



**“TO COMPARE THE EFFECTIVENESS OF OPEN KINETIC CHAIN EXERCISES
VERSUS CLOSED KINETIC CHAIN EXERCISES TO IMPROVE QUADRICEPS
STRENGTH AND FUNCTIONAL STATUS IN PATIENTS WITH KNEE
OSTEOARTHRITIS”**

Physiotherapy

Mohammad Chan Basha*	MPTH Scholar, Pacific College of Physiotherapy, Pacific Medical University Udaipur, Rajasthan, India *Corresponding Author
Dr. Jafar Khan	Dean & HOD Pacific College of Physiotherapy, Pacific Medical University, Udaipur Rajasthan, India
Dr. Renuka Pal	Associate Professor, Pacific College of Physiotherapy, Pacific Medical University Udaipur, Rajasthan, India
B. Sai Priya Moulika	MPTH Scholar, Pacific College of Physiotherapy, Pacific Medical University Udaipur, Rajasthan, India

ABSTRACT

The objective of the study was to compare and assess the effects of a 2-week Closed and Open Kinetic Chain exercise programme on Quadriceps Strength and Function in Knee Osteoarthritis patients. To compare the therapeutic benefits of Closed Kinetic Chain exercises with Open Kinetic Chain Exercises on the functional status and quadriceps strength in patients with knee osteoarthritis. **Methods:** 20 patients with a mean age of 55 to 75 years were compared. The study comprised both male and female participants. For Group-A (Closed Kinetic Chain Exercises) and Group-B, all ten patients were chosen at random (Open Kinetic Chain Exercises). For two weeks, patients receive treatment five days each week. The WOMAC scale is used to assess the result in terms of pain, stiffness, and functional status. **Results:** With a mean difference of 2.1 between the 0th and 14th days for both groups, Group B (CKCE) exhibited significantly more improvement than Group A (OKCE). At the end of the second week, Group-B displayed a lower mean than did Group-A. **Conclusion:** The study, therefore, concluded that alternative hypothesis “the Closed Kinetic Chain Exercises are not effective in improving Quadriceps strength and functional status of patients with Osteoarthritis of Knee” is rejected. As there is a significant decrease in pain and increase in function and muscle strength in patients with Osteoarthritis Knee underwent CKCE.

KEYWORDS

Knee Osteoarthritis, Open Kinetic Chain Exercises, Closed Kinetic Chain Exercises, Quadriceps Muscle, WOMAC.

INTRODUCTION

The most prevalent chronic, progressive, degenerative, and incapacitating illness affecting the elderly is this one. The Greek words "osteo," "arthro," and "itis," which translate to "of the bone," "joint," and "inflammation," respectively, are the source of the phrase osteoarthritis. The precise reason is not known¹. However, it is firmly considered that it develops as a result of ageing, joint wear and tear, or degenerative changes. Osteoarthritis has two types: Osteoarthritis can be either primary or secondary. Primary osteoarthritis results from the normal wear and tear of ageing, excessive use, or obesity. Men had a 40% lifetime risk and women had a 47% lifetime risk of having osteoarthritis of the knee, with higher risks among Asians who are obese².

Repetitive weight bearing or extended weight bearing on joints that are sensitive, competitive sports with insufficient rest intervals, an excessively sedentary lifestyle, and obesity are the main causes of primary knee osteoarthritis. The following factors contribute to secondary knee osteoarthritis: Post-traumatic; Varus or valgus deformity in the knee; Lower limb fractures¹.

The site of the joint's load-bearing contact shifts significantly to a zone that is not accustomed to heavy loads during the start period. As a result, the areas that are rarely loaded exhibit cartilage that has deteriorating characteristics, such as fibrillation. In the early stages of osteoarthritis, fibrillation and matrix consolidation are seen together with a loss of proteoglycans at the surface layer¹. Higher matrix consolidation, increased friction at the surface, increased tangential force at the articular surface, and increased fibrillation at the articular surface all contribute to an increase in shear stress in the collagen network. When cartilage degenerative changes reach a critical point when the tissue is sensitive to heavy stresses, the progression phase of the disease starts. Osteoarthritis progresses when additional compressive stresses are applied to the knee joint, increasing shear when fibrillation is present at the surface. Consistent knee pain, morning stiffness, crepitus, decreased joint functionality, restricted joint motion, tenderness on probing, and joint effusion are a few of these symptoms².

