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Effectiveness of Proprioceptive Training in Grade-II Acute Anterior Cruciate Ligament Injury in Athletes

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Abstract

Objectives: To design rehabilitation program that can improve proprioception in patient with grade-II anterior cruciate ligament (ACL) injury. Methods: 30 subjects fulfilling the inclusion criteria were recruited. Subjects were randomly distributed into standard non-operative ACL injury rehabilitation group (control group, n = 15) and proprioceptive training group (experimental group, n = 15). Standing balance was assessed by single leg stance and time HOP test. Control group subjects were given knee rehabilitation program like strengthening exercise, flexibility exercise while experimental group were given knee rehabilitation along with proprioception training on wobble board. Subjects completed 12 training sessions, each approximately 30 minutes for the duration of three weeks (4 sessions a week). Results: The results show that the experimental group significantly improved with ($P < 0.05$) than control group. Conclusions: The study shows that impaired proprioceptive are improved by giving training on wobble board in grade-II ACL injury in athletes.

Keywords: Acute Anterior Cruciate Ligament, Proprioception, Single Leg Stance Test, Time HOP Test

1. Introduction

Acute anterior cruciate ligament (ACL) injury is a common knee injury in sports and most commonly injured ligament in the general population too[1]. Over 70% of all, grade-II ACL injury occurs in recreational and competitive sports activities. ACL injury is a devastating injury that can significantly affect a patient's activity level and quality of life[2]. After ACL injuries, 31% patients reported moderate disability level in walking activities alone, 44% patients in routine activities of daily living and 77% patients in sports activities[3]. Acute conditions are the conditions that are present in a patient for 7–10 days[4]. A grade-II ACL injury results in partial micro tears with some haemorrhage. But there is no increased laxity and there exists a firm end point[5].

Since grade-II ACL injuries lead to long absence from sports and are one of the main causes of permanent sports disability, it is essential to rehabilitate the athlete effectively as early as possible. Grade-II ACL injury might disturb the sensory system i.e. defective proprioception or position sense. Non-operative treatment for grade-II ACL injury usually consists of rehabilitation that emphasizes joint mobility, increasing thigh muscle force production, endurance, agility training, and functional activity modification with protective bracing[6]. The success of rehabilitation programs depend on the subjects participating in high level activity such as sports activities that require jumping and pivoting manoeuvres of lower extremity should improve if treatment techniques that induce appropriate compensatory alterations in muscle activity are incorporated into treatment programs[7].

Every new activity introduced must be carefully monitored by the athletic trainer to determine athlete's performance and physical tolerance. If an activity does not produce additional pain or swelling, the level should be advanced; new activities should be introduced as quickly as possible[8].

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Impaired joint, "position sense" is overlooked in many rehabilitation programs and a major risk factor for recurrent injuries after the integrity of the muscles and ligaments has been restored .The terms "proprioceptive deficit", "proprioceptive training" and "proprioceptive rehabilitation" are being used increasingly in sports medicine. Proprioceptive training and rehabilitation attempt to maximize protection from injury and provide optimal functional restoration[9]. The perturbation training improved muscular reaction time. The proprioceptive program utilized balance, dynamic joint stability and perturbation training[2].

The objective of proprioceptive training is to improve the nervous system's ability to generate fast and optimal muscle firing pattern, increase dynamic joint stability, decrease joint forces, and return movement patterns and skill. Neuromuscular control can improve knee joint stability by enhancing unconscious motion responses by stimulating both afferent signals and control nervous system that are responsible for maintaining dynamic joint stability[10].

In perturbation training, multi-directional altered forces and torques are applied to the lower extremity in a controlled manner. Due to these techniques compensatory muscle activation patterns might be induced in patients with ACL deficiencies which could increase knee stability, this enhances the likelihood of returning patients to high level physical activity[11]. The proprioceptive and balance exercise improve outcomes in individual with grade-II ACL injured knee. Improvements in joint position sense, muscle strength, perceived knee joint function and hop test were reported to improve following balance exercises[12]. Hence, the aim of our study is to standardize an effective treatment regimen for grade-II ACL injured athletes.

2. Method

2.1 Study Settings and Population

This study was conducted at Young Men Christian Association (YMCA), Chennai and Pachaiyappa Arts and Science College, Chennai. The subjects for this study consist of 30 patients: 20 males and 10 females who were diagnosed to have acute grade-II ACL injury were randomly allocated into two groups.

