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IMPACT OF BLOOD FLOW RESTRICTION TRAINING (BFRT) VERSUS TRADITIONAL STRENGTH TRAINING IN KNEE OSTEOARTHRITIS ON PAIN AND QOL

Original Research

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ABSTRACT

Background: Osteoarthritis (OA) is the third leading cause of disability worldwide, significantly impacting pain, physical function, and quality of life (QoL). Among its types, knee osteoarthritis (KOA) is the most prevalent, affecting over 80% of individuals with OA. Effective conservative management is crucial for mitigating its physical and social burden. Exercise therapy, including strength training, has been widely utilized; however, the comparative efficacy of blood flow restriction training (BFRT) and traditional strength training remains underexplored.

Objective: This study aimed to compare the impact of BFRT and traditional strength training on pain and QoL in patients with KOA.

Methods: This randomized controlled trial was conducted between March 2024 and August 2024, enrolling 38 patients with KOA using a purposive sampling technique. Participants aged 40–70 years with clinically and radiologically confirmed KOA experiencing moderate-to-severe symptoms were included. Patients with contraindications to BFRT, such as vascular disorders or recent surgeries, were excluded. The interventions included BFRT with low-load resistance and traditional high-load strength training. Pain and QoL were assessed using the Visual Analogue Scale (VAS) and the Knee Injury and Osteoarthritis Outcome Score (KOOS), respectively. Ethical considerations were followed throughout the study, and SPSS version 24 was used for statistical analysis.

Results: Baseline VAS scores were 7.4 ± 1.1 for the BFRT group and 7.3 ± 1.2 for the traditional group ($p = 0.87$). Post-intervention, VAS improved significantly in both groups, with BFRT showing a greater reduction (3.2 ± 1.0) compared to the traditional group (4.5 ± 1.1, $p = 0.01$). KOOS scores improved from 48.6 ± 6.9 to 72.3 ± 7.5 in the BFRT group and from 47.9 ± 7.2 to 64.7 ± 8.1 in the traditional group ($p = 0.03$). Both groups demonstrated significant improvements, with BFRT showing superior results.

Conclusion: Both BFRT and traditional strength training significantly improved pain and QoL in KOA patients, with BFRT yielding more pronounced benefits. BFRT offers a promising low-load alternative for managing pain and enhancing QoL in individuals with KOA.

Keywords: Blood Flow Restriction Training, Exercise Therapy, Knee Osteoarthritis, Pain, Physical Function, Quality of Life, Strength Training.

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INTRODUCTION

Osteoarthritis (OA), a leading cause of disability worldwide, significantly impairs physical function, induces chronic pain, and diminishes the quality of life (QoL) for those affected. Among various forms of OA, knee osteoarthritis (KOA) is particularly prevalent, affecting over 80% of OA patients globally. In the United States, approximately 37% of individuals over the age of 60 are affected by KOA, and its impact is mirrored globally, with China reporting 968 years lived with disability (YLDs) per 100,000 individuals in 2012, of which 60% were attributed to those over 60 years of age. This chronic condition poses substantial social and economic burdens, with the rising prevalence of KOA necessitating cost-effective and sustainable treatment strategies (1, 2).

Although there is no definitive cure for KOA, the primary therapeutic goals include reducing pain, improving physical function, and enhancing QoL. Exercise therapy, being cost-effective, safe, and accessible, remains one of the most highly recommended non-pharmacologic treatments for KOA. Endorsed by the American College of Rheumatology, various exercise regimens, including resistance, aerobic, and aquatic exercises, have demonstrated significant efficacy. Among these, quadriceps strengthening exercises (QSE) have been particularly effective in alleviating joint pain and stiffness, offering both immediate and short-term benefits to KOA patients (3, 4, 5). However, adherence to exercise regimens is often suboptimal due to factors such as time constraints, program complexity, and lack of patient motivation, with nearly 44.2% of patients discontinuing their interventions prematurely. This highlights the need to identify exercise modalities that are not only effective but also sustainable in the long term (6).

