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ORIGINAL ARTICLE

Effect of Visual Biofeedback in Quadriceps Strengthening Exercises in Improving the Functional Outcomes of Patients with Unilateral Knee Osteoarthritis

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ABSTRACT
Osteoarthritis (OA) is a more commonly seen musculoskeletal disorder in the elderly and is accompanied by pain, weakening of the quadriceps muscle, and affecting the walking ability of a person. Although it is proved that quadriceps strength training using various biofeedback techniques was effective, this study focuses on quadriceps strength training using a sphygmomanometer as pressure biofeedback. To test the effectiveness of visual biofeedback in quadriceps strengthening exercise to improve the functional outcomes of patients with unilateral knee osteoarthritis. This study was designed as an experimental study followed by treatment for 4 weeks. The 14 patients with unilateral knee osteoarthritis who fulfilled the selection criteria were selected and taken as group A and B, given conventional therapy along with visual biofeedback-based quadriceps strengthening exercise and conventional therapy alone respectively. The pretest and posttest values were obtained through Western Ontario and Mc Master Universities osteoarthritis index (WOMAC) and Visual analog scale (VAS). The results show that there is a significant improvement in functional activities and pain reduction in the experimental group from which the study could be concluded that "visual biofeedback based quadriceps strengthening is effective in improving functional outcomes and reduction of pain".
Keywords: *Visual biofeedback based quadriceps strengthening, Western Ontario and Mc Master Universities Osteoarthritis Index, Visual analog scale, Pain, functional outcome.*

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INTRODUCTION

The knee joint is the essential and very important weight-bearing joint of our body. The joint geometry is alone not enough to maintain the complex mechanism of the knee joint, it also requires the support of soft tissue (ligaments, etc.) and muscular support. The passive stability is maintained by ligaments, menisci, and retinacula, and then active stability is maintained by muscular contraction [1]. In knee joint quadriceps is the important muscle-maintaining stability. Hence we came to know about the importance of muscle in the knee joint and will see how to strengthen it for stable joint and how it helps in osteoarthritis patients.

Osteoarthritis (OA) is a non-inflammatory degenerative disorder of synovial joints in which there is a deterioration of articular cartilage with a new bone formation called osteophytes [2]. In OA commonly affected joint is the knee. It is most common among women than men and the elderly population >45 are affected in a greater percentage. Risk factors for OA include older age, female gender, obesity, occupation, sports, and any history of injury to the knee, weak musculature, and genetic causes [3]. In the pathogenesis of OA knee quadriceps play an important role. When the quadriceps are stronger or strength of it is more the risk for tibiofemoral OA development [2] pathophysiology of OA starts with the destruction of cartilage, frays, and fibrillates leading to subchondral sclerosis, thickening of the joint capsule, consequently stiffness, and joint deformation occurs.

The clinical features like pain, muscle spasm, joint stiffness, muscle wasting and weakness, crepitus, loss of movement, deformity in progressed stage, loss of function are seen. Based on history and physical examination by the American College of Rheumatology criteria for the classification and reporting of

osteoarthritis knee the diagnosis is done. There are many other biochemical investigations like testing of synovial fluid, serological test, ESR, and serum uric acid to find out gout [4]. The X-ray is the most useful test that confirms osteoarthritis, Kellgren, and Lawrence system (1957) is a common method of classifying the severity of knee OA using five grades [5, 6].

There are a variety of treatments available which aims at educating the patient about disease and management, pain control, improve function and decrease disability, and altering the disease process and its consequences [4]. As there are many medical treatments like analgesics, NSAIDS, etc. surgical treatment in progressed stages of OA and conventional physical therapy treatments. Physiotherapist plays an important role in managing OA conservatively in early stages. The progression of the disease is influenced by muscle weakness along with pain and physical dysfunction, the key component in OA is muscle strengthening [2, 7]. Although studies are stating about the exercises for strengthening muscles in OA patients, then one study on visual biofeedback using a sphygmomanometer [8], there are no studies on using sphygmomanometer as visual biofeedback in OA patients, hence the need arises to evaluate the effect of sphygmomanometer as visual biofeedback in quadriceps strengthening exercise in OA. The objective of this study is to investigate the effect of visual biofeedback in quadriceps strengthening exercises in pain reduction and relieving functional disabilities of patients with unilateral knee OA.