The mechanical axis, or weight-bearing line, for a regularly aligned knee goes through the joint's centre between the intercondylar tubercles. Muscle imbalances, aberrant stresses on the knee joint, and

misaligned hip, ankle, or foot joints can all contribute to knee malalignment. The knee has a minor physiological (normal) valgus tilt because the femur is slanted up to 5° from vertical and the tibial longitudinal axis ordinarily create an angle of 180° to 185° medially³.

Genu-Valgum, often known as "knock knees," is an abnormal condition that arises if the medial tibiofemoral angle is more than 185°. Increased lateral compressive forces result from a change in the weight-bearing line into the lateral compartment. The ensuing anomaly known as Genu-Varum occurs when the medial tibiofemoral angle is 175° or less (bow legs). Here, there is a medial shift in the weight-bearing line, increasing the compressive stresses on the medial condyle⁷.

Genu-Recurvatum, a condition marked by excessive knee hyperextension, is brought on by a muscle imbalance. The level of hyperextension is increased in this situation due to the line of gravity being much anterior to the knee joint axis, which also places a significant amount of tension stress on the anterior cruciate ligament and posterior joint capsule⁷.

Weight-bearing loads on the knee in bilateral stance are evenly distributed between the medial and lateral condyles, however in unilateral stance, the weight-bearing line moves towards the medial compartment to accommodate for the reduced base of support below the centre of mass (or medial and lateral compartments). This movement increases the compressive strains on the medial compartment⁴.

The quadriceps muscle's lateral pull is estimated by Q-Angle. It is created by the junction of two lines, one drawn from the centre of the patella to the centre of the tibial tuberosity and the other from the anterior superior iliac spine of the pelvis to the centre of the patella. Males typically have a Q-angle of 10° to 15°, whereas females typically have one of 15° to 20°. Q-angle is raised when there is more lateral pull on the patella⁶.

Because the total muscle tension of the quadriceps will be higher than in the muscles shortened state, which is demonstrated by the quadriceps lag or the extension lag, in cases of significant quadriceps weakness, the quadriceps may not be able to produce enough torque to complete the last 15° of non-weight bearing knee extension⁸.

Aim of The Study:

The aim of the study was to analyse the Effectiveness of Open Kinetic Chain Exercises versus Closed Kinetic Chain Exercises to improve quadriceps strength and functional status in patients with Osteoarthritis.

METHODOLOGY:

Prospective study design. This study was approved by ethical committee of Pacific Medical University. During the period of study, ethical issues will be followed with utmost care and due respect towards the maintenance of privacy of the patients. Each patient will be given detailed explanation about both beneficial and potential harmful effects (if any) of the treatment which he/she supposed to receive. The participants will be explained about the purpose of the trial. The request for termination of the treatment by the patient at any time of the study shall never be denied. Subjects who are of age group between 55 to 75 years diagnosed with knee osteoarthritis. The study was conducted in Physiotherapy Department, Pacific Medical University, Udaipur, India. Patients were trained for five sessions per week for 2 weeks. Simple random sampling method. 20 subjects were divided into two groups 10 subjects in each group: Group A: 10 subjects; Group B: 10 subjects.

Inclusion criteria:

Mean age of 55 to 75 years; Clinical presentation of unilateral knee osteoarthritis; Ability to walk at least 100 meters on an uneven surface; According to the Kellgren and Lawrence grading system based on plain x-rays, patients with knee osteoarthritis in grades 2 and 3 were collected; Patients were diagnosed according to American College of Rheumatology Criteria of knee osteoarthritis; The patient's knee joint should be in close to or full passive range of motion; Vigorous joint motion causing crepitation; Morning stiffness lasting no more than 30 minutes.

