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Effect of Neuromuscular Stabilization Exercise in Patients with Osteoarthritis Knee

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ABSTRACT
OA knee is among the major causes of impairment and pain globally. Conservative treatment aims at reducing pain and minimizing functional impairment. Interventions with minimal side effects are beneficial. This study was done to find the effectiveness of neuromuscular exercises.Sixty-six participants were randomly allotted into 2 groups: Group I had 33 participants receiving strengthening exercises while group-II had 33 subjects receiving neuromuscular exercises. Interventions were given for 8 weeks, 3 times per week (24 sessions in total). Outcome measures used were VAS for pain, Range of Motion (goniometry) for Knee flexion and extension, and muscular strength (dynamometer) for knee flexors and extensors.The pain was measured on 1st day prior to treatment, after 10 days and at the end of the treatment week using VAS, ROM using a goniometer and muscle strength using a dynamometer.The results showed that pain, knee flexion and knee extension showed improvement and had significant improvement in group II i.e the experimental group whereas the strength of the knee flexor and extensor muscles didn't show significant improvement.This research work was done to observe the effectiveness of neuromuscular exercises on pain, knee ROM and knee flexor/extensor strength for patients with OA knee. The neuromuscular exercises showed improvement in pain and ROM of knee flexion and extension however did not show significant improvement in muscle strength.
Keywords: *Quadriceps Strengthening; Hamstring Strengthening*

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INTRODUCTION

OA is amongst the commonest degenerative diseases of the joints that have an impact on the QOL of people and adds a burden on healthcare costs [1,2]. OA Knee is a chronic joint disease that causes pain accompanied by functional loss and low QoL [3]. The term osteoarthritis is defined as a common, age-related, heterogenous disorder pathologically characterized by cartilaginous loss in synovial joints, and is correlated with varied grades of osteophytic development, subchondral bony changes and synovitis [4].Symptoms of OA kneeinclude stiffness of the joint and pain in the knee that limits activities of weight-bearing like climbing stairs, walking or standing up from sitting. It happensin about 10% of men and 13% of women above 60 years of age [5].Treatment of OA knee for the most part is aimed atlowering joint pain, as well as enhancing the mobility of the joint and QoL related to health. No permanent cure has been found for this condition and only about 1/3rd of people with knee OA ever undergoanatomical deterioration andwill require knee arthroplasty in the long run[6].

In an intact knee joint, when the agonistic quadriceps activates, it gives rise to an anterior force on the tibia respective to the femur, this force is then counteracted by the activation of the antagonistic hamstrings, thus producing joint stability [7]. Knee OA is frequently related to decreasedknee stability because of impaired quadriceps strength, discomfort, and a change in the structure of the joint [8].Therefore, therapeutic intervention should not only focus on strengthening the quadriceps but should also focus on improving the entire muscular balance at the knee [9].

There are a few muscle groups that support the knee. However, theprimary groups of muscles that control motion and stabilize the knee joint are the quadriceps and hamstrings. Hamstrings and quadriceps possess the potential to provide dynamic stability at the knee joint in the frontalplane because of their adduction and abduction moment arms. The balanced co-contraction of the hamstrings and the quadriceps in the frontal plane leads to increased contraction at the knee joint, which should assist in the stabilization of the joint [10]. The strong relationship between the quadriceps and hamstrings has been outlined by numerous researchers[11].

Theisokinetic hamstring: quadriceps ratio for healthy individuals has been reported as1.70:1 at 60°/s and 1.37:1 at 180°/s angular velocities of limb movement. This ratio is of utmost importance concerning knee stability and protection against excessive stress [12]. Strength training has become important as most researches focus on strengthening the quadriceps since the muscular weakness of the lower extremity is common in individuals with OA of the knee [13].

As people suffering from OA have a defective neuromuscular function and functional instability, neuromuscular exercises may prove useful to increase the effectiveness of the training programs[13].Neuromuscular exercises for the lower extremities include multiple joints as well as multiple muscular groups. Neuromuscular Exercises are based on neuro-muscular principles. It intends to improvesensory as well as motor control and attain functional balance. Functional stability of a joint is the ability to remain stable during any physical activity whereas sensorimotor control is the ability to produce coordinated movements through the controlled activity of the muscle [14]. These exercises also include other characteristics of sensorimotor function, such as balance, muscular strength, proprioception and coordination of the joints. In orderto attain the ideal demand of postural activity, the patients perform these exercises in the lying, sitting, and standing [14].

