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EFFECTIVENESS OF BLOOD FLOW RESTRICTION RESISTANCE TRAINING (BFRRT) ON QUADRICEPS AND HAMSTRING STRENGTH POST ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION (ACLR)

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ABSTRACT

Background: Anterior cruciate ligament reconstruction (ACLR) is one of the most common surgical interventions performed on the knee. Muscle atrophy, loss of strength and function especially in quadriceps and hamstrings can be observed even 1 year post ACLR affecting quality of life and increased chances of re-injury. Blood Flow Restriction Resistance Training (BFRRT) is a technique wherein a combination of low intensity resistance training with blood flow occlusion to produce results like high intensity resistance training. **Method:** The study design was an experimental study with a population of thirty samples randomly selected for this study. All subjects underwent Pre-test measurements for knee joint pain, Range of motion (ROM) and strength with knee muscle strength test, Knee girth measurement, Knee injury and Osteoarthritis Outcome Score (KOOS). After the Pre-test, the subjects were divided into two groups A and B, Group A received conventional physiotherapy along with BFRRT and Group B received conventional physiotherapy for 8 weeks. Post-test measurements were similarly taken on successful completion of treatment program. **Result:** Pre-test and post-test values obtained were analysed using paired & unpaired 't' test for 28 degrees of freedom at a 5% level of significance, There were significant difference between the experimental group for knee muscle strength test 68.32 and control group 59.23 and also there was a significant difference between the experimental group for Knee injury and Osteoarthritis Outcome Score (KOOS) (78.61) and control group (67.34) with P value <0.05 and hence null hypothesis was rejected which showed a significant improvement in Group A patients who received BFRRT and Conventional physiotherapy. **Conclusion:** Results of this study concluded BFRRT is effective in improving the strength in quadriceps and hamstring muscle post ACLR.

KEYWORDS : ACLR, BFRRT, Knee muscle strength test, Knee injury and osteoarthritis outcome score (KOOS).

I. INTRODUCTION

Anterior cruciate ligament (ACL) is the major ligament which stabilises knee joint. ACL runs diagonally from anterior aspect of tibial condyle to medial surface of lateral condyle of femur, ACL prevents tibia from sliding out anteriorly off the femur and it provides rotational stability to the knee joint.ACL can be injured or torn in many ways. The most common mechanism is that of a sudden pivoting or cutting maneuver during sporting activity, which is commonly seen in football, basketball and soccer. The ligament can also tear due to work injuries or automobile accidents. At the time of the injury, a "pop" or "snap" can sometimes be felt or heard. The amount of pain experienced at the time of the injury is somewhat variable but can be quite severe. Typically, the person is unable to continue play or activity, and has the impression that a significant injury has occurred. Immediate swelling of the knee develops at the time of injury-within the first several hours-but the extent of swelling can be limited if the knee is immediately iced or splinted, following ACL injury usual symptoms will be a pop in the knee at the time of injury, profuse to minimal swelling of the knee joint, inability to bear weight on the leg, instability of the knee joint. ACL tear can be diagnosed through history and physical examination. On physical examination it can be specifically assessed with the amount of motion present at knee joint and determine if the ACL is torn. Additionally, evaluation of other structures within the knee is done also, as ACL tears are often found in association with injury to other structures within the knee, such as the cartilage and collateral ligaments.ACL injuries are commonly classified in grades of 1, 2 or 3.Grade 1 injuries include ACLs that have suffered mild damage, e.g., the ACL is mildly stretched but still provides adequate stability to the knee joint. Grade 2 ACL injuries are described as an ACL that is stretched and partially torn. Grade 3 ACL tears happen when the ACL is torn completely in half and is no longer providing any stability to the knee joint. Adolescents may also commonly have a tibial avulsion ACL injury. With this type of injury, the ACL itself is not torn, but the bony attachment of the ligament to the tibia is pulled off. Depending on how far the bony attachment of the ligament is pulled off, the injury can result in weakness or instability of the knee if it is not fixed. Nonsurgical treatment is most appropriate for grade 1 injuries. This would include immobilization or bracing, physical therapy, and a gradual progression back to regular activities and sports. Surgical treatment is recommended for individuals with a grade 3 or complete ACL tear. Surgical options may vary based on the type of ACL injury, whether the patient has open or closed growth plates, and the type of injury.Majority of the evidence surrounding rehabilitation protocols post ACLR incorporate achieving full range of motion followed by resistance training, plyometrics and neuromuscular training to increase muscle strength and hypertrophy.Application of BFRRT causes metabolic stresses which facilitate endothelial nitric oxide syntheses, causing endothelial dysfunction in vessels of skeletal muscles, hence causing demand in increase blood flow, peripheral blood circulation, neurological activation of fast twitch fibres and hypertrophic influence on muscles promotes hypertrophy and muscle strength.

