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To compare the effectiveness of kinesthesia and balance exercises versus closed kinematic chain exercises on pain and functional performance in knee osteoarthritis

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Abstract
Background and Objective: Osteoarthritis is a chronic degenerative disorder of multifactorial etiology characterized by loss of articular cartilage, hypertrophy of bone at margins, sub-chondral sclerosis and range of biochemical and morphological etiologies of synovial membrane and joint capsule. Patient with OA knee most frequently complain of pain, stiffness, instability in joint and decrease in daily living activities. Physiotherapy is the main choice of treatment where in the conservative part is concerned, which includes exercise therapy-supervised strengthening exercise, manual therapy and taping. Electrical modalities like TENS and Ultrasound can be used to reduce pain. This study is aimed to compare the effectiveness of kinesthesia and balance exercises versus closed kinematic chain exercises to reduce pain and improve functional performance in Knee Osteoarthritis Patients.
Methods and materials: A total of 60 subjects met selection criteria for the study and were divided into 2 groups, 30 members in group A (kinesthesia and balance exercises) 30 members in group B (closed kinematic chain exercises). Both groups are given interventions 3 days per week for 8 weeks. Both groups were also given conventional physiotherapy program for 8 weeks. The outcomes of pain, ROM and functional disability were measured using Goniometer and WOMAC Scores.
Results: paired T test was used to analyze statistical significance between pre and post test scores within groups. Unpaired T test was used for Statistical analysis of data between groups, the results of the study showed that statistically kinesthesia and balance exercises are more effective than closed kinematic chain exercises when compared on post test values of Goniometric reading and WOMAC Scores.
Conclusion: In this 8-week study, both kinesthesia along with balance exercises and closed kinematic chain exercises showed significant changes in pain, ROM and functional disability in knee osteoarthritis. However, based on statistical analysis Kinesthesia and balancing exercises along with conventional physiotherapy is more effective than closed kinematic chain workouts in reducing pain and enhancing functional performance in knee osteoarthritis.

Keywords: Osteoarthritis of knee, closed kinematic chain exercises, kinesthesia and balance exercises, goniometer, western ontario mcmaster universities arthritis index

Introduction

Osteoarthritis is a chronic degenerative disorder of multifactorial etiology characterized by the loss of articular cartilage, hypertrophy of bone of the margins sub-chondral sclerosis & range of biochemical and morphological alterations of the synovial membrane and joint capsule [1]. The global prevalence of OA knee was 16.0% (95%CI,14.3%-17.8%) in individual aged 15 and over and was 22.9% in individual aged 40 and over correspondingly, there are around 654.1 million individuals (40 years older) with OA knee in 2020 worldwide [2]. Knee OA patients have decrease in muscle strength and functional capacity along with limited mobility in lower extremities. Deterioration in quadriceps function may cause impaired balance and gait, thus reducing mobility and function in patients with OA knee [4, 5]. Though pain is the most important symptom that often makes individuals with OA knee seek medical attention, the patient may also present with symptoms such as limitation of joint motion, muscle atrophy & weakness, joint instability, progressive functional limitation and associated disability depending on the severity and stage of the disease [11, 12].

Physiotherapy is one of the main conservative treatments for OA knee which includes electrotherapy modalities and different exercise programs. Recent studies focus on Balance and kinesthesia exercises which aimed at restoring motor control in the lower extremities, static positioning, voluntary movement execution and responsiveness to stress. Very few studies are done on kinesthesia, balance exercises and closed kinematic chain exercise. Therefore, the need of the study is to compare the effectiveness of kinesthesia & balance exercises and closed kinematic exercises on pain, function and ROM in subjects with osteoarthritis of knee.