Exclusion criteria:

Patients with a previous history of knee surgery; Patients undergoing intra-articular injection of hyaluronic acid/steroids in the last six months; Patients with a history of a pathological condition like malignancy, infection, rheumatoid arthritis, osteomyelitis and other pathologies of muscle, bone, ligaments; Patients with cardiac problems were not included; Patients with knee flexion deformity are also excluded; Patients with osteoporosis were excluded; Patients with a psychological problem and non-co-operative patients are excluded; Patients with osteoarthritis at other joints except for osteoarthritis of the knee were also excluded.

Procedure:

Everyone who took part in the project was required to sign a consent form. The ethical committee allotted the reference number – PMU/PMCH/IEC/2022/240. Following the agreement, a thorough explanation of the treatment process was given to each participant. For two weeks, patients received training five times each week. The length of each exercise session is roughly 45 minutes. There are three sets of 10 repetitions for each exercise. All participants voluntarily stopped taking their medications for the duration of a specific programme. While the trial was ongoing, patients were instructed not to alter their regular daily routines or engage in any additional physical exercise or physiotherapy. At days 0 and 14, or the pre-test and post-test of the therapy session, patients were evaluated using the WOMAC questionnaire. Patients follow their specific routine when performing their therapeutic workouts.

Intervention**Open kinetic chain exercise (OKCE) (Group-A)¹³**

In open kinetic chain exercise protocol, each exercise was held isometrically for a count of 10 seconds with a 3-second rest between the repetitions.

Quadriceps Setting:

Patient lying on their back, sitting in a chair, or long-sitting with their knees extended but not hyperextended. When the patella glides proximally as a result of the patient's isometric quadriceps contraction, ask them to hold the position for a count of 10, then do it again. Use verbal instructions like, "Try to draw your kneecap up and tighten your thigh muscle," and "Try to press your knee back and tense your thigh muscle." When the patient has correctly engaged the muscle, have them dorsiflex their ankles while maintaining an isometric quadriceps contraction. In order to prevent the patient from compensating with hip

extension due to an inhibited quadriceps, keep an eye on the gluteus maximus. The contraction was kept for 10 seconds, then there was a 3-second relaxation period before starting the following repetition. This practise is done throughout the entire curriculum.

Straight Leg Raise:

Patient lying on his or her back with the knee extended. Stabilize the pelvis and lower back when the opposing hip and knee are flexed and the foot is flat on the exercise bench. Now tell the patient to contract their quadriceps, lift their leg to a hip flexion angle of around 45 degrees, and keep their knee extended. The patient should hold the leg in place for 10 seconds while counting to 10. Then, they should lower it. To advance, limit the patient's hip flexion to only 30 and then 15 degrees, and have them hold each position. Put a weight cuff over the patient's ankle to increase resistance.

Vastus Medialis Oblique (VMO) Training:

Patient lying on his or her back with the knee extended. Next, stabilise your lower back and pelvis. This workout is performed similarly to Supine straight leg lift with linked external rotation and isometric hip adduction. The patient should hold the leg in place for 10 seconds while counting to 10. Then, they should lower it. To advance, limit the patient's hip flexion to only 30 and then 15 degrees, and have them hold each position. Put a weight cuff over the patient's ankle to increase resistance.

Short Arc Terminal Knee Extension:

Patient in long-sitting or supine position. Roll up a towel and place it under the knee to provide flexion assistance. The patient was made to sit short-seated at the edge of the table with the seat of a chair or stool placed under the heel to stop knee flexion at the right angle. Knee should be in some degree of flexion to start. As the patient tolerates it or as required by their condition, increase the degrees of flexion. At first, merely allow the patient to extend their knee against gravity's pull. If the patient does not feel discomfort or crepitation later, add a cuff weight to enhance the resistance. Combine the short-arc terminal knee extension with an isometric hold and/or a straight leg lift once the knee has fully extended. Ask the patient to invert their foot when they stretch their knees to lessen lateral shear pressures¹³.

Closed kinetic chain exercise (CKCE) (Group-B)¹³

Each exercise in the closed kinetic chain protocol was performed dynamically with a 3-second rest between the repetition.

