RESEARCH ARTICLE

Impact of strengthening exercises with and without blood flow restriction on quadriceps of knee osteoarthritis patients

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Abstract

Objective: To determine the effect of blood flow restriction with strengthening exercises on knee osteoarthritis patients.

Method: The case-control study was conducted at the Department of Physical Medicine and Rehabilitation, Combined Military Hospital, Okara, Pakistan, from June to December 2018, and comprised knee osteoarthritis patients who were assigned to two equal groups. The cases in Group A received strengthening exercises with blood flow restriction, while the controls in Group B received strengthening exercises without blood flow restriction. Both groups were given 4 sessions of treatment per week with 5-minute warm-up on a stationary bike for 4 weeks. Outcome was measured using visual analogue scale, Kujala scoring questionnaire and muscle girth measurement. Data was analysed using SPSS 20.

Result: Of the 30 patients, 15(50%) were in each of the two groups. There were 20(66.7%) females and 10(33.3%) men with an overall mean age of 66.5±6.5 years. Also, 18(60%) subjects were overweight on the basis of body mass index. There were significant improvement in terms of pain and disability in both the groups ($p<0.05$)), but only Group A showed significant improvement in muscle girth ($p<0.05$). Overall there was no significant difference between the groups ($p>0.05$).

Conclusion: Strengthening exercises reduced pain and disability, but the addition of blood flow restriction had no significant impact except in terms of muscle size.

Keywords: Knee osteoarthritis, Muscle strength, Strengthening programmes, Tourniquet, Vascular occlusion.
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Introduction

Knee osteoarthritis (KOA) is a chronic disorder with more prevalence in females compared to males,[1] caused by articular cartilage destruction, and affects the knee joint's surface and bones, and ultimately causes pain, reduces activities of daily life (ADLs) and affects quality of life (QOL) by restricting the movements. Patho-physiologically, the cartilage generation and destruction enzymes are not present in a balanced ratio.[2] KOA grade 1 means minor bone spurs, grade 2 means certain number of spurs and narrowing of joint space, grade 3 means multiple medium-sized bone spurs and further narrowing of space, and grade 4 indicates a large no of bone spurs, reduced joint space, sclerosis and bone deformity.[3]

KOA prevalence in Pakistan is high compared to other Asian countries as 25% rural and 28% non-rural areas are affected; northern region being much more affected than the southern region.[4] Key risk factors are gender, age >50 years, obesity, history of trauma, overuse or occupational injury and smoking etc.[5] Common symptoms include pain due to long-duration activity and weight-bearing, stiffness due to inactivity[6] and difficulty during climbing stairs and walking.[7]

In addition to pharmacotherapy and activity modification, multiple non-pharmacological options are available, which include the use of therapeutic modalities, assistive devices and strengthening exercises to different groups of muscles. Resistance training with blood flow restriction (BFR) has been found to decrease pain and disability and to improve strength and physical working.[8]

Resistance exercise with BFR or vascular occlusion is also an option for the management of KOA. It is done with a pneumatic cuff or tourniquet that lessens the blood flow and restricts the venous return, thereby raising the metabolic stimulus in working muscles.[9] BFR exercise results in favourable adjustments to muscle strength, mass and endurance.[10] It incorporates a collection of metabolites, cell swelling, enhanced motor unit recruitment, decreased protein breakdown and the multiplication of satellite cells, most likely expanding the muscle hypertrophic reaction.[11]

Various studies from Pakistan are available on KOA using different treatment options, but BFR has not been tried as

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a therapeutic option.[8,9]

The current study was planned to determine the effect of BFR with strengthening exercises on KOA patients.

Patients and Methods

The case-control study was conducted at the Department of Physical Medicine and Rehabilitation, Combined Military Hospital (CMH), Okara, Pakistan, from June to December 2018. After approval from the institutional ethics review committee, the sample size was calculated using 95% confidence level and 5% margin of error on the basis if an earlier study.[9] The sample was raised using non-purposive consecutive sampling technique. Those included were grade 2 KOA patients of either gender aged 50-75 years with complaint of pain at the knee joint or inability to perform ADLs. Those with history of recent/old trauma, knee replacement surgeries, movements restricted at the knee joint, other co-morbidities, like stroke and rheumatoid arthritis, pain due to other knee problems, like tendonitis, bursitis, anterior cruciate ligament (ACL) tear etc., were excluded. After taking informed consent from the participants, they were assigned to two equal groups. The cases in Group A received strengthening exercises of quadriceps, hamstrings and calf muscles with BFR, while the controls in Group B received strengthening exercises alone without BFR.