Materials and methods:

Patients diagnosed with osteoarthritis and referred to the outpatient physiotherapy department at KIMS General Hospital between September 2023 and December 2024 were included in the study and were retrospectively followed up in the outpatient department until September 2024. Total 60 patients diagnosed with osteoarthritis are randomly divided into two groups. Group A- Kinesthesia with balance exercises (30 subjects) and Group B- Closed kinematic chain exercises (30 subjects)

Inclusion Criteria: Both male and female subjects aged above 35 years, who have unilateral & bilateral OA knee and who have grades 1,2,3 of Osteoarthritis based on kellegren and Lawrence radiological criteria for OA are included. Exclusion Criteria: Any deformity of the lower limb e.g.: joint flexion contraction, Hyperextension of the knee joint, Severe OA, Rheumatologic disease are not included in the study.

Procedure

This is a Quasi experimental study, which includes 8-weeks intervention. Both male and female participants who are having osteoarthritis of knee were recruited from KIMS general hospital, Amalapuram. Subjects were assigned into two groups through simple random sampling. Pretest measures were taken by using Visual analogue scale, Western Ontario and McMaster University Osteoarthritis Index and Lequesne questionnaire. Subjects in the group A received kinesthesia along with balance exercises and subjects in Group B received closed kinematic chain exercises. Both the groups received conventional physiotherapy program. Post-test measurements were taken after 8 weeks of interventions.

Interventions in Group-A: Kinesthesia with Balance Exercises [19]

The Group A received kinesthesia and balance exercises regime as follows:

Week 1-3:

1. Modified Romberg exercise (standing in balance with eyes closed) consisting of following: a. On hardground, b) On soft ground (on a mat), 2. Retro walking (25m), 3. Walking on heels (25m), 4. Walking on toes (25m), 5. Walking with eyes closed (25m), 6. Standing on one extremity for 30 seconds (repeated in both extremities) Leaning forward, backward, and to the sides on one extremity (eyes opened) Leaning forward, backward, and to the sides on one extremity (eyes closed),Sitting down and standing up from a highchair slowly.

Week 3-5:

1. Exercise with "rocker-bottom" balance board, 2. Sitting down and standing up from a low chair slowly, 3. Plyometric exercise (crossing a height of 15cm by jumping), 4. 8 exercises consisting of a) Walking, slowly, b) wide circle, c) Walking quickly, d) wide circle, e) Walking slowly, f) narrow circle, g) Walking quickly, h) narrow circle.

Week-6-8: (in addition)

1. Exercise with "BAPS board" balance board a) Balance with 2 legs, eyes open, multidirectional b) Balance with 2 legs, eyes closed, multidimensional, c) Balance with one leg, eyes open, unidimensional d) Balance with one leg, eyes closed, unidimensional e) Balance with one leg, eyes open, multidimensional f) Balance with one leg, eyes closed, multidimensional.
2. Minitrampoline exercise (jumping and jogging) 3. Plyometric exercise (crossing a height of 15 cm by jumping) 4. Cardio across over maneuver.

The total course of the exercises was determined as 8 weeks.

Group-B: closed kinematic chain exercises [20]

Participants in the CKCE group individually underwent the following exercises:

1. **Quadriceps setting exercise:** Participants sat on a chair with their back supported, knee extended and heel on the floor. They pressed their heels against the floor and thighs against the seat of the chair. The position was held for a count of 10 after which the participant relaxed. This exercise was performed throughout the duration of the study.

2. **Mini-squats:** Participants assumed the standing position and bent both knees to about 30-60 degrees while maintaining the trunk in the upright position. The position was held for a count of 10; participants then relaxed and repeated the exercise 10 times. This exercise was carried out in the second week of the study only as it was discontinued once the patient started mini-squats with the weight. From the third week, participants now had a barbell with plastic weights placed across their shoulders for mini-squats with weight.

3. **Step-up and step-down:** Participants performed forward, backward and lateral step-ups and step-downs using a 5 cm high sturdy wooden box. They were instructed to keep their trunk upright and to ensure that their heel was the last to leave the floor and the last to return in order to emphasize the activities of the quadriceps muscle. Participants performed 10 repetitions of each component of the exercise. This exercise was carried out during the fourth week only. From week 5, ankle weight was strapped to participants' ankle region for step-ups and step-downs with weight.

