Blood Flow Restriction Training with Body-Weight Exercises for Hip Abductor Strengthening in Knee Osteoarthritis: A Case Series

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Abstract: ***Knee osteoarthritis (KOA) is commonly associated with pain, functional limitation, and lower-limb muscle weakness, including hip abductor weakness. Conventional high-load strengthening may be poorly tolerated by some individuals with KOA. This case series examined blood flow restriction (BFR) training combined with body-weight exercises for hip abductor strengthening in four adults with unilateral KOA. Participants completed three sessions per week for six weeks. Hip abductor strength, pain, WOMAC score, and hip abduction range of motion (ROM) were assessed before and after intervention. Improvements were observed in hip abductor muscle grades, pain, WOMAC scores, and mean hip abduction ROM. Pre-post changes in pain, WOMAC, and ROM were statistically significant; these analyses are considered exploratory because of the very small sample. The findings suggest that BFR combined with body-weight exercise may be a feasible low-load rehabilitation approach for selected patients. Larger controlled studies are required to determine the specific contribution of BFR.***

Keywords: Blood Flow Restriction; Knee Osteoarthritis; Hip Abductor Strengthening; Body-Weight Exercise; Rehabilitation

1. Introduction

Osteoarthritis is a common chronic musculoskeletal condition that contributes to pain, functional limitation, and loss of independence. The knee is a major weight-bearing joint affected by osteoarthritis. Knee osteoarthritis is characterized by progressive articular and periarticular changes and is commonly accompanied by pain after activity or weight-bearing, stiffness after inactivity, difficulty walking or climbing stairs, reduced muscle strength, and reduced functional capacity [1,3,4].

Individuals with knee osteoarthritis may demonstrate weakness of the hip abductors, particularly the gluteus medius. During gait, inadequate hip abductor force can contribute to pelvic drop and altered lower-limb mechanics. Hip abductor strength has been associated with functional mobility in people with knee osteoarthritis, supporting its clinical relevance [13,15].

Exercise-based management is an important component of knee osteoarthritis rehabilitation, and hip abductor strengthening has been supported by systematic review evidence [14]. Traditional strengthening commonly uses progressively increased external resistance; however, higher-load exercise may be difficult for patients with pain or limited exercise tolerance. BFR training provides a low-load approach in which a proximal cuff restricts limb blood flow during exercise, potentially increasing the training stimulus while limiting external load [5,16,19].

The present case series evaluated BFR training combined with body-weight exercises for hip abductor strengthening in patients with unilateral KOA, with additional assessment of pain, functional status, and hip abduction ROM.

2. Literature Survey

Tevald et al. reported reliable assessment of hip abductor strength and its association with function in people with knee osteoarthritis [15]. Thomas et al. reported beneficial effects of hip abductor strengthening in patients with knee osteoarthritis [14]. Ferraz et al. reported improvements in strength and physical function following resistance training with BFR in women with knee osteoarthritis [5]. Hughes et al. found a moderate overall effect of low-load BFR training on strength across clinical musculoskeletal populations [19].

Evidence is not uniformly conclusive. Segal et al. reported improvements with low-load training but did not demonstrate a clear additional strength benefit attributable specifically to BFR compared with low-load exercise alone [17]. Harper et al. reported feasibility of BFR resistance exercise in older adults with knee osteoarthritis [18]. Recent reviews and protocols emphasize promising clinical applications but also the need for standardized cuff parameters and larger controlled trials [8-12, 20-22].

3. Problem Definition

Patients with knee osteoarthritis may have hip abductor weakness, pain, and restricted mobility, while high-load strengthening may not be tolerated. There is therefore a clinical need for low-load strengthening strategies that can target hip abductor performance without requiring external resistance. This case series examined pre- to post-intervention changes following a six-week program of BFR combined with body-weight exercise.

4. Methodology/ Approach

Study design and setting. This was a case series using a quasi-experimental pre-test/post-test design. It was conducted at the Department of Physiotherapy, National Institute for Empowerment of Persons with Multiple Disabilities (Divyangjan), Chennai, between September and October 2025. The intervention and data collection period was six weeks.

