

# Blood Flow Restriction Combined with Kinaesthesia, Balance Training for Osteoarthritis Knee: A Rare Case Report

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## ABSTRACT

**Background:** Osteoarthritis knee is a prevalent condition and comprises 50% of all musculoskeletal disorders according to WHO. Therefore there is a need to bring about adjunct exercise protocols in the field of rehabilitation to bring faster recovery even in elderly with low loads.

**Case Presentation:** A patient, a 70-year-old female presented with complain of pain in the bilateral knee. Her problem list included crepitus, reduced knee range of motion with decreased strength, swelling, bony tenderness, morning stiffness which was managed by Blood flow restriction training (BFR) along with Kinaesthesia, Balance Training (KB). Until now in the literature, nothing has been found about the combination of these two approaches. Also, the pressure utilized in the past was too high for the geriatric population.

**Conclusion:** The results showed decrease knee pain, improved balance, hypertrophy, and increase range of motion.

**Keywords:** Blood flow restriction, proprioception, osteoarthritis knee, pressure, case report.

## BACKGROUND

The knee joint is a complex joint that bears the maximum bodyweight and maintains stability in different loading situations. Primary and secondary stabilizers are present around the joint helping to maintain stability. <sup>[1]</sup> Knee Osteoarthritis (OA) is one of the most common degenerative conditions resulting in pain,

stiffness, physical activity limitations, instability, and functional decline.

Knee OA-related functional decline is exacerbated by skeletal muscle weakness, especially in the quadriceps muscles. <sup>[2-3]</sup> Traditional skeletal muscle strength-building interventions frequently include high-load or high-intensity resistance exercise, which can cause joint pain in people with OA due to high-compressive forces. <sup>[4-5]</sup> As a result, joint pain can prevent some older people with knee OA from engaging in high-load resistance training. <sup>[6]</sup> Current guidelines for adults with OA include low-to moderate-intensity resistance exercise to reduce joint pain. However, this strategy can restrict gains in skeletal muscle strength. Alternative prevention methods for older adults with knee OA are currently lacking in evidence. <sup>[7,8]</sup> Novel strategies, such as BFR, may help older adults with knee OA reduce pain and improve physical function.

Blood flow restriction (BFR) is an accessory to a variety of different exercise modes (e.g., resistance exercise, walking, cycling) and has recently become a popular research topic. The BFR during exercise typically involves the application of pressurized cuffs to the proximal portion of each lower extremity or upper extremity. <sup>[9]</sup>

Nowadays, Blood flow restriction training (BFR) or KAATSU has emerged as an important tool for a wide range of

exercise modes (e.g., resistance exercise, walking, cycling) and has recently become a favored research topic. Occlusion training provides a unique and practical mode for exercise inside the clinical background as it leads to high-quality training adaptations, like day to day aerobic exercise which ranges from 10 to 30 percent of greatest functional capability<sup>[10]</sup> but these studies have employed lower intensity resistance exercises (LIRE) along with high blood flow restriction pressure. The functionality for LIRE accompanying Bfrt has been used with more than 180mmHg pressure<sup>[11]</sup> but it also leads to ache and uneasiness.

Low load BFR training resulted in less anterior knee pain during sessions compared to high load training in osteoarthritis knee patients.<sup>[10]</sup> Within the researches of BFR, it was historically prevalent for all subjects to exert irrational restrictive pressure before applying Bfr such as, Burgomaster et al in 2003 and Sumide, Sakuraba, Sawaki, Ohmura, and Tamura in 2009 have utilized pressures below diastolic pressure (approximately 50mmHg) which permits circulatory invasion to train muscle system.

The recent studies have emphasized impaired proprioceptive accuracy of the knee as a local factor for disease onset and progression of knee OA. Studies suggest proprioceptive impairments as a cause of

activity limitations and knee pain in OA patients. Balance has also been reported to be lower in people with knee OA, evidenced by a higher incidence of falls and increased postural sway.<sup>[12]</sup> Patients with moderate to severe OA have more deficits in balance control than those with mild disease.<sup>[13]</sup> Dynamic balance is more affected than that in standing in OA knee patients which increases the risk of fall. The stimulation of proprioceptors cause reflex contraction in the muscles which prevents the joints from mechanical injury.<sup>[12]</sup>

Kinaesthesia, Balance (KB) exercise protocols were designed to decrease proprioceptive impairment by using agility and balance movements to activate, challenge, and adapt the nervous system's proprioceptors. As the instability of the joint is also the causative factor in both the development of knee OA and the further degeneration of articular cartilage. Improved joint stability can improve symptoms and reduce the rate of disease progression. Kinaesthesia, Balance exercises are always given in individually as a separate treatment approach but this study attempts to find its effectiveness with Bfrt.

