

Comparison of Pilates Exercises and Closed Kinematic Chain Exercises on Pain, Muscle Strength and Functional Performance in Subjects with Knee Osteoarthritis

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Abstract

Objective: Osteoarthritis is one of the major public health problem which causes functional impairment that reduces the Quality Of Life. In India Osteoarthritis is the second most common and has prevalence rate of 22 to 39%. Both Pilates Exercises and Closed Kinematic Chain Exercises have been proved effective on Reducing Pain, Improving Muscle strength and Function. But there is a lack of literature regarding the effect of Pilates Exercises when compared to Closed Kinematic Chain Exercises. Hence the need of the study arises.

Materials and Methods: Prospective Study design. 68 subjects with mean age of 49 years having a clinical diagnosis of Knee Osteoarthritis were randomly allocated in to two groups. In Group-I (n=34) subjects were treated with Pilates exercises, where as in Group-II (n=34) subjects were treated with Closed Kinematic Chain exercises. Participants were given intervention thrice a week for 6 weeks. The outcome measures of this intervention were measured in term of VAS for Pain, Hand Held Dynamometer for Muscle strength and WOMAC score for Function.

Results: Statistical analysis of the data revealed that within group comparison both groups showed significant improvement in all parameters. Where as in between groups comparison Pilates Exercises showed better improvement compared to Closed Kinematic Chain Exercises.

Conclusion: After 6 weeks of Intervention both Pilates Exercises and Closed Kinematic Chain Exercises showed significant improvement on Reducing Pain, Improving Muscle strength and Functional performance. However Pilates Exercises were found to be more effective when compared to Closed Kinematic Chain Exercises.

Keywords: Knee osteoarthritis; WOMAC; Hand-held dynamometer; Pilates exercises; Closed kinematic chain exercises

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Introduction

Osteoarthritis is frequently slow progressive joint disease typically seen in the middle age to elderly people. Osteoarthritis of Knee progresses in a non-random manner that is directly related to asymmetric dynamic loading of the involving joint [1]. The World prevalence estimated for symptomatic Osteoarthritis of Knee is 9.6% among men, 18% among women. In India Osteoarthritis is the second most common and has prevalence rate of 22 to 39% [2].

Osteoarthritis generally can be subcategorized in to Primary (idiopathic) and Secondary Osteoarthritis. Common cause of Secondary Osteoarthritis includes post traumatic, dysplastic, infection, inflammatory etiology that are relatively well understood. Although the etiology of Primary Osteoarthritis remains largely undefined, genetic factors, age related physiological changes and biomechanical factors likely play an important role [3].

The main pathogenesis is characterized by erosion of the

progressive destruction and loss of articular cartilage, Hypertrophy of bone at the margins, Osteophytic lipping, Subchondral sclerosis and range of biomechanical and morphological alteration of the synovial membrane and joint capsule [4].

Risk factors associated with Osteoarthritis includes age, genetic susceptibility, obesity, low bone mineral density, repetitive knee trauma, meniscal injuries, muscle weakness, mechanical forces, joint laxity, joint hyper mobility, due to Syphilis, diabetic mellitus, leprosy and repetitive joint overuse [5].

Historically, Diagnosis is made with reasonable certainty based on history and clinical examination X-rays may confirm the diagnosis of knee radiographs are commonly graded by Kellegren & Lawrence grading system, whereas MRI has the capability to visualize all the structures within the knee joint, including soft tissue and cartilage and subchondral bone marrow lesions. Other investigations used for detecting underlying causes are Serological tests, ESR, Serum uric acid and Arthroscopy [6].

Management of Knee Osteoarthritis is not curable disease at present, as the mechanism by which it arises and progresses remains incompletely understood. Therefore, the goals of treatment is to alleviate the signs and symptoms of the disease and if possible to slow progression. The therapeutic spectrum ranges from general measures to Physiotherapy, Orthopaedic aids, Pharmacotherapy and finally Surgery & Rehabilitation.