KOA primarily manifests as progressive knee pain, leading to impaired joint function and restrictions in daily activities. Total knee arthroplasty (TKA), the standard surgical treatment, is often prohibitively expensive, emphasizing the importance of conservative approaches for managing KOA symptoms. Effective therapeutic strategies should address the systemic complications associated with KOA, such as inflammation and adipokine dysregulation, while also mitigating pain and improving functionality. Exercise interventions tailored to the individual's disease stage have shown potential to alleviate symptoms, though the optimal parameters of intensity, frequency, and duration remain inadequately defined in the literature. Current exercise prescriptions are often generic and fail to accommodate patient-specific needs, which limits their overall effectiveness (7, 8, 9).

Strengthening the extensor knee muscles is critical for alleviating pain and improving functionality in KOA patients. Traditional resistance training using high-load protocols, such as 12-repetition maximum (12RM), is effective for muscle hypertrophy and strength but may not be feasible for patients with joint pain. Blood flow restriction (BFR) training has recently emerged as an innovative alternative, enabling muscle growth and functional improvement with low-to-moderate load intensities. By temporarily restricting venous return and reducing arterial flow through pneumatic cuffs, BFR induces heightened metabolic stress in working muscles, facilitating strength gains without the need for high-resistance loads. This approach has shown promise for individuals who are unable to tolerate conventional high-resistance training due to pain or physical limitations, making it a potentially viable option for KOA management (10, 11, 12).

Despite its growing popularity, the specific effects of BFR training on critical outcomes such as pain relief, physical function, and QoL in KOA patients remain underexplored. While preliminary evidence suggests that BFR training could address the limitations of traditional resistance exercises, comparative studies evaluating its efficacy and safety relative to conventional strength training are limited. Therefore, this study aims to evaluate the effectiveness and reliability of blood flow restriction training compared to traditional resistance training in improving pain management and QoL in individuals with knee osteoarthritis. This research seeks to establish evidence-based recommendations for optimizing conservative management strategies for KOA patients (13, 14).

METHODS

This randomized controlled trial was conducted to evaluate the comparative efficacy of blood flow restriction training (BFRT) and traditional strength training in patients with knee osteoarthritis (KOA). A total of 38 patients were recruited using a purposive sampling technique from National Hospital Faisalabad, Moeen Physiotherapy Clinic, and Chiniot Hospital Faisalabad. The study was conducted over a six-month period from March 2024 to August 2024. Ethical considerations were strictly adhered to throughout the study, and all participants provided informed consent before enrollment.

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The inclusion criteria included patients aged 40–70 years with clinically and radiologically confirmed knee osteoarthritis presenting moderate to severe symptoms. Patients were excluded if they had contraindications to BFRT, such as vascular disorders or recent surgeries, ensuring the safety and homogeneity of the study population. The visual analog scale (VAS) for pain and the Knee Injury and Osteoarthritis Outcome Score (KOOS) were utilized as validated assessment tools to measure pain levels and quality of life, respectively.

Participants were randomly allocated into two groups: BFRT (n = 19) and traditional strength training (n = 19). Baseline demographic and clinical characteristics, including age, gender distribution, BMI, VAS, and KOOS scores, were assessed to ensure comparability between groups. The BFRT intervention involved low-load resistance training combined with intermittent pneumatic cuff-induced blood flow restriction, while the traditional group performed high-resistance quadriceps strengthening exercises without restriction. The interventions were administered under professional supervision, and adherence was monitored to ensure protocol fidelity.

The data were analyzed using SPSS version 24. Between-group and within-group comparisons were performed for outcome measures, with p-values < 0.05 considered statistically significant. While the methodology was rigorous, it is noteworthy that the purposive sampling technique used might limit the generalizability of the findings to a broader population. Additionally, no details regarding the randomization process, allocation concealment, or blinding of assessors were provided, which could introduce potential bias into the results.

