

# Effect of Partial Blood Flow Restriction Training in Improving Physical Functioning among Middle-Aged Subjects with Knee Osteoarthritis: A Pilot Study

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## Abstract

**Background:** Blood Flow Restriction (BFR) training combines low-intensity exercise with blood flow occlusion to produce outcomes comparable to those of high-intensity training. BFR is as effective as high-intensity protocols known to enhance knee extensor muscle strength in subjects with knee osteoarthritis (OA). Therefore, the aim of this study is to find out the effect of Partial Blood Flow Restriction Training on pain and physical functioning among knee OA subjects.

**Purpose:** To assess the effectiveness of Partial Blood Flow Restriction Training in Improving Physical Functioning Among Middle-Aged Subjects with Knee Osteoarthritis.

**Materials and Methods:** This is the pilot study where twenty subjects with knee OA were divided randomly into two equal groups. Group "A" received BFR training combined with conventional exercise two times/week and Group "B" received conventional exercise two times/week. Numeric Pain Rating Scale (NPRS), Western Ontario and McMaster Universities Arthritis Index (WOMAC) were used to evaluate subjects at two intervals (Pre-Test and Post-Test).

**Results:** The difference between the Group A and Groups B was statistically significant ( $p \leq 0.001$ ). Hence conventional exercise combined with blood flow restriction training shows significant improvement than conventional exercise among OA knee subjects.

**Conclusion:** This pilot study concluded that the conventional exercise combined with blood flow restriction training was effective in subjects with OA knee.

**Key Word:** Occlusion training, Kaatsu training, Degenerative joint disease, BFR training.

## Introduction

Knee osteoarthritis (KOA) is a common chronic joint disease accompanied by functional limitations and pain. The onset of knee OA is predisposed to

advanced age, female sex, obesity, previous joint damage, weak knee flexor and extensor muscles, occupation and genetics. The male prevalence was lower (31.2%) than that of females (42.1%)<sup>1</sup>.

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Knee symptoms vary depending on their underlying cause. Knee pain around the joint is the most common symptom of osteoarthritis (OA). Sharp, throbbing, dull, ongoing, or periodic pain is all possible. Studies indicate that enhancing the knee extensor muscles is the foremost step in the management of knee OA, with a widely recognized hypertrophy training protocol<sup>2,3</sup>. The traditional treatment goals include pain reduction and improved function. According to current guidelines, regardless of the severity of the disease, degree of pain, or functional status, physical activity is advised to treat knee OA<sup>4</sup>.

In addition, the World Health Organization's recommendations for physical activity show that patients need to engage in at least 150 min of moderate-to-strenuous exercise per week, split into sessions of at least 10 min. Owing to time and other factors, only 23% of individuals with knee OA successfully achieved this goal. Unfortunately, high-intensity resistance exercise (HIRE) necessitates the use of heavy loads, which can exacerbate pain in patients with knee OA and lead to swelling and inflammation. Therefore, adherence to exercise decreases with the appearance of these symptoms appear<sup>5</sup>.

Recent research has investigated new training modalities for enhancing muscle strength due to the low adherence of patients with knee OA to HIRE, including aquatic exercises, neuromuscular, high-speed, and blood flow restriction training (BFR)<sup>6</sup>.

The training technique known as blood flow restriction (BFR) completely restricts venous outflow while only partially allowing arterial inflow in working muscles also known as Kaatsu training<sup>7</sup>. When performed with less resistance, partial blood flow restriction training has been demonstrated to have a significant positive impact on local skeletal muscles, including an increase in local muscle mass, strength, and endurance. Therefore, patients who cannot undergo conventional resistance training may benefit from this method. BFR has produced positive outcomes in musculoskeletal rehabilitation. Increases in muscle mass, quadriceps strength, and functional ability in patients with knee OA have been achieved through blood flow restriction training<sup>8,9,10</sup>. The goal of this Pilot study was to determine whether individuals with knee osteoarthritis can be effectively

treated with traditional exercise and blood flow restriction training.

### Aim

The Aim of the study is to determine the effectiveness of Partial Blood Flow Restriction Training in Improving Physical Functioning Among Middle-Aged Subjects with Knee Osteoarthritis.

### Material and Method

This pilot study conducted on 20 subjects with OA knee, age between 40-60 years of both genders was taken from a private hospital in Chennai, during the period of July 2022 to August 2022. Convenient Sampling with random allocation method was used in the study.