Participants and sampling. Four participants aged 40–65 years with unilateral knee osteoarthritis were selected using convenience sampling. Based on the original eligibility wording, the eligible Kellgren–Lawrence category was grade 1; grade 2 or higher was not included. Both male and female participants were eligible. Exclusion criteria included peripheral vascular disease, hypertension, bilateral osteoarthritis, recent fracture, metabolic disorder, skin disease, cardiovascular disease, and recent corticosteroid or local injection for knee osteoarthritis. [This wording should be checked against the original clinical records before final submission if a different KL grade was actually used.]

Ethical procedure. Following institutional approval, participants were informed about the study and written informed consent was obtained before enrolment. Demographic and clinical information was collected and baseline assessment was completed before intervention.

Outcome measures. Hip abductor strength was assessed using Manual Muscle Testing (MMT). Pain was measured using the 10-cm Visual Analog Scale (VAS). The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used to assess pain, stiffness, and physical function. Hip abduction ROM was measured using a goniometer.

BFR procedure. A static BFR cuff was positioned at the proximal/upper part of the exercising thigh. Arterial occlusion pressure (AOP) was estimated using the study formula: $AOP = 47.1 + (0.53 \times \text{systolic blood pressure}) + (0.58 \times \text{thigh circumference}) + (0.45 \times \text{age}) - (4.3 \times \text{sex})$. The original records reported 60% AOP values of 91.7, 103.4, 106.1, and 97.3 mmHg for participants 1–4, respectively. The sex variable was entered according to the binary coding convention used for the source prediction equation; the exact numerical coding should be retained exactly as recorded in the original calculation sheet. Intervention cuff pressure was then prescribed as a percentage of each participant's estimated AOP, rather than using a single fixed pressure.

Intervention. Participants trained three days per week for six weeks (18 sessions), with each session lasting approximately 30–40 minutes. Weeks 1–2 used side-lying and standing hip abduction at 20–30% AOP. Weeks 3–4 added stepping and short-distance side walking at 30–40% AOP. Weeks 5–6 added longer-distance side walking and pain-free mini-squats at 40–60% AOP. Each exercise was performed for four sets using a 30/15/15/15 repetition pattern with approximately one minute rest between sets. Warm-up included standing hip circles and dynamic leg swings in a pain-free range. Cool-down included ankle-toe movements and deep breathing.

Statistical analysis. Data were entered and descriptively analyzed using SPSS. Paired-sample t-tests were used to examine pre- to post-intervention changes in VAS, WOMAC, and hip abduction ROM. With $n=4$ and no comparison group, these inferential analyses were treated as exploratory and were not interpreted as evidence of treatment efficacy. MMT findings were described using pre- and post-intervention grades.

5. Results

All four participants completed the six-week BFR body-weight exercise program. Hip abductor MMT grades improved in every participant: Participant 1 increased from grade 4 to grade 5, while Participants 2–4 increased from grade 3 to grade 4.

Pain improved across all four participants. VAS values decreased from 5.5 to 2 in Participant 1, 8 to 3 in Participant 2, 8 to 3 in Participant 3, and 7 to 3 in Participant 4. The group mean decreased from 7.1250 ± 1.18145 to 2.7500 ± 0.50000; paired $t=11.667$, $p=0.001$.

WOMAC scores decreased in all participants: 43/96 to 22/96, 66/96 to 25/96, 61/96 to 30/96, and 50/96 to 28/96. The group mean decreased from 55.0000 ± 10.42433 to 26.2500 ± 3.50000; paired $t=6.168$, $p=0.009$.

Hip abduction ROM increased in three participants and decreased in one participant (Participant 2: 48° to 44°). Overall, the mean increased from 38.2500 ± 2.36291° to 45.5000 ± 3.41565°; paired $t=-7.660$, $p=0.005$.