Numerous treatment procedures have been proposed in the rehabilitation of patients with OA knee. According to Jordan et al, physiotherapy for OA knee is a cost-effective mode of management. Various interventions have been applied for the management of OA knees such as thermotherapy, physical exercise, electrotherapy, weight-loss programs, acupuncture, bracing, self-management education programs, manual therapy, massage, and assistive devices[15].

Strength training is the commonest treatment approach for patients with OA knee who suffers from functional limitations. Supplementary forms of rehabilitation are also used such as heat packs, to relax the muscles. Quadriceps strengthening isa major part of exercise protocols for OA of the knee because quadriceps weakness is a frequent find among people with OA knee [16-24].

Neuromuscular exercise focuses on improving control over posture and overall functional performance [25]. The neuromuscularexerciseprogram has previously assessedyounger patients with ACL injuries[26-29]. The same principles can also be applied to other knee injuriessince the training favoursdaily life and more demanding pursuits [26-28]. Also, few studies have suggested that neuromuscular exercises are effective in treating degenerative knee diseases[30]. But there seems to be a dearth of studies to determine which of the protocols is more effective in general. So, a need arises to investigate and find out the most effective therapy for knee OA. This research was done to find the effectiveness of neuromuscular exercises on pain, muscular strength and ROM in patients with OA of the knee. The objectives of the research were:

1. To study the effectiveness of neuromuscular exercises on pain in patients with OA of the knee.
2. To study the effectiveness of neuromuscular exercises on muscular strength in patients with OA of the knee.
3. To study the effectiveness of neuromuscular exercises on ROM in patients with OA of the knee.

MATERIAL AND METHODS

Approval to continue with the research work was granted by the Institutional ethical board. The subjects were given a brief introductionabout the purpose of this research, the procedures to be undertaken, possible risks as well as the benefits. Upon the approval of the participants, a signed consent form was attained. The general condition of the patient was assessed before being subjected to the treatment.

Our study is an experimental study. The study setting and the source of data were the outpatient department of Krupanidhi College of Physiotherapy.The duration of the study was 1 year (12/9/2019 to 19/9/2020) with the duration of the treatment being 8 weeks; 3 sessions per week.66 subjects, both male and female aged between 40-60 years and diagnosed clinically with knee osteoarthritis, and morning stiffness for less than 30 minutes, Kellgren and Lawrence scores of 1 and 2 were recruited for the study. Subjects who underwentKnee surgery within the past 6 months, any deformity in the knee, any other diagnosis of the lower extremity that overlaps with the concerned diagnosis of the knee, rheumatoid arthritis, history of total knee arthroplasty, unable to ambulate without a walking aid, physiotherapy for the knee in the previous 6 months, any other neurological or musculoskeletal conditions other than diagnosed cases of OA of the knee, any symptom or sign suggestive of other causes of knee pain, uncontrolled hypertension were excluded from the study.

Diagnostic Criteria: The ACR Clinical Classification criteria for OA knee was used - the existence of knee pain together with at least 3out of the 6 items can classify OA knee in patients-Age more than 50 years, bony tenderness, bony enlargement, morning stiffness that that persists for less than half an hour in the morning, crepitus heard on the movement of the knee, no perceptible warmth.

Outcome measuresthat were used included VAS (visual analogue scale)- for pain**, a** goniometer for measuring knee flexion and extension**, a** dynamometer to measuremuscle strength for knee flexors and extensors

All the measurements were taken at baseline i.e., week 0 and at the end of the trial at week 8 to measure the muscular strength and ROM but for VAS, measurement was taken at baseline and then again after 10 days and then finally at the end of week 8.

Hypothesis:

Null Hypothesis: There is no significant effect of Neuromuscular exercises on pain, muscle strength and Range of motion in subjects with Osteoarthritis.

Alternate Hypothesis: There is a significant effect of Neuromuscular exercises on pain, muscle strength and Range of motion in subjects with Osteoarthritis.

Treatment Procedure

- A total of 66 patients were selectedbased on theselection criteria and divided into 2 groups, each group with 33 patients. The general condition of the patient was assessed before being subjected to the treatment.

