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Effectiveness of Blood Flow Restriction Training Versus Resistive Exercises on Pain, Strength of Quadriceps Muscle, Physical Function in Osteoarthritic Knee Patients

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ABSTRACT

Background: Osteoarthritis (OA), is degenerative condition of knee joint which is more prevalent. Various treatments are available for OA knee. Blood Flow Restriction Therapy (BFRT) is effective training using low-load so that the excessive fatigue and strenuous exercises for strengthening muscles could be avoided which prevails more in Resisted exercises. This study is to assess effectiveness of BFRT on long term symptoms relief for patients with OA Knee.
Objective: To assess effect of BFRT on pain, muscle strength and Quality of life of OA knee patients.
Method: Randomly 46 participants were allocated in conventional and experimental Groups. The intervention to both groups was given for 1 week daily and the outcomes taken pre and post intervention were NPRS, 1RM strength, WOMAC scale and girth measurement.
Results: Statistical significant difference was found in both the groups with p-values <0.05 for all the outcomes in within the group comparisons. In between the group comparisons, BFRT found to have more significance in mean difference compared to resisted exercises for all the outcome parameters.
Conclusion: It was concluded that BFRT has more effectiveness in reducing pain, improving strength, girth of muscle and physical function compared to simple resistive exercises in patients with Osteoarthritis of knee.

Keywords: *BFRT, OA knee, pain, physical function, Resisted exercise, strength*

INTRODUCTION

'Artho' means joint in Greek, and 'itis' indicates inflammation that is arthritis of the joints. [1] Due to this, bone rubbing results which causes pain, swollen knee, stiffness, and unable to move, bone spurs formation.[2] In India, knee OA is more prevalent above 40 years.[2] Pro-inflammatory cytokines, growth factors and chemokines, adipokines and anti-inflammatory cytokines interact to cause the changes in tissue metabolism, architecture and functioning of knee. [3]
Based on categories of OA knee, knee OA is classified into Primary and Secondary. Primary Osteoarthritis is directly linked to aging and wear and tear.[4] Factors

responsible for Secondary OA include trauma, congenital defects, crystal deposition, the existence of deficient cartilage (genetic), and inflammation (prior inflammatory disorders like RA).[4,5]

X-ray may reveal a narrowing of the joint space due to bone alterations, cartilage loss, and the development of Osteophytes.[6] Several other clinical signs include pain, swelling, stiffness, presence of an effusion, loss of range of motion, loss of active movement, tenderness, crepitus, bony enlargement of the knee, loss of ability to walk effortlessly.[2,3,4,6] Pain and loss of strength of muscle especially quadriceps are predominantly found due to arthritis.[8,9] This ultimately results in the activities like sit to stand, standing for prolong period and walking.[9] Hence, daily activities (ADLs) are affected which hampers the routine functions including household chores.[9]

According to a study, patients with knee OA showed a substantial correlation with a couple of demographic and social characteristics, which includes age, sex/gender, occupation, education residence, BMI and a history of prior knee injuries and family history.[10] In clinical practice, the NRS, VAS and VRS are frequently employed to test the severity of pain.[12] However, on comparing all these, different studies have found NRS as the most reliable and helpful in assessing chronic pain, especially in older and less educated patients.[12] Talking about the strength, to measure the strength of primary muscle affected by OA that is quadriceps, one-repetition maximum (1RM) test can be time-consuming but many researchers found it as the "gold standard" to measure of dynamic strength.[13] Poorer pain, stiffness and functional impairments are indicated by higher WOMAC ratings.[11] WOMAC Scale is found to be most reliable tool to measure the overall functional performance of patients with knee Osteoarthritis. Due to arthritic changes, there is muscular atrophy of muscle belly. Girth measurements are frequently employed to evaluate joint effusion or muscle atrophy.[14]

