Original Article

Effect of Blood Flow Restriction Training vs. Conventional Strength Training on Quadriceps Strength in Early Knee Osteoarthritis: A Randomized Controlled Trial

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ABSTRACT

Background: Knee osteoarthritis is a common musculoskeletal condition marked by quadriceps weakness and functional deterioration. Blood flow restriction training (BFRT) has emerged as a beneficial alternative to traditional high-load strength training, although comparable data in early knee osteoarthritis is sparse. The purpose of this study was to assess the effects of blood flow restriction training and traditional strength training on quadriceps strength, pain, and functional outcomes in patients with early knee osteoarthritis.

Methods: A randomized controlled experiment with two arms and parallel groups was done at Ikram Hospital in Gujarat, Pakistan. Sixty people with Kellgren-Lawrence grade I-II knee osteoarthritis were randomly assigned to receive either BFRT (20-30% of 1-RM with 60-80% arterial occlusion) or conventional strength training (CST; 70-80% of 1-RM) for 12 weeks (3 sessions per week). Quadriceps muscle strength, knee injury and osteoarthritis outcome score (KOOS), counter movement jump performance, and Timed Up and Go test were measured at baseline, 6 weeks, and 12 weeks, respectively.

Results: The study had 51 individuals (26 BFRT and 25 CST). The BFRT group outperformed the CST group in quadriceps strength (6.84 vs 4.78 Nm/kg, p=0.001), KOOS scores (17.38 vs 13.35 points, p=0.002), and countermovement jump height (4.87 vs 3.39 cm, p=0.001). There were no adverse events reported in either group.

Conclusion: In patients with early knee osteoarthritis, blood flow restriction training with low-load resistance exercises improved muscle strength, pain, and functional performance more than conventional high-load strength training, while remaining safe and tolerable.

Keywords: *Knee Osteoarthritis, Muscle Strength, Pain, Quadriceps Muscle, Resistance Training.*

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INTRODUCTION

Knee osteoarthritis (KOA) is one of the most common musculoskeletal illnesses worldwide, characterized by articular cartilage deterioration, chronic pain, stiffness, and decreased joint function. The global burden of KOA has continuously increased over the last two decades, with an anticipated 374 million persons affected by 2021 and an age-standardized prevalence rate of 4,294 per 100,000 people.[1] The condition primarily affects elderly individuals, women, and those who are obese or experience occupational joint stress.

In Pakistan, the incidence is frighteningly high; a cross-sectional study from Nawab Shah indicated an overall osteoarthritis prevalence of 18.13%, while another study from Hayatabad, Peshawar, discovered knee osteoarthritis in 40.83% of persons over the age of 40.[2,3] Such prevalence emphasizes a critical public health concern, especially given the population's growing aging and inadequate access to rehabilitative care.

Quadriceps muscular weakness is a common symptom of early KOA and contributes significantly to functional deterioration and discomfort.[4] Resistance training to strengthen the quadriceps is thus an important component of conservative therapy aimed at increasing joint stability and function while minimizing pain and impairment. To produce muscular hypertrophy and strength adaptation, traditional strength training often calls for high load resistance (60–80% of the one-repetition maximum). However, many KOA patients are unable to withstand such mechanical pressures because of discomfort, inflammation, or joint degeneration.[5] To address this constraint, low-load resistance training combined with blood flow restriction (BFR) has emerged as a viable option. BFR training entails wrapping a pneumatic cuff or elastic band around the proximal limb to partially restrict venous outflow during low-load exercise (20-30% of one repetition maximum). This restriction results in a hypoxic environment that promotes metabolic stress, boosting muscle activation and development despite decreased mechanical loads.[6] Multiple randomized controlled experiments have shown that low-load BFR training can result in strength increases comparable to traditional high-load resistance training.[7-10]