MATERIAL AND METHODS

This randomized experimental study was conducted in the outpatient department of Krupanidhi College of Physiotherapy after the approval of the institutional review board. The study was explained to subjects and written consent was got signed from them. The sampling technique was purposive sampling in which 14 (N=14) unilateral subjects were purposively selected. There are many studies on bilateral OA as the reason behind the purposive selection. The inclusion criteria include the common population affected, the female subjects with age ranging from 45-60 years, acute tibiofemoral osteoarthritis, Kellgren, and Lawrence classification grade 1 & 2. Then exclusion criteria includes subjects with acute inflammation and post-operative conditions, knee deformity (valgus/Varus), patellofemoral arthritis, meniscal/ligament injuries of knee joint, any recent history of trauma, recent injections to affected knee in last three months as these all affects the effects of treatment.

Sample Size Calculations:

The sample size was calculated with N as (N= 15) and prevalence of osteoarthritis 39% (i.e. p= 39%). Then by calculating with a formula for a sample size of unknown population (S.S (unknown)), we got 365.2 and with a formula for a sample size of known population (S.S (known)), we got 14 samples.

$$S.S(Unknown) - \frac{z^2 * p * (1-p)}{e^2}$$

$$S.S(Known) = \frac{S.S(Unknown)}{1 + \frac{S.S(Unknown)}{N}}$$

Method Flowchart:

The Experimental method flowchart is shown in the Fig.1.

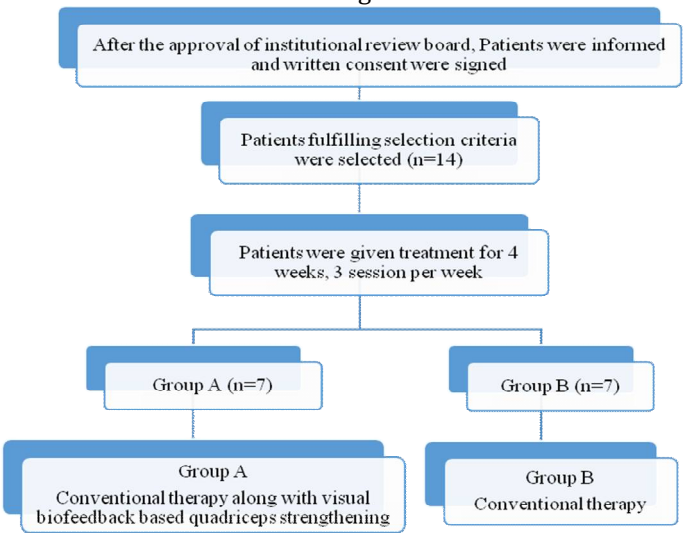

Fig. 1. Flowchart for the experimentalmethod.

Treatment for Group A:

Conventional therapy and biofeedback based quadriceps strengthening includes:

