International
Journal of Medical and Exercise Science
(Multidisciplinary, Peer Reviewed and Indexed Journal)

ORIGINAL ARTICLE

TO COMPARE THE EFFECTIVENESS OF BLOOD FLOW RESTRICTIONS PROTOCOL VERSUS CONVENTIONAL EXERCISE PROTOCOL ON INCREASING MUSCLE STRENGTH FOR POST SURGERY REHABILITATION OF ACL INJURY

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ABSTRACT

Background: The Anterior Cruciate Ligament (ACL) is a vital structure within the knee joint, providing stability and facilitating smooth movement. As one of the most commonly injured ligaments, ACL tears can significantly impact an individual's quality of life, particularly for athletes and individuals who engage in high-demand physical activities. Objectives of the study are to compare the effectiveness of blood flow restrictions protocol versus conventional exercise protocol on increasing muscle strength for post-surgery rehabilitation of ACL injury. **Methodology:** Two groups Pre and Post-test Quadi-Experimental study design. 20 patients with 4th week postoperative rehabilitation ACL reconstruction age between years both males and females were selected. Group A received Blood Flow Restriction Exercise Protocol whereas Group B received Conventional Exercise Protocol. Outcome Measure: Numerical Pain Rating scale and Manual Muscle Testing were measured used by Interventions. Pre-test and post-test scores were compared, and results were tabulated. **Result:** Both groups showed significant improvement in muscle strength and reduce pain. The group A showed statistically significant improvement in muscle strength and reduced pain when compared to Group B ($p<0.0001$). **Conclusion:** The study demonstrated that the BFR Exercise Protocol led to an increase in muscle strength, a reduction in pain, and improved knee flexion in patients undergoing ACL postoperative rehabilitation. Thus, it was concluded that the BFR Exercise Protocol is an effective treatment for ACL rehabilitation than conventional exercise protocol.

Keywords: ACL postoperative rehabilitation, Blood Flow Restrictions Protocol, Conventional Exercise Protocol, Numerical Pain Rating scale, Manual Muscle Testing.

Received on 26th July 2025; Revised on 24th August 2025; Accepted on 27th August 2025
DOI:10.36678/IJMAES.2025.V11I03.12

INTRODUCTION

The Anterior Cruciate Ligament (ACL) is a vital structure within the knee joint, providing stability and facilitating smooth movement. As one of the most injured ligaments, ACL tears can significantly impact an individual's quality of life, particularly for athletes and individuals who engage in high-demand physical activities[1].

Blood Flow Restriction (BFR) training has emerged as a promising adjunct to traditional rehabilitation protocols. This innovative approach involves the use of cuffs or bands to restrict blood flow to the exercised limb, creating a hypoxic environment that stimulates muscle growth and strength gains. BFR training has shown promise in enhancing muscle hypertrophy and strength, particularly in scenarios where high-intensity exercise is contraindicated or challenging to implement[2].

Conventional exercise protocols for ACL rehabilitation typically involve a combination of strengthening exercises, flexibility training, and functional activities. These protocols often focus on targeting the quadriceps, hamstrings, and hip muscles to restore muscle balance and promote knee stability. While conventional exercise protocols have been effective in promoting recovery, there is ongoing interest in exploring innovative approaches, such as BFR training, to further optimize rehabilitation outcomes[3].

METHODS

The study was conducted at JKKMMRF College of Physiotherapy Outpatient Department. The patient was informed about the whole procedure and treatment method. A written consent was obtained from their voluntary participation in this study. There were 20 patients with ACL postoperative rehabilitation were selected based on the inclusion and exclusion criteria and they were divided into 2 Groups, Group A and Group B. Group A was treated with Blood Flow Restrictions Protocol and Group B was treated with Conventional Exercise Protocol on ACL postoperative rehabilitation. Numerical Pain Rating Scale (NPRS) and Manual Muscle Testing were used as outcome measures. Each patient was given a Physiotherapy program for 4 weeks duration. The pre and post treatment values were measured before and after 4 weeks for comparison.