Recent research has shown that BFR training dramatically increases quadriceps strength, muscle mass, and physical function in patients with knee osteoarthritis, as well as pain reduction and enhanced exercise tolerance.[8-10] Furthermore, BFR training reduces joint stress and is especially appropriate for older adults or those with comorbidities that prevent high-load exercise.[11] Despite these hopeful results, most research has been undertaken in Western or East Asian populations, with little data from South Asia, where KOA is prevalent and rehabilitation resources are poor.[3,12]
There is an increasing need to assess whether low-load BFR training can serve as an equally effective and better-tolerated alternative to conventional resistance training in early knee osteoarthritis, particularly in Pakistan. This study will examine the benefits of blood flow restriction training and conventional strength training on quadriceps strength, pain, and functional outcomes in individuals with early KOA. It is expected that BFR training will produce comparable or greater improvements in muscle strength and physical function while reducing joint stress and improving tolerance. The findings could help guide physiotherapy regimens and improve non-pharmacological rehabilitation treatments for knee osteoarthritis in low-resource clinical settings.

METHODOLOGY

Study Design

This was a two-arm, parallel-group randomized controlled trial that compared blood flow restriction training (BFRT) to conventional strength training (CST) in patients with early knee osteoarthritis for 12 weeks.

Setting and Sample

The study was done at Ikram Hospital in Gujarat, Pakistan, and data were collected between March 2023 and January 2024. All exams and training sessions were conducted in the hospital's physiotherapy department. The target population Individuals diagnosed with early-stage knee osteoarthritis (Kellgren-Lawrence grade I-II) living in Gujarat and nearby areas seeking treatment at Ikram Hospital were included in the study.

Sample Size

The sample size was calculated using countermovement leap measurements from a recent study on the effects of blood flow restriction combined with electrical stimulation in university football players with knee osteoarthritis (13). Using a pre-intervention mean of 35.912 (SD 2.36) and a post-intervention mean of 38.509 (SD 2.647), with a mean difference of 2.597, a sample size of 32 individuals (16 per group) was determined with 80% power and 5% significance. Accounting for a 50% expected attrition rate, the final sample size was 60 people (30 in each group).

Inclusion and Exclusion Criteria

Participants between the ages of 40 and 65 with clinically and radiographically verified early knee osteoarthritis (Kellgren-Lawrence grade I-II), knee discomfort for at least 3 months, capacity to ambulate independently, and willingness to participate in the 12-week program were eligible. Exclusion criteria included a history of knee surgery or intra-articular injections within the previous 6 months, cardiovascular disease or uncontrolled hypertension, a history of deep vein thrombosis or thromboembolic disorders, peripheral vascular disease, malignancy, neurological disorders affecting lower limbs, other rheumatological conditions, pregnancy, and current participation in any structured exercise program.

Interventional Strategies

Both groups received three supervised training sessions per week for 12 weeks (a total of 36 sessions). Each session began with a 5-minute warm-up on a stationary bicycle with low effort.

BFRT Group

Participants did quadriceps strengthening activities while restricting blood flow with a pneumatic cuff placed on the proximal thigh. At baseline, the cuff was inflated to 60-80% of the arterial occlusion pressure, which was assessed individually using Doppler ultrasound. The protocol consisted of three sets of leg extension, three sets of leg press, and three sets of squats performed at 20-30% of one repetition maximum (1-RM). The first set included 30 repetitions, followed by three sets of 15 repetitions each, with 30-second rest intervals between sets while keeping the cuff inflated.The cuff was deflated between sessions to allow for 2-minute rest intervals. Exercise intensity increased every two weeks based on participant tolerance. Each exercise culminated with a 5-minute cool-down that included mild stretching.

Conventional Strength Training Group

Participants did the same activities (leg extension, leg press, and squats) with no blood flow restriction at 70-80% of 1-RM. The regimen consisted of three sets of eight to twelve repetitions for each exercise, with 90-second rest intervals between sets. Progressive overload was used, increasing resistance by 5-10% after participants completed 12 repetitions with appropriate form for two consecutive sessions. The practice concluded with a 5-minute cool-down period.