1. Straight leg raising (SLR) (Fig. 2) – In this patient will be in a supine lying position, Ask the patient to bend one leg at the knee. Hold the other leg straight and raise it from the bed up to 45 degrees. Instruct the patient to hold this position for 5 seconds and then slowly lower the leg to the bed. The subject performs 2 sets of 10 repetitions on both sides with 5 seconds of rest between repetitions.
2. Hip abductor strengthening (Fig. 3) - Patient will be Side-lying. In side-lying, ask the patient to lift the top leg upwards and sideways. Hold it for 5 seconds. The subject performs 2 sets of 10 repetitions on both sides with 5 seconds of rest between repetitions.
3. Knee extension exercise (Fig. 5) – In sitting, the subject is asked to fully extend the knee from 90 degrees of flexion. Hold it for 5 seconds. The subject performs 2 sets of 10 repetitions on both sides with 5 seconds of rest between repetitions.
4. Hamstring muscle stretch (Fig. 6) – In long sitting, ask the patient to sit with one leg along the edge of the bed and another leg down. The subject is asked to lean forward to touch the toes. The subject should feel the stretch along the back of the thigh and hold it for 10 seconds. The subject performs 2 sets of 10 repetitions for both sides with 5 seconds of rest between repetitions.
5. Knee flexion (Fig. 7) - In standing ask the patient to hold on to support and to flex the knee against the gravity up to 90 degrees and hold it for 5 seconds and then extend the knee. The subject performs 2 sets of 10 repetitions with 5 seconds of rest between repetitions.
6. Mini squats (Fig. 8) – In standing, Ask the patient to hold onto a chair/support. Ask her to squat down until her knee is over the great toe (roughly about 30-45 degrees). Return to standing. Repeat 2 sets of 10 repetitions with 5 sec of rest between repetitions.
7. Step-ups (Fig. 9) – Initially standing on stairs, ask the patient to step onto the stepping block or bottom step of stairs with the right foot. Bring up the left foot, then step down with the right foot followed by the left foot. Alternate it with the other foot. Repeat the same, 2 sets of 10 with 5 seconds rest between repetitions.
8. Calf muscle stretching (Fig. 10) - Standing on a step. Stand on edge of the step and lower both the heels slowly. Feel the stretch along the back of the leg. Or standing in front of wall place one leg forward with knee bent and other leg stretched backward and hands supporting on the wall, feel the stretch on the leg in back. Repeat same for other legs. Hold it for 10 sec. Repeat 2 sets of 10 repetitions with 5-sec rest between the repetitions. Alternatively, calf muscle can be stretched in stride standing.
9. Popliteus muscle activation exercise (Fig. 11) - Supine lying, prone lying, or standing. In supine, ask the patient to bend the knee 40^0-45^0. Then ask the subject to move the foot inwards, so that internal rotation of the tibia takes place. Hold for 10 sec. Repeat 2 sets of 10 repetitions with 5-sec rest between the repetitions. In a standing or prone lying the patient is asked to flex the knee along with tibial internal rotation.
10. Visual Biofeedback based Quadriceps Strengthening [8] (Fig. 12) - In this we apply the principles of pressure feedback measured directly by the effort of quadriceps contraction, using a cost-effective simple operating gadget, to quantify the progress and to maintain the isometric strength of the quadriceps. Although the patient may not be oblivious to the muscle activity, they can see the results of the efforts. Although there are many studies for visual biofeedback-based training like EMG, ultrasound [9], this study aims to see the effect of using a sphygmomanometer as pressure biofeedback for strengthening a muscle. Procedure – The patient is half lying with back support. A poly water bottle is filled with water and a sphygmomanometer cuff is wrapped around the bottle and placed under the subject's knee. The base pressure is set at 100 mm Hg. Then the subject is explained and asked to do isometric quadriceps by pressing the bottle, then the pressure changes are shown. First, it is done on the normal leg then on the affected leg for comparisons and setting goals. Initially, 10-15 repetition is done and increased gradually.

Treatment for Group B:

Group B receives only conventional therapy which includes Straight leg raising (SLR), Hip abductor strengthening, Isometric quadriceps, Knee extension exercise, Hamstring muscle stretch, Knee flexion, Mini squats, Step-ups, Calf muscle stretching, Popliteus muscle activation exercise. The procedure for exercises is the same as mentioned for Group A except for the change in procedure for isometric quadriceps in which the patient will be in a sitting or supine position. The knee in partial flexion the patient paces a towel or roll under the knee. The knee is straightened and holds extension. Hold the position for about 5 sec.