#### Inclusion criteria:

- Age – 40 to 60 years, both gender
- Individuals experiencing unilateral knee pain.
- NPRS score of 3 or higher
- Subjects who meet the ACR clinical & Radiological Criteria for knee Osteoarthritis' primary OA criteria
- Kellgren & Lawrence radiographic changes of grade 1 or higher

#### Exclusion criteria:

- Subjects with a diagnosis of active synovitis, intense trauma, surgical procedures, other arthritis and a use of recent intra-articular corticosteroid injections on knee
- Foot deformities or lower extremity amputation
- Neurological dysfunction on the central or peripheral levels, including spinal stenosis, persistent lumbar pain, chronic peripheral vascular disease together with claudication, and peripheral nerve damage either with or without foot drop.
- Bilateral or unilateral TKA
- Thromboembolism
- Medically unstable, as evidenced by uncontrolled blood pressure, uncontrolled blood sugar, or unstable coronary artery disease

**Outcome measures:**

Assessment was performed at baseline (before starting of treatment) and after four weeks of study.

- NPRS - Numerical Pain Rating Scale
- WOMAC - Western Ontario and McMaster Universities Arthritis Index

**Procedure**

Twenty samples were randomly chosen based on the inclusion and exclusion criteria, and subjects were selected for a pilot study design. Before beginning the procedure, all subjects provided written informed consent after being informed of the study. The NPRS and WOMAC were used to evaluate the pre-test and post-test. The study participants were randomly divided into two groups: Group A (n=10) and Group B (n=10), using the closed-envelope method. Blood flow restriction training combined with conventional exercise were performed in the Group A. Conventional exercise was performed in the Group B. Quadriceps muscles were mainly strengthened.

Each training session during the intervention began with a 10-minute general warm-up. To initiate any adjustments, the maximal load for each strengthening exercise (30% of one repetition maximum for the Group A and 30% of one repetition maximum for the Group B group) was examined during the initial rehabilitation session.

**Group B (Conventional exercise):** Patients in this group underwent lower limb muscle stretching and strengthening exercises, including quadriceps exercises (30% of one Repetition Maximum), over the course of 8 therapy sessions (two sessions each week) over a period of four weeks.

- SLR with weighted ankles - In a supine position, the patient was asked to raise the exercise limb with the knee in full extension, and then lower the limb back to the initial position; resistance (30% 1RM) was provided by ankle weights.
- Sitting Knee Extension with Weighted Ankles - Sitting with knee at 90° flexion, the patient was asked to fully extend the knee. Resistance (30% 1RM) was provided by ankle weights.

- Hip Adduction and Abduction with Weighted Ankles - For Adduction: Lying sideways, the patient was asked to bend the hip and the knee of the upper leg and raise the lower leg, keeping it straight; extra resistance (30% 1 RM) was provided by ankle weights; For Abduction: Lying sideways, the patient was asked to bend the knee and hip of the lower leg and raise the upper leg, keeping it straight; extra resistance (30% 1RM) was provided ankle weights.
- Calf Raises - In a standing position, the patient was asked to rise up on toes and return.
- Stretching of the Hamstring Muscle - In a supine position, the patient was asked to raise the exercise limb with the hip and knee in 90 ° flexion then the patient was asked to extend the knee fully while holding the thigh (15 repetitions for 30s).

**Group A (BFR Training with Conventional exercise):** Participants in this group underwent the same protocol as Group B over 8 sessions of therapy (two sessions per week for four weeks) combined with BFR training. A lower limb-specific sphygmomanometer that can restrict blood flow to the thighs was used in the BFR. Exercises for the Group A were SLRs with BFR using weighted ankles, BFR with weighted ankle while seated extension of the knee, BFR using weighted ankles with adduction and abduction of the hip, calf raises, and stretching of the hamstring muscle with the same protocol as Group B.

**Blood flow restriction cuff placement:** Relatively small (5–6 cm wide) restrictive cuffs were used to restrict the blood flow. For the majority of people, restricting the cuff pressure for the lower body to between 160 and 240 mmHg is appropriate. A lower-limb-specific sphygmomanometer was used. Quadriceps exercises were performed while the pressure cuff was inflated to 190 mmHg. Using a measuring tape, the length from the inguinal crease to the upper part of the knee patella was determined, and an outline was created on the lower limb, 33% distal to the inguinal crease. To obtain a precise picture of the cuff location, thigh circumference was evaluated at this point. Blood gathered in the vessels far from the cuff as a result of the device.