RESULTS

The study included 38 participants evenly divided between the blood flow restriction training (BFRT) and traditional strength training groups. The mean age was 58.3 ± 6.1 years for the BFRT group and 59.1 ± 6.3 years for the traditional training group, with no significant difference between groups ($p = 0.65$). Gender distribution was equal in both groups, with 50% male and 50% female participants ($p = 0.75$). Similarly, body mass index (BMI) showed no significant difference, with the BFRT group having a mean BMI of 27.8 ± 3.4 kg/m² and the traditional training group 28.1 ± 3.6 kg/m² ($p = 0.82$). Baseline assessments for pain using the visual analog scale (VAS) and quality of life using the Knee Injury and Osteoarthritis Outcome Score (KOOS) were comparable, with p-values of 0.87 and 0.78, respectively.

Post-intervention analysis demonstrated significant improvements in both groups, with the BFRT group showing superior outcomes. The VAS score for pain reduced more markedly in the BFRT group, from 7.4 ± 1.1 at baseline to 3.2 ± 1.0, compared to a reduction from 7.3 ± 1.2 to 4.5 ± 1.1 in the traditional training group. This difference between groups was statistically significant ($p = 0.01$). Similarly, KOOS scores reflecting quality of life increased substantially in the BFRT group, from 48.6 ± 6.9 to 72.3 ± 7.5, while the traditional training group showed an increase from 47.9 ± 7.2 to 64.7 ± 8.1, with a statistically significant between-group difference ($p = 0.03$).

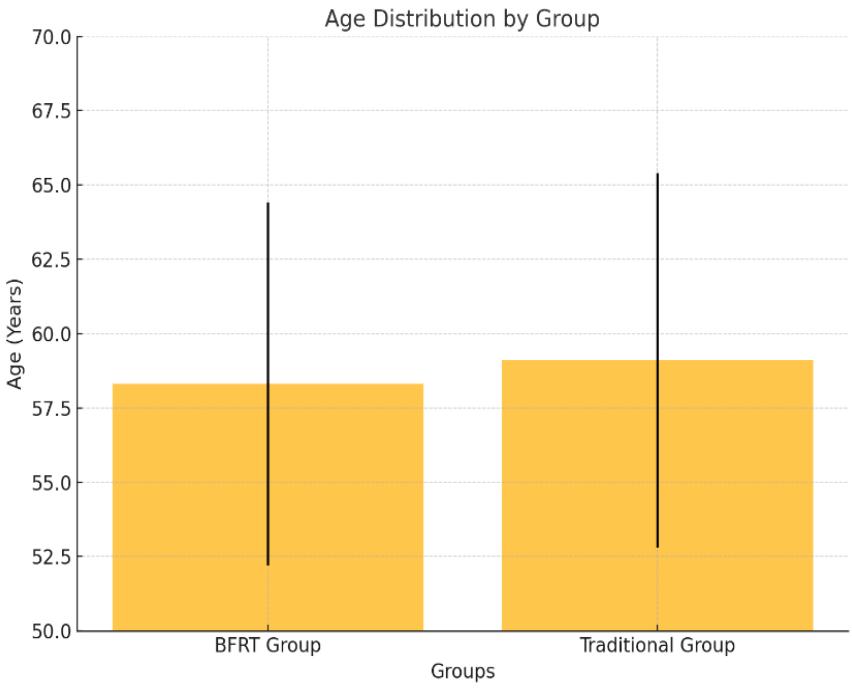
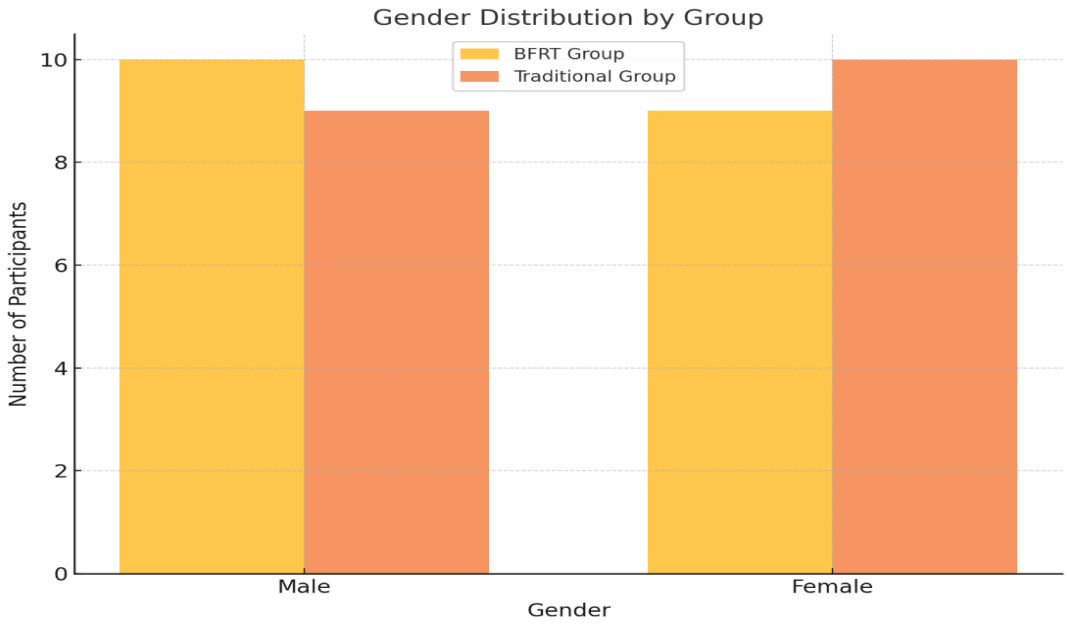