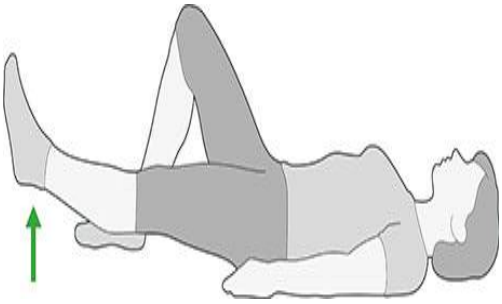

Fig. 2. Straight leg raising (SLR)

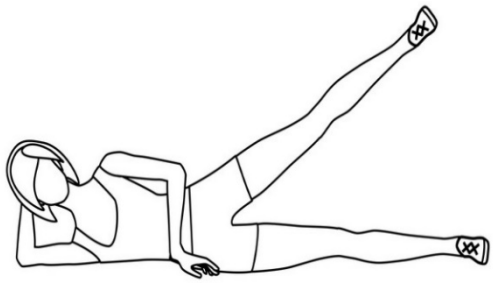

Fig. 3. Hip abductor strengthening

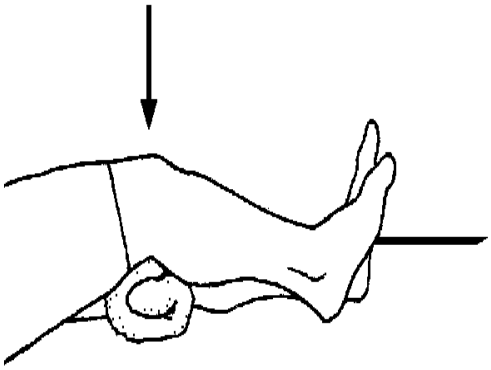

Fig. 4. Isometric quadriceps

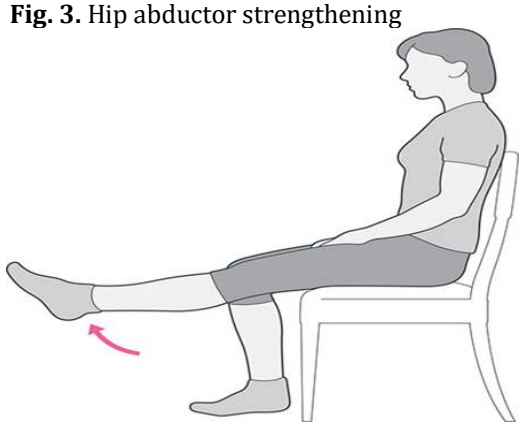

Fig. 5. Knee extension exercise

Fig. 6. Hamstring muscle stretch

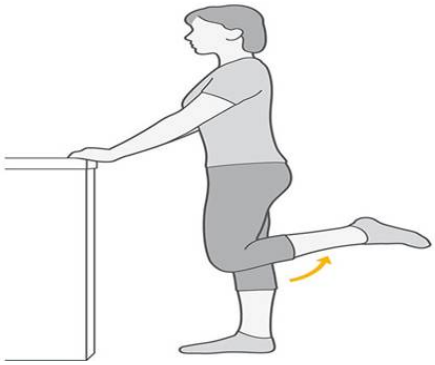

Fig. 7. Knee flexion exercise

Fig. 8. Mini squats

Fig. 9. Step ups

Fig. 10. Calf muscle stretch

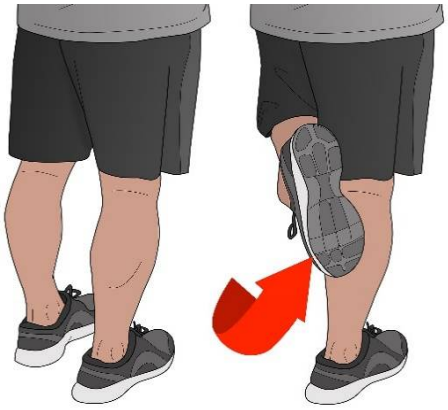

Fig. 11. Popliteus muscle activation exercise

Fig. 12. Visual biofeedback-based quadriceps strengthening exercise using a sphygmomanometer.

The treatment duration was 4 weeks with 3 sessions per week. Each session lasts from 20- 30 mins and a home program of walking for 15 mins was given for 5 days of a week. [10, 11]

Outcome Measures:

Visual analog scale (VAS) is used for pain assessment and for measuring functional disability Western Ontario and Mc Master Universities Arthritis Index (WOMAC). Pre and post-intervention measurement was taken using VAS and WOMAC.

