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The role of proprioceptive training in post-operative ACL injury Rehabilitation

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Abstract

Background: The ACL is a tissue that connects the thighbone to the shinbone, at the knee. Most ACL injuries occur during certain sports such as football, basketball and tennis. Proprioceptive training appeared to decrease the incidence of injury to the knee and specifically the ACL. ACL injury leads to a decrease in proprioceptive abilities which can be improved with ACL surgery and postoperative rehabilitation. Proprioceptive training improve the stimuli within the body relating to position and movement. The goal of the study to evaluate the effect of Proprioceptive training in post-operative ACL injury.

Purpose: The purpose of the study is to determine the effect of Proprioceptive training program versus strength training program in post-operative ACL injury rehabilitation.

Methods: This experimental study was conducted on 20 post-operative ACL injury patients (men and women). They were divided in to two groups of 10 each, Group 1 experimental and Group 2 control. Informed consent obtained from all individuals. In experimental group taking the outcome measures by Lachman test and anterior drawer test in international knee documentation committee scale. Its final grading taken after the three weeks of proprioceptive training. In control group include strengthening exercise of quadriceps, the hamstring and the calf muscle, stationary cycling. Each session consist of 5 - 10 min warm up 30 - 40 min strength training exercise and 5 min cool down. After three weeks take outcome and analyze the data.

Results: The 3 weeks proprioceptive training was effective in post-operative ACL injury patient.

Keywords: ACL –Anterior cruciate ligament

Introduction

The anterior cruciate ligament (ACL) is the most commonly ruptured ligament in the human knee joint. It is estimated that half a million people in the United States sustain clinically significant ACL injury annually. The ACL plays a major role in maintaining the normal function of the knee. Like all ligaments, the ACL guides joint motion by preventing unphysiological and excessive motions. In addition, it works in partnership with the muscles and articular surfaces to transmit the loads of activity across the joint. Once the integrity of the ACL is disrupted a reduction in function ability and stability of the affected knee is often seen. Despite all the information data on the ACL, the understanding of its structure, function, and biology is not to the point where the ligament can be restored to its pre-injury state. The ACL injury results in alters somatosensory information that adversely affects motor control. This may subsequently lead to an increase risk for recurrent injury, decreased performance, or both. Histologically, it has been demonstrated that the human ACL contains mechanoreceptors that can detect changes in tension, speed, acceleration, direction of movement and the position of the knee joint. Currently, proprioception training following an ACL injury is emphasized in the attempt to maximize the sensory information mediated by the joint and musculotendinous afferent to dynamically stabilize the joint. Although diminished or altered proprioception and kinesthesia have been documented after ACL injuries, very few prospective studies have examined the effectiveness of proprioceptive training after ACL injuries. Of those prospective studies found in the literature, none involved the ACL reconstructed population. Diminished proprioception in joints are secondary to injury. Decrease in proprioception may lead to further instability secondary to poor coordination of the dynamic stabilizers. This ultimately may initiate vicious cycle of re injury secondary to proprioceptive deficiency.

Since, proprioception is thought to be involved in mediating the control of muscular coordination and reflexes, it is the postulation that these mechanisms of the knee depend, to a certain degree on the proprioception of the knee secondary to an injury of the ACL may contribute to progressive knee instability.

The success of rehabilitation programs depend on the subjects participating in high level activity such as sports activities that require jumping and pivoting maneuvers of lower extremity should improve if treatment techniques that induce appropriate compensatory alterations in muscle activity are incorporated into treatment programs. 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.

Proprioception refers to specialized variation of the sensory modality of touch that encompasses the sensation of joint movement and joint position. It has 3 components a static awareness and joint position, awareness and detection of movement and acceleration, and closed loop efferent activity which starts reflects response and regulate muscles. Proprioception is receptor and neural arch mediated, it has been demonstrated that a significant number of mechanic receptor exist in the fibers of ACL. These receptors play an important role in the complicated neural network of proprioception.

The ACL is one of the key ligaments that help stabilize knee joint. The ACL connects thighbone (femur) to shine bone (tibia). Many people hear a pop or feel a "popping" sensation in the knee when an ACL injury occurs. Knee may swell, feel unstable and become too painful to bear weight. Depending on the severity of ACL injury, treatment may include rest and rehabilitation exercise to help regain strength and stability or surgery to replace the torn ligament followed by rehabilitation. A proper training program help reduce the risk of an ACL injury. ACL injuries often happen during sports and fitness activities that can put stress on the knee:

- Suddenly slowing down and changing direction (cutting)
- Pivoting with foot firmly planted
- Landing awkwardly from a jump

- Stopping suddenly

Receiving a direct blow to the knee or having a collision, such as a football tackle After ACL injury, regardless of whether surgery will take place or not. Physiotherapy management focuses on regaining range of movement, strength, proprioception and stability. Exercise should encourage ROM, strengthening of Quadriceps and Hamstrings and proprioception. Integrating some of these exercises into a rehabilitation programme at this post-operative stage as appropriate for the patient.