The goals of treatment, as stated in many of the guidelines are reducing Pain, improve quality of life, improve mobility, improve walking and delay progression of Knee Osteoarthritis. Pharmacological management of Osteoarthritis includes analgesics/anti-inflammatory agents, glucocorticoids, opioids, Symptomatic slow-acting drugs for Osteoarthritis (SYSADOA) and anti-cytokines. Surgeries in Osteoarthritis are Total joint replacements, uni-compartmental Knee replacement, and osteotomy and arthroscopic debridement. Physiotherapy for Knee Osteoarthritis Electrotherapy including Ultrasound, Transcutaneous Electrical Nerve Stimulation (TENS), Muscle stimulation, Pulsed Electrical Stimulation (PES), Short Wave Diathermy (SWD), Kinesiotaping, Acupuncture. Exercise therapy includes Strength training, Balance & Perturbation training, Aquatic therapy, Manual therapy, Proprioceptive Neuromuscular Facilitation technique (PNF), Retro walking, Functional task training and Aerobic exercises [7].

Recently Pilates exercises and Closed Kinematic Chain exercises have drawn much attention in the management of Knee Osteoarthritis. Studies suggested that these exercises are more effective on Reducing Pain, Improving Muscle Strength and Functional performance in subjects with Knee Osteoarthritis.

Pilate's exercises were designed by Joseph Pilate in Germany in 1883. Pilates exercises may effect in increasing neurological coordination, improve recruitment of muscle fibre, stimulation of proprioception and bring about co-contraction of muscle around the knee joint; focus on activating specific muscle at correct speed, quality, precision and control of movement with specific joint awareness. Pilates focus on balance and strengthening of ligaments, joints, older adults have the opportunity to increase

their level of functional strength and improve the efficiency of daily life [8].

Closed Kinematic Chain exercises have been argued to be more functional as it stimulates the role of lower limb muscles in daily activities and it has been cited as simultaneous segmental movement producing superior eccentric contraction and co-contraction of muscles, as well as reducing shear forces while adding compression forces and control the movement across the joint in chain of the thereby enhancing joint stability. Closed Kinematic Chain exercises are functional, safe and effective exercises muscle strength and facilitating joint position sense [9].

Both Pilates Exercises and Closed Kinematic Chain Exercises have been proved effective on Reducing Pain, Improving Muscle strength and Functional performance in Knee Osteoarthritis. However literature is limited in their comparison.

Materials and Methods

1. **Study design** : Prospective study
2. **Ethical clearance and informed consent**: The study protocol was approved by the Ethical Committee of GSL Medical College & General Hospital; the investigator explained the purpose of the study and given the patient information sheet. The participants were requested to provide their consent to participation in the study. All the participants signed the informed consent and the rights of the included participants have been secured.
3. **Study setting**: The study was conducted at out Patient Department of Physiotherapy, GSL Medical College and General Hospital, Rajamahendravaram, Andhra Pradesh, India.
4. **Study duration**: The study was conducted during the period between July 2019 and June 2020.
5. **Sampling method**: Simple Random Sampling.
6. **Intervention duration**: 6 weeks of training programme which includes Pilates Exercises and Closed Kinematic Chain Exercises.
7. **Sample size**: A total of 150 subjects were screened in that 68 subjects were recruited who are willing to participate in the study. Recruited participants were explained the purpose and relevance of the study. Those willing to voluntarily be included in the study after obtaining informed consent. Participant's age, weight, height, and body mass index were determined. All the eligible Participants were consecutively randomized to Pilates Exercises Group or Closed Kinematic Chain Exercises Group with 34 in each group.
8. **Inclusion criteria**: Participants with diagnosis of Knee Osteoarthritis having symptoms of pain and at least 3 features of the following items according to American College of Rheumatology (ACR) criteria; Age 40-75 year (both male and female), Able to ascend and descend stairs, Unilateral Osteoarthritis of Knee, Grade 1 and

Grade 2 Osteoarthritis of Knee (Kellgren & Lawrence system classification), Pain from past 3 months, BMI (mild to moderate), Pain and limitation of ROM, Tenderness, Early morning stiffness about 30 min.

