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Effect of Core Stability Training on Knee Proprioception after Anterior Cruciate Ligament Reconstruction

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Abstract

Background: Decreased core stability reduce activity participation of athlete. Deficits of core stability is neuromuscular risk factor for anterior cruciate ligament (ACL) injury.

Purpose: This study was conducted to study the effect of core stability training (CST) on knee proprioception and function after ACL reconstruction.

Methods: Thirty patients of both gender after ACL reconstruction. Their age ranged from 20-30 years. All patients were referred by the orthopedic surgeon who was responsible for diagnosis and surgery based on clinical and radiological examination. They were randomly assigned into 2 groups group A included 15 patients received standard ACL rehabilitation protocol and group B included 15 patients received CST in conjugation with standard ACL rehabilitation protocol. Three sessions per week for 8 weeks. The study was conducted in the duration from August 2016 till August 2017 at a private orthopedic and arthroscopic center.

Evaluation: The digital inclinometer has been used to assess knee proprioception (joint position sense) after ACL reconstruction.

Results: Showed that both standard ACL rehabilitation protocol (group A) and CST in conjugation with standard ACL rehabilitation protocol (group B) were effective in improving the knee proprioception.

Conclusion: There was no significant difference in knee proprioception between standard rehabilitation protocol with or without CST, however there was clinical difference and high percent of improvement in adding CST to standard rehabilitation protocol.

Key Words: *Core stability – ACL reconstruction – Rehabilitation – Proprioception.*

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Introduction

THE ACL rupture is one of the most common knee injuries in sports [1]. The majority of ACL injuries occur with a noncontact mechanism. The rate for that noncontact ACL injuries ranges from 70 to 84% of all ACL tears in both female and male athletes [2,3].

Conservative treatment provides inadequate results, as patients have to cope with instability problems as they return to sport or leisure activities, with increased risk of residual instability and chronic associated injuries [4]. Poor proprioception is one of the risk factors of ACL injury [5].

Core stability training affects and improves proprioception by involving the core body muscles and joints and putting ligaments under the stress. As all body segments are correlated through kinetic chain, muscles, and fascia, it seems that conducting core stability exercises affects lower limb joints proprioception like the knee [6].

Core stability training is used extensively in injury prevention and rehabilitation, it is also being used as a means to enhance sports performance [7,8,9]. Core stability exercise was effective in improving function post ACL reconstruction [10].

Subjects and Methods

The study design is randomized controlled trail which was conducted from August 2016 till august 2017. Patients undergoing ACL reconstruction bone-patella tendon-bone graft their age ranged from 20-30 years and both genders. The participants were selected from a private orthopedic and arthroscopic center. After inclusion in the study all patient were asked to sign an informed consent form.

Patients were excluded if they had congenital musculoskeletal deformity, rheumatic disease and any traumatic knee condition (ruptures to other knee ligaments, repairable meniscal tears).

All patient were randomly assigned using closed envelope method into 2 groups group (A) included 15 patients received standard ACL rehabilitation protocol and group (B) included 15 patients received CST in conjugation with standard ACL rehabilitation protocol.

Fig.(1): Knee Joint position sense assessment by a digital inclinometer.

Assessment procedure:

Knee proprioception assessment:

Joint position sense:

Proprioceptive acuity was assessed by active repositioning of the lower limb using a digital inclinometer to measure knee joint position sense (JPS) **[11]**.

The patient was instructed to sit with the hips and knees at 90 flexion and the digital inclinometer was attached to the lateral aspect of the leg (Fig. 1). The patient was blindfolded and tested in quiet surroundings. From this position the leg was passively extended to each of the target angles of 20, 30, 40, 50 and 60 of knee. The leg was held there for 5 seconds to allow the subject to memorize the position. Then, the leg was slowly returned to the start position. After the 5-s interval, patient was asked to actively reproduce the test angle, was told to hold it for about 2 seconds, this angle was recorded. Each patient performed three practice tests to become familiar with the test process before the actual test. Each patient proprioceptive acuity was recorded as the difference between the knee angles at the target and reproduced positions.