**Treatment Protocol:**

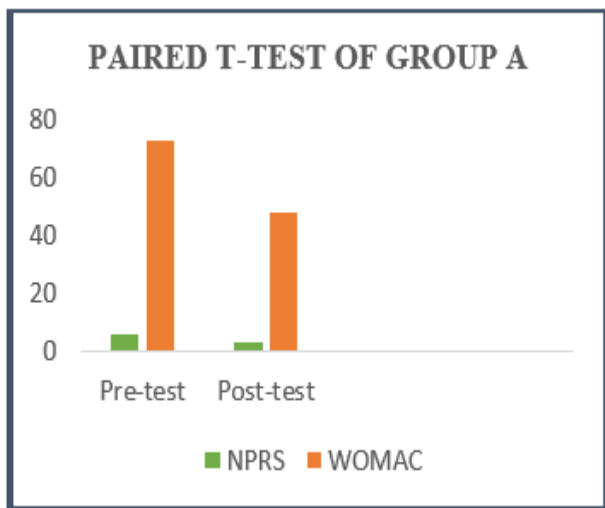
- Duration of the session: 30-40 minutes
- Frequency: Single session per day/4 weeks
- Sets: 2 sets
- Repetitions: 15 repetitions
- Rest: 2-3 mins break between sets.

**Data Analysis**

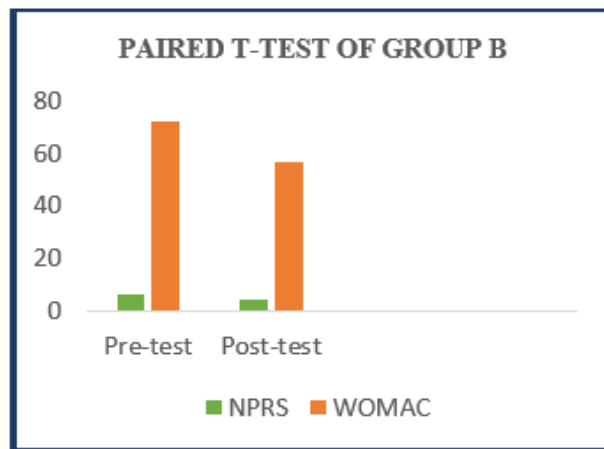
Pre-test and post-test values of Numerical Pain Rating Scale and Western Ontario and McMaster Universities Arthritis Index scale are analysed using the paired t-test within the groups and unpaired t-test between groups.

**Result**

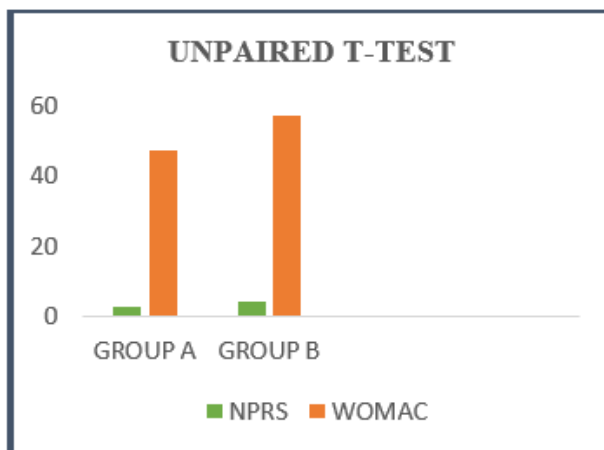
The Pilot study was conducted on 20 subjects. Both the groups has 10 subjects each. All 20 subjects completed the study successfully, pre-test and post-test values of NPRS and WOMAC were presented in the following Figures: 1,2,3. The mean for NPRS was 2.47 for Group A and 4.20 for Group B, with p value  $= < 0.0001$  and t value was 7.2113 indicating that the results were extremely statistically significant. The mean for WOMAC was 47.60 for Group A and 57.13 for Group B, with p value  $= < 0.0001$  and t value was 13.3296 indicating that the results were extremely statistically significant.