9. **Exclusion criteria:** Traumatic injury to knee, Neurological diseases, Limb length discrepancy, Any intra articular injection to the knee, Any history of Hip, Knee, Ankle injury, Surgery prior to the study, Any local systemic infection, Subjects in regular Medications/Intra articular injections, Fixed deformity in limb

Outcome measures

- Pain intensity (VAS)** [10]: The VAS scale is a reliable, valid, responsive and frequently used pain outcome measure. The instrument used consisted of horizontal lines, 10 cm long with anchor points of 0 (no pain) and 10 (severe pain). The severity of Knee Pain was evaluated by VAS.
- Hand Held Dynamometer (HHD)** [11,12]: The baseline Hand Held Dynamometer (HHD) was used in the current study for the isometric strength assessment of the Knee flexors and extensors for the study participants. Hand Held Dynamometer is a portable and digital instrument that is used to measure strength of the muscle in kilogram (kg) by holding in a hand.
- WOMAC** [13]: This Questionnaire is used to assess the health status of Osteoarthritis patient introduced in 1988. It is consisted of 33 items which evaluates the health and function of the patient from various aspects including: Clinical symptoms (5 questions), Severity of joint stiffness ((2 questions), Degree of pain (9 questions) and Activity of daily living (17 questions). Each question has five subscales where best situation score as never or none and the worst one names as extreme or always. Here higher scores are representative of better situation and less pain.

Interventions

Group- I: Pilates exercises [8] (**Table 1**).

Group- II: Closed kinematic chain exercises [9]

At week one:

- Standing with feet together in eyes-closed and training balance time without sway.
 - On hard ground
 - On soft ground (on mat)
- Retro walking (25 m)

- Walking on heels (25 m)
- Walking on toes (25 m)
- Walking with eyes closed (25 m)
- Standing on one extremity for 30 second (repeated in both extremities), leaning forward, backward, and to the sides on one extremity (eyes open) leaning forward, backward, and to the sides on one extremity (eyes closed) and sitting down and standing up from a high chair slowly.
- Stair-up and down a regular 3 steps staircase (17 cm high and 23 cm wide).
- Standing with feet approximately shoulder width apart and extend arms out slightly forward and lower than the shoulder. Lift both heels off the floor and try to hold the position for 10 seconds. This was followed by climbing a regular 3 steps staircase (17 cm high and 23 cm wide) up and down.
- Standing with feet side by side, hold arms in the same position as described in the previous exercise. Place one foot on the inside of the opposing ankle and try to hold the position for 10 seconds, followed by climbing a regular three steps staircase (17 cm high and 23 cm wide) up and down.

At week two (in addition to exercises during week one):

- Exercise with Wobble board.
- Sitting down and standing up from a low chair slowly.
- Plyometric exercise (crossing a height of 15cm by jumping).
- (a) Walking slowly in a wide circle of 10 meter radius

(b) Walking quickly in a wide circle of 10 meter radius

(c) Walking slowly in a narrow circle of 5 meter radius

(d) Walking quickly in a narrow circle of 5 meter radius.

At week three (in addition to exercises during two)

- Walk heel-to-toe along a 3m line marked on a medium-density Polyfoam mat.
- With the knee straight but not hyper extended, execute single (relatively small) leg raises to the front, then back. This was continued alternating front to back.

Table 1 Pilates exercises.

Duration	Exercises	Duration	Frequency
Week 1	Hundred	5 repetitions	Thrice weekly
Week 2	(Week 1) + One Leg Stretch, Double Leg Stretch	6 repetitions	Thrice weekly
Week 3	(Week 2) + Clams	7 repetitions	Thrice weekly
Week 4	(Week 3) + One Leg Kick	7 repetitions	Thrice weekly
Week 5	(Week 4) + Side Leg Kick	8 repetitions	Thrice weekly
Week 6	(Week 5) + One Leg Circle	10 repetitions	Thrice weekly

- Plyometric exercise (crossing a height of 15 cm by jumping).

The exercises performed on the third week were repeated all through rest of the weeks

Statistical Analysis

All statistical analysis was done by using SPSS software version 21.0 and Microsoft excel-2007. Descriptive data was presented in the form of Mean \pm Standard deviation and Mean difference percentages were calculated and presented. Independent student "t" test was performed to assess the statistical significant difference in mean value between the groups for Pain, Muscle strength and Functional performance. Paired Student "t" test was performed to assess the statistical difference with in the groups for Pain, Muscle strength and Function score from Pre-test and Post- test values. For all statistical analysis, $P < 0.05$ was considered as statistically significant.