Figure 1 Age Distribution by Group

Within-group analysis revealed significant improvements in both interventions. The BFRT group demonstrated a mean VAS reduction of -4.2 ± 0.8 and a KOOS improvement of +23.7 ± 4.2, both with $p < 0.001$. The traditional training group showed less pronounced improvements, with a VAS reduction of -2.8 ± 0.9 and a KOOS improvement of +16.8 ± 5.3, both also statistically significant ($p < 0.001$). While both interventions were effective, BFRT yielded greater reductions in pain and improvements in quality of life.

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The chart above visualizes the gender distribution in the BFRT and Traditional Training groups, showing an equal male-to-female ratio in both groups.

Table 1: Baseline Characteristics of Participants

Variable	BFRT Group (n = 19)	Traditional Training Group (n = 19)	p-value
BMI (kg/m²)	27.8 ± 3.4	28.1 ± 3.6	0.82
VAS (Baseline)	7.4 ± 1.1	7.3 ± 1.2	0.87
KOOS (Baseline)	48.6 ± 6.9	47.9 ± 7.2	0.78

Table showed means was BFRT group 58.3 ± 6.1 and Traditional group 59.1 ± 6.3 and 50% were female and 50% were male.

Table 2: Comparison of Outcome Measures Between Groups

Outcome Measure	BFRT Group (Mean ± SD)	Traditional Group (Mean ± SD)	Mean Difference	p-value
VAS (Pain)				
Baseline	7.4 ± 1.1	7.3 ± 1.2	-	0.87
Post-intervention	3.2 ± 1.0	4.5 ± 1.1	1.3	0.01
KOOS (QoL)				
Baseline	48.6 ± 6.9	47.9 ± 7.2	-	0.78
Post-intervention	72.3 ± 7.5	64.7 ± 8.1	7.6	0.03

Table 2 revealed between group analysis was VAS score was baseline 0.87 and after intervention was 0.01 KOOS at baseline p value was 0.78 and after treatment results were p =0.03

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Table 3: Comparison of Outcome Measures Within Groups (n = 19 per group)

Outcome Measure	Group	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Mean Difference	p-value
VAS (Pain)	BFRT	7.4 ± 1.1	3.2 ± 1.0	-4.2 ± 0.8	<0.001
	Traditional Training	7.3 ± 1.2	4.5 ± 1.1	-2.8 ± 0.9	<0.001
KOOS (QoL)	BFRT	48.6 ± 6.9	72.3 ± 7.5	+23.7 ± 4.2	<0.001
	Traditional Training	47.9 ± 7.2	64.7 ± 8.1	+16.8 ± 5.3	<0.001