Treatment procedure:

Group A (control group): Fifteen patients received standard ACL rehabilitation protocol (appendix I) **[12-15]**. Exercises in this group included patellar mobilization, gait training active knee range of motion exercises, quadriceps isometrics, hamstring isometrics, straight leg raising exercises, wall slides, Step-ups in pain-free range, Incision mobilization, Prone hangs, wall squat, squat, step ups and downs, lungs and balance exercise. Exercise was done for 3 times a week for 8 weeks duration.

Group B (study group): Fifteen patients received CST (appendix II) **[15]** in conjugation with standard ACL rehabilitation protocol. CST was done for 3 times per week for 8 weeks duration. CST included abdominal bracing, straight leg raise, bridging, quadruped exercise, quadruped exercise on ball, Side plank and curl up. Abdominal bracing was performed in conjunction with each exercise.

Statistical Analysis:

Descriptive statistics were used to describe subject characteristics in form of mean±standard deviation of age, weight, height and body mass index (BMI) of both groups.

MANOVA test was used to test the mean difference within and between groups using SPSS for windows, version 22 (SPSS, Inc., Chicago, IL).

Results

General Characteristics:

The current study was conducted on 30 patients (11 females and 19 males) after ACL reconstruction. As indicated by the independent t test, there were no significant differences (p>0.05) in the mean values of age, body mass, and height between both tested groups (Table 1). Chi square revealed there was no significant differences between both groups in sex distribution (p>0.05).

Table (1): Physical characteristics of patients in both groups (A&B).

Items	Group A	Group B	Comparison
	Mean±SD	Mean±SD	p-value
Age (years)	23.46±2.74	23.6±2.82	0.897
Body mass (Kg)	70±8.12	71.13±6.70	0.68
Height (cm)	173±7.25	174.53±6.75	0.554
BMI (kg/m2)	23.29±1.48	23.24±1.58	0.922
	Group A	Group B	p-value
Female	5 (33.3%)	6 (40%)	0.705
Male	10 (66.7%)	9 (60%)	

*SD: Standard deviation. p : Probability.
S : Significance. NS: Non-significant.

Absolute angular error:

1- *Within groups analysis*:

As presented in Table (2) and illustrated in Fig. (2), within groups comparison the median score [Interquartile Range (IQR)] of absolute angular error in the "pre" and "post " treatment were 4.05 (2) and 2.9 (2.48) respectively in the group A. Wilcoxon Signed Rank tests revealed that there was a significant reduction in the absolute angular error in the "post treatment" (p=0.001 *). Meanwhile, the median score (IQR) of absolute angular error in the "pre" and "post" treatment were 3.8 (4) and 1.78 (3.2) respectively in the group B. Wilcoxon Signed Rank tests revealed that there was a significant reduction in the absolute angular error in the "post treatment" (p=0.001*).

2-*Between groups analysis:*

Considering the effect of the tested group (first independent variable on the absolute angular error, "Mann-Whitney tests" revealed there was no significant difference between the both groups pretest (p=0.787). In addition, "Mann-Whitney tests" revealed that there was no significant difference of the median values of the "post" treatment between both groups with (and$p$=0.407). In spite of there was no statistical significant difference between both groups, there was clinical difference and high percent of improvement in favour to group B.

Table (2): Absolute angular error pre and post-test at both groups.

Absolute angular error	Pre test	Post test	p-value
	Median (IQR)	Median (IQR)	
Group A	(2)	2.9 (2.48)	0.001 *
Group B	3.8 (4)	1.78 (3.2)	0.001 *
p- value	0.787	0.407	

*Significant level is set at alpha level <0.05.
p-value probability value.

