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Combined effect of blood flow restriction training and proprioceptive training on conservatively managed multi-ligament knee injury patient: A case report

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ABSTRACT

Purpose: The study aimed to determine the combined effect of blood flow restriction training and proprioceptive training on conservatively managed multi-ligament knee injury patients. *Background:* A multiple ligament knee injury is defined as a tear of at least two of the major four ligaments: The anterior cruciate ligament (ACL), the posterior cruciate ligament (PCL), the posteromedial corner (PMC), and the posterolateral corner (PLC). Multiple ligament knee injuries can occur as a result of both high-energy trauma, such as automobile collisions or falls from extreme heights, and low-energy trauma, such as sports injuries. Muscle weakness is typical in multiple ligament knee injuries; high-load resistance training is the most effective method of strengthening muscular strength and achieving muscle hypertrophy. On the other hand, high-load, high-intensity exercises may not be therapeutically appropriate in certain individuals requiring muscular building. *Clinical findings:* Clinical evaluation revealed quadriceps muscle atrophy and balance impairments. *Results:* The study found improvements in girth measurement, static and dynamic balance scores, and the Lysholm knee scoring scale. *Conclusion:* The case study demonstrated the benefits of proprioception neuromuscular facilitation and blood flow restriction training for the treatment of multi-ligament knee injuries, implying that this approach may be beneficial for people in terms of improving girth and function and that it can be used in conjunction with traditional rehabilitation.

Keywords: Blood flow restriction training, multi-ligament injury, proprioceptive neuromuscular facilitation

1. INTRODUCTION

Knee stability is largely dependent on the integrity of the surrounding

musculature; anterior instability of the knee occurs when the anterior cruciate ligament (ACL) is torn. The ACL is essential for appropriate knee function because it is the principal constraint on anterior tibial translation. It, along with the posterior cruciate ligament (PCL), determines the biomechanical course of the knee due to its strategic location near to the joint's central pivot and its unique design (Xie et al., 2021). A multiple ligament knee injury is defined as a tear of at least two of the major four ligaments: The anterior cruciate ligament (ACL), the posterior cruciate ligament (PCL), the posteromedial corner (PMC), and the posterolateral corner (PLC). Multiple ligament knee injuries can occur as a result of both high-energy trauma, such as automobile collisions or falls from extreme heights, and low-energy trauma, such as sports injuries.

Multiple ligament knee injuries account for < 0.02% of all orthopedic injuries in the general population; patients experience a significant loss of lower limb strength due to muscle atrophy and atherogenic inhibition (Held et al., 2020). Muscle weakness is typical in multiple ligament knee injuries; high-load resistance training is the most effective method of strengthening muscular strength and achieving muscle hypertrophy. On the other hand, high-load, high-intensity exercises may not be therapeutically appropriate in certain individuals requiring muscular building. Blood Flow Restriction Training (BFRT) is a strategy that combines low-intensity exercise with blood flow obstruction to create outcomes comparable to high-intensity exercise. It entails applying a pneumatic cuff (tourniquet) proximally to the muscle being trained.

It can be used on both the upper and lower limbs. The cuff is then inflated to a certain pressure in order to achieve partial arterial and total venous blockage. The patient is then instructed to undertake resistance exercises at a modest intensity of 20-30% of one repetition maximum (1RM), with high repetitions per set (15-30) and brief rest intervals (30 seconds) between sets. Athletes and leisure athletes utilize BFRT to achieve muscle growth. It can also be used in clinical populations where high-intensity exercises are not possible due to the stage of their ailment or pathology (Barber-Westin and Noyes, 2019; Hughes et al., 2019). The proprioceptive neuromuscular facilitation (PNF) theory is based on Neuromuscular Mechanisation. The work of sensory receptors is critical in improving the joint's motor range and the muscular-muscular compatibility of the muscle groups acting on it (Attito et al., 2018).

2. CASE PRESENTATION

After a traffic collision, the patient, a 34-year-old male civil engineer, was transported to the hospital with a right knee injury. The patient immediately felt the knee joint "giving way" after hearing a "popping" noise. A swelling and immovable knee was discovered during a clinical examination. There were no open wounds or symptoms of neurovascular diseases. MRI revealed a grade II tear of the anterior cruciate ligament, lateral collateral ligament, and posterior horn of the medial meniscus, as well as mild synovial effusion with partial tear and avulsion of the posterior cruciate ligament from its tibial attachment during hospitalization. The patient's injured leg was stabilized with a four-week cylindrical cast. The patient received physiotherapy rehabilitation three months after the injury. The patient complained of pain, instability, and atrophy when he arrived at the physiotherapy department. He had no prior complaints, addictions, or family history of such issues.