On the first visit, muscle bulk, pain intensity and knee joint activity of all participants were determined. Demographical data was noted using a proforma and body mass index (BMI) was calculated. BMI 18-24.9kg/m^2 was considered normal weight and >25kg/m^2 as overweight. Both groups received a total of 16 physiotherapy sessions; 4 sessions per week for 4 weeks. During each session, 5-minute warm-up was performed by each participant on a stationary bicycle followed by strengthening exercises in the lying position at moderate speed with 5-second rest between each contraction and a total 3 sets of 10 repetitions per session. The participants were told to discontinue routine exercises apart from the treatment exercises.

Group A participants performed strengthening exercises with BFR using a tourniquet on the most proximal portion of the involved muscle and on arterial supply for each muscle, as on femoral artery for thigh muscles and on tibial artery for calf muscles. The BFR pressure was high enough for venous return occlusion, but was not too high to completely block the arterial flow. The control Group B performed strengthening exercises without tourniquet application.

Pain was measured using visual analogue scale (VAS) scores, while Kujala Scoring Questionnaire (for assessment of pain at knee joint)[12] was used for assessing knee joint activity. Muscle girth measurement was taken with the help of flexible inches tape by measuring the respective muscle bulk. The assessments and measurement was done by the therapist at baseline and post-intervention on the last day of the 4th week.

Data was analysed using SPSS 20. Paired-t and independent-t tests were used. P<0.05 was considered significant.

Results

Of the 30 patients, 15(50%) were in each of the two groups. There were 20(66.7%) females and 10(33.3%) males with an overall mean age of 66.5+6.5 years. Also, 18(60%) subjects were overweight on the basis of BMI value (Table-1).

There were significant improvement in terms of pain and disability in both the groups (p<0.05), but only Group A showed significant improvement in muscle girth (Table-

Table-1: Descriptive data.

Variables	Frequency Distribution		
	N = 30 (%)	BFR group (N=15)	Non-BFR group (N=15)
Gender			
Female	20(66.7%)	11(73.3%)	9(60%)
Male	10(33.3%)	4(26.7%)	6(40%)
Age			
50-62 years	11(36.7%)	4(26.7%)	3(20%)
63-75 years	19(63.3%)	11(73.3%)	12(80%)
Body Mass Index			
Normal	12(40%)	6(40%)	6(40%)
Overweight	18(60%)	9(60%)	9(60%)

BFR: Blood flow restriction.

Table-2: Pain, disability and muscle girth assessment in participants with and without blood flow restriction (BFR).

Variables	Blood Flow Restriction group				Non-Blood Flow Restriction group			
	Initial Mean	Final Mean	Mean Difference	P value	Initial Mean	Final Mean	Mean Difference	P value
Pain Assessment	2.67±0.48	2.00±0.53	0.67±0.61	0.001	2.46±5.16	2.13±5.16	0.33±0.48	0.019
Knee Disability Index	4.47±1.50	5.67±1.91	-1.20±0.08	0.001	4.53±1.59	5.07±1.62	-0.53±0.51	0.001
Muscle Girth	1.47±0.51	1.80±0.67	-0.33±0.48	0.019	1.40±0.63	1.47±0.63	-0.06±0.25	0.334

Table-3: Inter-group comparison of pre- and post-intervention assessment.

Blood Flow Restriction v/s Non Blood Flow Restriction											
VAS before		VAS after		Kujala score before		Kujala Score after		Muscle girth before		Muscle girth After	
MD	P value	MD	P value	MD	P value	MD	P value	MD	P value	MD	P value
0.20	0.22	0.00	0.02	-0.07	0.40	0.60	0.36	0.07	0.66	0.60	0.18

VAS: Visual analogue score; MD: Mean Difference.

Table-4: Inter-group outcomes based on different body mass index (BMI) groups.