Quadriceps Setting Exercises

Patient was made to sit with extended or slightly flexed knee and heel on the floor. Ask the patient to focus on tightening their quadriceps while placing their heel on the floor and thigh on the seat of the chair. Ten seconds of muscle contraction followed by three seconds of relaxation should be repeated.

Stationary Bike

On the stationary cycle, the patient is made to sit comfortably. Correctly adjust the seat height so that your knees don't bend at an angle more than 90 degrees as you pedal. While pedalling, the knee joint shouldn't lock, and it shouldn't be overly bent in the bottom position either. The seat should be parallel to the ground and not slant forward or backward. When the handlebars are raised high enough, the body should be able to stay mostly upright. Throughout the entire revolution, the patient's foot must be totally resting on the pedal. It is not recommended to pedal faster than 50 to 60 revolutions per minute. Five to seven minutes of cycling are required of the patient. Gradually upping the resistance.

Step-Up and Step-Down Exercises

Standing patiently. As soon as the patient is able, start with a low step made of wood that is 2 to 3 inches tall. To prevent "valgus collapse," make sure the patient maintains an upright posture and a knee that is parallel to the ground. Apply a graduated manual resistance force to the lateral aspect of the forward thigh to encourage gluteus medius firing during forward step-ups. When completing eccentric (step down) and concentric (step up) quadriceps workouts, concentrate on controlling your body weight. In order to emphasise the quadriceps and reduce pushing off using the plantar flexors of the trailing extremity, teach the patient to "keep the toes up" or that the heel must be the last to leave the floor and the first to return. Use ankle weights to stiffen the opposition. Despite the increasing difficulty, the patient should still do step ups and downs while maintaining alignment and control. As you advance,

gradually incorporate rotational movements as well as walking onto or off of higher tiers.

Partial Squats, Mini-Squats and Short-Arc Training

Standing patiently. The patient should first flex both knees between 30 and 45 degrees before extending them. Prior to Gain ground by using elastic resistance placed beneath both of your feet or holding weights in your hands. lowering the knees, the patient should first lower the hips as if sitting down while keeping the trunk straight and concentrating on maintaining a posterior weight shift. To guarantee gluteal activation and reduced stresses on the patello-femoral joint, the knees should remain in line with the toes and not advance past them. This will prevent valgus collapse. In the later stages of treatment, increase the range of knee flexion when performing squats. By executing unilateral resisted mini squats or squatting on the unstable surfaces, you can make the workout more challenging¹⁶.

Hamstring Setting (Hamstring Sets)

The patient is long-sitting or resting on his or her back with a towel roll beneath the knee. Have the patient contract their knee flexors in an isometric manner for 10 seconds while softly pressing the heel of their foot into the treatment table. Ask the patient to relax for three seconds, then instruct them to contract once again¹⁶.

Hamstring Curls

The patient is standing. As a balancing aid, ask the patient to grasp on to something sturdy. Ask the patient to flex their knee to a 90-degree angle, where resistance is provided by gravity. Use ankle weights to increase the amount of resistance¹⁶.

Outcome Measures⁸:

Western Ontario and McMaster Universities Arthritis Index (Womac). By evaluating seventeen functional activities, five pain-related activities, and two stiffness categories, it was created to measure the dysfunction and pain associated with osteoarthritis of the lower limbs. It has been extensively utilised in clinical trials and is one of the most sensitive tools available for evaluating osteoarthritis of the hip and knee.

Statistical Analysis:

Microsoft Excel 2007 and SPSS software version 20.0 were used to conduct the statistical analysis; Mean $\pm$ SD and percentages were used to display descriptive data; Data was graphically depicted and tallied; T-test was used to compare the means of two groups while examining differences and similarities within each group; Statistics were judged significant at $P \leq 0.05$.