Both surgical and non-surgical approaches, such as pharmacological or physio-therapeutic approaches, may be employed for treating OA. [2,6] Particular exercises can strengthen the knee muscles and improve flexibility and range of motion.[7] As a result, resistance training (RT) is widely used in the management of Osteoarthritis (OA), with the goal of strengthening and hypertrophying the quadriceps as a first-line therapy.[3,4] The maximal torque produced by that muscle contraction determines the resistance load in this case.[4] Here, there's the risk that exhaustion and hard weightlifting sessions could result in strained muscles.[4] Therefore, research on exercises with BFRT for strengthening can be done in order to prevent all of them. Data indicating that resistance training at Low Intensity (LI-RT) with blood flow restriction therapy (BFRT) achieves similar strength adaptations to normal resisted training with high intensity (HI-RT) with comparatively less exertion and reducing the levels of fatigue and strenuous load.[4,5] The cause of reduction in pain and hypertrophy of muscle is the intramuscular hypoxic environment in BFRT.[6] The chances of fatigue and strenuous weight lifts sometimes leading to muscle strain is possible in simple resistive exercises. Hence, in order to avoid all these, study on blood flow restriction training for strengthening is essential to be carried out. Also, the aim of this study was to find the effect on strengthening in OA Knee patients with BFRT and with simple resistive exercises and to get similar effects so that BFRT can be added as protocol in clinical practice for OA patient.

MATERIALS & METHODS

In this study, participants were recruited from patients who all were diagnosed as Osteoarthritis of knee and referred from Orthopedics Unit and Physical therapy department, Shree Krishna Hospital, Karamsad. A total of 46 participants aged between 40-60 years were recruited for the study. Informed consent was taken prior to

commencing the study and treatment approaches and training were explained well. According to the requirement of the study, participants both male and female, aged in range of 40-60 years and who were diagnosed with knee OA were included in the study. Patients who have CVS or musculoskeletal illnesses, taking any kind of medications, had trauma or deformity of lower limb, or any other problems like back pain or radicular pain were excluded. Participants were randomly assigned into two groups; Group A was experimental group and Group B was conventional. Total 2 participants discontinued the training, 1 from each group. So, total of 22 participants were analysed in each group. Outcomes were NRS, 1RM, WOMAC Scale and Girth measurement which were taken pre and post intervention. NRS was taken by rating the severity of pain the patient perceives on a 0-10 scale where 0 represents no pain and 10 represents worst pain possible. 1RM strength was measured by calculating the amount of weight lifted in a single attempt. For low load BFR training, 30% of 1RM was considered and for high load Resisted Training, 80% of 1RM was taken. WOMAC was scored based on 24 parameters covering pain, stiffness and physical function levels where total score was 96. The test questions were scored on a scale of 0-4 which corresponds to 0-none, 1-mild, 2-moderate, 3- severe and 4-extreme. In girth measurement, winding the measure-tap at the knee (i.e. at patella), above (Ab) 2, 4 and 6 inches to knee considering patella as reference point, the measures were recorded in centimeters.

In Blood Flow Restriction Training, that is in experimental group, a tourniquet cuff was tied at the junction of proximal two-thirds and distal one third of thigh and then cuff was inflated up to the pressure of 120- 140 mmHg, considering 30% of 1 RM (low-load), weight was tied accordingly at the distal joint that is at ankle and then exercises were performed

In Resisted Exercises, that is in conventional group, taking 80% of 1 RM (high-load) appropriate load or weight was tied at the distal end that is ankle and then exercises were performed.

Exercises given in both the groups;

1. Last degree extension
2. Straight leg raise
3. Straight leg abduction
4. Straight leg extension
5. High sitting knee extension

Intervention was given for one week. Three sets of each exercise with 10 repetitions each were performed daily. One minute of rest was given between the sets. After completion of intervention for 1 week, outcomes were again taken.

STATISTICAL ANALYSIS

Paired t-test was employed to know the improvement (if any) from both treatment regimens viz. BFRT and High Intensity Resistance Training. Independent sample t-test on difference score was applied to check the improvement was significant in different groups. As the sample size may not be sufficient for contrasting the improvements across groups, the difference in improvements was accompanied by 95% Confidence Interval to provide rough estimate of the difference.