Methodology

1. Study Design
Pre-test pro- test experimental study design
2. Sampling Method
Simple random sampling
3. Sample Size
20 Subjects
4. Selection Criteria

Inclusion Criteria

- According to the grade and level of Injury the age limit between 18-45 years are included in this study.
- The history of post- ACL surgical repair
- Symptom free contra-lateral knee
- Recreational football players

Exclusion criteria

- Previous knee injury
- Arthritis
- Any history of other injury
- Presence of associated PCL injury
- Meniscal lesion

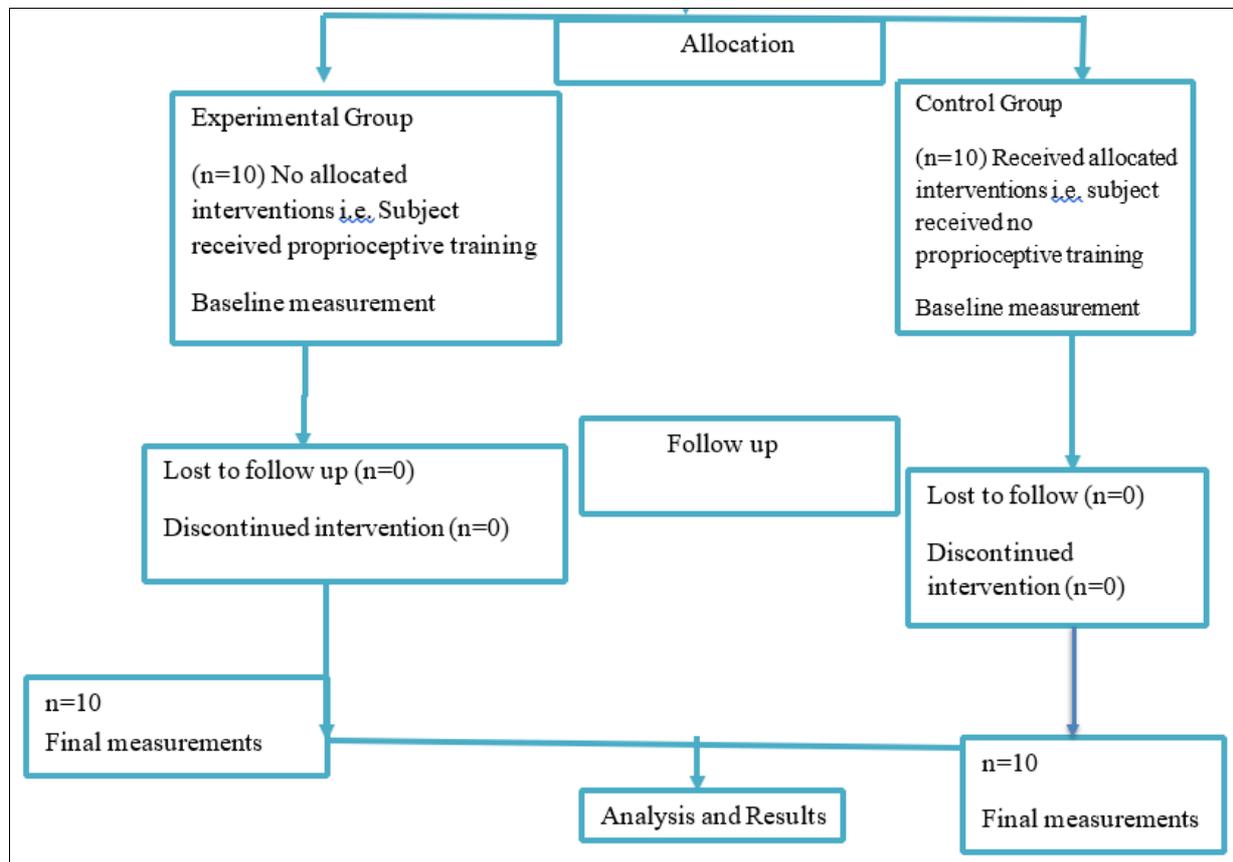
5. Materials Used

1. Wobble board
2. Goniometer for measuring ROM
3. Local available furniture (foot stool, stair, balance board)

Study Procedure

Flow Chart





The population included 20 subjects fulfilling both inclusion and exclusion criteria. Subjects for experimental group (n=10) and control group (n=10) were randomly selected from Cosmopolitan hospital, Trivandrum. Informed consent was obtained from each subject prior to participation. A description about the procedures was given to the subjects before commencing the study. A total of 20 subjects was divided into two groups by random sampling method, Group A {n=10} & Group B {n=10}.