RESULTS:

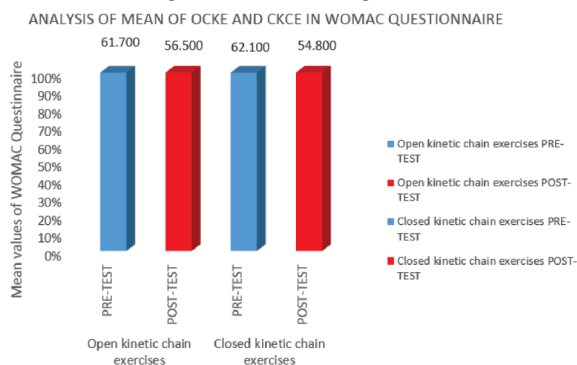
The aim of the study was to find the effectiveness of open kinetic chain exercises versus closed kinetic chain exercises in patients with osteoarthritis of knee. A total of 20 subjects were included in this study. All the subjects underwent baseline assessment and included subjects were randomised into two groups consisting of 10 in each group. In this study the treatment session was for 2 weeks, 20 participants completed the treatment session; 10 in Group A and 10 in Group B completed training. Both the group showed statistically significant scores in WOMAC Questionnaire, where p value was set at $p \leq 0.05$ was significant.

GROUP		Mean	Std. Deviation	P - Value	Inferences
Open kinetic chain exercises	PRE-TEST	61.700	10.656	0.000	Highly significant
	POST-TEST	56.500	9.708	0.000	
Closed kinetic chain exercises	PRE-TEST	62.100	8.227	0.000	Highly significant
	POST-TEST	54.800	7.440	0.000	

DISCUSSION:

The study's main objective is to examine the claim that closed kinetic chain workouts have a more notable impact on quadriceps strength and function than open kinetic chain activities. Quadriceps weakness, one of several factors that contribute to the beginning and progression of osteoarthritis, is the major factor that may be modified by resistance training to increase the strength of the musculature surrounding the knee joint. The quadriceps strength is a crucial area to focus on since a weak quadriceps muscle can lead to increased joint strains from a

reduced ability to alternate loads across the joint, whereas strengthening activities improve pain and function while also making the quadriceps stronger. Quadriceps strengthening may activate the pain-suppressing endorphin system, favourably shift sensory input to the central nervous system, and engage the gate control mechanism in addition to enhancing blood flow and cartilage nourishment¹⁰.



Analysis Of Mean Values Of Open Kinetic Chain Exercises And Closed Kinetic Chain Exercises In Womac Questionnaire

The exercises used in the current study, open and closed kinetic chains, are progressive resistance exercises. They boost the muscles' ability to generate force. The benefits of open-kinetic chain exercises include the following: They put more of an emphasis on a specific joint or muscle; only muscles related to one joint are worked out; the resistance type places different demands on the quadriceps muscle in terms of maximum effort at different ranges; muscle reactivation makes the muscle work more effectively; and keeps movement aligned, which in turn helps to prevent joint injuries. The advantages of closed kinetic chain exercises in the lower limb include: they promote more functional patterns, allow simultaneous activation of antagonistic muscle groups, which increases joint stability and stimulates functional movement patterns, they stimulate co-contraction of the hamstring, which helps to reduce anterior tibial translation, and they involve multiple joints during the exercise, which increases mechanorecognition⁹. The inner and middle quadriceps muscle ranges, where there is a consistent tension in the range either in concentric contraction or eccentric contraction, respond well to open kinetic chain workouts. When a muscle contracts concentrically, the internal tension pulls the bone component in the direction of the muscle pull; when a muscle contracts eccentrically, the internal tension pulls the bony component apart in the direction of the muscle pull, supported by gravity force. Isotonic contractions are utilised to increase muscle strength and mass, but they consume more energy. The closed kinetic chain exercises are effective throughout the range (full range) of quadriceps muscles where the muscles contract both isometric and isokinetic. Without changing the length of the muscle, an isometric contraction aids in the creation of intramuscular tension. Although there is no movement at the bone level during isometric contraction, force is generated. Less energy is expended during this contraction, which reduces fatigue and increases muscle strength¹².