2.2 Inclusion Criteria

Male and female athletes with grade-II ACL injury after confirmation using Lachman's test[13] hockey, football and basketball players[1]; age between 17–35 years[14] ; MRI scan showing grade-II injury and no other associated ligament or meniscus injury[1, 12, 13].

2.3 Exclusion Criteria

Athletes with grade-I or III ACL injury[5, 8], fracture of lower limb, upper limb and spine, post surgical intervention or associated other ligaments or meniscus injury, inability to weight bear, dermatological infection or open wound in lower limb, restricted joint range of motion [8, 12], neurological pathology[15], vestibular and visual disturbances[8, 12, 15].

2.4 Tools

Single leg stance test[16] and time HOP test[17].

2.5 Procedure

The study was approved by Meenakshi College of Physiotherapy, Chennai review board and complies with the principle laid down in the declaration of Helsinki in 2005. A written informed consent was received from thirty athletes suffering from grade-II ACL injury.

The study was performed using non-probability sampling technique by assigning fifteen athletes in control group and experimental group respectively. The control group received standard ACL injury rehabilitation program and the experimental group received standard rehabilitation program augmented with a perturbation training program on wobble boards.

The subjects completed 12 training sessions each approximately 30 minutes for 3 weeks (4 sessions a week). For both groups, pre-test and post-test measurements were assessed using single leg stance test and time HOP test.

2.6 Standard Non-operative Rehabilitation Program

The standard rehabilitation program consisted of resistive exercises for the quadriceps femoris and hamstring muscle groups, cardiovascular endurance training, agility skill training and sports specific skill training[18].

The resistive exercises include leg extensions, leg curls and leg press progressive resistance exercises. 1-repetition maximum (1RM) was established at the beginning of the resistance exercise. The patient was asked to perform 2 sets of 10 repetitions at 50% of 1RM, 2 sets of 8 repetitions at 75% of 1RM and 2 sets of 5 repetitions with maximum effort[19]. The concentric portion of the exercise was hold for 1 to 2 seconds, while the eccentric portion of the lift was hold for 2 to 4 seconds, with a recovery period of 60 to 90 seconds between sets[8].

These guidelines were used for all three resistive exercises. The leg extension exercise was performed through a joint excursion from 90 to 45 degree of flexion to minimize anterior tibial shearing during the exercise[1].

Cardiovascular training techniques were selected based on each subject's sports activities. A graded running program was used for subjects involved in running sports. The running program began with treadmill running and progressed to level surface running and finally to figure of eight running[12].

Running activities were progressed based on subjects' tolerance. Tolerance was determined by monitoring complaints during or following activity or an increase in swelling after the activity. When subjects tolerated treadmill running for 10 to 15 minutes without inducing pain or swelling, they were progressed to level surface running in a track or road[1,5].

Agility training techniques such as side sliding, cariocas, multi-directional quick short and stop running figure of eight running were used to improve lower extremity coordination and the ability to quickly change movement direction[1, 5, 8, 11, 12]. Power squat testing with a weight equal to 60 percent of the individual's body weight is used. The individual is asked to perform 5 squat repetitions in 5 seconds. As ability is increased, the volume is increased to 200 to 250 foot contacts of low to moderate intensity. A work/rest ratio of 1:2 was given[8]. Sports-specific skills were initiated when subjects tolerated full-effort agility training without pain or swelling[1, 8, 11, 12].

2.7 Proprioceptive Training Program[1, 5, 8, 12]

Perturbations were applied while the subjects stand on the wobble board with double limb support and latter followed by single limb support. Propioceptive training including anterior-posterior, medial-lateral and multi-directional perturbations were given. The wobble board is made up of an 18 to 24 inch disc with half a sphere fixed to the centre of the disc. During wobble board perturbations training, the subjects stand on the wobble board with two leg support and were asked to maintain and balance at this position on the board. Once a subject masters this balanced position, the therapist manually applied anterior and posterior perturbations to disturb the position. During perturbations, the amount of tilting varied approximately from 2.5 to 7.5 cm, the time approximately from 1 to 5 seconds and the speed of tilting perturbations varies gradually from a quick application to a slow, application of tilting. Subjects were instructed to respond by regaining the balanced position on the board. The same process was repeated for medial and lateral tilting perturbations. Each bout lasted approximately 1 to 1.5 minutes. The total treatment time was approximately 6 to 9 minutes for this activity. When subjects were able to perform this activity with minimal difficulty in double limb support, the treatment was progressed to single limb support. This was given after standard non-operative ACL injury rehabilitation program for the experimental group.