Group A: Experimental Group

In experimental group 10 subjects randomly select after taking the outcome measures Cincinnati knee rating scale and in International Knee Documentation Committee Scale. Its final grading taken after the three weeks of proprioceptive training. The proprioceptive training include:

Balance exercises

Single leg stance: (For progress to the same exercise with your eyes closed): It engage knee and ankle proprioceptors and lunge also strength and balance the knee joint.

Regimen

Frequency - 5 Times
Set - 2
Duration - 10 minutes / 3 weeks

Crossover walk: It is ideal for our subject because it is recommended for postoperative ACL Injury Patients.

Regimen:

Frequency - 5 Times
Set - 2
Duration - 10 minutes / 3 weeks

Backward running: (Retro running): It improve the balance and it will strengthen Patients calf, quadriceps and shins to balance muscular strength.

Regimen

Frequency - 5 Times
Set - 2
Duration - 10 minutes / 3 weeks

Each proprioceptive training session consist of 5-10min warm-up, 30 - 40min proprioceptive training and 5min cool down.

Fig 1: 1&2 shows exercises in Group A (Experimental group)



Fig 1: Cross over side walking



Fig 2: Retro walking



Fig 3: Single leg stance

Group 2: Control Group

In control group 10 subjects randomly select from the willing participants. The group include strengthening exercises of Quadriceps, the Hamstrings and the calf muscle, stationary cycling. Each session consist of 5-10 min warm up 30-40min Strength training exercise and 5 min cool down.

Strengthening exercise

- Quads isometric exercise
- Straight leg raise
- Hamstring curl
- Hamstring isometrics

Quads isometric exercise: Patient lying on the supine position with half flexed knee slightly pressed on the couch.

Regimen

Frequency - 5 Times /session
Set - 2
Duration - 10 minutes



Fig 4: Quads isometric exercise

Straight leg raise: Patient in supine position with knee extended and stabilizing the hip and slightly elevate possible range.

Regimen

Frequency - 5 Times
Set - 2
Duration - 10 minutes



Fig 5: Straight leg raise

Hamstring curl: Patient in upright position with support on the wall gently flexed the knee.

Regimen

Frequency - 5 Times
Set - 2
Duration - 10 minutes / 3 weeks



Fig 6: Hamstring curl

Hamstring isometrics: Patient lying in supine position with fully extended knee, the heel placed on the rolled towel and press for 10 seconds.

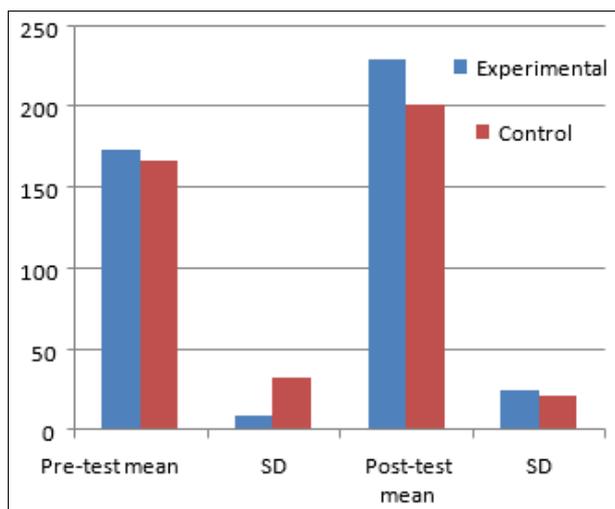
Regimen

Frequency - 5 Times
Set - 2
Duration - 10 minutes / 3 weeks



Fig 7: Hamstring isometrics

Statistical Analysis



Graph 1: Statistical Analysis of Cincinnati Knee Rating Scale Using T-Tests

Table 1: Mean S.D and t-value to compare pre-test and post-test knee function on Cincinnati knee rating scale in Experimental Group (Paired t test)

Test	Mean	SD	Mean Change	n	t	df	f table value	p-value
Pre-test	173	8.23	-56	10	-6.72	9	2.627	0.0001
Post-test	229	24.24						

The mean column displays the mean pre-test and post-test knee functional scores among post surgical ACL injury patients in the experimental group. SD is the standard deviations of the balance scores in pre & post respectively. Mean change -56 units is the difference between pre-test and post-test (173 units & 229 units). p value <0.0001, there is a significant difference existing between the pre-test and post-test knee function scores among post surgical ACL injury patients in the experimental group. This proves the effect of proprioceptive training effective in post surgical ACL injury patients.