Clinical findings

Before the physical examination, the patient provided informed consent. During the general examination, the patient was completely conscious, cooperative, and aware of time, location, and person. He was likewise at ease in the supine, sitting, and standing postures. He was afebrile, with an abdominal-thoracic breathing pattern and rate of 21 breaths per minute and a pulse rate of 83 beats per minute. The patient was examined while lying flat, with both ASIS at the same level. Observation revealed quadriceps muscle atrophy and a normal gait for the patient. Tenderness and spasm were not detected on palpation.

The active knee range of motion on the affected (right) side was $0\text{-}110^0$, the passive range was $0\text{-}125^0$ with soft capsular end feel, and the range on the non-affected (left) side was $0\text{-}125^0$. On both the non-affected and affected sides, hip and ankle range of motion was normal. Before the intervention, the difference in girth measurement was 1cm at 3 inches above the midpoint of the patella and 3cm at 6 inches and 9 inches above the midpoint of the patella. Similarly, before the intervention, a balance and proprioception examination were performed, and a Lysholm scale score of 67 (fair) was obtained.

Therapeutic intervention

The patient's short-term therapy goals were to educate him, enhance his knee range of motion, quadriceps and hamstring muscle strength, and restore thigh girth. Long-term therapy goals included maintaining range of motion, strength, and girth. After a thorough evaluation and discussion of the patient's condition and BFRT indications, blood flow restriction training was introduced in the first session and continued on a daily basis throughout the rehabilitation process. The portable sphygmomanometer cuff was

wrapped around the top of his thigh and inflated to roughly 160 mm Hg; the patient was then instructed to complete the following exercises (Table 1), with 30 seconds of rest in between.

Table 1 Protocol for blood flow restriction training combined with proprioceptive exercises

Phase I (Week 1)	Description
Static quadriceps	*Hold for 10 seconds, Ten repetitions.*
Static hamstrings	*Hold for 10 seconds, Ten repetitions.*
Static glutes	*Hold for 10 seconds, Ten repetitions.*
Heel slides	*Ten repetitions.*
Bridging	*Ten repetitions.*
Hip flexion	*Ten repetitions.*
Hip abduction	*Ten repetitions.*
Hip extension	*Ten repetitions.*
Prone knee bend	*Ten repetitions.*
Dynamic quadriceps	*Ten repetitions.*
Heel raises (on a solid surface)	*Ten repetitions.*
Toe raises (on a solid surface)	*Ten repetitions.*
Unilateral stance (on a solid surface)	*Ten repetitions.*
Eye open and eye close (on solid surface)	*Ten repetitions.*
Mini squats	*Ten repetitions.*
Half Lunges	*Ten repetitions.*
PNF- Combination of isotonic	*Supine, the patient was requested to perform combined concentric, eccentric, and stabilising contractions of one group of muscles (agonists) without relaxation. There is no rest between the many sorts of muscular actions. This has been carried out 5-6 times.*
Phase II (Week 2)	Description
Continue the above exercises as described.	
Unilateral bridging	*Ten repetitions.*
Heel raises (on a foam surface)	*Fifteen repetitions.*
Toe raises (on a foam surface)	*Fifteen repetitions.*
Unilateral stance (on a foam surface)	*Fifteen repetitions.*
Eye open and eye close (on a foam surface)	*Fifteen repetitions.*
Squats	*Fifteen repetitions.*
Lunges	*Fifteen repetitions.*
PNF- Combination of isotonic	*Ten repetitions.*
Phase III (Week 3)	Description
Continue the above exercises as described	
Unilateral bridging	*Fifteen repetitions.*
Heel raises (on bosu ball)	*Fifteen repetitions.*
Toe raises (on bosu ball)	*Fifteen repetitions.*
Unilateral stance (on bosu ball)	*Fifteen repetitions.*
Squats (on bosu ball)	*Fifteen repetitions.*
Squat walking	*Two rounds.*
Lunge walking	*Two rounds.*
Eye open and eye close (on bosu ball)	*Fifteen repetitions.*
PNF- Combination of isotonic	*Fifteen repetitions.*

Figure 1: Concentric contraction

Figure 2: Isometric contraction

Figure 3: Eccentric contraction

Figure 4: Single leg stance

Figure 5: Squats

3. RESULTS

In the current research, a multi-ligament injury patient was trained for three weeks using a combination of blood flow restriction training, proprioception exercises, and traditional exercises. Girth measurements were taken on the affected lower limb at three, six, and nine inches above the midpoint of the patella, pre-intervention, and post-intervention, and revealed a difference of 1cm at the three-inch mark and 2cms at the six and nine-inch marks (Table 2). Romberg's test, Y-balancing test, and balance error scoring scale were used to examine balance and proprioception, which revealed statistical and clinical improvements post-intervention (Tables 3 and 4). Lysholm scale score also improved from 67 to 91 post-intervention (Table 5).