Data Analysis:

The study's objective was to show improvement in pain reduction and functional activities level in patients with unilateral tibiofemoral knee osteoarthritis, by using visual analog scale and western Ontario and Mc Master universities index various statistical tools were used to measure the differences in the patients of group A and group B. Statistical deviation and test of significance which is in table 1.

The comparing values of group A and B stating that there is a reduction of pain in group A and B but more difference, reduction in group A with a significance value of p=0.001. Then when seeing for WOMAC values between groups shows significant improvement, that is a reduction of functional disability or improve functional independence in both groups but tremendous changes in group A by seeing t=20.127 in group A and t=6.971 in group B.

Table 1: The table showing a comparison between the two groups.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAS PRE TEST-A - VAS POST TEST-A	3.571	.535	.202	3.077	4.066	17.678	6	.000
Pair 2	VAS PRE TEST-B - VAS POST TEST-B	1.143	1.773	.670	-.497	2.782	1.706	6	.139
Pair 3	WOMAC PRE TEST-A - WOMAC POST TEST-A	19.571	2.573	.972	17.192	21.951	20.127	6	.000
Pair 4	WOMAC PRE TEST-B - WOMAC POST TEST-B	10.286	3.904	1.475	6.675	13.896	6.971	6	.000

RESULTS AND DISCUSSION

The results when comparing within groups pre and post states that there is a significant improvement (p=0.004) for group A VAS. Whereas VAS correlation of group B is not that much significant as group A (p=0.325). when comparing pre and post of WOMAC for group A shows significant improvement stating there is a reduction in functional disabilities with p=0.058. In group B, the WOMAC values pre and post do not show that significant improvement like group A.

The post mean values of VAS of group A and B shows that group B has more mean value (5.57) stating more pain in group B (Fig. 13). Then the post mean values for WOMAC of group A and B stating group B with more functional disabilities(35.28) (Fig. 14).

The results comparing values of group A and B stating that there is a reduction of pain in group A and B but more difference, reduction in group A with a significance value of p=0.001. Then when seeing for WOMAC values between groups shows significant improvement, that is reduction of functional disability or improve functional independence in both groups but tremendous changes in group A by seeing t=20.127 in group A and t=6.971 in group B. (Table. 1).

