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Physiotherapy Management combined with Blood Flow Restriction: A single case study

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Abstract
The optimum long-term treatment for patellofemoral pain is uncertain, although current assessments and treatments emphasize physiological functioning and education above biological or tissue pathology. The 27-year-old man experienced patellofemoral pain for four years despite little physiotherapy management. Many doctors urged him to avoid excessive exertion, stopping him from enjoying sports. A month of 12 physiotherapy management and Blood Flow Restriction treatments reduced the patient's symptoms by 1%. This case study highlights the necessity for more significant research on patellofemoral pain workouts with physiotherapy and blood flow constraints.

Keywords: Patellofemoral pain; blood flow restriction; physiotherapy management; muscle physiology

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1.0 Introduction

Patellofemoral pain (PFP) is severe and limits function. At any given time, 1 in 6 young people seek medical assistance. The symptoms encourage people to avoid exercising, which causes fear and worry (Fuhad et al., 2023). The long-term outlook is dismal because 91% of patients have discomfort and disability after diagnosis. Strengthening exercises reduce pain and impairment best (Smith et al., 2018). A recent study indicated that the optimal long-term patellofemoral pain (PFP) treatment is unknown (Fuhad et al., 2023). A proposal advises focusing assessment and therapy on physiological pain and education rather than biomedical/tissue pathology (Fuhad et al., 2023). Pain-inducing exercises reduce fear avoidance and catastrophic thoughts and improve pain and physical function (de Oliveira Silva et al., 2019; Fuhad, 2022). This case study explains how to examine and treat a patient with severe and debilitating patellofemoral pain (PFP) that has not improved with physiotherapy.

2.0 Case Description

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2.1 Patient history

A 27-year-old male sought medical attention for chronic pain in the front of his left kneecap that had been present for one year. The symptoms developed slowly for months, remained constant, and were not the result of any physical harm. The symptoms were intermittent but consistently unpleasant, including ascending and descending stairs, rising from a chair, sitting for over 30 minutes, and walking. Resting and avoiding sitting with bent knees for more than 30 minutes relieved the problems. The patient participated in multiple sporting activities before developing knee pain, which he gradually reduced over several months. He worked as a junior physiotherapist and participated in cheerleading part-time, regularly participating in physical activity. He wanted to get back to cheering, swimming, and cycling but could not due to substantial discomfort, worries about worsening his condition, and advice from several healthcare professionals to avoid uncomfortable activities.

Four years ago, the patient consulted an orthopaedic physician, who diagnosed them with osteochondritis dissecans of the patella. The patient reported persistent symptoms, and bilateral X-rays at that time showed no abnormalities. The instruction is that the patient avoid certain activities and not bend the knee beyond a 90-degree angle, which he has followed diligently. Previous physiotherapy treatment included stretching and strength exercises for the lower limbs and foot orthotics, but this did not improve. He stopped wearing the insoles years ago. The patient said that previous healthcare providers had recognised his incorrect foot posture and weak muscles around the patella as reasons for his pain. The patella was misaligned due to the interaction of these two factors, leading to elevated pressure behind the patella. The patient was in excellent health and had no noteworthy medical background. He reported that his knee had no episodes of locking or instability.

2.2 Examinations

2.2.1 Subjective Assessment

A 10-cm horizontal line was assessed for patellofemoral knee discomfort 24 hours after the testing session. The far left is 'pain-free.' The far-right signifies severe pain. The specified value was measured using a standard ruler and converted into a pain score. The VAS has been confirmed reliable in previous studies and used with individuals suffering from PFPS (Begum et al., 2019). Initially, the patient's pain level was rated at six on the Visual Analogue Scale (VAS) and decreased to 2 after 12 visits.