The objectives of this study were to assess the safety and efficacy of BFR training with KB training in older adult in knee OA.

## LITERATURE REVIEW

Author(s)/ Year/Country	Title	Study population & sample size	Study Design	Conclusions	Results
Takahiro Sumide Keishoku Sakuraba Keisuke Sawaki Hirotohi Ohmura Yoshifumi Tamura 2009 Japan	Effect of resistance exercise training combined with relatively low vascular occlusion	Healthy young males, n=21	Experimental study	50 mmHg occlusion pressure increased the electromyographic (EMG) activity during 40% 1RM exercise in the upper limb which might be due, at least in part, to the accumulation of metabolic byproducts, such as lactate	Total muscle work increased significantly in the 50- and 150-pressure groups (P < 0.05, P < 0.01, respectively).
Murat Karabulut James McCarron Takashi Abe Yoshiaki Sato Michael Bembena 2009 United Kingdom	The effects of different initial restrictive pressures used to reduce blood flow and thigh composition on tissue oxygenation of the quadriceps	6 young healthy males	Experimental study	30mmHg was optimal pressure for muscle growth.	There were significant negative correlations between tissue oxygenation and leg lean body mass, total lean body mass, and thigh circumference when initial restrictive pressure was set at 30 mmHg

## CASE PRESENTATION

A 70-year-old female patient with chief complaints of on & off pain in the bilateral knee on medial & lateral side (Rt>Lt) since 1 month came with difficulty in prolonged standing, walking, pain while climbing up & down the stairs with no mechanism of injury. She had gradual onset with the nature of pain as constant and the type of pain as dull aching. In terms of severity of pain, it was level 4 (i.e. Pain during and after specific activity which affected her performance). Location assessed through body diagram depicted medial side of knee joint bilateral and slight pain at the lateral joint line (bilateral). The intensity of pain according to Numeric pain rating scale during rest was 3 and 2 on the right and left knee respectively, on the activity it was 6 and 5 on right and left knee respectively. The pain was aggravated by prolonged standing, ascending and descending stairs, rising from a chair, after prolonged sitting (more than 2 hours), and after 10 minutes of walking. The pain was eased by hot fomentation and supine lying. The patient complained of morning stiffness which subsided following movements and activity. Also after prolong sitting she felt stiffness in both knees. She adopted a side-lying sleeping posture with both knees flexed on a hard mattress. Personal history revealed walking stating that after 15 minutes of a walk she took 5 minutes of rest then she walked for 10 min. The patient had the first episode of pain in the bilateral knee 8 years back, but left knee pain was milder compared to the right knee which was managed by medications & physiotherapy. For the last 2 years, she was taking physiotherapy treatment at her home (2-3 session/week), after discontinuing the treatment her pain had increased for which she has started her treatment. Objective assessment- In general observation, it is observed that she had an antalgic gait and the type of footwear used was sneakers which depicted more weight-bearing on the medial side of the foot. The patient did not use any assistive devices. The swelling was