Variables	Blood Flow Restriction group BMI				Non Blood Flow Restriction group BMI			
	Normal weight		Overweight		Normal weight		Overweight	
	*MD	P value	*MD	P value	*MD	P value	*MD	P value
VAS	0.67±0.51	0.02	0.11±0.33	0.34	1.1±0.40	0.01	0.33±0.50	0.08
Kujala Score	0.5±0.54	0.07	0.56±0.52	0.01	0.67±0.51	0.02	1.67±1.00	0.01
Muscle Girth	0.40±0.52	0.03	0.11±0.33	0.34	0.40±0.52	0.03	0.52±0.54	0.07

VAS: Visual analogue score; MD: Mean Difference; *Mean difference between initial score and score at the end of research.

2). Inter-group analysis showed no significant difference with respect to outcome measures (Table-3).

Pain, disability and muscle girth values for those having normal weight showed significantly more improvement (Table-4).

Discussion

The study found KOA to be more prevalent in females which is in line with literature.[13] The sample of the present study ranged 50-75 years and 66.7% participants were female, which, again was consistent with a study done with KOA females aged 55-74 years.[13]

In the present study, 60% participants were overweight on the basis of BMI >25kg/m^2. Other studies support the fact and have observed that reducing weight was helpful for beneficial effects in KOA.[14] Other studies stated that as glucose load increased, alterations in the mechanical properties occurred and ultimately resulted in destruction of the cartilage.[15]

For the management purpose, a study interpreted that the quadriceps strengthening exercises were beneficial for KOA patients for not only improving the strength of the quadriceps, but also hamstring and calf muscles due to the anatomy of the knee joint.[16] Another study confirmed that the cross-sectional area of muscle and strength were increased with the help of BFR exercises.[17]

The current study showed that pain and disability of the knee joint due to arthritis were improved with the help of strengthening exercises through vascular occlusion. Another study reported that quadriceps strengthening, which is very effective in KOA performed with BFR, had led to decreased pain during daily activities.[18]

The current study verified that muscle action was improved by BFR exercises and they also enhanced the level of daily activities. One study observed that BFR increased muscle fatigue though it lasted for a short period of time.[10] Overall, most studies are in favour of BFR exercises regarding muscle strength, size and cross-sectional area.[19]

In the current study the muscle girth, or cross-sectional area, was only significant in subjects with BFR training and not in subjects with strengthening exercises alone. One study showed that strength training, or conditioning, also increased the cross-sectional area of quadriceps muscle.[20] In the current study, BFR technique was conducted under supervision in a clinical setup and no harm was observed. According to one study, it was shown that the participants had many concerns about this technique, like muscle soreness, bruising, pain etc.[21]

As the sample size was small in the current study, no long-term follow-up was done and BFR was applied mostly on the quadriceps, the findings cannot be generalised to overall population. Further studies regarding long-term follow up, a large sample size and muscles other than quadriceps are highly recommended. In the current study, no indications and contraindications were mentioned and the regime was performed according to subject's tolerance level. In another study, however, it was highlighted that proper BFR modality would be needed and identification of indications, contraindications, modality procedure, cuff tolerance, intensities would have to be determined for this regimen to be safe for subjects and there will be a need to modify the relatable risk factors.[22]

In terms of limitations, there is a lack of prior research in this area locally which means no comparable literature regarding BFR was available. Also, data might be indicative of some cultural or other types of biases.

Conclusion

KOA patients were found to have significant improvement in pain and disability through strengthening exercises along with BFR, but muscle size only increased with BFR exercises due to its metabolite-accumulation mechanism.

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Conflict of Interest: None.