RESULT

Table 1: Baseline characteristics for age and gender distribution;

Groups	No. of participants			Minimum	Maximum	Mean± SD
	Total	Male	Female			
Experimental	22	4	18	40	60	57± 8.94
Conventional	22	4	18	40	60	53.04± 7.10

Table 1 shows the baseline characteristics in form of age and gender, where the age for experimental and conventional groups are comparable at baseline, while there was unequal distribution found in gender in both the groups.

Table 2: pre and post values for NRS, 1RM, WOMAC and girth measurements for both the groups (within the group comparison)

Outcome measures	Experimental group		Conventional group	
	Pre	Post	Pre	Post
NRS	6.22± 1.99	1.04± 1.29	6± 1.92	2.27± 1.57
1 RM	1.20± 0.36	2.68± 0.47	1.31± 0.45	2.09± 0.54
WOMAC SCALE; Pain	10.5± 3.85	1.86± 1.58	9.45± 3.01	2.95± 1.61
Stiffness	2.09± 1.84	0.27± 0.45	3.90± 1.99	0.72± 0.76
Physical function	31.90± 10.94	4.86± 3.89	30.59± 9.33	8.63± 5.38
Total score	44.72± 14.62	7.09± 5.60	43.31± 11.95	13.54± 7.79
At patella	37.90± 4.2	37.45± 4.20	39.38± 4.43	38.95± 4.35
Ab 2 inches	38.95± 4.35	41.09± 4.50	41.43± 5.39	41.52± 5.16
Ab 4 inches	43.38± 4.92	44.27± 5.03	44.72± 6.05	45.09± 6.18
Ab 6 inches	47.45± 5.40	47.75± 5.52	48.36± 6.74	48.5± 6.85

The table 2 shows the within the group comparison between experimental and conventional groups for NRS, 1RM, WOMAC and girth measurements where p-value was found to be significant (<0.05) for all the outcomes comparing pre to post within the groups while for girth measures it was significant for 'at patella' and 'ab 4 inches' for both the groups while significant difference was found in experimental group comparing pre to post for ab 6 inches measurement.

Table 3; Post intervention values comparing between the groups

Outcome measures	Experimental group	Conventional group	Mean difference	P-value
NRS	5.18 ± 1.68	3.72± 0.93	1.45	<0.05
1 RM	-1.47± 0.36	-0.77± 0.42	-0.70	<0.05
WOMAC; PAIN	8.63 ± 3.31	6.5± 2.89	2.13	<0.05
STIFFNESS	1.81± 1.65	3.18± 0.31	-1. 36	<0.05
PHYSICAL FUNCTION	27.04± 9.32	21.95± 9.37	5.09	0.07
Total score	37.63± 12.65	29.77± 12.86	7.86	<0.05
At patella	0.45± 0.65	0.43± 0.66	0.02	0.90
Ab 2 inches	-0.29± 0.70	- 0.09± 0.62	-0.20	0.31
Ab 4 inches	-0.88± 0.65	-0.36± 0.58	-0.52	<0.05
Ab 6 inches	-0.29± 0.52	-0.13± 0.56	-0.15	0.33

The table 3 shows between the group comparisons for both the groups post interventions for NRS, 1RM, WOMAC scale and girth measurement. There was statistical significance (p value <0.05) for all the components except for physical function in both the group, however comparing the mean differences, it was more significant for experimental group as compared to conventional group. Talking about the girth, the p-values found to be statistically significant for above 4 inches. While on comparing the values of mean differences for at patella, above 2 inches, above 6 inches, it shows more significance for experimental group compared to conventional group.