II. Aim and Need of Study

The aim of this study is to find the effectiveness of blood flow restriction resistance training (BFRRT) on quadriceps and hamstring strength post anterior cruciate ligament reconstruction (ACLR).

Upon reviewing many literatures, studies had been conducted on various strength training program post ACLR, but none other studies have been done, to find out the effectiveness of blood flow restriction resistance training (BFRRT) on quadriceps and hamstring strength post anterior cruciate ligament reconstruction (ACLR). Hence, the need of this study is to find out the effectiveness of blood flow restriction

resistance training (BFRRT) on quadriceps and hamstring strength post anterior cruciate ligament reconstruction (ACLR).

III. Objective of the study

To find out the effects of blood flow restriction resistance training (BFRRT) on quadriceps and hamstring strength post anterior cruciate ligament reconstruction (ACLR).

IV. MATERIALS AND METHODS

This Experimental study included 30 subjects from Department Of Physiotherapy, Sri Venkateshwaraa Medical College Hospital & Research Centre, Ariyur, Pondicherry - 605 102 . Subjects were divided into two groups (Group A- 15 & Group B- 15). The subjects were included based on the selection criteria. The inclusion criteria of the study were with both genders, age group between 17-29 years who underwent ACL reconstruction, completed nine weeks post surgery rehabilitation protocol & without pain and complications, Subjects who were willing to participate in the study, and exclusion criteria were subjects with pain and post operative complications and subjects who were not willing to participate in the study. The subjects pre-test and post-test values were collected using Knee muscle strength test, knee muscle girth measurement and Knee injury and osteoarthritis outcome score (KOOS) in both groups. The study was conducted for a period of 6 months and during the study time subjects in Group A received conventional physiotherapy along with BFRRT and Group B received conventional physiotherapy for a period of 5 sessions in a week for 8 weeks.

V. Outcome Measure

(i) Knee muscle strength test
(ii) Knee injury and osteoarthritis outcome score (KOOS)
(iii) Muscle girth measurement

VI. Procedure:

Subjects who fulfilled inclusion criteria were included for study. The benefit of the study and treatment intervention was well explained to the subjects and a written informed consent was taken and secured. The subjects were assessed using KOOS, Knee muscle strength for muscle strength and muscle girth for muscle atrophy. Here general strengthening exercises with Delorme PRE were used as a conventional therapy for both groups. The patients were allocated randomly into 2 groups consisted of 15 subjects in each group.

Group A: Progressive Resisted Exercise (pre) And Blood Flow Restriction Resistance Training (bfrrt).

Patients in group A (Experimental group) were provided with General strengthening exercise and Delorme Progressive resisted exercise program similarly as Group B. Apart from these exercises patients were treated with Blood Flow restriction resistance training (BFRRT), all these exercises were given for about five sessions in a week and for a period of eight weeks in duration given.

BFRRT Exercise Program

Patient is to perform BFRRT in a stable rough surface in striding standing position with legs at one and half foot apart, at the level of junction of upper one third and lower two third of thigh pressure cuff is tied with 80 mm/Hg of pressure and is maintained throughout the completion of exercise sets, the pressure maintained will occlude the flow of blood and hence the benefits of BFFRT will be achieved. The patient is allowed to do half squatting with the pressure cuff in situ as per the below protocol. Physiotherapist position is behind the patient in stabilizing patient body.