Pre-intervention measurement

- The patient's pain level using VAS score timed up and go test, ROM for knee flexion and extension were measured prior to the intervention. Participants on the first 10 days were given pain relieving modalities (IFT + US) only. On the 11th day, the patient's pain level was assessed using VAS. Theparticipants were then divided into two groups– a group I (control) and group II (experimental).
- **Group 1**– conventional therapy (CONTROL GROUP).
  The patients in group 1 were given conventional exercises that includes strengthening exercises for the quadriceps and hamstrings.
- **Group 2**– neuromuscular exercise (EXPERIMENTAL GROUP).
  The patients in group 2 were given neuromuscular exercise protocol.

Intervention

Ultrasound (10 sessions, 5 times a week)- Dosage – 2.0 w/cm^2**,** frequency **-** 1 MHz, mode – Continuous mode, treatment area – over the anterior aspect of the knee joint, duration -5 minutes

Interferential Therapy (10 sessions, 5 times a week)-Frequency = 4000 Hz, base = 90 Hz, sweep = 40 Hz, beat frequency = 90-130 Hz, quadripolar, duration was 10 minutes. IFT intensity was increased until the normal tingling sensation is felt by the patient.

GROUP I: Quadriceps and Hamstring Strengthening Exercises

Each of the strengthening exercises wascarried outin 3 sets and each exercise was repeated 10 times with a 3-second hold or until fatigue. The exercises werehalted on any complaint of increased pain by the participant.

The subject progressed to the next level when they were able to perform the exercises comfortably.

Quadriceps Strengthening

LEVEL 1- Isometric quadriceps set:

Subject in a long sitting position with the knees in extension. Instruction was given to isometrically contract the quadriceps bilaterally as vigorously as possible without causing any pain.

LEVEL 2–End-range knee extension:

The subject was positioned in a long sitting position on the treatment couch. The target limb was instructed to be flexed at 20-30° over a rolled towel. The contra-lateral knee was flexed so that the foot waslying flat on the surface. The symptomatic knee was then fully extended, finallyloweringgradually until the foot returns to theoriginal resting position on the couch.

LEVEL 3–End-range knee extension with cuff weights:

They were positioned in long sitting on the treatment couch. The target limb was instructed to be flexed at 20-30° over a rolled towel. The contra-lateral knee was in flexion so that the foot was lying flat on the surface of the couch. The symptomatic knee was then fully extended with weight cuffs tied to the ankle. It is to be noted that progression from Level 2 to Level 3 was done by usingweightcuffs to the ankles as tolerated by the subject. The subject then gradually lowered the foot until it returns to the original resting position on the couch.

Hamstring Strengthening

LEVEL 1 - Hamstring Curls in prone:

The subject was in a prone position on the treatment couch. The subject was instructed to flex the knee from full extension to 90° of flexion and then return the limb to the full range of knee extension position.

LEVEL 2 - Level 2 was a progression to Level 1, where the movement was done with weight cuffs applied to the distal leg. The subject was in a prone position on the treatment couch. The subject was instructed to flex the knee from full range of extension to 90° of flexion, all while their ankle was tied with a weight cuff, then returned the limb to full knee extension position.

LEVEL 3 – The subject kept the symptomatic knee flexed and hip extended against resistance, subject stood facing towards the anchor that held the TheraBand which was then looped behind her/his heel. The subject was instructed to contract the hamstrings and gluteal muscles for slight knee flexion and hip extension.

GROUP II: Neuromuscular Exercises [25]

The neuromuscular exercise training program takes place in groups, it consists of 3 parts: a warm-up period, a circuit program, and a cool-down period. The training session lasts for 60 minutes (1 hour).

Part 1. Warm Up

The warm-up period will consist of walking exercises forward and backwards, normal squatting (5 repetitions), lunging (5 repetitions), and side-walking for ten minutes.

Part 2. Circuit Program

The key elements will be: core stability exercises; exercises for postural orientation; exercises for lower extremity muscle strength and functional exercises

Exercise circle 1: Core Stability

Level 1

A. Pelvic-lift- The subject lies supine with knees flexed at 90 degrees and arms to the sides, the subject puts both legs in the exercise ball, putting the load on both legs at the same time and lifting the pelvis up from the table.

B. Sit-up- Subject lies supine with both legs in the exercise ball and knees flexed at 90 degrees and arms holding the knees. The subject then pulls the upper body all the way up towards the knees while putting a simultaneous load on the ball.

