitendinosus-gracilis tendon graft. Non-probability sampling method was used to select subjects. Demographic characteristics of participants are shown in Table 1. The exclusion criteria for ACL-reconstructed subjects included any other orthopedic injuries (except meniscal injuries), neurological and strength deficits, range of motion restriction, pain and joint effusion at the time of testing (8-11). Subjects with ACL-reconstruction had been advised by their surgeons to resume previous physical activities. Participants had the Tegner score of 8.5.

Table 1. Demographic Characteristics of the Subjects With ACL-Reconstruction

Variables	Mean	Standard Deviation
Males/females	N: 16/2	-
Age, y	25.3	2.27
Height, cm	176	6.11
Weight, kg	70.5	4.32
Time after surgery (months)	7.1	0.9
Tegner activity level	8.5	0.5

Abbreviation: ACL, anterior cruciate ligament.

For dynamic balance measurement pre and post wearing custom-fit functional knee brace, subjects with ACL-reconstruction were tested using a posturographic platform Prokin 254 (Pro-Kin Software Stability, TecnoBody, Italy), according to standardized methods. During the balance test, the participants were instructed to stand still on a force plate on both limbs and ACL-reconstruction limb with eyes open or closed.

In both legs test, the standing position was determined with their feet positioned comfortably within an area defined by dimensions equal to their foot length, keeping arms comfortably at their sides during the stances and look forward. In ACL-reconstructed leg test, subjects stood on the center of force platform. Balance tests were performed for 30 seconds and the mean of three trials was calculated for statistical analysis. Both and single leg in open or closed eyes condition tests was randomized.

The study was approved by the Ahvaz Jundishapur University of Medical Sciences ethics committee for health sciences research involving human subjects (code number: Eth-290, date: June 18, 2011). All subjects signed written informed consent before testing.

The standard deviation (SD) of body sway along the anteroposterior (AP) and mediolateral (ML) axis, mean velocity of center of velocity (COP) along AP and ML axis and the area ellipse (measured in 2 mm) were calculated.

For statistical analysis, statistical package for the social sciences (SPSS) version 19 (SPSS Inc., Chicago, IL, United States) was used. The normality of the distribution of all variables was assessed by the Shapiro-Wilk test. Descriptive statistics of continuous variables were reported as mean $\pm$ SD. Pre and post-test comparisons for continuous data were assessed with paired T-test. A $P < 0.05$ was considered statistically significant.

4. Results

Means and standard deviation for postural control variables during the ACL-reconstructed leg and double leg tests pre and post wearing knee brace are illustrated in Tables 1 and 2. Results of Shapiro-Wilk test showed that all data had normal distribution. Results of the paired T-test revealed a significant effect on the selected postural control variables for the brace conditions especially in low challenging conditions (double leg, open eyes test situation). Mean velocity, standard deviation of sway amplitude and sway area of COP in the bracing conditions decreased significantly ($P < 0.05$). However, there was no significant effect on the selected postural control variables of the brace condition in high challenging condition (single leg, closed eyes test situation) ($P > 0.05$). Only the standard deviation of sway amplitude in anterior-posterior direction in bracing condition showed a significant decrease (P value: 0.02).

Table 2. Postural Control Variables Pre and Post Wearing Knee Brace in ACL-Reconstructed Leg Stance

Variables	Visual Condition	Pre-Test, Mean ± SD	Post-Test, Mean ± SD	P Value
SD sway amplitude, AP	Open eyes	5.22 ± 1.69	3.66 ± 0.76	0.02
	Closed eyes	10.22 ± 4.5	8.63 ± 0.98	0.27
SD sway amplitude, ML	Open eyes	4.76 ± 1.78	3.11 ± 0.75	0.14
	Closed eyes	8.55 ± 3.16	6.88 ± 2.19	0.33
Mean velocity AP	Open eyes	16.1 ± 5.58	13.83 ± 4.14	0.053
	Closed eyes	22.38 ± 3.89	20.83 ± 1.13	0.49
Mean velocity, ML	Open eyes	18.44 ± 6.95	13.77 ± 4.9	0.082
	Closed eyes	40.33 ± 17.19	28.53 ± 10.65	0.39
Ellipse area, mm^2	Open eyes	233.73 ± 60.4	184.10 ± 22.01	0.051
	Closed eyes	482.43 ± 167.12	340.67 ± 132.86	0.31

Abbreviations: ACL, anterior cruciate ligament; SD, standard deviation; AP, anteroposterior; ML, mediolateral.