2.2.2 Objective Assessement

The patient's walking pattern, posture, and lower limb alignment were within normal parameters during observation. His foot position was not systematically measured, but it was evaluated to have a somewhat typical appearance. The patient did not experience any pain while at rest, and an examination of the knee showed no signs of swelling, bruising, or evident bone abnormalities. A first assessment revealed that the patient could bend and extend both knees completely. The individual had mild to severe pain behind the kneecap during the last stages of regular bending of the knee. The patella's location and mobility were determined to be within normal parameters during the knee's physiological range of motion assessment. Examination of the knee revealed the absence of discomfort with palpation of the patella tendon and an absence of tenderness along the joint line. The repetitive movements of the spine did not cause any pain, and there were no indications of any alarming symptoms that could signal a systemic disease or sudden sickness.

2.2.3 Experimental Assessment

2.2.3.1 Handheld dynamometer

The Handheld Dynamometer estimates the maximal power applied and the time required for muscular exhaustion. It gives trustworthy, accurate, and uniform measurements of muscular strength that can be employed in conjunction with different manual muscle testing approaches. The examiner uses a portable, small-sized device on the patient's limb as they execute a maximum static muscular contraction. The technology can evaluate the muscles placed proximally and distally from the body's axis in all extremities. In their work, Mentiplay et al. (2015) did a concurrent validity analysis and identified substantial connections between handheld dynamometry (HHD) and fixed dynamometry for the hip and knee. The intraclass correlation coefficients (ICCs) were determined to be 0.70, indicating a moderate to strong association. The results imply that the Handheld Dynamometer (HHD) demonstrates remarkable reliability and validity in assessing isometric lower limb strength and power in healthy adults (Mentiplay et al., 2015).

2.2.3.2 Muscle performance

a) Anteriormedial lunge left and right

   The individual is positioned behind a start line for the anteromedial lunge. The test involves the individual lunging forward with the uninvolved limb, causing the front leg to bend to 90 degrees and cross the midline. The individual must uphold proper balance and a straight posture of the trunk. The distance is calculated from the starting line to the heel of the leading limb in the lunge-out position. The most significant distance from 3 trials is measured and noted. 80% of the maximum distance is measured and indicated with tape as the aim for the timed lunges. The participant is instructed to perform as many lunges as feasible within 30 seconds, excluding any lunges below the 80% threshold. Any deviation from the motion route or additional steps taken by the subject will result in excluding the lunge from the count. Test the limb in question by comparing it to the 80% mark of the unaffected limb..

b) Step down left and right.

c) The step-down test is conducted unilaterally from an 8-inch (20.32 cm) high platform. Subjects move downward towards the floor. The lower leg lightly touches the floor with the heel before fully extending the knee, considered one repeat. Each repeat must be done so that the stepping limb is not used to speed up returning to the step. The amount of times the subject completes an action within a 30-second timeframe is documented. Both limbs are examined.
d) Bilateral Squat
e) Subjects begin the test by standing with their knees fully extended, shoulder-width apart, and weight evenly distributed on both legs. Subjects bend to a knee position of 90 degrees and straighten back to full extension. One repetition involves a complete cycle of standing straight, bending the knees to 90 degrees, and returning to a standing position. The quantity of bilateral squats performed within a 30-second timeframe is documented.
f) Balance and reach
The subject commences the test from a starting line. The individual extends one leg forward, ensuring the heel touches the floor while keeping most body weight on the rear leg. Testing begins with the limb that is not participating. The distance is calculated from the starting line to the heel of the front limb. The most significant distance from 3 trials is measured and noted. 80% of the maximum distance is measured and indicated with tape. The subject performs balance-and-reach lunges as often as feasible throughout a 30-second test period. Only lunges where the subject's heel extends past the 80% mark are documented. Test the affected limb using 80% of the strength of the unaffected limb.