Inclusion criteria were Group between 18 to 45 years, Both Female & Male, At 4th postoperative week of recovery, Quadriceps volume quantified after ACL reconstruction, Ability to perform to postoperative evaluation of leg, Underwent unilateral ACL reconstruction.

Procedures:

Group A: A Blood Flow Restriction (BFR) training program was implemented, consisting of a series of exercises including isometric quadriceps contractions, leg extensions, straight leg raises, half squats, and resistance walks using an elastic tube to give 10 weeks, where treatment started on postoperative week 4 and ends on week 10. The exercise protocol involved 3 sets of 10-15 repetitions, with a 30-60minute rest period between sets, performed once daily with minimal external loading.

Group B: A Conventional Exercise training program was implemented, consisting of a series of exercises including Knee sliding, isometric quadriceps contractions, leg

extensions, straight leg raises, half squats, high load Squat to give 10 weeks, where treatment started on postoperative week 4 and ends on week 10. The exercise protocol involved 3 sets of 15-20 repetitions, with a 30–60-minute rest period between sets, performed once daily with minimal external loading.

Statistical Analysis

Table 1: Descriptive statistics for Manual Muscle Testing (MMT) Group A and Group B

Group	MMT	Mean	Standard Deviations	Paired 't' value
Group A	Pre Test Post test	2.70 4.70	0.667	9.487
Group B	Pre Test Post Test	2.60 3.90	0.483	8.510

Descriptive statistic for Manual Muscle Testing in Group A shows That paired't' test values of pre vs post-test values of Group A was 9.487 at 0.05% level which was greater than tabulated 't' values 2.15. Group B shows that Paired 't' test values of pre vs post-test values of Group B was 8.510 at 0.05% Level which was greater than tabulated 't' values 2.15. This showed like there in significant difference between pre vs post-test results of Group A and Group B For MMT. This exposed that there was significant difference in post-test mean Values in response to MMT in Group A and Group B.

Table 2: MMT (Post Test Analysis)

MMT	Mean	Mean difference	Standard deviation	Unpaired 't' value
Group A	2.0	0.7	0.653	2.69
Group B	1.3			

The unpaired t-value of 2.69 exceeded the critical t-value of 2.05, indicating a statistically significant difference at the 0.05 level between the mean differences of Group A and Group B. The pre-test topost-test mean change in Group A was 2.0, while in Group B, it was 1.3, resulting in a mean difference of -0.7 between the two groups. These findings suggest a greater reduction in knee pain and improvement in strength in Group A compared to Group B following the intervention.

Table 3: Descriptive statistics for Numerical Pain Rating Scale (NPRS)– Group A and Group B

Group	NPRS	Mean	Standard deviations	Paired 't' value
Group A	Pre Test Post Test	5.60 2.30	0.483	21.6
Group B	Pre Test Post Test	5.50 4.10	0.516	8.573

Descriptive statistic for Numerical Pain Rating scale in Group A shows That paired't' test values of pre vs post-test values of Group A was 21.6 at 0.05% level which was greater than tabulated 't' values 2.15. Group B shows that Paired 't' test values of pre vs post-test values of Group B was 8.573 at 0.05% Level which was greater than tabulated 't' values 2.15. This showed as there in significant difference between pre vs post-test results of Group A and Group B for NPRS. This exposed that there was significant difference in post-test mean Values in response to NPRS in Group A and Group B.

Table 4: NPRS (Post Test Analysis)

NPRS	Mean	Mean difference	Standard deviation	Unpaired 't' value
Group A	3.30	1.9	0.97	3.1
Group B	1.40			

The unpaired t-value of 3.1 exceeded the critical t-value of 2.05, indicating a statistically significant difference at the 0.05 levels between the mean differences of Group A and Group B. The pre-test topost-test means change in Group

A was 1.9, while in Group B, it was 1.40, resulting in a mean difference of 4.7 between the two groups. These findings suggest a greater reduction in knee pain in Group A compared to Group B following the intervention.