CKCE	
Week1	(a) Quadriceps setting (10 reps)
Week2	(a) Quadriceps setting (10 reps) (b) Mini-squats (10 reps)
Week3	(a) Quadriceps setting (10 reps) (b) Mini-squats with weight (new10 RM)
Week4	(a) Quadriceps setting (10 reps) (b) Mini-squats with weight (new10 RM) (c) Step-up and step-down
Week5-8	(a) Quadriceps setting (10 reps) (b) Wall slides with weight (new10 RM) (c) Step-up and step-down with Weight

Summary of exercise training and progression for participants in the CKCE group

Conventional Physiotherapy [22]

Ultrasound, Transcutaneous electrical nerve stimulation (TENS), Hot pack, strengthening exercises are administered to subjects in both groups.

Results

Statistical analysis was performed by using SPSS software version 21.0, with significance level "P" value kept at< 0.05. Descriptive statistical data were presented in the form of mean +/-standard deviation and mean difference percentages were calculated and presented. All 60 subjects completed the entire study program for 8weeks in outpatient basis. To observe the treatment impact before and after the treatment within the groups, analysis is carried out by using Paired t-test. Between the groups analysis is carried by independent student t test.

Table 1: Analysis of Pre-test and post test mean value of WOMAC scores in Group A& Group B

	Group	Tests	Mean	S.D.	T-Value	P-Value
WOMAC	Group A	Pre-Test	44.7	4.49	0.42	0.33
		Post Test	33.6	4.16		
	Group B	Pre-Test	44.5	4.3	0.13	130.44
		Post Test	38.6	4.0		

The above table infers that there was a significant difference between pre-test and post-test scores of WOMAC scores within Group A and Group B, p<0.05.

Table 2: Analysis of Pre-test and post test mean value of flexion and extension ROM in Group A & Group B

	Group	Tests	Mean	S.D.	T-Value	P-Value
Flexion ROM	Group A	Pre-Test	81.1	1.26	40.2	0.0
		Post Test	100.6	1.37		
	Group B	Pre-Test	80.1	1.21	25.6	0.0
		Post Test	88.5	1.22		
Extension ROM	Group A	Pre-Test	39	0.90	0	0.5
		Post Test	10.5	0.99		
	Group B	Pre-Test	36.6	0.99	0	0.5
		Post Test	12.6	0.62		

The above table infers that there was a significant difference between pre-test and post-test scores of flexion and extension ROM within Group A and Group B, p<0.05.

Table 3: Analysis of Post-test mean value of WOMAC, flexion and Extension ROM in Group A & Group B

	Group	Test	Mean	SD	T Value	P Value
WOMAC	Group A	Post Test	33.6	4.1	9.4	0
	Group B	Post Test	38.6	4.0		
Flexion ROM	Group A	Post Test	100.6	1.3	0.03	0.9
	Group B	Post Test	88.5	1.2		
Extension ROM	Group A	Post Test	10.5	0.99	4.0	0.0
	Group B	Post Test	12.6	0.62		

The above table infers that there was a significant difference between Post-test scores WOMAC, flexion and extension ROM within Group A and Group B, p<0.05.

Discussion

The aim of the study was to assess the effectiveness of kinesthesia and balance exercises and closed kinematic chain exercises combined with conventional physiotherapy for improving pain and functional performance in knee osteoarthritis patients. Various therapeutic approaches have been used to help to reduce knee OA symptoms and improve physical function related to activities of daily living. Some evidence suggests that in kinesthesia and balance exercises may produce better results in symptomatic relief and function performance in comparison to traditional therapeutic exercises.