2.2.3.3 Real-time Ultrasound

a) Bulk Muscle

Kishigami et al. (2022) conducted measurements to determine the thickness of the rectus femoris (RF), vastus lateralis (VL), vastus intermedius (VI), and vastus medialis (VM) muscles. Compute Pearson's correlation coefficient (r) and Spearman's correlation coefficient (rho) to compare the ultrasonic thickness measurements of these muscles with the MRI muscle thickness data. The thickness of the superficial quadriceps and hamstring muscles in persons with patellofemoral pain syndrome (PFPS) determined by MRI is similar to the measurements obtained using real-time ultrasonography.

b) Muscular flexibility

The patient lying on their back with their hip and knees in a straight position while rotating the lower limb internally or externally is essential to thoroughly evaluating the muscle's lateral or medial side. The examination with a moderate-to-high-frequency transducer can be conducted depending on the muscle's thickness. A practical quality management system assessment using a multifrequency (5–12 MHz) linear transducer may be accomplished. A 5-MHz transducer is recommended for better visualisation of deep planes in cases of significant muscular hypertrophy (Pasta et al., 2010).

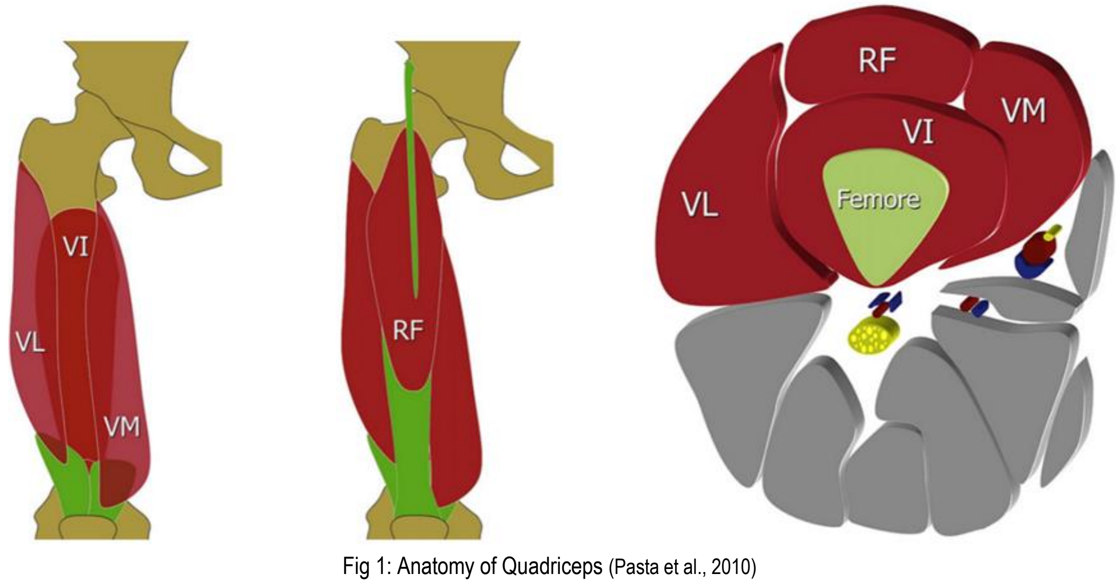

Fig 1: Anatomy of Quadriceps (Pasta et al., 2010)

3.0 Evaluation

Based on the examination, the patient's indications and symptoms were symptomatic of PFP. He experienced discomfort when pressure on the patellofemoral joint was applied. The patella tendon displayed no pain following palpation, yet the subject expressed signals of worry and unease towards movement and physical exertion. The evaluation of this patient using the outcome measure in the questionnaire below:

3.1.1 KOOS-PF (Quality of Life evaluation)

The KOOS-PF subscale evaluates pain and functionality in the patellofemoral joint. The 11-point KOOS-PF, developed in collaboration with healthcare experts, has shown reliable measurement properties and is endorsed for clinical and research use in individuals with patellofemoral pain.

3.1.2 Tampa Scale (Kinesiophobia)

The Tampa Kinesiophobia Scale (TSK) is a self-administered questionnaire designed to assess an individual's fear of pain caused by movement when experiencing musculoskeletal discomfort. The TSK-11 is a dependable and accurate tool that provides doctors with valuable insights into patients' avoidance of physical activity and shifts in their focus on body sensations when dealing with musculoskeletal pain (Weermeijer & Meulders, 2018).