Table 2: Mean S.D and t-value to compare pre-test and post-test knee function on Cincinnati knee rating Scale in Control Group (paired t test)

Test	Mean	SD	Mean Change	n	t	df	Table Value	p-value
Pre-test	166	31.34	-35	10	-6.45	9	2.624	0.0003
Post-test	201	20.24						

The mean column displays the mean pre-test and post-test knee functional scores among post surgical ACL injury patients in the control group. SD is the standard deviations of the balance scores in pre & post respectively. Mean change -35 units is the difference between pre-test and post-test (166 units & 201 units). p value <0.0003, there is a significant difference existing between the pre-test and post-test knee function scores among post surgical ACL injury patients in the control group.

Table 3: Mean S.D and t-value to compare pre-test knee function scores between Experimental and Control Groups using t-test

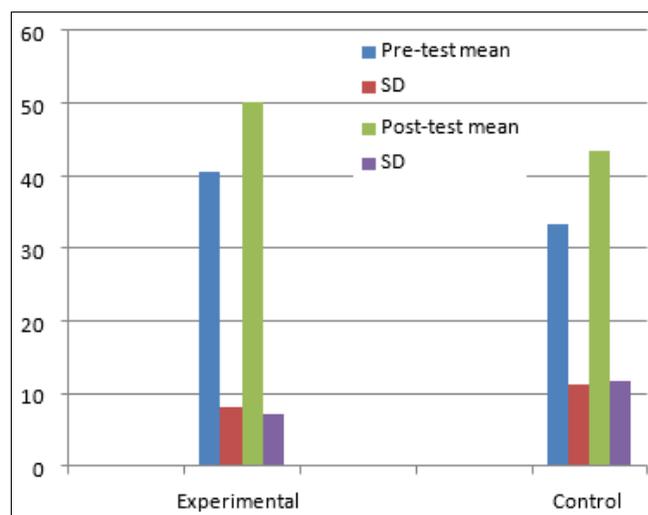
Group	Pre-test Mean	S.D	Difference in Mean	n	t	df	table value	p-value
Experimental	173	8.23	7	10	0.68	9	2.627	<0.50
Control	166	7.22						

The Mean column in the t- test table displays the mean pre-test knee function scores in the experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (7 units) shows the difference between mean in two groups (173 units & 166 units). p-value <0.50 there is no significant difference in pre-test knee function scores between the experimental and the control groups. So, we can consider the groups as homogenous in the baseline level.

Table 4: Mean S.D and t-value to compare post-test knee function scores between Experimental and Control Groups using t-test

Group	Mean	S.D	Difference in mean	n	t	df	table value	p-value
Experimental	229	24.24	7	10	0.68	9	2.624	<0.11
Control	201	20.24						

The Mean column in the t test table displays the mean post-test knee function scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (28 units) shows the difference between mean in two groups (229 units & 201 units). p-value <0.001, there is a significant difference in post-test knee function scores between the experimental and the control groups.



Graph 2: Statistical Analysis of IKDC Scale Using T Test

Table 7: Mean, S.D. and t-value to compare the pre-test knee function scores between Experimental and Control Groups using t-test

Group	Pre-test Mean	S.D	Differences mean	n	T	df	table value	P value
Experimental	40.35	8.089	7.14	10	1.64	9	2.624	<0.11
Control	33.21	11.08						

The Mean column in the t-test table displays the mean pre-test knee function scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (7.14 units) shows the difference between mean in two groups (40.35 units & 33.21 units). p value <0.11, there is no significant difference in pre-test knee function scores between the experimental and control groups. So, we can consider the groups as homogenous in the baseline level.

Table 8: Mean S.D. and t-value to compare the post-test knee function scores between Experimental and Control Groups using t-test

Group	Mean	S.D	Difference in mean	n	t	df	table value	p-value
Experimental	50.11		6.71	10	1.569	9	10.1	<0.001
Control	43.4							

The Mean column in the t-test table displays the mean post-test knee function scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (6.71) shows the difference between mean in two groups (50.11 units & 43.4 units). Since the *t-value* 10.1 units is greater than the table value 2.467 units, $p < 0.001$, there is a significant difference in post-test knee function scores between the experimental and the control groups.