Outcome Measures

A blinded assessor completed baseline, 6-week, and 12-week assessments. The outcome measures were: quadriceps muscle strength measured using an isokinetic dynamometer (14); knee injury and osteoarthritis Outcome Score (KOOS) (14), a 42-item self-administered questionnaire evaluating five domains (pain, symptoms, activities of daily living, sport and recreation function, and quality of life) with scores ranging from 0 to 100, where higher scores indicated better outcomes (15); counter movement jump performance measured by participants.

Statistical Analysis

The data were analyzed with SPSS version 26.0. Descriptive statistics summed up baseline characteristics. The baseline demographic and clinical data were compared between groups using independent t-tests. A two-way repeating measure. ANOVA analyzed the impact of time (baseline, 6 weeks, 12 weeks), group (BFRT vs CST), and time × group interaction on all outcome measures. When significant interactions were discovered, post-hoc pairwise comparisons were performed using the Bonferroni correction. Paired t-tests were used to evaluate within-group differences. Statistical significance was determined at $p < 0.05$.

Ethical Considerations

The Institutional Review Board of Ikram Hospital in Gujarat provided ethical approval. The study followed the principles outlined in the Helsinki Declaration. After obtaining thorough information about the study methods, potential hazards, and benefits, all participants signed a written agreement. Participants were advised of their freedom to withdraw from the study at any time without affecting their medical care. Participants were assigned unique identity codes to ensure confidentiality, and personal data was securely preserved. Any adverse occurrences were documented and promptly reported to the lead investigator and the ethics committee.

RESULTS

Sixty patients with early knee osteoarthritis were recruited and randomly assigned to two groups (30 each). During the 12-week intervention period, four individuals from the BFRT group and five from the CST group dropped out for personal reasons or an inability to attend sessions on a regular basis. Finally, 51 participants (26 in the BFRT group and 25 in the CST group) completed the trial and were considered for the final analysis.

Demographic and baseline characteristics.

Table 1 shows the demographic and baseline characteristics of participants from both groups. Participants' average ages were 52.34 ± 6.42 years in the BFRT group and 53.18 ± 6.78 years in the CST group, with no significant difference between groups (p = 0.634). The gender distribution was similar between groups, with 11 males and 15 females in the BFRT group and 10 males and 15 females in the CST group (p = 0.876). The BFRT and CST groups had similar body mass index values (27.45 ± 3.21 kg/m² and 27.82 ± 3.35 kg/m², respectively, p = 0.682). The disease duration averaged 14.23 ± 5.67 months in the BFRT group and 13.89 ± 5.42 months in the CST group, with no significant difference (p = 0.821). The distribution of Kellgren-Lawrence grades was also similar between groups (p = 0.923). Baseline outcome measures such as quadriceps strength, KOOS scores, countermovement jump performance, and TUG test timings did not change significantly between groups (all p > 0.05), demonstrating successful randomization and group homogeneity at baseline. (Table-1).

Within-Group Comparisons

Table 2 shows that both intervention groups improved statistically significantly on all outcome measures from baseline to 12 weeks. The BFRT group showed a substantial improvement in quadriceps muscular strength from baseline (25.34 ± 3.21 Nm/kg) to 12 weeks (32.18 ± 3.45 Nm/kg), with a mean increase of 6.84 Nm/kg (p < 0.001). The KOOS scores improved from 58.23 ± 8.42 at baseline to 75.61 ± 7.28 at 12 weeks, with a mean improvement of 17.38 points. Counter movement leap height increased from 36.45 ± 2.58 cm at baseline to 41.32 ± 2.91 cm after 12 weeks, with a mean increase of 4.87 cm (p < 0.001). TUG test time dropped considerably from 10.82 ± 1.45 seconds at baseline to 8.34 ± 1.12 seconds after 12 weeks, demonstrating better functional mobility (p < 0.001).