Table 3. Postural Control Variables Pre and Post Wearing Knee Brace in Double Leg Stance

Variables	Visual Condition	Pre-Test, Mean ± SD	Post-Test, Mean ± SD	P Value
SD sway amplitude, AP	Open eyes	3.27 ± 0.57	2.43 ± 0.6	0.001
	Closed eyes	4.83 ± 1.04	3.55 ± 0.98	0.002
SD sway amplitude, ML	Open eyes	2.83 ± 0.6	2.22 ± 0.54	0.004
	Closed eyes	4.72 ± 1.31	2.55 ± 0.61	0.001
Mean velocity, AP	Open eyes	10.04 ± 4.1	6.66 ± 1.09	0.001
	Closed eyes	15.5 ± 3.89	12.8 ± 2.53	0.04
Mean velocity, ML	Open eyes	10.88 ± 6.22	7.38 ± 2.42	0.017
	Closed eyes	16.55 ± 5.64	11.09 ± 3.91	0.02
Ellipse area, mm^2	Open eyes	95.83 ± 19.1	52.31 ± 12.1	0.005
	Closed eyes	128.23 ± 38.4	106.1 ± 18.73	0.12

Abbreviations: SD, standard deviation; AP, anteroposterior; ML, mediolateral.

5. Discussion

An important finding of the study was the significant effects of functional knee brace on postural control in double leg stance in subjects with ACL-reconstruction, in contrast to the double-leg stance, single leg stance and closed eyes functional knee brace had no effect on the selected postural control parameter.

Patients with ACL deficit after ACL-reconstruction showed loss of proprioception acuity and there may be deficits in inter-joint coordination (13). Thus, disturbance in the dynamic stabilization of the knee joint with ACL-reconstructed is expected (5). Therefore, enhancement of stabilization of knee may restore proprioception acuity and balance control in subjects with ACL deficit (4, 7, 14). Biomechanical investigations showed that functional knee braces are able to restore knee stability. Giotis et al. (7) reported that braces decrease rotational knee instability under high-demand activities. Palm et al. (15) showed that elastic knee braces increase postural stability in patients with anterior cruciate ligament rupture but they reported no difference in the postural stability between uninjured and injured legs in the braced condition.

The brace affected amplitude of postural sway in the anteroposterior direction to control single leg standing balance, but had no significant effect in mediolateral postural sway. This finding was consistent with previous research. Birmingham et al. reported no effect of brace on mediolateral COP sway in subjects with ACL-reconstruction (9). Kuster et al. (10) found that wearing knee bandage had no significant effect on the one legged stance balance control mediolateral sway amplitude.

Although the brace improved balance control during the double leg standing balance, it did not affect the challenging balance conditions (single leg and closed eyes). A persistent increase of sway variables in difficult conditions indicated that subjects with ACL-reconstruction showed a significantly balancing deficit in ACL-reconstructed leg. Thus, the more challenging tests are recommended for balance control test in the subjects with ACL-reconstruction.

These findings were consistent with previous research by Birmingham that reported knee brace had no significant effect on balance control in challenging balance tasks (10). The more balance demanding tasks need considerable motor activity (16). Increased sensory motor activity demand in the more challenging balance tasks is not compensated with functional knee brace (9). Biomechanical studies reported that knee stability does not restore by wearing functional knee braces under high forces related to challenging activities (7). Beynnon et al. (17) showed that knee bracing was effective to reduce abnormal anteroposterior laxity in patients with chronic ACLtear in static conditions. However, they reported that braces were not effective in reducing the abnormal translations in dynamic conditions.

The current study had some limitations. First, postural situation tests consisted of nonfunctional tasks. Future researches are needed on the effect of knee bracing on postural stability in functional tasks. Second, all participants in the study were male; therefore results of present study can be generalized to male athletes. Moreover, further research should evaluate the long-term effects of knee brace on postural control.

5.1. Conclusion

ACL functional knee brace improves postural control in the simple balancing task in the subjects with ACL-reconstruction. But this improvement is limited in more difficult balancing tasks.

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