3. Results

Data analysis was performed using the IBM SPSS (Version 20.0) statistical package.

Table 1 shows the mean, standard deviation and standard error of mean values for experimental and control groups respectively. By using Independent sample t-test, we have found the highly significant difference between the experimental and control group at 0.05 level of significance.

Table 1. Comparison of single leg stance time and time HOP test

Assessment tool	Group	Mean	Standard deviation	Standard error of mean	T-value	P-value
Single leg stance time	Experimental group	21.333	4.220	1.089	4.038	0.016
	Control group	9.866	2.531	0.653		
Time HOP test	Experimental group	4.532	0.560	0.323	5.315	0.006
	Control group	1.313	0.8951	0.513		

4. Discussion

Anterior Cruciate Ligament (ACL) injury is one of the most common incidents an athlete may encounter during sports performance. Various non-operative conservative management procedures for ACL injury have demonstrated positive or negative results but not proven to be a consistently reliable solution.

The treatment protocol discussed in this study was administered 4 times / week with an interval of one day, across a period of 3 weeks[20]. This methodology draws evidence from the study of G.Kelley et al., who concluded that perturbation trained subjects were 4.88 times more likely to have successful outcome with non-operative treatment compared to subjects who did not receive the perturbation training[1]. His work was based on the protective effect proprioceptive training is found to provide for continuous participation in high-level physical activities following non-operative ACL injury rehabilitation. Although the mechanism for this protective effect cannot be completely determined from the results of his study, he further stated that it was in a way related to adaptations in neuromuscular control of knee stability. Subjects in the perturbation program were given additional exposure to potentially destabilizing forces about the knee in a controlled and progressive manner[1].

According to T.L. Chmielewski, this additional exposure could provide an opportunity for the neuromuscular system to adapt to those forces by developing successful compensatory muscle activity patterns[7].

Treatment techniques that attempt to promote the development of these protective compensatory patterns could be designed to encourage involuntary muscular responses to destabilizing forces[21].

Further, the application methods of perturbation training techniques have contributed to the success of experimental group. A key principle underlying perturbation training is that athletes with ACL deficiencies should be exposed to carefully controlled forces that destabilize the knee joint to trigger appropriate responses while protecting the knee joint from risk of further injuries. During the proprioceptive training, subjects were asked not to overcome the forces applied by the therapist, but rather to match the forces as they were applied and released. This instruction helped in eliciting more selective lower-extremity muscle contractions in response to the applied load. Also the subjects felt better prepared for higher-skilled muscular responses to destabilizing forces when they returned to full athletic competition[7].

The results of the statistical analysis indicate that subjects in the standard group have unsuccessful rehabilitation compared with proprioceptive group (experimental group). The subjects either experienced an episode of the knee giving way or needed more time in HOP test and a decreased single leg stance time. Adding the proprioceptive training to current standard non-operative ACL rehabilitation programs helps to return athletes to their sporting activities in e more predictable manner. The higher scores of the proprioceptive training group for single leg stance time and HOP tests further support this finding.

Interactions found in single leg stance test and time Hop test scores indicated subjects in both groups improved their scores from the pre-treatment test session to the post-treatment test session. Both treatment programs were capable of returning subjects to their activities; however, the proprioceptive training program demonstrated better rate of success during rehabilitation.

Independent sample 't' test was used for the comparison within the group. The comparison is between the pre and post-test measurement. When the 'p' value is less than 0.05 the significance is about 95% and the 'P' value of 0.001 suggest that there is 99.9% significance in the result. This finding is well supported by results of Fitzgerald et al. in a randomized trial; it is found that perturbation training resulted in 93% of subjects who completed the training successfully returning to high level activity without episode of incidence of knee instability. This demonstrates efficiency in wide contrast from the traditional rehabilitation group where only 50% of subjects returned to high-level activities[17].

5. Conclusion

Despite the training programs have proved to enhance the full functionality of athletes, the proprioceptive training program has shown much better improvement than the other. In experimental group, there is higher level of improvement in single leg stance time and reduced time in time HOP test compared to control group. Therefore proprioceptive training program is more effective in the rehabilitation of acute ACL injury in athletes than non-operative standard rehabilitation program alone. The present study supports the recommendation of proprioceptive training program in grade-II acute ACL injured athletes.