Subjects were assessed for Pain, Range of motion and Functional performance at baseline and at the end of intervention using WOMAC for pain and functional performance and Universal Goniometer for ROM. In Group-A, Subjects showed statistically significant changes when compared to pre-test and post-test in functional performance (WOMAC) and ROM values (Universal Goniometer). According to Saloni Viral bhai Shah *et al*, Kinesthesia and agility exercises can improve pain, function and proprioception in OA knee. The reason for improvement might be due to stimulation of mechanoreceptors and developing sensorimotor control with kinesthesia and balance training [6]. Rogeus *et al* stated that kinesthetic, balance and agility exercises have added benefits compared to strength training alone and may improve physical function, decrease knee instability and pain [26]. Another study by Diracoglu *et al* has also stated that kinesthesia and balance training in combination with strengthening exercises can improve functional outcomes (WOMAC, Quality of life, Strength of quadriceps, Proprioceptive sensations). The mechanism behind these studies may be due to activation of feed forward mechanism by mechanoreceptors and it is useful for preparation, response and planning for task execution. These exercises also reduce risk falls and decrease joint position sense error leading to proper movement pattern and also decrease the chance of re-injury. Addition of kinesthesia and Balance exercises along with standard strengthening exercises increase dynamic strength and improve neuromuscular restoration of the patient [3].

In Group-B, significant improvements in WOMAC (Pain and Functional performance) scores and Universal goniometer (ROM) measures are seen when compared on pr- test and post-test measures within the group. The result of this study coincides with Trisna Susan *et al*, which concludes that performing closed kinetic chain (CKC) therapy in a standing position can effectively train lower limb muscles, leading to significant improvements in functional ability, particularly in areas like balance and gait, suggesting that this approach is a beneficial rehabilitation strategy for individuals with lower limb impairments. The principle of closed kinematic chain exercises is to simultaneously strengthen the agonist and antagonist muscles, with the quadriceps performing eccentric contractions to control knee flexion and concentric contractions to extend the knee, while the hamstrings and soleus stabilize the tibia [27].

Physical activity in the form of knee joint range of motion exercises will reduce the sensation of pain in the joints. Exercise can significantly reduce pain in OA knee patients due to the principle of physiological stress, which essentially means that controlled mechanical loading through exercise can stimulate the cartilage cells to produce more proteoglycans, thereby improving cartilage health, while simultaneously enhancing muscle strength, joint mobility, synovial fluid metabolism, and blood circulation, ultimately providing better nutrition to the surrounding cartilage and reducing pain [28]. According to Olagbegi OM *et al*, has stated that physical activity in the form of knee joint motion exercises will reduce the sensation of pain in the joints. The mechanism of pain reduction can be explained by gate control theory, pain intensity is reduced

and transmission is blocking at the gate by the release of endorphins [5].

According to Nicola E. Walsh *et al*, has entitled an evidence-based guidelines and current practice for physiotherapy management of knee osteoarthritis. Physiotherapy can be done to reduce pain in case of knee OA using modalities in form of Infrared rays, Ultrasound, Transcutaneous electrical nerve stimulation (TENS), Shortwave diathermy, Microwave diathermy and Exercise, strength training exercises can increase joint stability, and muscular performance leads to reduction of pain and improvement of quality of life. The study findings indicating that 8 weeks of interventions kinesthesia and balance exercises along with conventional physiotherapy was more effective than closed kinematic chain exercises with conventional physiotherapy in reducing pain and improving functional performance in OA knee. This study concludes that kinesthesia and balance exercises is a useful adjunct in treatment of OA knee along with rehabilitation [29].

Limitations of the study: Generalizability of the findings is limited due to short- term follow up and longer follow up is needed.

Implications of future research: Large and well-designed prospective studies would add more information to the literature.

Conclusion

The Global Burden of Disease studies recently indicated that knee OA is the major health disorder and the second global cause of disability. Both kinesthesia along with balance training exercises and closed kinematic chain exercises are effective in reducing pain, improving knee ROM and reducing functional disability in knee Osteoarthritis. However, when compared between groups, kinesthesia and balance exercises showed statistically significant improvement than closed kinematic chain exercises. Hence it can be concluded that kinesthesia and balance exercises along with conventional physiotherapy is more effective in reducing pain and improving functional performance OA knee.

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