Hence, proprioceptive training effective in post surgical ACL injury patients.

Results

Experimental Group

1. Evaluation of Cincinnati Knee Rating Scale

By comparing the pre – test and post – test knee function rate in post surgical ACL injury patients in the experimental group mean change -56 units is the difference between pre-test and post-test (173 units & 229 units). *p* value 0.0003, there is a significant difference existing between the pre-test and post-test knee function scores among post surgical ACL injury patients in the experimental group. This proves the effect of proprioceptive training effective in post surgical ACL injury patients.

2. Evaluation of IKDC scale

By comparing the pre – test and post – test knee function rate in post surgical ACL injury patients in the experimental group mean change (-9.76 units) is the difference between pretest and post-test (40.35 units & 50.11 units). *p* value <0.002, there is a significant difference existing between the pre-test and post-test IKDC scores among post surgical ACL injury patients in the experimental group. This proves the effect of proprioceptive training in post surgical ACL injury patients.

Control Group

1. Cincinnati Knee Rating Scale

By comparing pre – test and post – test knee function score in post-surgical ACL injury patients in the control group Mean change -35units is the difference between pre-test and post-test (166units & 201 units). *p* value -0.0001, there is a significant difference existing between the pre-test and post-test knee function scores among post surgical ACL injury patients in the control group.

So we have seen that there is significant change in knee function score among the post-surgical ACL injury patients in experimental group whereas there is no significant change in knee function among post-surgical ACL injury patients in the control group. Hence

Proprioceptive training is very effective to improve knee function after ACL injury.

2. IKDC Knee Rating Scale

By comparing pre – test and post – test score in post surgical ACL injury patients in the control group the mean difference (-10.19) shows the difference between mean in two groups (33.21 units & 43.4 units). Since the *t-value* 8.62 units is

greater than the table value 2.467 units, $p < 0.001$, there is a significant difference in post-test knee function scores between the experimental and the control groups.

Discussion

The treatment protocol discussed in this study was administered 3 times /week with an interval of one day, using the rehabilitation 40% of patients attend the sessions. Across a period of 3 weeks. Over 70% of all, grade-II ACL injury occurs in recreational and competitive sports activities. In this study the treatment protocol was set as 3 times per week with alternative days. 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. Acute conditions are the conditions that are present in a patient for 7–10 days. A grade-II ACL injury results in partial micro tears with some hemorrhage. But there is no increased laxity and there exists a firm end point.

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 patten. Further, the application methods of proprioceptive training techniques have contributed to the success of experimental group. 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. The treatment protocol discussed in this study was administered times / week with an interval of one day, across a period of 3 weeks

The results of the statistical analysis indicate that subjects in the control group have unsuccessful rehabilitation compared with proprioceptive group (experimental group). Adding the proprioceptive training to current standard post -operative ACL rehabilitation programs helps to return athletes to their sporting activities in more predictable manner. The higher scores of the proprioceptive training group for single leg stance time and further support this finding. Interactions found in single leg stance test and time 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 in IKDC scale of experimental group When the ‘p’ value is less than 0.005 the significance is about 90% and the ‘P’ value of 0.002 suggest that there is 95.9% significance in the result. The comparison between the pre and post –test measurement in Cincinnati knee rating scale in experimental group when the ‘p’ value is 0.0003, there is significance in result. It is found that proprioceptive training resulted in 99% of subjects who completed the training successfully returning to high level activity without episode of incidence of knee instability.

Limitation

- Due to the lack of female patients in our study the generalization of the study not possible.
- There is small sample size

- Due to Covid -19 pandemic and lockdown issues makes adequate routine check up difficulty and travelling issues

Conclusion

It is observed that, 3 session /week up to 3 weeks proprioceptive training leads to a significant improvement in knee function in post surgical ACL injury patient. This observation is supported by stastical analysis Based on the outcomes of the study, it can be concluded that proprioceptive training effective in post surgical ACL injury patient and this increase overall physical activity in injured person.

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, cross over side walking and retro walking exercise compared to control group. Therefore proprioceptive training program is more effective in the rehabilitation of acute ACL injury in athletes than post-operative standard rehabilitation program alone. The present study supports the recommendation of proprioceptive training program in grade-II acute ACL injured athletes.

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