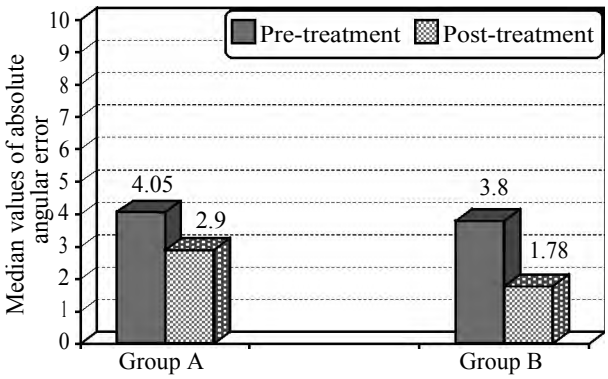

Fig. (2): Median values of absolute angular error between both groups at different measuring periods.

Discussion

Anterior cruciate ligament injury is one of the most common knee injuries in sport. This injury lead to impair function and loss proprioception [16]. Anterior cruciate ligament reconstruction is a common procedure to allow patients to return to their former active lifestyle [17]. Anterior cruciate ligament reconstructed knee had a lack of proprioceptive ability [17]. Deficits in core neuromuscular control is risk factor for ACL injury [18].

The goal for rehabilitation after ACL reconstruction is to restore the patients' dynamic knee stability and to enable them to return to their desired activity levels [19,20]. Core stability training should be considered as a part of rehabilitation protocol after ACL reconstruction [21].

The current study investigate the effect of postoperative CST on knee proprioception after ACL reconstruction.

The current study showed a significant (p<0.05) improvement in knee proprioception in both groups. These results confirmed the effective role of standard rehabilitation protocol with or without CST on knee proprioception after ACL reconstruction.

So the current study agreed with Vathrakokilis et al., [16] found eight weeks a standard rehabilitation protocol of strengthening and range-of-motion exercises improve proprioception which evaluated with the Biodex stability system. The results of the current study agree with this study due to similarity of training protocol (strengthening and range-of-motion exercises) and duration of training (8 week).

This agreement is due to the ACL not only serves a mechanical role by limiting passive knee mobility but also serves sensory role through the mechanoreceptors deep in its tissue, which communicate with the neuromuscular system to provide proprioceptive feedback, so after ACL reconstruction patients had a lack of proprioceptive ability and need training focusing on improving knee proprioception and function [16].

But the current study found that there was no significant difference in knee proprioception between standard rehabilitation protocol with or without CST, however there was clinical difference and high percent of improvement in adding CST to standard rehabilitation protocol.

Till the author is knowledge there no studies explained the effect of CST on proprioception after

ACL reconstruction but only on the healthy population, so compare the result of the current study to the following

The current study disagreed with Asadi et al., **[6]** found significant differences in proprioception after 6 weeks CST. These results confirmed the effective role of CST in proprioception improvement on 30 non athlete male students (15 men for exercising core stability, and the other 15 as control group) and assessment proprioception (joint position sense) by digital goniometer. This disagreement due to the current study on patient after ACL reconstruction who had a lack of proprioceptive ability, so improve proprioception not as a healthy subject.

As noted in the current study, adding CST to standard rehabilitation protocol showed a favorable clinical result over standard rehabilitation protocol post ACL reconstruction in terms of proprioception.

Conclusion:

Based on the findings of the present study the following can be concluded:

- Both standard ACL rehabilitation protocol and CST in conjugation with standard ACL rehabilitation protocol are effective treatment for improve knee proprioception after ACL reconstruction.
- There was no significant difference in knee proprioception between standard rehabilitation protocol with or without CST, however there was clinical difference and high percent of improvement in adding CST to standard rehabilitation protocol.

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Appendix

Appendix I

Post-operative Rehabilitation Program Phases

Immediate Postoperative Phase (Week 1):

Criteria to start next phase:

1- Knee active/passive ROM 0° to 90°.

2- Active quadriceps contraction with superior patellar glide.

3- Walk without crutch.