RESULT

The study, which was conducted for 3 months period of intervention, based on statistical analysis the results of this study showed that There was significant improvement in both Groups. The result also showed that the subject who participated in experimental Group A showed good improvement in reducing pain, improving range of motion and muscle power function than in Group B.

DISCUSSION

The aim of this study was to compare the effectiveness of blood flow restrictions protocol versus conventional exercise protocol on increasing muscle strength for post-surgery rehabilitation of ACL injury. A total number of 20 subjects with the effectiveness of blood flow restrictions protocol versus conventional exercise protocol by Quasi sampling method after considering the inclusion and exclusion

criteria. The information contents were obtained from individually.Manual Muscle Testing and Numerical Pain RatingScale were taken as the parameter. Pre test data were collected for group A and group B for post-surgery rehabilitation of ACL injury patients were subjected to the effect of blood flow restrictions protocol versus conventional exercise protocol for a period of 6 weeks.The paired 't' test was used to compare the pre vs post test result of Group A and Group B separately.The unpaired 't' test was to compare the mean difference of Group A and Group B .

In the analysis and interpretation of manual muscle test between group A and group B

The unpaired t-value of 2.69 exceeded the critical t-value of 2.05, indicating a statistically significant difference at the 0.05 levels between the mean differences of Group A and Group B. The pre-test to post-test mean change in Group A was 2.0, while in Group B, it was 1.3, resulting in a mean difference of 0.7 between the two groups. These findings suggest a greater reduction in knee pain and improvement in strength in Group A compared to Group B following the intervention.

In the analysis and interpretation of numerical pain rating scale between group A and group B. The unpaired t-value of 3.1 exceeded the critical t-value of 2.05, indicating a statistically significant difference at the 0.05 level between the mean differences of Group A and Group B. The pre-test topost-test mean change in Group A was 3.30, while in Group B, it was 1.40, resulting in a mean difference of 1.9 between the two groups. These findings suggest a greater reduction in knee pain in Group A compared to Group B following the intervention.

Ohta et al. (2003) aimed to investigate the effectiveness of low-load resistance training combined with moderate blood flow restriction in patients following anterior cruciate ligament (ACL) reconstruction. The results demonstrated that incorporating moderate blood flow restriction into low-intensity resistance training is a beneficial method for initiating early muscle strengthening after ACL surgery[4].

Hughes et al. (2019) conducted a randomized clinical trial comparing BFR resistance training with conventional high-load resistance programs in patients recovering from ACL reconstruction. The findings showed that both approaches resulted in similar improvements in muscle size and strength. However, participants in the BFR group reported less knee pain and swelling, suggesting it may be more comfortable and effective in restoring function[5].

Physiological Effects of Blood Flow Restriction Exercises Protocol:

BFR training allows significant muscle hypertrophy using low-load resistance exercises (20–30% 1RM). The restriction of blood flow causes early fatigue and increased recruitment of fast-twitch muscle fibers, which stimulates muscle protein synthesis. The greatest advantage of BFR is strength improvement without loading the joint significantly. This makes it particularly useful post-ACL surgery where the knee joint needs to be protected.[7]BFR training results in elevated systemic hormones like Growth Hormone (GH) and Insulin-like Growth Factor-1 (IGF-1), which promote muscle repair and regeneration[6-8].

Physiological Effects of Conventional Exercise Protocol[9].

Conventional resistance training (60–80% 1RM) enhances neuromuscular coordination and muscle fiber size via mechanical overload.[9]Conventional protocols incorporate functional and mobility exercises that improve proprioception, balance, and coordination which are essential in ACL rehabilitation[10].

CONCLUSION

The study demonstrated that the BFR Exercise Protocol led to an increase in muscle strength, a reduction in pain, and improved knee flexion in patients undergoing ACL postoperative rehabilitation. Thus, it was concluded that the BFR Exercise Protocol is an effective treatment for ACL rehabilitation than conventional exercise protocol. Additionally, the Numerical Pain Rating Scale and Manual Muscle Testing were found to be reliable assessment tools for evaluating rehabilitation progress.

Acknowledgment: We are thankful close to all staffs those, given more Support Engaged in this study.

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