Results and Discussion

Aim of the study was to evaluate the effectiveness of Pilates exercises (Group-I) and Closed Kinematic Chain exercises (Group-II) on Pain, Muscle strength and Function performance in subjects with Knee Osteoarthritis. In this study subjects were assessed for Knee Pain, Muscle strength and Function using VAS, HAND HELD DYNAMOMETER and WOMAC respectively (Tables 2-4).

In this study subjects were assessed for Knee Osteoarthritis underwent either Pilates Exercises or Closed Kinematic Chain Exercises which are performed for six weeks the parameters were assessed before and after exercise training.

In this study (Group-I) Pilates exercises have showed statistically significant difference within the groups from pre-test to post-

test values in Reducing Pain, Improving Strength & Function in subjects with Knee Osteoarthritis.

In this study (Group-II) Closed Kinematic Chain exercises have showed statistically significant difference within the groups from pre-test to post-test values in Reducing Pain, Improving Strength & Function in subjects with Knee Osteoarthritis.

In the present study VAS is used to assess intensity of Pain. Since there is reliability and validity is established. The result showed that Pilates exercises p value (<0.0006) of VAS from pre-test to post-test are highly significant within group. Regarding the explanation of reducing pain, stimulation of mechanoreceptors associated with myelinated alpha beta and alpha delta at spinal level and high centers releasing endorphins [14]. Our study supported by Kaur Rajinder et al., reported that Pilates exercises shows more significant improvement in Knee Proprioception, reducing Pain and Functional ability in people with Knee Osteoarthritis [8].

There were highly significant p value (<0.0001) of Knee flexor and extensor strength of Pilates exercises from pre-test to post-test within group. A study done by Phrompaet et al. where it was stated that prime purpose of Pilates training is to improve flexibility and general body status and also activate specific group of muscles [15].

Some Pilates exercises like Hundred and Single leg circles contain some components of isometric exercises increase the activation of the muscle around the knee joint and to eliminate the inhibition. By training the quadriceps isometrically, motor unit activation is increased and the muscle is strengthened without triggering the pain that often comes from moving the joint against resistance [15]. Quadriceps muscles get stronger and could absorb more of the shock in the joint, a reduction in protective muscle guarding

Table 2 Comparison of mean score of VAS in between the groups.

Groups	Pre VAS		Post VAS		P-value	Inference
	Mean	SD	Mean	SD		
Group-I	5.77	1.22	2.47	0.77	0.0006*	Highly Significant
Group-II	6.10	1.26	3.62	0.93	0.0004*	Highly Significant

Table 3 Comparison of mean score of Knee flexor and knee extensor strength in between the groups.

Groups	Pre knee flexor strength		Post knee flexor strength		P-value	Inference
	Mean	SD	Mean	SD		
Group-I	8.27	2.06	14.73	2.06	0.0001*	Highly Significant
Group-II	8.07	1.90	13.55	2.02	0.0002*	Highly Significant
Groups	Pre knee extensor strength		Post knee extensor strength		P-value	Inference
	Mean	SD	Mean	SD		
Group-I	9.33	1.93	15.83	2.06	0.0009*	Highly Significant
Group-II	9.69	1.73	14.62	1.91	0.0005*	Highly Significant

Table 4 Comparison of mean score of WOMAC in between the groups.

Groups	Pre WOMAC		Post WOMAC		P-value	Inference
	Mean	SD	Mean	SD		
Group-I	32.63	7.13	51.37	7.18	0.0002*	Highly significant
Group-II	32.69	10.66	46.83	6.73	0.0001*	Highly significant

and spasm in the peri-articular muscles was a likely subjects experienced. Cibor et al. attributed these improvements to gain in strength [16].

The result showed that Pilates exercises p value (<0.0002) of WOMAC from pre-test to post-test are highly significant within group. This has been explained by Hurley et al. suggested that, pain is related to functional performance but is not proportional to it. It has been reported that an increase in muscle strength of elderly is a major factor for improving functional performance as the weakening of the quadriceps femoris muscle in degenerative Osteoarthritis patients decreases functional performance and thus determines the severity of disability [17]. According to previous research, the weakening of femoris muscle correlates with a decrease in joint position sense and a degradation of functional performance. Furthermore, weakening of muscle strength and degradation of proprioception both affect the functional performance. These studies suggest that muscle strength and proprioception need to be improved first, in order to improve functional performance [18].