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References

1. Ferraz RB, Gualano B, Rodrigues R, Kurimori CO, Fuller R, Lima FR, et al. Benefits of resistance training with blood flow restriction in knee osteoarthritis. Med Sci Sports Exerc. 2018; 50:897-905.
2. Iqbal MN, Haidri FR, Motiani B, Mannan A. Frequency of factors associated with knee osteoarthritis. J Pak Med Assoc. 2011; 61:786-9.
3. Tennent DJ, Hylden CM, Johnson AE, Burns TC, Wilken JM, Owens JG. Blood flow restriction training after knee arthroscopy: a randomized controlled pilot study. Clin J Sport Med. 2017; 27:245-52.
4. Ali SS, Ahmed SI, Khan M, Soomro RR. Comparing the effects of manual therapy versus electrophysical agents in the management of knee osteoarthritis. Pak J Pharm Sci. 2014; 27:1103-6.
5. Plotnikoff R, Karunamuni N, Lytvyak E, Penfold C, Schopflocher D, Imayama I, et al. Osteoarthritis prevalence and modifiable factors: a population study. BMC Public Health. 2015; 15:1195.
6. Case R, Thomas E, Clarke E, Peat G. Prodromal symptoms in knee osteoarthritis: a nested case–control study using data from the Osteoarthritis Initiative. Osteoarthritis Cartilage. 2015; 23:1083-9.
7. Segal N, Davis MD, Mikesky AE. Efficacy of blood flow-restricted low-load resistance training for quadriceps strengthening in men at risk of symptomatic knee osteoarthritis. Geriatr Orthop Surg Rehabil. 2015; 6:160-7.
8. Yasuda T, Ogasawara R, Sakamaki M, Ozaki H, Sato Y, Abe T. Combined effects of low-intensity blood flow restriction training and high-intensity resistance training on muscle strength and size. Eur J Appl Physiol. 2011; 111:2525-33.
9. Cerqueira MS, de Brito Vieira WH. Effects of blood flow restriction exercise with very low load and low volume in patients with knee osteoarthritis: protocol for a randomized trial. Trials. 2019; 20:135.
10. Husmann F, Mittlmeier T, Bruhn S, Zschorlich V, Behrens M. Impact of blood flow restriction exercise on muscle fatigue development and recovery. Med Sci Sports Exerc. 2017; 50:436-46.
11. Dankel SJ, Jessee MB, Abe T, Loenneke JP. The effects of blood flow restriction on upper-body musculature located distal and proximal to applied pressure. Sports Med. 2016; 46:23-33.
12. Bourlez J, Canovas F, Duflos C, Dagneaux L. Are modern knee outcomes scores appropriate for evaluating patellofemoral degeneration in osteoarthritis? Evaluation of the ceiling and floor effects in knee outcomes scores. Orthop Traumatol Surg Res. 2019; 105:599-603.
13. Postler A, Ramos AL, Goronzy J, Günther KP, Lange T, Schmitt J, et al. Prevalence and treatment of hip and knee osteoarthritis in people aged 60 years or older in Germany: an analysis based on health insurance claims data. Clin Interv Aging. 2018; 13:2339-49.
14. Losina E, Walensky RP, Reichmann WM, Holt HL, Gerlovin H, Solomon DH, et al. Impact of obesity and knee osteoarthritis on morbidity and mortality in older Americans. Ann Intern Med. 2011; 154:217-26.
15. Wallace IJ, Worthington S, Felson DT, Jurmain RD, Wren KT, Maijanen H, et al. Knee osteoarthritis has doubled in prevalence since the mid-20th century. Proc Natl Acad Sci. 2017; 114:9332-6.
16. Bennell KL, Kyriakides M, Hodges PW, Hinman RS. Effects of two physiotherapy booster sessions on outcomes with home exercise in people with knee osteoarthritis: a randomized controlled trial. Arthritis Care Res (Hoboken). 2014; 66:1680-7.
17. Cook SB, LaRoche DP, Villa MR, Barile H, Manini TM. Blood flow restricted resistance training in older adults at risk of mobility limitations. Exp Gerontol. 2017; 99:138-45.
18. Giles L, Webster KE, McClelland J, Cook JL. Quadriceps strengthening with and without blood flow restriction in the treatment of patellofemoral pain: a double-blind randomised trial. Br J Sports Med. 2017; 51:1688-94.
19. Yasuda T, Loenneke JP, Thiebaud RS, Abe T. Effects of blood flow restricted low-intensity concentric or eccentric training on muscle size and strength. PLoS One. 2012; 7:e52843.
20. Lixandrao ME, Ugrinowitsch C, Berton R, Vechin FC, Conceição MS, Damas F, et al. Magnitude of muscle strength and mass adaptations between high-load resistance training versus low-load resistance training associated with blood-flow restriction: a systematic review and meta-analysis. Sports Med. 2018; 48:361-78.
21. Patterson SD, Brandner CR. The role of blood flow restriction training for applied practitioners: A questionnaire-based survey. J Sports Sci. 2018; 36:123-30.
22. Centner C, Wiegel P, Gollhofer A, König D. Effects of blood flow restriction training on muscular strength and hypertrophy in older individuals: a systematic review and meta-analysis. Sports Med. 2019; 49:95-108.