Level 2

A. Pelvic-lift – the subject lies supine with knees semi-flexed and arms to the sides, the subject pulls both legs on the exercise ball, putting the load on both legs at the same time and lifting the pelvis up from the table.

B. Sit-up- Subject lies supine with both knees flexed, both legs are placed on the ball, arms crossed over chest. The subject then pulls the upper body towards the knees while putting the load on the ball.

Level 3

A. Pelvic-lift- the subject lies supine with both legs on the exercise ball, but alternately loads the non-affected and affected leg while lifting the pelvis off of the treatment table.

B. Sit-ups- the subject lies supine with knees in flexion, both legs on the exercise ball, and hands placed behind the neck. The subject now pulls up their upper body towards the knees.

Exercise circle 2: Postural orientation

Level 1

A. Slide-exercise forwards-backwards: this exercise is done with the subject in standing and weight-bearing is done on the affected leg. The other leg or the unaffected leg is on a sliding surface (cardboard paper). The subject then slides the unaffected leg i.e. the leg which is placed on the sliding surface backwards – forwards, while simultaneously flexing and extending the knee i.e. the affected limb.

B. Slide-exercise sideways: this exercise is done with the subject in a standing position, weight-bearing is done on the affected leg and the unaffected or the other leg is placed on a sliding surface. The subject then slides the unaffected limb sideways, while flexing and extending the weight-bearing limb at the knee.

Level 2

A. Slide-exercise (forwards–backwards): The subject standing on an uneven surface. Weight-bearing is done on the affected leg which is placed on a foam pillow. The other leg or the unaffected leg is on the sliding surface (cardboard paper). The subject then slides the unaffected leg i.e. the leg which is placed on the sliding surface backwards – forwards while simultaneously flexing and extending the limb bearing the weight at the knee.

B. Slide-exercise (sideways): The subject is in a standing position. Weight-bearing is done on the affected leg which is placed on a foam pillow and the unaffected or the other leg is placed on a sliding surface. The subject then slides the unaffected limb sideways, while flexing and extending the limb bearing the weight.

Level 3

A. Forward lunge: The subject is in the standing position. The subject is instructed to take a large step forward with the affected leg and then return to the previous position. Hand support can be taken for balance if required.

B. Sideways lunge: The subject is in the standing position. Instruction is given to take a large step sideways with the affected leg and then return to the previous position. Hand support, if required can be taken for balance.

Exercise circle 3: Lower extremity muscle strength

Level 1

A. Hip abductors/adductors: The subject stands on a single leg with a TheraBand around the other leg. The TheraBand is pulled outwards and inwards. An appropriate position should be maintained in the joints of the lower extremity ascompared to the other joints and the trunk.

B. Knee extensors/flexors: This exercise is done in a sitting position. Theraband is placed around one foot. The subject is instructed to pull the Theraband forward using the knee extensors and to pull the Theraband backwards using the knee flexors. There should be tension in the Theraband even in the resting position.

Level 2

A. Hip abductors/adductors: The subject is standing on one leg and Theraband around the other leg. The subject is instructed to pull the Theraband out using the hip abductors and inward using the adductors of the hip. There should be tension in the TheraBand even in the resting position. At this level, the Therabandresistance is increased.

B. Knee extensors/knee flexors: This exercise is done in the sitting position. TheraBand is placed around one foot. The subject is instructed to pull the Theraband forward using the knee extensors and pull the TheraBand backwards using knee flexors. There should be tension in the TheraBand even in the resting position. In level 2 of this exercise, the resistance of the TheraBand is increased.

Level 3

A. Hip abductors/adductors: The subject stands on one leg in a foam pillow (unstable surface) and Theraband around the other leg. The subject is instructed to pull the Theraband outwards using the hip abductors and pull the TheraBand inwards using the hip adductors. There should be tension in the Therabandeven in the resting position.

B. Knee extensors/flexors: This exercise is done in sitting. Theraband is placed around one foot. The subject is instructed to pull Theraband forward using the extensors of the knee and pull backwards using the flexors. It is to be noted that there should be tension in the Therabandevenat rest. In level 3 of this exercise, the resistance of the Theraband is further increased.