4.0 Intervention

The physiotherapy exercise combines resistance training and blood flow restriction (BFR) techniques, which enhance patellofemoral pain (PFP) improvement. The selected exercises in the regimen are described below.

a) Incorporate RECOVERFUN AIR CUFF WITH PUMP into the workout regimen specified below.
b) Straps encircling the nearest section of the limbs
c) Bilateral blood occlusion pressure (LOP) accounts for 80% of the total. The LOP is the lowest pressure to halt arterial blood flow into a leg beyond the tourniquet. LOP is usually determined manually by Doppler ultrasound or calculated using available prediction equations.
d) 10-minute intervention followed by a 5-minute rest period while seated, measured with a timer.
e) Perform hold for 10 seconds, rest for 5 seconds with 15 repetitions each. Use the Interval timer app for better timing.

<table>
<tr><td>
</td><td>Static arch exercise
1. Lie on the back and place a bolster underneath the knee.
2. Press down both kneecaps and raise the feet without raising the leg.
3. Press down both kneecaps and raise one of the feet without raising the leg. Do it alternately.
4. Work for 10 seconds, rest for 5 seconds, and repeat 15 sets.</td></tr>
<tr><td>
</td><td>Vastus medialis exercise
1. Lie on the back and do a straight leg raise at 45 degrees.
2. Rotate the feet outward.
3. Work for 10 seconds, rest for 5 seconds and repeat 15 sets.</td></tr>
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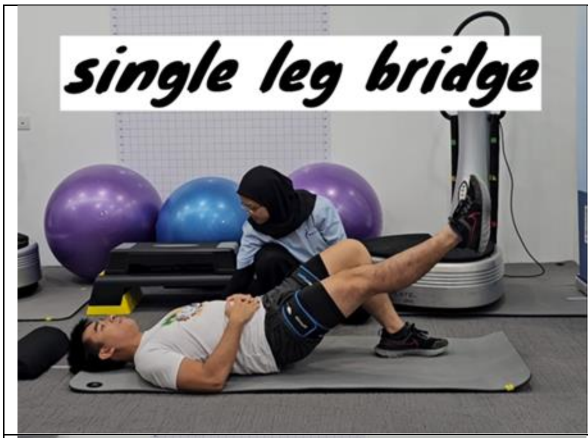
<tr>
<td>
</td>
<td>Single leg bridge

1. Lie on the back and bend the knees.
2. Inhale slowly and let the abdomen blow out.
3. Exhale slowly and let the abdomen cave in while lifting the buttock and lifting out one leg on the opposite knee. Breathe out. Do it alternately
4. Work for 10 seconds, rest for 5 seconds and repeat 15 sets.</td>
</tr>
<tr>
<td>
</td>
<td>Abductor SLR

1. Lie on the side and do a straight leg raise at 45 degrees.
2. Work for 10 seconds, rest for 5 seconds and repeat 15 sets.
3. Fig 2:Physiotherapy exercise and Blood Flow restriction</td>
</tr>
</table>

Fig 2:Physiotherapy exercise and Blood Flow restriction

4.1 Follow up.

Performing a follow-up exercise program three times a week for four weeks aims to sustain and enhance the progress made during the first therapy..

Physical Assessment

Posture

(walking pattern, posture, and lower limb alignment)

↓

Screening

- Numerical pain
- KOOS-PF
- Handheld dynamometer
- Knee muscle performance test
- Ultrasound screening
- Tampa Scale

↓

Physical training program

- Incorporate RECOVERFUN AIR CUFF WITH PUMP into the workout regimen specified below.
- Straps encircling the nearest section of the limbs
- Bilateral blood occlusion pressure (LOP) accounts for 80% of the total. The LOP is the lowest amount of pressure needed to halt arterial blood flow into a particular leg beyond the tourniquet. LOP is usually determined manually by Doppler ultrasound or calculated using available prediction equations.
- 10-minute intervention followed by a 5-minute rest period while seated, measured with a timer.
- Perform hold for 10 seconds, rest for 5 seconds with 15 repetitions each. Use the interval timer app for better timing
- of rest periods while seated, measured with a timer.
- Perform hold for 10 seconds, rest for 5 seconds with 15 repetitions each.