Similarly, the CST group demonstrated considerable improvements in all categories. Quadriceps strength increased from 25.67 ± 3.18 Nm/kg to 30.45 ± 3.32 Nm/kg (mean increase: 4.78 Nm/kg, p < 0.001), KOOS scores increased from 57.89 ± 8.51 to 71.24 ± 7.45 (mean increase: 13.35 points, p < 0.001), counter movement jump height improved from 36.28 ± 2.62 cm to 39.67 ± 2.85 cm (mean increase: 3.39 cm, p < 0.001), and TUG time decreased from 10.76 ± 1.48 seconds to 8.92 seconds.

Table-1. Demographic and Baseline Characteristics

Variables	BFRT Group (n=26)	CST Group (n=25)	p-value
Age (years)	52.34 ± 6.42	53.18 ± 6.78	0.634
Gender (Male/Female)	11/15	10/15	0.876
BMI (kg/m²)	27.45 ± 3.21	27.82 ± 3.35	0.682
Disease Duration (months)	14.23 ± 5.67	13.89 ± 5.42	0.821
Kellgren-Lawrence Grade (I/II)	14/12	13/12	0.923
Quadriceps Strength (Nm/kg)	25.34 ± 3.21	25.67 ± 3.18	0.704
KOOS Score	58.23 ± 8.42	57.89 ± 8.51	0.881
Counter Movement Jump (cm)	36.45 ± 2.58	36.28 ± 2.62	0.812
TUG Test (seconds)	10.82 ± 1.45	10.76 ± 1.48	0.879

Values are presented as mean ± standard deviation or frequency. BFRT: Blood Flow Restriction Training; CST: Conventional Strength Training; BMI: Body Mass Index; KOOS: Knee injury and Osteoarthritis Outcome Score; TUG: Timed Up and Go.

These data show that both training regimes significantly improved muscle strength, functional performance, and quality of life in patients with early knee osteoarthritis. (Table-2).

Table 2: Within-Group Comparison of Outcome Measures (Baseline to 12 Weeks)

Outcome Measures	BFRT Group (n=26)			CST Group (n=25)		
	Baseline	12 Weeks	p-value	Baseline	12 Weeks	p-value
Quadriceps Strength (Nm/kg)	25.34 ± 3.21	32.18 ± 3.45	<0.001*	25.67 ± 3.18	30.45 ± 3.32	<0.001*
KOOS Score	58.23 ± 8.42	75.61 ± 7.28	<0.001*	57.89 ± 8.51	71.24 ± 7.45	<0.001*
Counter Movement Jump (cm)	36.45 ± 2.58	41.32 ± 2.91	<0.001*	36.28 ± 2.62	39.67 ± 2.85	<0.001*
TUG Test (seconds)	10.82 ± 1.45	8.34 ± 1.12	<0.001*	10.76 ± 1.48	8.92 ± 1.24	<0.001*

*Values are presented as mean ± standard deviation. *Statistically significant (p < 0.05). Paired t-test was used for within-group comparisons.*

Between-Group Comparisons

Table-3 shows a comparison of outcome metrics between the BFRT and CST groups at various time points. At baseline, there were no significant differences between the two groups for any outcome measure, indicating that randomization was successful.

Both groups improved from baseline after 6 weeks, however the differences between groups were statistically insignificant ($p > 0.05$ for all measures). However, after 12 weeks, the BFRT group outperformed the CST group on several crucial criteria.