Table 2 Girth measurements

Girth measurement	Pre-intervention		Post-intervention
	Non affected side	Affected side	Affected side
3 inches above the midpoint of the patella	38 cm	37 cm	38 cm

6 inches above the midpoint of the patella	45 cm	42 cm	44 cm
9 inches above the midpoint of the patella	51 cm	48 cm	50 cm

Table 3 Clinical improvements in Balance and proprioception assessment

Balance and proprioception assessment	Pre-intervention		Post-intervention	
Static balance assessment	Eye open	Eye close	Eye open	Eye close
Romberg test	48 seconds	36 seconds	120 seconds	100 seconds
Balance error scoring scale				
Double leg stance (on a solid surface)	48 seconds	36 seconds	120 seconds	100 seconds
Single-leg stance (on a solid surface)	35 seconds	5 seconds	60 seconds	13 seconds
Tandem stance (on a solid surface)	38 seconds	7 seconds	65 seconds	20 seconds
Double leg stance (on foam surface)	40 seconds	37 seconds	68 seconds	60 seconds
Single leg stance (on foam surface)	18 seconds	5 seconds	40 seconds	7 seconds
Tandem stance (on foam surface)	34 seconds	5 seconds	74 seconds	45 seconds

Table 4 Clinical improvements in Balance and proprioception assessment

Balance and proprioception assessment	Pre-intervention		Post-intervention
Dynamic balance assessment	Affected side	Non-affected side	Affected side
Y- balance test			
Anterior	76.2 cm	76.2 cm	76.5 cm
Posteromedial	69.8 cm	72.3 cm	72.0 cm
Posterolateral	73.6 cm	73.6 cm	73.8 cm

Table 5 Lysholm scale assessment

Lysholm scale score	Pre-intervention	Post-intervention
	67 (Fair)	91 (Excellent)

4. DISCUSSION

The ability to relieve shearing and torsional pressures on the ACL with ground contact is essentially dependent on quadriceps strength, which is critical in ACL rehabilitation. Thigh muscular atrophy is a serious side effect of ACL injury and subsequent surgery that causes thigh muscle weakness in the first 12 weeks after surgery and can linger for more than 2 years. ACL surgery involves a number of short- and long-term consequences, including decreased protein synthesis, muscle mass loss, difficulty activating muscles, an increased incidence of osteoarthritis, and recurrence. Muscle atrophy cannot be avoided due to the limited weight-bearing and unloading environment during ACL rehabilitation. Previous studies have shown that using an occlusion cuff and blood flow restriction training in conjunction with low-intensity resistance training can help restore the femoral muscle cross-sectional area following an ACL repair.

However, no research has been conducted on individuals with multi-ligament injuries who are being handled conservatively. Finding ways to promote muscular strength and growth without putting undue strain on the tibiofemoral joint seems plausible in order to assure successful rehabilitation and decrease the healing period. Blood flow-restricted exercise may provide a viable solution to this problem because the weights required to generate physiological improvements in muscle strength and growth are lower than what is generally used (Relph and Herrington, 2016). In the current study, a multi-ligament injury patient was trained for three weeks (six times per week) with blood flow restriction training, proprioception exercises, and conventional training.

Following the intervention, the participant's girth and proprioception improved significantly, and this change was reflected in the patient-reported knee outcomes.

There were no adverse incidences throughout training. It is hypothesised that the reduced blood flow creates an ischemic/hypoxic environment, which increases metabolic stress, recruits more fast-twitch muscle fibres, elevates systemic hormones, induces cell swelling, and produces more reactive oxygen species (De-Freitas et al., 2017; Ruas et al., 2018; Hughes et al., 2019). It has been reported that combining BFR and low-intensity resistance exercise (frequently defined as exercise performed below 30% maximal effort) induces physiologic responses that are somewhat similar to high-intensity exercise (>70% maximal effort) in terms of exercise-induced muscle anabolism and various improvements in muscle performance (e.g., functional capacity, strength). The ability to provide an appropriate exercise stimulus with a lower mechanical load, which may be undertaken in the early phases following injury or in the early postoperative period after surgery, is of clinical interest in these phenomena.