5.0 Results

Table 1: Pre Post Treatment and Improvement

Variables	Pre		Post		% of improvement	
	Right	Left	Right	Left	Right	Left
Strength (kg)						
Hamstrings	35	38.33	43.3	40	1.23	1.04
Quadriceps	49.3	41.6	53.3	50	1.08	1.20
Muscle Bulk						
RF	15.90	11.21	17.09	12.89	1.07	1.14
VL	14.61	11.54	14.87	16.67	1.01	1.44
VMO	27.56	17.09	27.73	24.44	1	1.43
VI	12.89	15.28	16.68	17.23	1.29	1.12
Muscle Length (mm)						
RF	191	191.87	192.11	193.41	1	1
VL	191.38	191.75	190.74	152.72	-0.99	-0.79
VMO	191.44	193.16	193.01	192.35	1	-0.99
VI	191.22	192.77	194.10	192.20	1.02	-0.99
Muscle Performances						
Anteriormedial lundge	15 rep	16 rep	20 rep	22 rep	1.33	1.38
Step Down	30 rep	35 rep	40 rep	45 rep	1.33	1.29
Bilateral Squat	20 rep	24 rep	30 rep	30 rep	1.5	1.25
Balance and Reach	56cm	60cm	60cm	60cm	1.07	1

5.1 Muscle strength

The patient has shown an increase in muscle strength in both the Quadriceps and Hamstrings

5.2 Muscle bulk and muscle length

According to the findings, the patient has exhibited an augmentation in muscle mass but reduced muscle flexibility. Previous research has demonstrated that excessive muscle growth can restrict the complete movement of nearby joints. This limitation in flexibility has been associated with higher muscle mass and strength (Gao et al., 2023).

5.3 Muscle performance

The patient saw a significant 1% reduction in symptoms after attending 12 appointments in 1 month.

5.4 Quality of Life

The patient improved his quality of life experienced when kneeling and squatting after 12 sessions.

Table 2: KOOS PF Pre and Post

	Questionnaire	Pre	Post
1	How severe is your knee stiffness after exercise?	None	None
2	How often do you experience knee pain over the past week?	None	None
3	How often does the pain limit your activity?	None	None
4	Rising from sitting (including getting out of the car)	None	None
5	Kneeling	Moderate	None
6	Squatting	Moderate	None
7	Heavy household activities (including carrying and lifting)	None	None
8	Hopping/ jumping	None	None
9	Running/ Jogging	None	None
10	After sports and recreational activities	None	None

11	Have you ever modified your sport or recreational activities due to your knee pain?	Moderate	None

KOOS PF (Crossley et al., 2018)

5.5 Kinesiophobia

The patient did not suffer from Kinesiophobia.

Table 3: Tampa Scale for Kinesiophobia Pre and Post

	Questionnaire	Pre	Post
1	I'm afraid that I might injury myself if I exercise	Strongly disagree	Strongly disagree
2	If I were to try to overcome it, my pain would increase	Strongly disagree	Strongly disagree
3	My body is telling me I have something dangerously wrong	Strongly disagree	Strongly disagree
4	My pain would probably be relieved if I were to exercise	Strongly disagree	Strongly disagree
5	People are not taking my medical condition seriously enough	Strongly disagree	Strongly disagree
6	My accident has put my body at risk for the rest of my life	Strongly disagree	Strongly disagree
7	Pain always means I have injured my body	Strongly disagree	Strongly disagree
8	Just because something aggravates my pain does not mean it is dangerous	Strongly disagree	Strongly disagree
9	I am afraid that I might injure myself accidentally	Strongly disagree	Strongly disagree
10	Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening.	Strongly disagree	Strongly disagree
11	I would not have this much pain if there were not something potentially dangerous going on in my body.	Strongly disagree	Strongly disagree
12	Although my condition is painful, I would be better off if I were physically active.	Strongly disagree	Strongly disagree
13	Pain lets me know when to stop exercising so that I don't injure myself	Strongly disagree	Strongly disagree
14	It is really not safe for a person with a condition like mine to be physically active.	Strongly disagree	Strongly disagree
15	I can't do all the things normal people do because it's too easy for me to get injured.	Strongly disagree	Strongly disagree
16	Even though something is causing me a lot of pain, I don't think it's actually dangerous.	Strongly disagree	Strongly disagree
17	No one should have to exercise when he/she is in pain	Strongly disagree	Strongly disagree