Treatment:

- Patellar mobilization; in all direction
- Control of pain and inflammation: ice pack application 10 minute pre and post session.
- Gait training; Improve gait pattern. If pain is tolerated, aim at walking without crutches from day 4. Sufficient neuromuscular control and a non-limping gait pattern are criteria for walking without crutches.
- Neuromuscular electrical stimulation (NMES); was applied with the patient in a seated position and the knee in 60° of flexion (varying angles are used based on pain and comorbidities). The patient relaxes while electrical stimulation was applied.
- Supine wall slides (Fig. 1): Patient was asked to slide foot on the wall (10 repetitions).

Fig. (1): Supine wall slides.

- Quadriceps set (Fig. 2): Patient supine lying position with below under knee, was asked to contract quadriceps with pull patella up (10 repetitions).

Fig. (2): Quadriceps set.

- Straight leg raise: Patient supine lying position with one knee flexed and other extended, was asked to raise lower limb upward with knee extended and foot dorsiflexion (Fig. 3b) (10 repetitions).

Fig. (3): Straight leg raise.

- Home exercise program: Supine wall slides, self-patellar mobilizations 3x10 repetitions (3 times per day), quadriceps set and straight leg raise 3x10 repetitions (3 times per day).

Early Postoperative Phase (Week 2):

Criteria to start next phase:

1- Knee flexion greater than 110°.

2- Walking with full knee extension

3- Reciprocal stair climbing

4- Straight leg raise without a knee extension lag.

Treatment:

- Quadriceps set (3x10 repetitions) and gluteal sets (3x0 repetitions).
- Straight leg raise: (3x10 repetitions).

- Incision mobilization as needed (if skin is healed).
- Hip abduction from side lying (3x10 repetitions).
- Wall squats (Fig. 4): The patient begins, back against the wall and legs shoulder-width apart, by lowering down into a squat position of up to 90° of knee flexion, as pain and strength allow. The exercise is progressed by adding a hold time in the squat position and progressing to 90° of knee flexion if not achieved initially.

Fig. (4): Wall squats.

- Prone hangs if lacking full extension begin without weight for 10 minutes and progress to increased weight (1kg) around the ankle for 10 minutes (Fig. 5).

Fig. (5): Wall squat and b. prone hangs.

Intermediate Postoperative Phase (Weeks 3-5):

Criteria to start next phase:

Knee flexion ROM to within 10° of uninvolved side.

Treatment:

- Quadriceps set (3x10 repetitions) and gluteal sets (3x10 repetitions).
- Straight leg raise: (3x10 repetitions).
- Hip abduction from side lying (3x10 repetitions).
- Tibiofemoral mobilizations with rotation for ROM if joint mobility is limited: Patient side-lying position with flexed knee, one hand on femur and other on upper medial aspect of knee and pull forward with rotation.
- Begin balance and proprioceptive activities (Fig. 6): Progressing from weight shifting during bi-lateral stance progressing to unilateral stance exercises on stable and unstable surfaces, with eyes open and eyes closed.

Fig. (6): Standing on unstable surface.

Late Postoperative Phase (Weeks 6-8):

Criteria to start next phase:

1- Normal gait pattern.

2- Full knee ROM (compared to uninvolved side).

3- Knee effusion of trace or less.

Treatment:

- Progress exercises in intensity and duration.
- Squat (Fig. 7A) and single limb squat (Fig. 7B).

Fig. (7): A- Squat and B- Single leg squat.

• Step ups and step downs (Fig. 8).

Fig. (8): Step ups.

• Lungs (Fig. 9).

Fig. (9): Lungs.

• Progress balance and proprioceptive activities (Fig. 10): Progressing from bilateral stance to unilateral stance exercises on different unstable surfaces with eyes open and eyes closed.

Fig. (10): Standing on rocker board with weight shift.

Appendix II

Core Stability Training

Week 1:

• Abdominal bracing (Fig. 11) which activates many muscles including the transversus abdominis, external obliques, and internal obliques.