Table 1: Participant baseline characteristics and estimated occlusion pressure

Participant	Age (yr)	Thigh circumference	BP	Estimated AOP (mmHg)	60% AOP (mmHg)
1	40	40 cm	110/70	152.8	91.7
2	52	42 cm	110/70	172.4	103.4
3	50	45 cm	110/70	176.9	106.1
4	45	41 cm	110/70	162.2	97.3

Table 2: Six-week BFR body-weight exercise protocol

Phase	Weeks / exercises	BFR pressure	Sets/repetitions
Initiation	1–2: Side-lying & standing hip abduction	20–30% AOP	4 × 30/15/15/15
Progression	3–4: Hip abduction, stepping, short side walking	30–40% AOP	4 × 30/15/15/15
Advanced	5–6: Hip abduction, stepping, longer side walking, mini-squats	40–60% AOP	4 × 30/15/15/15

Table 3: Individual pre- and post-intervention outcomes

Participant	MMT	VAS	WOMAC	Hip abduction ROM
1	4→5	5.5→2	43→22	40°→50°
2	3→4	8→3	66→25	48°→44°
3	3→4	8→3	61→30	35°→42°
4	3→4	7→3	50→28	40°→46°

Table 4: Group pre- and post-intervention outcome summary

Outcome	Pre-test mean ± SD	Post-test mean ± SD	Paired t; p
VAS	7.1250 ± 1.18145	2.7500 ± 0.50000	11.667; 0.001
WOMAC	55.0000 ± 10.42433	26.2500 ± 3.50000	6.168; 0.009
Hip abduction ROM	38.2500 ± 2.36291°	45.5000 ± 3.41565°	−7.660; 0.005

6. Discussion

The present case series demonstrated improvement in hip abductor MMT grades, pain, WOMAC scores, and mean hip abduction ROM after six weeks of BFR combined with body-weight exercise. These findings are broadly consistent with literature supporting hip abductor strengthening in knee osteoarthritis [14,15] and with studies reporting beneficial strength and functional responses to low-load BFR exercise [5,19].

The reduction in pain and WOMAC scores may reflect the overall effects of structured therapeutic exercise and repeated participation in rehabilitation. Previous BFR research has suggested that low-load BFR can be useful when higher mechanical loads are difficult to tolerate [5,18-20]. However, Segal et al. found that low-load exercise itself may account for some of the observed improvement, without a clear additional strength advantage from BFR [17]. Therefore, the present results should be interpreted as preliminary observations rather than evidence that BFR alone produced the changes.

The individualized pressure prescription is an important methodological feature. The study used estimated AOP and progressed the intervention from 20–30% to 40–60% AOP across the six-week program. Contemporary literature emphasizes that BFR protocols vary in cuff width, pressure, and application, making transparent pressure reporting important for reproducibility [8,16,22].

The principal limitations are the sample size of four, uncontrolled pre-post design, short intervention period, and reliance on MMT for strength assessment. There was no non-BFR comparison group; consequently, changes cannot be attributed specifically to BFR. Natural variation, repeated testing, body-weight exercise, and other nonspecific effects may have contributed to the observed outcomes.

7. Conclusion

This case series demonstrated improvements in hip abductor strength, pain, WOMAC scores, and mean hip abduction ROM after six weeks of BFR training combined with body-weight exercise in four individuals with unilateral knee osteoarthritis. The intervention shows preliminary potential as a low-load rehabilitation option for selected patients. Because of the small sample and absence of a comparison group, controlled studies with larger samples are required to determine the specific efficacy and contribution of BFR.

8. Future Scope

Future studies should recruit larger samples and use randomized controlled designs with an appropriate comparison group. Longer follow-up is needed to determine whether gains are maintained. Researchers should standardize cuff width and pressure prescription, report the exact method used to determine AOP, and consider objective measures such as dynamometry or electromyography. Direct comparisons of BFR plus body-weight exercise with conventional strengthening and low-load exercise without BFR would help determine the specific contribution of BFR.

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