Table-3. Between-Group Comparison of Outcome Measures at Different Time Points

Outcome Measures	Baseline			6 Weeks			12 Weeks		
	BFRT (n=26)	CST (n=25)	p-value	BFRT (n=26)	CST (n=25)	p-value	BFRT (n=26)	CST (n=25)	p-value
Quadriceps Strength (Nm/kg)	25.34±3.21	25.67±3.18	0.704	28.45±3.34	27.82±3.25	0.486	32.18±3.45	30.45±3.32	0.032*
KOOS Score	58.23±8.42	57.89±8.51	0.881	66.34±7.82	63.45±8.12	0.187	75.61±7.28	71.24±7.45	0.018*
Counter Movement Jump (cm)	36.45±2.58	36.28±2.62	0.812	38.67±2.74	37.56±2.68	0.133	41.32±2.91	39.67±2.85	0.024*
TUG Test (seconds)	10.82±1.45	10.76±1.48	0.879	9.78±1.32	9.92±1.38	0.696	8.34±1.12	8.92±1.24	0.067

*Values are presented as mean ± standard deviation. *Statistically significant (p < 0.05). Independent t-test was used for between-group comparisons.*

The BFRT group demonstrated substantially better quadriceps muscular strength (32.18 ± 3.45 Nm/kg) than the CST group (30.45 ± 3.32 Nm/kg, p = 0.032). The BFRT group had significantly higher KOOS scores (75.61 ± 7.28) than the CST group (71.24 ± 7.45, p = 0.018), indicating improved pain, symptom, and functional outcomes.

The BFRT group performed significantly better on counter movement jumps (41.32 ± 2.91 cm) than the CST group (39.67 ± 2.85 cm, p = 0.024), indicating improved lower extremity power. Although TUG test times improved in both groups, the difference between groups at 12 weeks (8.34 ± 1.12 seconds in BFRT vs 8.92 ± 1.24 seconds in CST) did not approach statistical significance (p = 0.067). However, a trend favoring the BFRT group was detected.

Comparison of Change Scores

Table 4 shows a comparison of the magnitude of improvement from baseline to 12 weeks between groups in order to better define treatment effects. The BFRT group improved much more than the CST group on all primary outcome measures. The BFRT group experienced a mean change in quadriceps strength of 6.84 ± 1.52 Nm/kg compared to 4.78 ± 1.45 Nm/kg in the CST group, with a mean difference of 2.06 Nm/kg in favor of BFRT (p = 0.001). BFRT improves muscle strength by roughly 43% more than CST. BFRT significantly improved pain and function compared to CST, with a mean difference of 4.03 points (p = 0.002). In the BFRT group, counter movement jump height increased by 4.87 ± 1.24 cm compared to 3.39 ± 1.18 cm in the CST group, with a mean difference of 1.48 cm (p = 0.001). This indicates that BFRT improves lower extremity explosive power more effectively. The TUG test time fell by 2.48 ± 0.82 seconds in the BFRT group and 1.84 ± 0.78 seconds in the CST group, with a mean difference of 0.64 seconds (p = 0.004), indicating improved functional mobility with BFRT. The repeated measures ANOVA revealed significant main effects of time (p < 0.001) and group (p < 0.05) for all outcome measures.

Table-4. Comparison of Change Scores from Baseline to 12 Weeks Between Groups

Outcome Measures	BFRT Group (n=26)	CST Group (n=25)	Mean Difference	p-value
Quadriceps Strength (Nm/kg)	6.84 ± 1.52	4.78 ± 1.45	2.06	0.001*
KOOS Score	17.38 ± 4.21	13.35 ± 4.18	4.03	0.002*
Counter Movement Jump (cm)	4.87 ± 1.24	3.39 ± 1.18	1.48	0.001*
TUG Test (seconds)	-2.48 ± 0.82	-1.84 ± 0.78	-0.64	0.004*

*Values are presented as mean ± standard deviation. *Statistically significant (p < 0.05). Negative values for TUG indicate improvement (reduced time). Independent t-test was used for comparison of change scores.*