BFRRT Exercise Program

1. **Week -1** - 1 set, 5 repetitions per set
2. **Week- 2** - 1 set, 10 repetitions per set
3. **Week- 3** - 2 sets, 5 repetitions in 1st set, 7 repetitions in 2nd set
4. **Week- 4** - 2 sets, 8 repetitions in 1st set, 9 repetitions in 2nd set
5. **Week- 5** - 2 sets, 10 repetitions in 1st set, 11 repetitions in 2nd set
6. **Week- 6** - 2 sets, 12 repetitions in 1st set, 13 repetitions in 2nd set
7. **Week- 7** - 2 sets, 14 repetitions in 1st set, 15 repetitions in 2nd set
8. **Week- 8** - 2 sets, 16 repetitions in 1st set, 17 repetitions in 2nd set

Group B: General Strengthening Exercise And Progressive Resisted Exercise (pre).

Patients in group B (Control group) were provided with General strengthening exercise and De lorme Progressive resisted exercise. In General strengthening exercise Quadriceps and Hamstring setting exercise along with short arc and long arc quadriceps and hamstring strengthening exercise were given, all these exercises were given for about five sessions in a week and for a period of eight weeks duration given.

De lorme Resisted Exercise Program

1. **Week -1** - 1 set, 10 repetitions max per set with 2 kg of resistance
2. **Week- 2** - 2 sets, 10 repetitions max per set with 3 kg of resistance
3. **Week- 3** - 3 sets, 10 repetitions max per set with 3.5 kg of resistance
4. **Week- 4** - 3 sets, 15 repetitions max per set with 4 kg of resistance
5. **Week- 5** - 3 sets, 15 repetitions max per set with 4.5 kg of resistance
6. **Week- 6** - 3 sets, 15 repetitions max per set with 5 kg of resistance
7. **Week- 7** - 3 sets, 20 repetitions max per set with 5 kg of resistance
8. **Week- 8** - 3 sets, 20 repetitions max per set with 5 kg of resistance

V. Statistical Analysis

The data obtained were analyzed between experimental and control group manually using both the paired and unpaired't-test and were tabulated to find out the efficiency of BFRRT in improving strength on quadriceps and hamstring muscle post ACLR. The calculated 't' value obtained from paired 't-test of group A and Group B (Table 1) & (Table 2) respectively (within group analysis) of the Knee muscle strength test for 14 degrees of freedom and 5% level of significance at $p<0.05$ to be considered as a significant difference, paired't-test of group A and group B (Table 3) & (Table 4) respectively (within group analysis) of Knee injury and osteoarthritis outcome score (KOOS),followed by Unpaired 't' Test Value (Between Group Analysis) of group A & group B (Table 5) & (Table 6).

Table 1: Paired 't' Test Value (Within Group Analysis) Within group analysis of Knee muscle strength test outcome measure in Experimental group

Experimental Group	Mean	SD	t - Value	p - Value
Pre Test	35.03	5.32	26.42	<0.05
Post Test	68.32	7.836		

The p value of Knee muscle strength test for Experimental group is <0.05, considered significant.

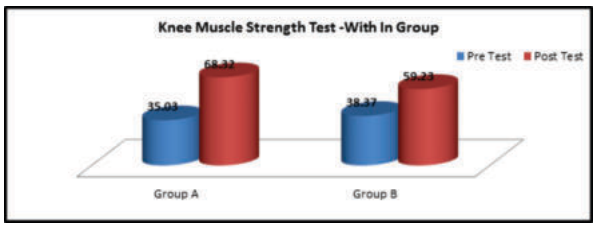
The t value of Knee muscle strength test for Experimental group is 26.42 with 14 degree of freedom

Table 2: Within group analysis of Knee muscle strength test Outcome measure in Control group

Control Group	Mean	SD	t - Value	p - Value
Pre Test	38.37	5.730	18.68	<0.05
Post Test	59.23	6.132		

The p value of Knee muscle strength test for Control group is <0.05, considered significant.