Tampa Scale (Pool et al, 2009; Rozmiarek et al., 2022)

6.0 Discussion

Physiotherapists and sports trainers may use blood flow restriction (BFR) training to improve rehabilitation outcomes in various clinical populations. This innovative method uses a tourniquet or cuff on the top half of a limb to partially limit arterial blood flow and entirely block venous blood flow during exercise (Hornikel et al., 2023).

1) Enhanced Muscle Adaptations: BFR training has been shown to induce more significant muscle

BFR training has demonstrated superior muscular growth and strength increases compared to conventional resistance training, even with moderate loads (Geng et al., 2024; Hornikel et al., 2023). BFR induces metabolic stress and mechanical tension in the muscle by establishing a hypoxic environment, resulting in increased muscle protein synthesis and cellular adaptations (Geng et al., 2024; Hornikel et al., 2023). When integrated into physiotherapy treatments, BFR can expedite muscle recovery, especially in persons with muscular weakness or atrophy caused by injury, surgery, or lack of use.

2) Pain Management

BFR training induces analgesic effects by decreasing pain perception and enhancing pain tolerance both during and after physical activity, which is especially advantageous for those with chronic pain problems like patellofemoral pain syndrome or osteoarthritis, who may feel pain during traditional resistance training. BFR can enhance physiotherapy treatments by adjusting pain pathways and encouraging tissue repair to reduce pain and enhance function(Fuhad et al., 2023).

3) Quality of Life

Quality of life data from BFR trainees before and after the intervention is needed to examine how BFR affects quality of life. A favourable shift in this case study suggests enhanced quality of life; however, little evidence exists. BFR intervention was examined to see if it affects pain, functionality, and quality of life. The results show that this method improves pain intensity and everyday activity.

4) Kinesiophobia

Despite preliminary evidence that BFR training may reduce kinesiophobia, more research is needed to determine its exact effects and processes. BFR training should be studied for its long-term effects on kinesiophobia and compared to other therapies for movement and reinjury phobia. Interdisciplinary BFR training and psychological interventions may improve kinesiophobia management and recovery.

5) Evidence

Research shows that BFR training and physiotherapy improve outcomes more than traditional rehabilitation methods (Fuhad et al., 2023; Geng et al., 2024; Hornikel, 2023). BFR training reduces muscle blood flow during exercise, causing metabolic stress and mechanical tension. This process induces adaptive responses that boost muscle growth and performance even during low-intensity workouts.

6) Clinical practice
Integrating BFR with physiotherapy can enhance patient outcomes by improving muscle function, promoting tissue healing, and facilitating neuromuscular adaptation. This combined approach can expedite recovery, improve functional results, and boost patients' overall quality of life.

7) Limitations
This study was conducted using a case study methodology. The findings are constrained by a small and unrepresentative sample, which limits their applicability and generalizability to other contexts or groups.

8) Future Directions
More research is needed to determine BFR training's therapeutic advantages and the optimum regimens for varied patient demographics and medical issues. Long-term study is required to discover if BFR can sustain increases and prevent age-related muscle loss, ensuring its clinical acceptance and use. Physiotherapists should be encouraged to use evidence-based BFR training.

6.0 Conclusion

Combining blood flow restriction with physiotherapy can improve rehabilitation results and empower patients. This combination approach improves patient care and rehabilitation by inventing, cooperating, and applying evidence-based techniques.

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Paper Contribution to Related Field of Study

Research on physiotherapy exercise with BFR could provide insights into how this innovative approach can enhance rehabilitation and PFPS.

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