6. Conflict of Interest

No conflicts of interests between the authors during the elaboration of this paper.

7. References

1. Fitzgerald GK, Axe MJ, Mackler LS. The efficacy of perturbation training in non operative anterior cruciate ligament rehabilitation programs for physically active individuals. Research Reports Physical Therapy. 2000 Feb; 80(2):128–40.
2. Ihara H, Nakayama A. Dynamic joint control training for knee ligament injuries, Am J sports. Med. 1986 Jul; 14(4):309–15.
3. Smith HC, Vacek P, Johnson RJ, Slauterbeck JR, Hashemi J, Shultz S, Beynnon BD. Risk factors for anterior cruciate ligament injury: a review of the literature – part 2: hormonal, genetic, cognitive function, previous injury and extrinsic risk factor. Sports Health. 2012 Mar; 4(2):155–61.
4. Magee DJ. Orthopaedic physical assessment. 4th ed. Elsevier India private limited; 2002.
5. Zachazewski JE. Athletic injuries and rehabilitation. 3rd ed. New York: Mc Graw-Hill Publishers; 1998.
6. Brotzman BK, Wilk E. Clinical orthopaedic rehabilitation. 2nd edition. Tennesscc: Mosby; 2002.
7. Chmielewski TL, Hurd WJ, Rudolph KS, Axe MJ, Mackler LS. Perturbation training improves knee kinematics and reduces muscle co-contraction after complete unilateral anterior cruciate ligament rupture. Physical Therapy. 2005 Aug; 85(8):740–9.
8. Prentice WE. Rehabilitation techniques for sports medicine and athletic training. 4th ed. New York: Mc Graw-Hill Publishers; 2004.
9. Laskowski ER, Aney KN, Smith J. Refining rehabilitation with proprioception training; expending return to play. The physician and sports medicine. 1997; 25(10).
10. Behm D, Colado JC. The effectiveness of resistance training using unstable surfaces and devices for rehabilitation. The international Journal of Sports Physical Therapy. 2012; 7(2):226–41.
11. Brukner P, Karim Khan. Clinical sports medicine. 2nd ed. New York: Mc Graw-Hill Publishers; 2000.
12. Cooper RL, Taylor NF, Feller JA. A systematic review of the effect of propriceptive and balance exercises on people with an injured or reconstructed anterior cruciate ligament. Res Sports Med. 2005; 13(2):163–78.
13. Hooks TR, Wilk KE, Reinold MM, Trapuzzano T, Barrentine SW, Andrews JR. The effect of unilateral ACL injury and reconstruction on proprioception. A comparison of deficits for the involved and non-involved lower extremity. Journal of the American physical therapy association. 2004 Jun 30–Jul 3.
14. Heroux ME, Tremblay F. Cortico-motor excitability associated with unilateral knee dysfunction secondary to anterior cruciate ligament, Knee Surgery, Sports Traumatology, Arthroscopy. 2006; 14(9):823–33.
15. Ageberg E, Roberts D, Holmstrom E, Fride T. Balance in single-limb stance in patients with anterior cruciate ligament injury. The American Journal of Sports Medicine. 2005; 33(10):1527–35.
16. Al-Othman A, Moussa M, Eraky MZ. A simple outpatient tests for proprioception in the anterior cruciate ligament - deficient knee. Orthopaedics. 1998; 21(6):677–9.
17. Fitzegerald GK, Lephart SM, Hwang JH, Wainner, Robert MS. HOP tests as predictors of dynamic knee stability. Journal of Orthopaedics & Sports Physical Therapy. 2001; 31(10):588–97.
18. Kisner C, Colby LA. Therapeutic exercise, Foundations and Techniques. 3rd ed. New Delhi: Jaypee Brothers; 2000.
19. Noyer FR, Mooar PA, Matthews DS, Butler DL. The Symptomatic anterior cruciate deficient knee, part 1: The long-term functional disability in athletically active individuals. Journal of Bone Joint Surg Am. 1983; 65 (2):154–62.
20. Hall CM, Brody LT. Therapeutic exercise (Moving towards function). 2nd ed. New York: Mc Graw-Hill Publishers; 1997.
21. Riemann Bl, Lephart SM. The Sensorimotor system, part II: The role of proprioception in motor control and functional joint stability. Journal of Athletic training. 2002; 37(1):80–4.