Fig. (11): Abdominal bracing.

Patient was asked to contract abdominal muscles and hold for (8 seconds, 10 repetition).

• Bracing with heel slide (Fig. 12) (10 repetitions with 8 seconds hold).

Fig. (12): Bracing with heel slide.

• Bracing with stand (Fig. 13) (10 repetitions with 8seconds hold).

Fig. (13): Bracing with stand.

Week 2:

- Bracing with heel slide (20 repetitions with 8seconds hold).
- Bracing with stand (20 repetitions with 8seconds hold).
- Bracing with walking

Week 3 and 4:

- Bracing with straight leg raising (Fig. 14) (20 repetitions with 4 second hold).
- Bracing with bridging (Fig. 15).

Patient was asked to contract abdominal muscles with raise pelvis upward and hold for (8 seconds, 20 repetition).

Fig. (14): Bracing with straight leg raising.

Fig. (15): Bracing with bridging.

Week 5 and 6:

- Quadruped with bracing (Fig. 16): The patient was in a 4-point stance with knees and hands on the plinth (hips flexed to 90° and hands beneath shoulder joint) with bracing (20 repetitions with 4 seconds hold).
- Quadruped arm lifts with bracing (Fig. 17): The patient was in a 4-point stance with knees and hands on the plinth (hips flexed to 90° and hands beneath shoulder joint) with bracing (20 repetitions with 4 seconds hold).
- Quadruped leg lifts with bracing (Fig. 18): The patient in quadruped with bracing, was asked to raise leg upward (20 repetitions with 4 second hold).
- Quadruped alternate arm and legs lifts with bracing: The patient in quadruped with bracing, was asked to flexed the arm and extended the contralateral hip until both upper- and lower-body segments were parallel to the trunk, held for the 4 second contraction, Then alternate limbs (20 repetition).

Fig. (16): Quadruped with bracing.

Fig. (17): Quadruped arm lifts with bracing.

Fig. (18): Quadruped leg lifts with bracing.

Week 7 and 8:

• Quadruped exercise on Swiss ball (Fig. 19): The patient in quadruped on Swiss ball with arm lifts, quadruped on Swiss ball with leg lifts and quadruped on Swiss ball with alternate arm and legs lifts with bracing (each exercise 20 repetition with 8 seconds hold).