Exercise circle 4: Functional exercises

Level 1 Exercises

A. Chair stands: this exercise starts with the subject being in the seated position with feet parallel to each other, loading both legs the subject stands up from the chair. Slight hand support can be taken for stability.

Level 2 Exercises

A. Chair stands: Level 2 of this exercise starts with the subject in the seated position, feet parallel to each other. The subject now gets up from the chair loading both legs but without hand support.

Level 3 Exercises

A. Chair stands: level 3 starts with the subject in the seated position. The subject places one foot in front of the other and stands up from the chair, with or without any hand support for stability.

Part 3: Cool-Down

The cool-down period consists of forward walking and backward walking for about ten metersand stretching exercises for the lower limb musculature for a minimum of ten minutes.

Post-intervention measurement: The patient underwent assessment for pain, ROM and muscle strength using VAS, goniometer and dynamometer respectively after completion of the treatment.

Statistical Analysis

Table 1: Baseline Data for Age (Group I)

Descriptive Statistics					
	Number	Min	Max	Mean	SD
Age	33	40.0	60.0	49.030	6.5215
Valid N (listwise)	33				

The mean age in group I is 49.030 and the SD is 6.5215

Table 2: Baseline Data for Age (Group II)

Descriptive Statistics					
	Number	Min	Max	Mean	SD
age	33	40.0	59.0	48.182	6.1158
Valid N (list-wise)	33				

The mean age in group II is 40 and the SD is 6.1158

Table 3: Pre-post Flexion T-test for Group I

		Paired Differences in Group I					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1	PRE-TEST VAS – POST-TEST VAS	3.455	1.481	.258	2.929	3.980	13.400	32	.000
2	PRE-TEST FLEXION ROM – POST-TEST FLEXION ROM	-3.485	4.017	.699	-4.909	-2.061	-4.984	32	.000
3	PRE-TEST EXTENSION ROM – POST-TEST EXTENSION ROM	1.758	2.513	.437	.867	2.649	4.018	32	.000
4	PRE-TEST FLEXORS MS – POST-TEST FLEXORS MS	-.364	.489	.085	-.537	-.190	-4.276	32	.000
5	PRE-TEST EXTENSORS MS – POST-TEST EXTENSORS MS	-.152	.364	.063	-.281	-.022	-2.390	32	.023

GROUP I:

The mean after comparing the pre and post-test VAS scores was valued at 3.455 with a standard deviation of 1.481 which was statistically significant (p-value<0.001).

The post-test scores of VAS showed significant improvement in the values in comparison to the pre-test scores of VAS in group I.

The mean after comparing the pre and post-test flexion ROM was valued at -3.485 with an SD of 4.017 which was statistically significant (p-value<0.001).

The post-test scores of flexion ROM showed significant improvement in the values in comparison to the pre-test scores of flexion ROM in group I.

The mean after comparing the pre and post-test extension ROM was valued at 1.758 with an SD of 2.513 which was statistically significant (p-value <0.001).

The post-test scores of extension ROM showed significant improvement in the values in comparison to the pre-test scores of extension ROM in group I.

The mean after comparing the pre and post-test flexor muscle strength was valued at -.364 with an SD of .489 which was statistically significant (p value<0.001).

The post-test scores of flexor muscle strength showed significant improvement in the values as compared to the pre-test scores of flexor muscle strength in group I.

The mean after comparing the pre and post-test extensor muscle strength was valued at -.152 with an SD of .364 which was not statistically significant (p value>0.001).

The post-test scores of extensor muscle strength did not show significant improvement in the values as compared to the pre-test scores of extensor muscle strength in group I.

Group II:

The mean after comparing the pre and post-test VAS scores was valued at 3.303 with a standard deviation of 1.075 which was statistically significant. (p value<0.001).

The post-test scores of VAS showed significant improvement in the values as compared to the pre-test scores of VAS in group II.

The mean after comparing the pre and post-test flexion ROM was valued at -2.212 with an SD of 1.341 which was statistically significant (p value<0.001).

The post-test scores of flexion ROM showed significant improvement in the values as compared to the pre-test scores of flexion ROM in group II.

The mean after comparing the pre and post-test extension ROM was valued at 2.030 with an SD of 1.591 which was statistically significant (p value<0.001).