observed and the left patella was superior as compared to the right (supine). Observational gait analysis (Fig 1) - right arm swing was absent. During initial contact, the patient bearded more weight on the medial aspect of the foot instead of heel strike, lack of knee extension in midstance, limited knee flexion range of motion pre-swing to mid-swing. In palpation normal warmth was present. Grade 1 tenderness present at left and right lateral condyle of femur and grade 2 tenderness bilateral over medial knee joint line. Examination- the Active range of motion of left knee flexion was 5-105° and passive range of motion was 0-120° with empty end feel, Active range of motion of left knee extension was 105-5° with passive range of motion 120-0 with empty end feel. The Active range of motion of right knee flexion was 5-100° with passive range of motion of 0-112°, the Active range of motion of right knee extension was 100-5° and right knee passive range of motion was 112-0° with empty end feel. Reduced range of motion of internal rotation of hip bilateral. Isokinetic Dynamometer reveals decreased strength of hip extensors, internal rotators, knee flexors, and extensors. Muscle length testing revealed mild hamstring tightness bilaterally which was assessed by 90-90 angle (popliteal angle left-105°, right- 100). Ober's test revealed tightness bilateral. Joint play of tibiofemoral joint was grade 2 in anterior and posterior translation, in patellofemoral joint medial and inferior joint play was grade 2 bilaterally. In quantitative posture analysis through plumb-line, in anterior view genu varum and externally rotated tibia bilateral (Fig 2), in posterior view more toe out at right side (fig 3), lateral view bilateral flexed knee posture (fig 4) was observed. Q angle was assessed by universal goniometer in the supine position and it was 14 right side and 16 left side. Insall-Salvati ratio was 1.4 on the right side and 1.3 on the left side. In quantitative gait analysis step length of right side was 36cm and left side 38cm. stride length was 74.5cm on right side and 75cm

on left side. The width of base of support was 7cm and the degree of out was more on right side (8 degrees and 5 degrees left side). Girth measurement showed a difference of 4 cm at 5cm above the knee joint line on right side. Balance was assessed through one leg standing with eyes open and the patient was able to stand for 19sec with eyes open on right side & 23sec on left side. A digital goniometer was used to measure the knee kinesthesia and joint repositioning errors along with knee range of motion. Measurements were taken on 1st day and after 4 weeks when the protocol was completed. The patient was in supine lying and the digital goniometer was wrapped on the lateral aspect of the knee joint with the fulcrum at the lateral joint line, fixed arm in line with the greater trochanter of the femur and the movable arm in line with the lateral malleolus. Patient was provided with earphones and dark glasses to occlude vision and eliminate cues from the digital goniometer. A trial was first administered to the subjects for each angle position. During testing, the knee was placed in complete extension and the subject was then first told by the researcher about the knee position at angles of 30, 45, 60, and 90 degrees. The subjects were asked to remember the position knee joint at different angles. The knee was then passively returned to the initial position of knee extension by the researcher. The patient was instructed to bring the knee at the most appropriate position to match each

target angle as told by the researcher. Hold time at each angle was 5 seconds after which subjects return the knee joint to the initial position with a 10 second rest period. Out of McConnell, patellar glide test and Clarke's test only patellar glide test was positive, bilateral-ray showed narrowing of bilateral joint space (medial>lateral, osteophytes at distal ends of femur mild medial subluxation of left medial femoral condyle over tibial condyle and narrowing of patellar space subchondralsclerosis). The diagnosis was bilateral grade III Osteoarthritis of the knee with genu varus deformity according to American College of Rheumatology. Treatment included exercises such as heel walking, forward wedding march Cross over walk, Modified grapevine, Toe walking, Semi tandem walking Sidestepping, High knee march (10times every 5 days per week for 4 weeks) followed by hot fomentation for 15 minutes. After the entire exercise, patient performed static Quadriceps exercise with blood flow restriction i.e. 2 sets of 10 repetitions with cuff applied proximally over distal femur at a pressure of 50mmHg. This whole protocol was continued for 4 weeks with all the exercises performed 10 times 5 days per week.

**SUMMARY OF THE CASE**

1	Patient (gender ,age)	Female ,70 years old
2	Final diagnosis	Osteoarthritis knee
3	symptoms	Pain,stiffness,creptius,instability
4	Medications	none
5	Clinical intervention	BFRT with KB training
6	Specialty	Physiotherapy