The t value for Control group is 18.68 with 14 degree of freedom.



Graph 1:
Within group analysis of pre and post test value of Knee muscle strength test shows Experimental group is more significant than control group with the significant value of p<0.05.

Table 3: Within group analysis of Knee injury and osteoarthritis outcome score (KOOS) in Experimental group

Experimental Group	Mean	SD	t - Value	p - Value
Pre Test	33.13	4.57	19.63	<0.05
Post Test	78.61	6.52		

The p value of Knee injury and osteoarthritis outcome score (KOOS) for Experimental group is <0.05, considered significant.

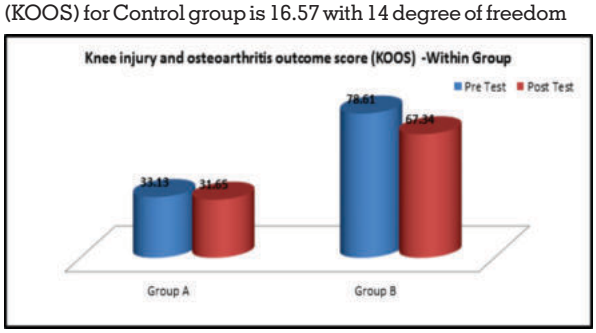
The t value of Knee injury and osteoarthritis outcome score (KOOS) for Experimental group is 19.63 with 14 degree of freedom.

Table 4: Within group analysis of Knee injury and osteoarthritis outcome score (KOOS) in Control group

Control Group	Mean	SD	t - Value	p - Value
Pre Test	31.65	4.31	16.57	<0.05
Post Test	67.34	5.32		

The p value of Knee injury and osteoarthritis outcome score (KOOS) for Control group is <0.05, considered significant.

The t value of Knee injury and osteoarthritis outcome score (KOOS) for Control group is 16.57 with 14 degree of freedom



Graph 2:

Within group analysis of pre and post test value of Knee injury and osteoarthritis outcome score shows Experimental group is more significant than control group with the significant value of p<0.05.

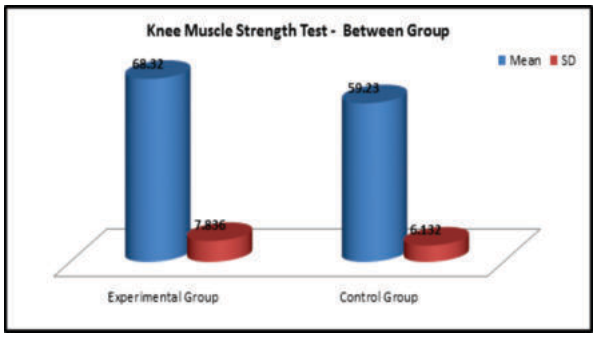
Unpaired 't' Test Value (Between Group Analysis)
Knee muscle strength test:

Table 5: Showing the post - test values of Experimental group & Control group: (unpaired t - test values)

Group	Mean	SD	t - value	p - value
Experimental Group	68.32	7.836	6.375	<0.05
Control Group	59.23	6.132		

The „p" value of Knee muscle strength test is < 0.05 considered significant.

The „t" value of Knee muscle strength test is 6.375 with 28 degree of freedom.



Graph 3:

In between Experimental group and Control group Knee muscle strength test value analysis shows that Experimental group is more significant than Control group with the significant p value of <0.05.

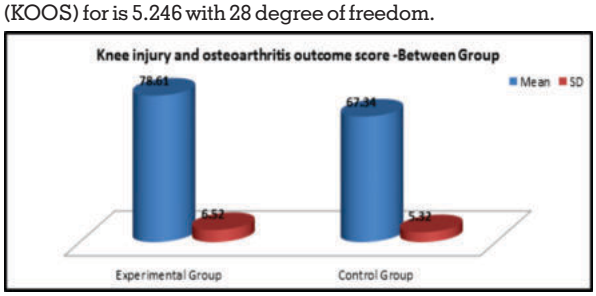
Knee injury and osteoarthritis outcome score (KOOS):

Table 6: Showing the post test values of Experimental Group & Control group (Unpaired „t" test – values)

Group	Mean	SD	t - value	p - value
Experimental Group	78.61	6.52	5.246	<0.05
Control Group	67.34	5.32		

The „p" value of Knee injury and osteoarthritis outcome score (KOOS) <0.05, is considered significant.