Skeletal muscle has also been observed to release a range of myokines during intense activity, which can function in an autocrine, paracrine, or endocrine manner. Lactate and CO2 are examples of metabolites that are generated and released into the circulation. As a result, it is claimed that releasing these effectors into the bloodstream immediately after the occlusive stimulus may improve anabolism (for muscle, bone, and connective tissue) both locally and systemically. For example, in response to increases in systemic lactate concentrations, BFRT has been shown to acutely increase systemic growth hormone (GH) release similar to high-intensity exercise (Hedt et al., 2022; Gao et al., 2023).

5. CONCLUSION

The case study demonstrated the benefits of proprioception neuromuscular facilitation and blood flow restriction training for the treatment of multi-ligament knee injuries, implying that this approach may be beneficial for people with multi-ligament knee injuries to expedite the results of physiotherapy because these individuals have muscular atrophy and balance issues. This method is a safe and effective way to enhance girth and function, and it can be employed in conjunction with standard rehabilitation.

Abbreviations

BFRT: Blood Flow Restriction training
ACL: Anterior cruciate ligament
PCL: Posterior cruciate ligament
PLC: Posterolateral corner
PMC: Posteromedial corner
MLKI: Multiple ligament knee injury

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Author contributions

All authors contribute equally for manuscript work & production.

Informed consent

Written and oral informed consent was obtained from patients included in the study.

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Conflict of interest

The authors declare that there is no conflict of interest.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

REFERENCES AND NOTES

1. Attito AA, El-Awady OE-E, Nicoleta C. Effects of proprioceptive neuromuscular facilitation (pnf) method on functional abilities for gymnasts with cruciate ligament 2018; 18(1):10-16.
2. Barber-Westin S, Noyes FR. Blood Flow-Restricted Training for Lower Extremity Muscle Weakness due to Knee Pathology: A Systematic Review. Sports Health 2019; 11(1): 69–83. doi: 10.1177/1941738118811337
3. De-Freitas MC, Gerosa-Neto J, Zanchi NE, Lira FS, Rossi FE. Role of metabolic stress for enhancing muscle adaptations: Practical applications. World J Methodol 2017; 7(2):46–54. doi: 10.5662/wjm.v7.i2.46
4. Gao B, Li L, Shen P, Zhou Z, Xu P, Sun W, Zhang C, Song Q. Effects of proprioceptive neuromuscular facilitation stretching in relieving pain and balancing knee loading during stepping over obstacles among older adults with knee osteoarthritis: A randomized controlled trial. PLoS One 2023; 18(2):e0280941. doi: 10.1371/journal.pone.0280941
5. Hedt C, McCulloch PC, Harris JD, Lambert BS. Blood Flow Restriction Enhances Rehabilitation and Return to Sport: The Paradox of Proximal Performance. Arthrosc Sports Med Rehabil 2022; 4(1):e51–e63. doi: 10.1016/j.asmr.2021.09.024
6. Held MFG, North D, Bormann RBV, Wascher DC, Richter DL, Schenck RC. Advances and trends in multi-ligament injuries of the knee relevant to low-resource settings. JASSM 2020; 1(1):118–125. doi: 10.25259/JASSM_16_2020
7. Hughes L, Rosenblatt B, Haddad F, Gissane C, McCarthy D, Clarke T, Ferris G, Dawes J, Paton B, Patterson SD. Comparing the Effectiveness of Blood Flow Restriction and Traditional Heavy Load Resistance Training in the Post-Surgery Rehabilitation of Anterior Cruciate Ligament Reconstruction Patients: A UK National Health Service Randomised Controlled Trial. Sports Med 2019; 49(11):1787–1805. doi: 10.1007/s40279-019-01137-2
8. Relph N, Herrington L. The effect of conservatively treated acl injury on knee joint position sense. Int J Sports Phys Ther 2016; 11(4):536–543.
9. Ruas CV, McManus RT, Bentes CM, Costa PB. Acute Effects of Proprioceptive Neuromuscular Facilitation on Peak Torque and Muscle Imbalance. J Funct Morphol Kinesiol 20 18; 3(4):63. doi: 10.3390/jfmk3040063
10. Xie T, Han X, Zhou S, Zhu L, He Q. A case report of multi-ligaments injury of the ACL-MCL-PT combined with an occult fracture of the posterolateral tibial plateau. Trauma Case Rep 2021; 33:100457. doi: 10.1016/j.tcr.2021.100457