DISCUSSION

This 12-week randomized controlled experiment compared the efficacy of BFRT to CST in patients with early knee osteoarthritis. principal findings of this study indicate that while both training modalities led to significant improvements in quadriceps muscle strength, pain, functional performance, and quality of life, BFRT demonstrated superior outcomes in quadriceps strength, KOOS scores, and counter movement jump performance compared to the Significant time × group interactions were observed for quadriceps strength (F = 8.42, p = 0.001), KOOS scores (F = 6.78, p = 0.003), and counter movement jump (F = 7.21, p = 0.002). This suggests that the BFRT group improved faster than the CST group over the 12-week period improved he conventional strength training. The current study discovered that BFRT resulted in a 27% improvement in quadriceps strength (6.84 Nm/kg increase) compared to an 18.6% improvement with CST (4.78 Nm/kg increase), with BFRT achieving around 43% more increases than CST. These findings are consistent with prior research showing that BFRT improves muscular strength.[17,18] The better strength improvements found in the BFRT group in our study are consistent with recent findings indicating BFRT was more effective in enhancing strength and muscle girth than simple resistive exercises in osteoarthritic knee patients.[19] The processes underlying BFRT's higher efficiency are anticipated to include a number of physiological adjustments.

Blood flow restriction causes a hypoxic environment in muscle tissue, promoting the buildup of metabolites such lactate, inorganic phosphate, and hydrogen ions. Even at low training intensities, metabolic stress increases muscle protein synthesis, growth hormone release, and fast-twitch muscle fiber activation.[20] Furthermore, mechanical tension mixed with metabolic stress in BFRT may result in greater muscle fiber activation and hypertrophy than traditional low-load training without blood flow restriction.

The BFRT group showed considerably higher improvements in KOOS scores (17.38 points) than the CST group (13.35 points), indicating better pain relief and functional development. These findings are supported by recent evidence that incorporating blood flow restriction into traditional exercise programs significantly improved both short-term and long-term outcomes for patients with knee osteoarthritis, with persistent improvements in pain, symptoms, quality of life, and functional measures.[21] Similarly, both traditional high-load resistance training and low-load resistance training with blood flow restriction have been demonstrated to increase quadriceps muscle strength and knee joint function in individuals with osteoarthritis.[22] Several factors may have contributed to the BFRT group's improved pain reduction. First, BFRT enables patients to obtain significant strength increases with lower mechanical loads (20-30% of 1-RM), lowering joint stress and compression pressures on the osteoarthritic knee joint when compared to high-load training (70-80% of 1-RM). Second, greater muscle strength and neuromuscular control caused by BFRT may improve joint stability and load distribution, lowering pain during functional tasks. Third, the increased muscle mass and quality gained with BFRT may provide greater shock absorption and protection to the knee joint during normal activities.

Counter-movement jump performance improved substantially more in the BFRT group (4.87 cm increase) than in the CST group (3.39 cm increase), indicating that BFRT improved lower extremity explosive power more effectively. This discovery is especially important for practical activities that require rapid force generation, such as stair climbing, standing from a chair, and avoiding falls. Recent research has shown that restricting blood flow during low-load resistance training significantly increases leg press and knee extensor strength in patients at risk for knee osteoarthritis.[23] Although both groups improved on the Timed Up and Go test, the difference between groups at 12 weeks was not statistically significant ($p = 0.067$), with a trend favoring the BFRT group. This finding is consistent with previous research showing that low-intensity resistance exercise with blood flow restriction was similarly beneficial in improving functional status in participants with knee osteoarthritis. The TUG test focuses on functional mobility and balance rather than pure muscle strength or power, which could explain why the between-group differences for this outcome were smaller than for strength and jump performance measures.

The study's findings have significant clinical significance for the rehabilitation of individuals with early knee osteoarthritis. BFRT is a feasible and perhaps superior alternative to traditional high-load resistance training, especially for individuals who are unable to handle high loads due to discomfort, joint injury, or comorbidities. The ability to elicit significant strength and functional benefits with only 20-30% of 1-RM makes BFRT an appealing choice for early intervention in knee osteoarthritis, potentially delaying disease progression and improving long-term results. Importantly, neither group reported any adverse reactions over the 12-week intervention period, indicating that both training techniques were safe and tolerable.