**Fig 1: Comparison of pre and post-test values of NPRS and WOMAC in GROUP A**



**Fig 2: Comparison of pre and post-test values of NPRS and WOMAC in GROUP B**



**Fig 3: Comparison of post-test values of NPRS and WOMAC in GROUP A and GROUP B.**

**Discussion**

This Pilot study was done to see the effect of partial blood flow restriction training in improving physical functioning among middle-aged subjects with knee osteoarthritis. Study included 20 subjects in the age of 40 to 60 years. Groups were divided into half by random allocation of groups. Group A received partial blood flow restriction training combined with conventional exercise and Group B received only conventional exercise. The duration of the study was 4 weeks and exercises were given 2 days/week. There is no drop-out during the treatment.

Pre-test and Post-test analysis was done for Group A and Group B for which partial blood flow

restriction training combined with conventional exercise was given, data was analysed using paired t- test within the groups for NPRS and WOMAC showed statistical difference in all two outcome measures that is pain and physical functioning.

The Unpaired t test was used to examine significant changes in post- test values between the Group A and B in both cases. The beneficial effects were significantly greater in Group A than Group B.

According to preliminary research, BFRT can increase muscle strength in individuals with risk factors for knee OA. This study has implications for OA management<sup>11,12</sup>. Preliminary research suggests that individuals with risk factors associated with knee OA may benefit from BFRT by strengthening their muscles. Although adequate research is currently lacking, it is probable that lower joint stress and less pain will have different impacts on long-term adherence to physical activity in patients with knee OA<sup>13,14,15</sup>.

An arterial blood pressure monitor was also used to check the readings before and after each training session, and no clinically significant changes were found<sup>15, 16</sup>. Similar to how resting blood pressure was unaffected by the 6-week intervention, BFRT's safety case for this population was strengthened. In fact, BFRT has been found to be safe in a number of populations in the past, with a low incidence of unfavourable events; however, these populations did require professional assistance and proper control of training variables<sup>17</sup>.

To determine the impact of a twelve-week HIR training program on pain, function, and strength in patients with OA knee, Bryk<sup>18</sup> conducted a clinical trial on 14 patients. The Knee Injury and Osteoarthritis Outcome Score (KOOS) and Arthritis Self-Efficacy Scale (ASES) both experienced a statistically significant increase in the function subscale.

The impact of isolated resistance training on arthritis symptoms and physical performance in patients with knee OA was examined by Angela K. Lange<sup>19</sup> in a systematic review of 18 RCTs involving 2832 patients. They found that patients with knee OA benefited from resistance training in terms of physical function.

Yokokawa<sup>20</sup> examined the effects of dynamic balance training versus LLR training with BFR in elderly individuals at a risk of developing knee OA. One of the two groups was randomly chosen from 51 participants 65 years. Prior to and following the eight-week program, performance in both groups was evaluated. Blood samples from participants (n=11) were also collected, and growth hormone and lactate levels were measured. Performance and balance after the program showed overall improvement, but there were no group differences. The functional mobility test (TUG) was used to measure it.

The results of this pilot study showed promising outcomes in the intervention group, suggesting that BFR training with conventional exercise has a positive impact on pain and physical function among individuals with OA knee which was clinically significant. Despite the promising results, there are some constraints in this pilot study that should be taken into account. The generalizability of the results is restricted by the small sample size. Additionally, the short duration of the intervention does not allow for long-term assessment of its effects. Future research with larger, randomized controlled trials and longer follow-up periods would be necessary to validate these findings.

## Conclusion

When performed properly, BFRT has the potential to help subjects with osteoarthritis of the knee by preventing muscle atrophy and improving muscle strength. In subjects with knee OA, adding BFR to LLR exercise produced functional mobility gains comparable to those of high-load conventional exercise programs; this type of exercise is advantageous to patients who felt they had a reduced tolerance for the high-load programs. As a result, it might be a beneficial form of exercise for improving physical function and effectively strengthening the quadriceps muscles while reducing discomfort and harmful joint loading in persons with knee OA. If additional research confirms the results of this study, BFRT should be applied more frequently in patients with osteoarthritis.

**Ethical clearance:** The study was approved by the committee of institutional scientific review board. All study participants were informed about the

study objectives, and those who agreed to Participate signed informed consent forms.

**Funding:** This study was a self-funded study.

**Conflicts of interest:** The authors declare that they have no conflicts of interest.

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