Pilates exercises improve physical and mental conditioning through increasing strength, flexibility balance and postural awareness by stretching and strengthening exercises. This method focuses on building motions and activities that help to strengthen minor muscles, which turns help to strengthening major muscles. Pilates exercises may affect the proprioception via mental effort focuses on activating special muscle at correct speed and control of movement [8].

The results showed that Closed Kinematic Chain exercises p value (<0.0004) of VAS from pre-test to post-test had showed highly significant within group. Due to reduction in pain and consequent improvement in function following quadriceps strengthening exercises have been attributed to increased stability of the knee joint which is enhanced by improvement in quadriceps muscle strength. Evidence from literature also suggests that quadriceps strengthening may activate the pain suppressing beta endorphin system, favorably alter sensory input to the central nervous system and the gate control mechanism (regulating pain perception) and as well improve blood flow and cartilage nutrition [19].

In Closed Kinematic Chain exercise group the analysis of Strength and Function in knee had showed significant Knee flexor and extensor strength p value (<0.000) and WOMAC p value (<0.0001) when analyzed from pre to post intervention within group. Regarding the improvement in Muscle strength is declines are thought to primarily result from the atrophy of type-II B fibers, which are responsible for the rapid production of power. Type-II B fibers have demonstrated the ability to hypertrophy after undergoing high tension and fatigue inducing exercises. Hence muscle weakness is correctable with appropriate strength training programme [20].

This result of the study showed significant improvement in physical function, energy role limitation pain and severity of Osteoarthritis at the post rehabilitation period.

Our study finding were supported by previous study done by Vander et al. who stated that interaction between Muscle

strength and Proprioception contributed significantly to the variance in functional ability and an increase of muscle strength would result in bigger improvement of functional ability. This functional status and motor control improvement might have been due to improvement in dynamic stabilization, synergistic and synchronous working of the muscle groups resulting from repetitive movements that that characterize activity of daily living [9].

Closed Kinematic Chain exercises increases agonist recruitment and antagonistic inhibition trains all muscles to work together synergistically, occurs in all three cardinal planes, elicits concentric, eccentric and isometric contractions and fascilitate proper proprioceptive feedback mechanisms [9].

When compared between the groups Pilates exercises and Closed Kinematic Chain exercises shows statistically significant in post values. The result of the study shows that Pilates exercises is more effective than Closed Kinematic Chain exercises to improve the Pain, Muscle strength and Functional ability of Osteoarthritis in Knee patients. The improvement in Group-I is more than Group- II and having statistically highly significant.

This study proved that, Pilates method increase the sensitivity of mechanoreceptors which provide the necessary enhancement of reflex neuromuscular protective mechanism. Pilates exercises were specifically designed to improve coordination of the entire body and also helpful in increases recruitment of muscle fibers, which brings about co-contraction of muscle and improve stimulation of Proprioception around knee joint [21]. These exercises are effective in reducing Pain, improving lower limb muscular strength, balance, flexibility, and spinal mobility. Thereby it increases the quality of life. Hence we can conclude that patients with mild to moderate Knee Osteoarthritis can achieve significant benefits using Pilates exercises in addition to Conventional Physiotherapy.

Limitations

- Less sample size
- Lack of control group in the present study
- No blinding of evaluators of outcomes
- Lack of follow up in the present study
- Medications and activities of daily living were not taken in to account
- Home exercises were not monitored.

Recommendations for Further Research

- Sample size can be increased with inclusion of more number of subjects to generalize the effects of these techniques in larger population.
- In the present study the gender distribution showed more number of females affected with Osteoarthritis of Knee

than the male subjects. Hence in future study can do individual like male and female.

- The duration of study can be increased by 8 weeks or 12 weeks.

Conclusion

The present study concluded that six weeks of Interventions of Pilates exercises and Closed Kinematic Chain exercises were shown statistically improvement on Reducing Pain, Improving Muscle strength and Functional performance. However more Percentage of improvement was found in subjects received Pilates exercises when compared to Closed Kinematic Chain exercises. From the findings of the current study, it can be recommended that the Pilates exercises protocol can be prescribed to the participants with mild to moderate Knee Osteoarthritis.

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