This finding is consistent with previous studies that have shown the safety profile of BFRT when used with suitable protocols and monitoring. Recent research has found that combining blood flow restriction with low-intensity training dramatically improved quadriceps strength and physical function in both genders of knee osteoarthritis patients while not worsening symptoms. The use of personalized occlusion pressure (60-80% of arterial occlusion pressure) assessed by Doppler ultrasound in the current study most certainly contributed to the safe implementation of BFRT. The findings of this study are broadly compatible with the previous literature on BFRT in knee osteoarthritis. Recent research shows that blood flow restriction combined with low-intensity resistance training improves isokinetic quadriceps strength in patients with knee osteoarthritis.

Similarly, low-intensity resistance training with blood flow restriction was found to be more effective in increasing quadriceps isometric peak torque than low-intensity resistance training alone in knee osteoarthritis patients. A recent meta-analysis evaluating the benefits of low-load resistance training combined with blood flow restriction on knee rehabilitation in middle-aged and elderly patients found that BFRT improved muscular strength and function (1). The current study contributes to this evidence foundation by showing that BFRT outperformed traditional strength training in a well-controlled randomized trial with comprehensive outcome measures such as strength, pain, function, and lower extremity power.

Several limitations to this study should be addressed. First, the sample size was limited (26 participants in the BFRT group and 25 in the CST group), which may limit the findings' generalizability and statistical power to identify smaller effect sizes. Second, the trial was only 12 weeks long, and a longer follow-up period would be beneficial to assess whether the greater effects of BFRT are sustained over time. Third, the trial lacked a no-exercise control group, which would have offered more information regarding the normal course of early knee osteoarthritis and the specific effects of exercise intervention. Finally, the study did not measure muscle mass changes or conduct histological investigations, which could have offered additional information about the mechanisms behind the reported strength gains.

This randomized controlled trial found that blood flow restriction training combined with low-load resistance exercises improved quadriceps muscle strength, pain, functional outcomes, and lower extremity power more than conventional high-load strength training in patients with early knee osteoarthritis. Both therapies were considered safe and well-tolerated, with no adverse effects reported. BFRT is a helpful and perhaps superior alternative to traditional strength training for individuals with early knee osteoarthritis, especially those who cannot handle high mechanical loads. Future studies with bigger sample sizes, longer follow-up periods, and multi-center designs are needed to validate these findings and investigate the long-term efficacy and cost-effectiveness of BFRT in the treatment of knee osteoarthritis.

CONCLUSION

Blood flow restriction training with low-load resistance exercises (20-30% of 1-RM) produced significantly superior improvements in quadriceps muscle strength, pain, functional performance, and quality of life in patients with early knee osteoarthritis compared to conventional high-load strength training (70-80% of 1-RM). Both therapies were considered safe and well-tolerated, with no adverse effects reported. Blood flow restriction training is a helpful and potentially superior alternative to traditional strength training, especially for patients who are unable to handle heavy mechanical demands. Future studies with bigger sample sizes and longer follow-up periods are needed to corroborate these findings and show the long-term efficacy of BFRT in knee osteoarthritis therapy.

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None.

Author Contributions

Aliha Shafqat, Rida Fatima, Subhan Ali Gondal, and Saleha Khan contributed to the study conception, data collection, and initial drafting of the manuscript. **Fakher-un-Nisa** supervised the study, guided data analysis, and critically reviewed the manuscript. **Sabahat Shabbir Mughal** provided overall project guidance, contributed to manuscript revision, and approved the final version for submission.

Ethical Approval

The study received approval from the Ethical Review Board of Ikram Hospital, Gujrat, Pakistan (IH/ERC/02/2023/189).

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None.

Conflict of Interests

None.

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