Within-group analysis revealed significant improvements in both interventions. In the BFRT group, the mean VAS pain score decreased substantially from 7.4 ± 1.1 at baseline to 3.2 ± 1.0 post-intervention, with a mean difference of -4.2 ± 0.8 ($p < 0.001$). Similarly, the KOOS quality of life score increased markedly from 48.6 ± 6.9 to 72.3 ± 7.5, showing a mean improvement of +23.7 ± 4.2 ($p < 0.001$). In the traditional training group, VAS scores also improved, declining from 7.3 ± 1.2 to 4.5 ± 1.1, with a mean difference of -2.8 ± 0.9 ($p < 0.001$). The KOOS scores in this group rose from 47.9 ± 7.2 to 64.7 ± 8.1, with a mean improvement of +16.8 ± 5.3 ($p < 0.001$). These results indicate that while both interventions were effective, BFRT led to more pronounced improvements in pain reduction and quality of life.

DISCUSSION

This study explored the comparative effects of blood flow restriction training (BFRT) and traditional strength training on pain reduction and quality of life (QoL) in patients with knee osteoarthritis (KOA), adding valuable evidence to the field of conservative management for this condition. Both interventions demonstrated significant improvements in these outcomes, with BFRT yielding superior results. These findings align with and extend prior research, including Ferraz et al., which emphasized the potential of BFRT to enhance clinical outcomes in KOA patients (15).

The marked pain reduction observed in the BFRT group, with a mean change of -4.2 ± 0.8, corroborates the findings of Patterson et al., who highlighted the analgesic effects of low-load exercises combined with vascular occlusion. This approach stimulates muscle hypertrophy while minimizing joint stress, an essential consideration for KOA patients with limited tolerance for high-intensity exercise (16). Additionally, the analgesic effects may be explained by the stimulation of endogenous pain modulatory mechanisms, such as the release of beta-endorphins and neuromodulators, as described by Wang et al. (2022), which aligns with the present study's outcomes (17). Traditional strength training also demonstrated significant pain relief, with a mean reduction of -2.8 ± 0.9, consistent with the findings of Nancekievill et al. (2023), which attributed pain reduction to enhanced periarticular muscle strength and joint biomechanics. However, the smaller magnitude of change suggests that conventional methods may be less effective in patients with advanced KOA (18).

The QoL improvements observed in the BFRT group, with a mean increase of +23.7 ± 4.2, further highlight its advantages. As noted by Segal et al. (2015), BFRT enhances mobility and participation in daily activities by strengthening muscles without imposing excessive mechanical stress on the joints. The traditional strength training group also demonstrated improvements in QoL, with a mean increase of +16.8 ± 5.3, consistent with findings by Bennell et al. (2017), which reported that resistance training improves functional capacity and self-efficacy. However, the more pronounced improvements in the BFRT group underscore its potential as a more effective intervention for patients with severe joint degeneration (19, 20).

This study's strength lies in its head-to-head comparison of BFRT and traditional training, offering insights into both interventions within a controlled framework. The inclusion of both objective (VAS) and subjective (KOOS) outcome measures ensured a comprehensive evaluation of physical and psychosocial rehabilitation aspects. However, limitations include the relatively small sample size and the lack of long-term follow-up data to assess sustained benefits and potential adverse effects. Moreover, while the study effectively highlighted the advantages of BFRT, the absence of a more detailed assessment of cost-effectiveness and patient adherence limits the practical

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applicability of the findings. These results contribute to the growing evidence base supporting the use of BFRT as a viable and potentially superior option for managing pain and improving QoL in KOA patients.

CONCLUSION

This study concluded that both blood flow restriction training (BFRT) and traditional strength training significantly improved pain levels and quality of life in patients with knee osteoarthritis. However, BFRT demonstrated superior outcomes, offering more pronounced reductions in pain and greater enhancements in quality of life. These findings underscore the potential of BFRT as an effective, low-load intervention for managing knee osteoarthritis, particularly for individuals with limited tolerance for high-intensity exercise. By addressing both physical and functional limitations, BFRT presents itself as a promising approach to improve the overall well-being of patients with knee osteoarthritis.

AUTHOR CONTRIBUTIONS

Author	Contribution
Muhammad Danial Baig Chughtai	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Baber Ikram	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Abdul Hannan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Umama Uzair	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aqsa Arif	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aleena Jafar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Resha Manahil	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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