The „t" value of Knee injury and osteoarthritis outcome score (KOOS) for is 5.246 with 28 degree of freedom.



Graph 4:

In between Experimental group and Control group Knee injury and osteoarthritis outcome score value analysis shows that Experimental group is more significant than Control group with the significant p value of <0.05.

VI. DISCUSSION

The purpose of the present study was to find out the effectiveness of Blood flow restriction resistance training exercise (BFRRT) in improving strength in Quadriceps and hamstring muscles post ACLR. The result of the study demonstrated that group A (Experimental Group) with Conventional exercise & BFRRT showed improvement in strength and girth measurement than group B (Control Group) treated with Conventional exercises. Overall 30 subjects were included with age group between 17 to 29 years of both genders were selected on the basis of inclusion criteria were randomly allocated into two groups.15 subject from experimental group were treated with BFRRT exercise along

with Conventional strengthening exercise and 15 subject from control group were treated with Conventional strengthening exercise.

Pre and post treatment values were assessed and recorded using Knee muscle strength test, Knee injury and osteoarthritis outcome score (KOOS), Muscle girth measurement before and after treatment for analysis. From the statistical analysis, experimental group showed (paired „t"test) with measured outcome tools viz., Knee muscle strength test is 26.42 and Knee injury and osteoarthritis outcome score (KOOS) is 19.63 whereas for control group Knee muscle strength test is 18.68 and Knee injury and osteoarthritis outcome score (KOOS) is 16.57. In between group analysis (unpaired „t" test) with Knee muscle strength test is 6.375 and in Knee injury and osteoarthritis outcome score (KOOS) is 5.246.

Hence with the recorded data after analysing with paired and unpaired t test, found experimental group treated with Conventional exercise & BFRRT were showed significant improvement in Quadriceps and Hamstring strength than the control group treated with conventional exercise. Based on this result the data accepts the alternate hypothesis and reject the null hypothesis. This result was significance at „p" value <0.05.

Curley et.al (2021) studied the efficacy of BFRR training in improvement of quadriceps and hamstring strength with chronic knee pain after knee surgery, showed improvement in strength and endurance in quadriceps and hamstring muscle after knee surgery, **Kilgas,et.al (2019)** conducted a study in functional improvement in lower limb after BFRR training in patients reduced pain & improvement in muscle strength and endurance after BFRR training, **Fatela, P., et.al.,(2019)** conducted a study and showed with results after BFRRT in improvement of motor unit conduction system thereby improvement in muscle strength and endurance after BFFRT. **Erickson, L., et.al (2018)** conducted a study on BFRRT in strength improvement in quadriceps and hamstring strength. Results showed a increased strength and endurance in quadriceps post BFRR training. **Shimizu, R et.al (2016)** conducted a study on the effects of BFRRT in improvement of strength in elderly patient post BFFR training regime they conclude that the BFFRT may represent an effective method for reducing pain and improving strength and functional improvement in elderly patients.

These results from discussion clearly shows similar effects on my study which concluded that blood flow restriction resistance training is an effective method in improving strength and endurance in quadriceps and hamstring muscle post ACLR.

VII. CONCLUSION

The study concluded that Blood flow restriction resistance training are proven to be more effective in improving strength and endurance along with improvement in girth levels in quadriceps and hamstring muscle post Anterior cruciate ligament reconstruction surgery when comparing to conventional strengthening exercise performed by control group.

Future Scope:

In future, studies can be conducted with large sample size, can be done in different populations and with different outcome measures. Studies can also be done on ddifferent stages of ACLR rehab, sophisticated BFR equipment can be used in future studies, studies can be done in better understanding of nutrition and in-depth protocol including warm up, cool down with specified BFRRT regimes.

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