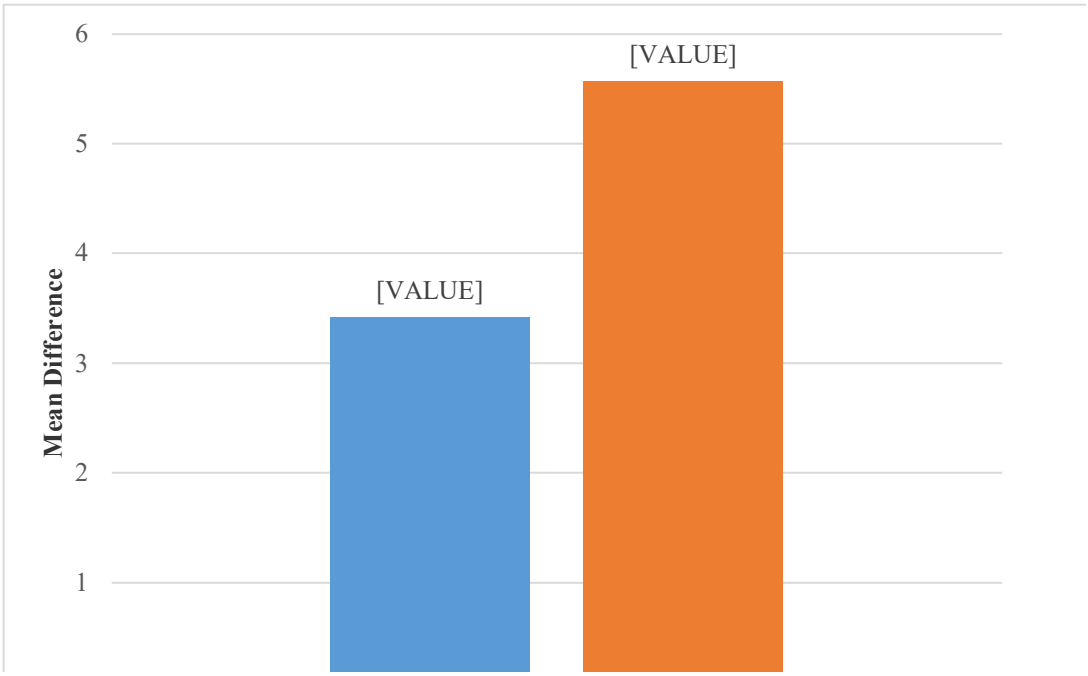

Fig. 13. Post Mean Value of Group A and Group B for VAS

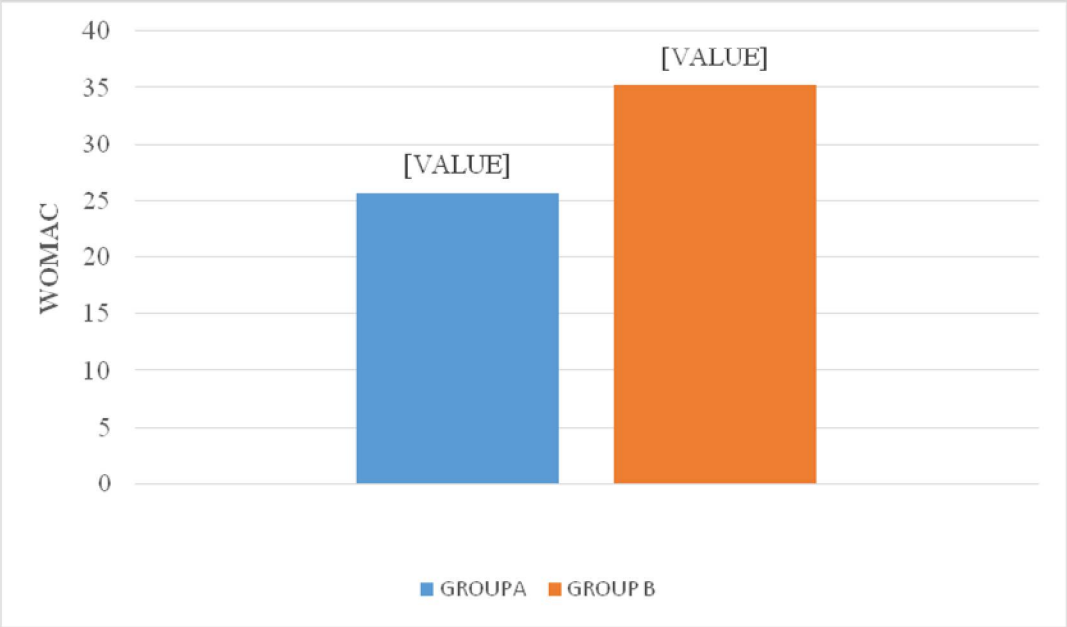

Fig. 14. Post Mean Value of Group A and Group B for WOMAC

The levels of disability in patients with osteoarthritis knee are due to muscle weakness and this may be the precursor to osteoarthritis knee [7]. Overall physical activity levels can be increased by resistance training and muscle mass loss can also be minimized. Disease progression on subjects with OA knee can be protected by hip muscle strengthening [12, 13].

Generally, physiotherapeutic treatment of OA patients uses pain-relieving modalities, few isometric and mobilization exercises. In this study, both hip and knee muscles mainly quadriceps and popliteus strengthening and activation are concentrated.

Popliteus is the key muscle for knee flexion, i.e. tibial internal rotation. During movement performed in midrange knee flexion when capsuloligamentous structures are unable to function optimally, activation of major muscle like quadriceps femoris, hamstring, and gastrocnemius activation along with synergistic hip and subtalar joint musculature activation to control femoral & tibial rotation, popliteus is also very essential. Hence popliteus activation is essential in lower extremity injury prevention & functional rehabilitation program [10, 11]. Mohanakrishnan et al stated in their study that BFB (Biofeedback) is a supporter of receptor feedback, it also enhances by serving as an immediate, precise, and concurrent source of information to the patient. Patient as a layman although not aware of the muscle activity, they can see the results of their efforts. They also said that BFB has an advantage in facilitatory feedback response along with making quadriceps neural changes than electrical stimulation [8].