The post-test scores of extension ROM showed significant improvement in the values as compared to the pre-test scores of extension ROM in group II.
The mean after comparing the pre and post-test flexor muscle strength was valued at -.182 with an SD of .392 which was not statistically significant. (p value>0.001).
The post-test scores of flexor muscle strength did not show significant improvement in the values as compared to the pre-test scores of flexor muscle strength in group II.
The mean after comparing the pre and post-test extensor muscle strength was valued at -.212 with an SD of .485 which was not statistically significant. (p value>0.001).
The post-test scores of extensor muscle strength did not show significant improvement in the values as compared to the pre-test scores of extensor muscle strength in group II.

Table 4: Pre-post Flexion T-test forGroup II

		Paired Differences Group 2					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1	PRE-TEST VAS – POST-TEST VAS	3.303	1.075	.187	2.922	3.684	17.653	32	.000
2	PRE-TEST FLEXION ROM – POST-TEST FLEXION ROM	-2.212	1.341	.233	-2.687	-1.737	-9.479	32	.000
3	PRE-TEST EXTENSION ROM – POST-TEST EXTENSION ROM	2.030	1.591	.277	1.466	2.594	7.332	32	.000
4	PRE-TEST FLEXORS MS – POST-TEST FLEXORS MS	-.182	.392	.068	-.321	-.043	-2.667	32	.012
5	PRE-TEST EXTENSORS MS – POST-TEST EXTENSORS MS	-.212	.485	.084	-.384	-.040	-2.514	32	.017

RESULTS
The results showed that pain and knee ROM i.e., flexion of theknee and extension of theknee showed significant improvement whereas muscular strength of the knee flexors as well as the knee extensors didn't show significant improvement in the experimental group i.e., the group was given neuromuscular exercises.

DISCUSSION
The reason for this research was to find whether neuromuscular exercises are effective in osteoarthritis knee so that they can be used as first-line physiotherapeutic management of knee OA. The control group, the group I was given strengthening exercises for the quadriceps and hamstrings while the second group, group II was given neuromuscular exercises. The treatment was conducted for eight weeks; thrice per week (i.e., 24 sessions). Outcome measures used were VAS for scoring the intensity of pain experienced by the subject, a goniometer to assess the ROM of knee flexion and extension, and a dynamometer was used to assess the strength of knee extensors and flexors. Results were analyzed using an unpaired t-test. The research showed a positive impact on pain scores which was statistically significant in both groups I and group II. In group I as well as in group II, significant improvement was seen in knee ROM (flexion and extension). However, the flexor muscle strength showed improvement in group I but failed to show significant improvement in group II. Extensor muscle strength however showed insignificant improvement in both groups.
Neuromuscular training focuses on improving sensori-motor control, functional independence or stability. Various injuries of the knee might result in functional uncertainty and could mean a sudden loss of control in the injured joint while being in the weight-bearing position, reduced strength, differences in patterns of muscle activation, decreased functional performance, defective postural control and lack of proprioception. These limitations are often observed in patients suffering from knee

OA;therefore, it justifies the usage of a neuromuscular training exercise in people suffering from OA knee.

Previous research has dealt with exercises for OA hip and OA knee and various types of research were conducted where patients with OA were trained using functional exercises. But the key components of neuromuscular training such as the principles of training, level and progression of the training, individually-tailored training protocol and the quality of performance of exercise lacked in the previous studies.

It was observed that in people suffering from knee OA, the symptoms associated with it along with the limitations in functions were all heterogeneous. Therefore, it was proved that factors like gender, age, desired or the previous level of activity, type of the injury, the seriousness of the injury, symptoms and limitations in performing various functions were to be taken into account during the neuromuscular exercise program.

From this study, we can say that neuromuscular exercise is effective for people suffering fromthe knee. Neuromuscular training aims at correcting the instability of the knee. A neuromuscular training program is described as being based on bio-mechanical and neuro-muscular principles that aim at improvingsensori-motor control and achieving overall functional stability and not just being involved in strengthening a particular group of muscles.

Study limitations: 1) The sample size was small to find any significant results, 2) The study used a convenient sampling method which resulted in smaller sample size, and 3) The study setting had limitations. Future studies could be performed on larger sample size, a larger study setting could be proven helpful in attaining a larger sample size.

CONCLUSION

To summarize, it can be concluded that neuromuscular exercises prove beneficial in the treatment of pain and ROM in individuals suffering from OA knee and can be used as a means of conservative therapy for OA knee.

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