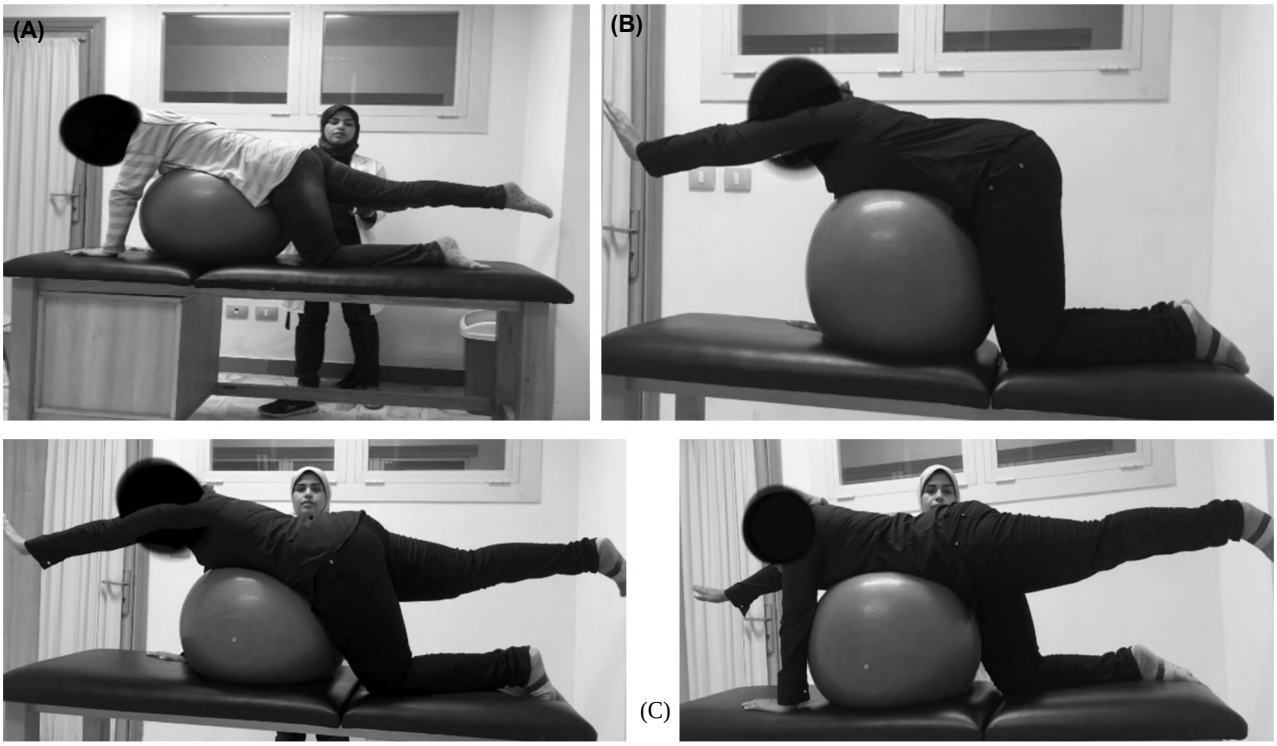

Fig. (19): Quadruped exercise on Swiss ball A- With leg lift, B- With arm lift and C. With alternate arm and leg lift.

• Side plank with knee flexed (Fig. 20): The patient was asked to lie on side and Place forearm on plinth under shoulder perpendicular to body and knee flex, the patient was asked to Raise body upward by straightening waist and hold 4 second, 20 repetition.

Fig. (20): Side plank with knee flexed.

• Curl up with bracing (Fig. 21): The patient was supine and is asked to flex the knees to 90°. The patient was instructed to reach up with the fingertips of both hands to touch (not hold) both knees and hold the position for 4 seconds, 20 repetition.

Fig. (21): Curl up with bracing.

تاثير تدريب الثبات الجذعى على الاستقبال الحسى العميق للركبه بعد اعاده بناء الرباط الصليبى الامامى

اجريت هذه الدراسه على ثلاثين مريضا بعد اعاده بنا الرباط الصليبى الامامى للركبه وكان متوسط العمر من عشرين الى ثلاثين عاماً تم تقسيمهم الى مجموعتين متساويتين المجموعه الاولى (أ) والمجموعه الثانيه (ب).

المجموعه الاولى:

تتكون من خمسه عشر مريضا تلقوا اعاده تاهيل بعد اعاده بناء الرباط الصليبى الامامى للركبه.

المجموعه الثانيه:

تتكون من خمسه عشر مريضا تلقوا اعاده تاهيل بعد اعاده بناء الرباط الصليبى الامامى للركبه مع تدريب الثبات الجذعى.

طريقة القياس:

تم تقيم الاستقبال الحسى العميق للركبه عن طريق استخدام جهاز الميل الرقمى.

اظهرت النتائج وجود تحسن فى المجموعتينالاولى والثانيه.

الاستنتاج:

- كلا من العلاج بتطبيق اعاده تاهيل بعد اعاده بناء الرباط الصليبى الامامى للركبه واعاده تاهيل بعد اعاده بناء الرباط الصليبىالامامى للركبه مع تدريب الثبات الجذعى يعطى نتائج كبيرة.
- لا يوجد فرق فى التحسن بين تطبيق اعاده تاهيل بعد اعاده بناء الرباط الصليبى الامامى للركبه واعاده تاهيل بعداعاده بناءالرباط الصليبى الامامى للركبه مع تدريب الثبات الجذعى.