The visual biofeedback-based quadriceps strengthening was given to a patient for 4 weeks of treatment, the patient was assessed by VAS scale and WOMAC scale and pain was decreased and finally, after 4 weeks the pain reduced and they were able to be functionally independent.

LIMITATION:

- The study has the following limitations as the sample size of this study was small and there is a lack of follow up therefore the long term effects of the interventions in the present study remains unknown
- Evidence from a larger sample is needed.
- Long term follow up is needed

CONCLUSIONS

This study concludes that there is a significant improvement in muscle function and reduction of pain in patients with unilateral tibiofemoral knee osteoarthritis brought about by group A visual biofeedback based quadriceps strengthening along with conventional therapy and the results are obtained in comparison with group B conventional therapy based on the statistical analysis from the data collected using visual analog scale and western Ontario and McMaster osteoarthritis index, and from the results obtained we can conclude that there is an effect of sphygmomanometer based visual biofeedback in quadriceps strengthening.

REFERENCES

1. Masouros SD, Bull AM, Amis AA. (2010). Biomechanics of the knee joint. Orthopaedics and Trauma. 24: 84-91.
2. Nath J, Saikia KC. (2015). Pathophysiology of knee osteoarthritis and importance of quadriceps strengthening in rehabilitation. International Journal of Recent Scientific Research. 6: 3176-3180.
3. Abari I S. (2016). ACR Revised Criteria for Early Diagnosis of Knee Osteoarthritis. Autoimmune Diseases and Therapeutic Approaches. 3: 1-5.
4. Hunter DJ, Lo GH. (2009). The management of osteoarthritis: an overview and call to appropriate conservative treatment. Medical Clinics of North America. 93: 127-143.
5. Köse Ö, Acar B, Çay F, Yilmaz B, Güler F, Yüksel HY. (2018). Inter-and intra-observer reliabilities of four different radiographic grading scales of osteoarthritis of the knee joint. The journal of knee surgery. 31: 247-253.
6. Kellgren JH, Lawrence JS. (1957). Radiological assessment of osteo-arthrosis. Annals of the rheumatic diseases. 16: 494.
7. SS Subramanian. (2017). Hip muscles and quadriceps strengthening exercises in osteoarthritis knee- Evidence based case study report. Int J Pharm Bio Sci. 8, (B): 470-473.
8. Mohanakrishnan J, Mohanakrishnan B, Salaja R, Balaji GG. (2016). Sphygmomanometer as biofeedback in acute anterior cruciate ligament reconstruction rehabilitation: A cost-effective technique. International Journal of Clinical and Experimental Physiology. 3: 100-104.
9. Choi YL, Kim BK, Hwang YP, Moon OK, Choi WS. (2015). Effects of isometric exercise using biofeedback on maximum voluntary isometric contraction, pain, and muscle thickness in patients with knee osteoarthritis. Journal of physical therapy science. 27: 149-153.
10. Jakson K Joseph, Sandeep P H, Kavya MS. (2017). Role of popliteus muscle retraining in knee rehabilitation- A case report. International Journal of Adapted Physical Education & Yoga, 2: 1-6.
11. Nyland J, Lachman N, Kocabey Y, Brosky J, Altun R, Caborn D. (2005). Anatomy, function, and rehabilitation of the popliteus musculotendinous complex. Journal of Orthopaedic& Sports Physical Therapy. 35: 165-79.
12. Chang A, Hayes K, Dunlop D, Song J, Hurwitz D, Cahue S, Sharma L. (2005). Hip abduction moment and protection against medial tibiofemoral osteoarthritis progression. Arthritis & Rheumatism. 52: 3515-3519.
13. Bennell KL, Hunt MA, Wrigley TV, Hunter DJ, McManus FJ, Hodges PW, Li L, Hinman RS. (2010). Hip strengthening reduces symptoms but not knee load in people with medial knee osteoarthritis and varus malalignment: a randomised controlled trial. Osteoarthritis and Cartilage. 18: 621-628.