DISCUSSION

In this study, the minimum age considered was 40 years and maximum age taken was 60 years for both the groups. On comparing the groups, there was homogenous distribution for age. A review done by Allen KD et al. in 2022 that took a comprehensive approach regarding epidemiology of Osteoarthritic knee across the different parts of world found that it is most common after 40 years and till 65 years of age groups.[15] The age group taken in this study is quite near to age group of current study. Henceforth, it was ought to accept that OA knee was more prevalent after 40 years of age. There was unequal participation of men and women in the current study. A systemic review conducted

by Stefania Pagani, Matilde Tschon et al., in 2021 on gender for the prevalence of Osteoarthritis apart from other variables gathering all the cohort and cross-sectional studies, they concluded that women are found to be more affected by arthritis of knee joints compared to men.[16]

In this study, Blood flow restriction training has been found to be effective in reducing pain, improving the strength of quadriceps muscle, hypertrophy of muscle and hence improvising the overall functional performance in patients with OA knee. After applying pressure over the Quadriceps muscles that induced, intramuscular hypoxic environment, was found to be the chief factor behind the working of BFR training. Evidences stated that it stimulates vascular endothelial growth and increased levels of metabolic stress that could promote hypertrophy, achieving results to muscle activation and get effect, just like a standard muscle gain training.[17] Though it helps in reducing the joint stress while loading activities and thus increasing exercise tolerance.[17] This ultimately affects the pain perception and reducing the levels of pain. Barber-Westin S et al in 2019 did a study that said mechanical tension and metabolic stress were found to be responsible to activate different mechanisms that could induce muscle growth.[18] Combing all these reasons behind the impact of BFRT, different evidences have concluded that BFRT is fruitful for muscle strengthening. Further, BFRT is also helpful in gaining mass or hypertrophy of muscles. It has been hypothesized Stasinopoulos D et al., in 2021 that an intramuscular anaerobic environment induces vascular growth in endothelium and high amount of metabolic stresses activation of type 2 fibers, that facilitates hypertrophy of muscles in BFR training.[19] All these factors could be the probable reason of hypertrophy of muscle in present study.

Apart from that, BFRT is proved to be effective in improving the physical function of patients. The WOMAC scores have reduced suggesting improvement in the symptoms of knee OA. Most of the evidences showed improvement in pain and physical function domain, hypothesis can be kept that on reduction of pain, functional performance is correspondingly improved.[20,21] Improving strength of surrounding knee muscles progresses towards improved physical function.[18,20,21]

In conventional training with simple resistive exercises, significant improvement was found in reducing the pain, improving strength and hypertrophy of muscle and hence, improving the functional status in OA knee patients in the present study. Joseph B. Lesnak et al., in 2020 gave many causes of alleviation of pain through resisted exercises apart from hyperalgesia and endogenous opioids, mechanisms such as serotonergic system, endocannabinoids, noradrenergic system, role of adenosine receptors, neuroimmune mechanism induced analgesia.[22] All these results coincided with the present study.

Also, in this study, there was marked improvement in muscular strength and atrophy of muscle by resisted exercises.

Various evidences have found that the fast twitch fibers type 2 and combination of both neural and skeletal muscle adaptations obtained from higher-load respond to higher exercise intensity with great amount of hypertrophy compared to type 1 fibers and increases muscular strength.[8,9] Considering the reduction in all these symptoms and improving strength, there was also improvement in physical function where WOMAC scores have been reduced suggesting relief of symptoms. A systemic review and meta-analysis conducted by Van Cant J et al., in 2020 on Osteoarthritic knee patients, considering WOMAC scale as outcome found that the scores were reduced on WOMAC scale and physical function was hence improved by quadriceps muscle strengthening exercises with resisted loads.[8] These evidences were much similar to the results reported in the present study for conventional prototype.

However, on comparing the effects of BFRT and RE, BFR training was proved to be quite more effective than RE because of

its anaerobic mechanism of strengthening and using low-load, it gives much less stress on joints and reduces the chances of fatigue and improving the physical function while high-load resistance training gives strenuous exercises.

CONCLUSION

This study concluded that both BFRT and Resisted exercises gave significant improvement in reducing the symptoms and improving function. However, BFRT was more effective in reducing pain, improving strength, hypertrophy of muscle and physical function using low-load as compared to simple resistive exercises in patients with Osteoarthritis of knee.

Declaration by Authors

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