Figure 1: Observational Gait Analysis

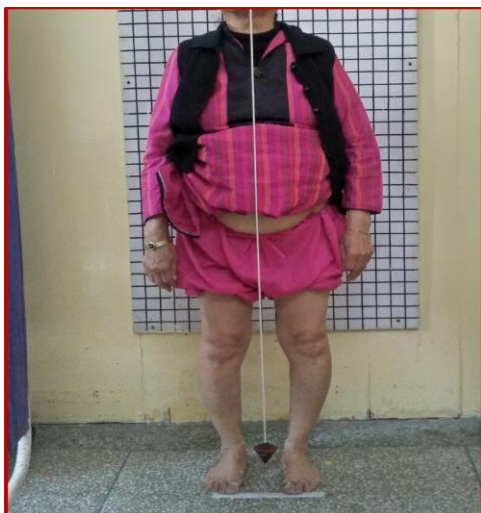


Figure 2: Anterior View



Figure 3: Posterior View



Figure 4: Lateral View

## DISCUSSION

This case report describes the successful use of Blood flow restriction

along with KB training. All the findings reported by patient suggested that pain during activity might be because of stretching of the tight capsule and severe condition as both ascending and descending steps increase the pain. The findings of examination suggested crepitus might be due to destruction of the smooth articular surface and Restricted range of motion can be attributed to the tightness of muscles, stiffness, pain, malalignment with Capsular pattern restriction in knee joint bilateral. The BFR resulted in a decrease in knee pain along with an increase in girth of the thigh when taken after 4 weeks from the initial evaluation. KB training resulted in improvement in range of motion, strength, and gain in motor control.

According to ACSM to gain strength and hypertrophy, the exercise should be performed at 60-70% of 1RM but various factors like age, obesity, lack of time, previous surgeries lead to reduced tolerance to high load strength training protocols which necessitate the use of alternative approaches which are less tiring, approachable and can be done with low loads with faster recovery. Some authors had reported the clinical effectiveness of muscle-strengthening exercises in patients with knee OA and have suggested that the exercise should not include high joint load.<sup>[11]</sup> If the knee joint is overloaded, patients with knee OA may aggravate symptoms such as pain, swelling, and inflammation.<sup>[14-15]</sup> The pressure used in the current intervention is sufficient to cause a hormetic relationship. It is likely that if the restrictive pressure is too low, muscular responses may not be significantly augmented. Furthermore, extremely high pressures (i.e. those that occlude arterial inflow during inter-set rest and/or exercise) may not enhance muscular development more than moderate pressures and maybe a safety concern.<sup>[16]</sup> Various mechanisms have been explored in the literature regarding increase in hypertrophy. The results obtained in this study might be attributed to the specificity of training particularly

isometric exercise. Another possible explanation for increased girth can be optimum pressure and presence of type 1 fibers in quadriceps which are responsible for hypertrophy.

Reduction of pain can also be attributed to KB training which leads to stimulation of mechanoreceptors when a muscle group is activated. It is supported by researchers [17] also that stimulation of A-beta fibers leads to closing the pain gate responsible for causing pain. Moreover, repeated proprioceptive training with functional elements increased cumulative neural inputs to the central nervous system via mechanoreceptors and proprioceptors in the joint capsules, ligaments, muscles, tendons, and other authors [18-21] reported that afferent inputs from muscles and tendons were more important than those from ligamentous mechanoreceptors, possibly because of mechanical stabilization. Accordingly, in several studies, proprioceptive training was implemented to address neuromuscular control and coordination elements. Another factor besides the pain gate theory can be the inclusion of dynamic and functional exercises as proprioception exercises. The second objective of the KB program is to encourage preparatory agonist-antagonist concentration. An efficient coactivator of the musculature restores the normal force couples that are necessary to balance joint forces and increase joint congruency, thereby reducing the loads imparted onto the static structures. [22] Improvement in balance appears to be due to strengthening of the major muscle groups, such as knee flexor and knee extensor for postural stability because muscle mass and muscle strength were positively correlated to balance. [23,24] More recently, it has been postulated that Low-intensity blood flow restriction training with Kb training results in increased water content of the muscle cells, which induces a cascade of anabolic intracellular signaling to occur resulting in greater increases in muscle size.

## CONCLUSION

We recommend BFRT with KB training to focus on cause of osteoarthritis rather than on symptoms by merely strengthening the muscles.

## Research Gaps In The Literature/ Outcome

No study in the literature has focused on girth of quadriceps and KB training always remains a neglected part of rehabilitation. The pressure used in the past was too to be practiced in clinics. Also, most of the research has been done combining BFR with isotonic exercise which is not suitable for geriatric in early course of treatment.

## List of Abbreviations

- BFR- Blood flow restriction
- OA- osteoarthritis
- KB- Kinaesthesia, Balance Training

**Conflict of Interest:** The authors have no competing interests to declare.

**Ethical Consideration:** Ethical approval was not required at the institution to publish an anonymous case report.

**Informed Consent:** Informed consent was obtained from the human subjects using the form approved by the institutional ethics committee before commencing any work.

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