The resistance during an isokinetic contraction is inversely proportional to the muscle's generated torque. The muscle is often stronger in the middle range compared to the beginning and end ranges. If the resistance is constant, the muscle must work harder while maintaining the same speed and velocity at the start and end of the range of motion. Muscles become more flexible as a result of this type of contraction. The theory behind closed kinetic chain exercises is that they rapidly transition from the learning phase of strength building into the muscular building phase by recruiting muscles in functional and familiar patterns⁹.

Due to the weight-bearing position of the limb, closed kinetic chain exercises were more painful than open kinetic chain exercises in the acute phase. Furthermore, by recruiting and engaging muscles in such functional patterns, proprioception and coordination may be enhanced, lowering the chance of injury. The extensor mechanism gains strength during closed kinetic chain activities. In comparison to open kinetic workouts, the force of the knee muscles increases following closed kinetic activities. Both the active and passive ranges of knee flexion significantly increased due to eccentric elements of two different workout regimens. The eccentric muscle workouts increase

muscular tension and cause maximum firing, which results in a more effective training outcome¹⁰.

CONCLUSION:

In individuals with osteoarthritis of the knee, open kinetic chain workouts are more successful in enhancing quadriceps strength and functional status. The alternative hypothesis, "The closed kinetic chain workouts are not beneficial in improving quadriceps strength and functional status of patients with osteoarthritis knee," is thus disproved, according to the study. Patients with osteoarthritis of the knee who received Closed Kinetic Chain Exercises saw a considerable reduction in discomfort, an improvement in function, and an increase in muscular strength.

Limitations:

The length and sample size are modest; The senior patient with osteoarthritis may have felt discomfort from the therapeutic exercise routine because it was a little chaotic for them.

Recommendations:

Future studies should take into account the long-term effects of closed kinetic chain exercises and open kinetic chain activities in individuals with knee osteoarthritis. It is possible to explore future study on coupled chain exercises.

REFERENCES

1. John Ebenezer: Essentials of orthopedics for physiotherapists.
2. J. Maheshwari, 3rd edition, essentials of orthopedics.
3. Davidsons, principle and practice of medicine, 20th edition, page-1097.
4. Physical rehabilitation, 5th edition Susan B O Sullivan.
5. Carolyn Kisner; therapeutic exercise- foundations and techniques; 6th edition; pp: 831-837.
6. M. Dena Gardiner; the principles of exercise therapy; 4th edition; pp: 9-20.
7. Carol A. Oatis; kinesiology- the mechanics and pathomechanics of human movement; second edition; pp: 738- 805.
8. Salaffi, F., Leardini, G., Canesi, B., Mannoni, A., Fioravanti, A., Caporali, R., Lapadula, G., Punzi, L., & GONorthrosis and Quality Of Life Assessment (GOQOLA) (2003). Reliability and validity of the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index in Italian patients with osteoarthritis of the knee. *Osteoarthritis and cartilage*, 11(8), 551–560.
9. BabatundeOlusolaAdegoke; the effectiveness of open versus closed kinetic chain exercises on pain, function and range of motion in patients with knee osteoarthritis, *Baltic journal of health and physical activity* 2019; 11(3):39-52.
10. Olagbegi OM, Adegoke BOA, Odole AC; Effectiveness of combined chain exercises on pain and function in patients with the knee osteoarthritis, *Bangladesh J Med Sci*, 2016; 15(2): 178-188.
11. Verma S; Comparing open kinetic chain with closed kinetic chain exercise on quadriceps strength and functional status of women with osteoarthritis knee. *Med Sportiva*, 2012; 8(4): 1989-1996.
12. Adel Rashad Ahmed, Abdulmohsen Hassan Al-Ghamdi; A comparison of closed versus open kinetic exercises in treatment of patients with patellofemoral pain; vol. 10, no. (2), july-2005.
13. OladapoMichealOlagbegi, BabatundeOlusolaAdegoke and Adesola Christiana Odole; Effectiveness of three modes of kinetic chain exercises on quadriceps muscle strength and thigh girth among individuals with knee osteoarthritis; Olagbegi et al. *Archives of physiotherapy* (2017) 7:9 DOI 10.1186/s40945-017-0036-6.
14. K. Bose and K.C. Chong, Singapore; the clinical manifestations and pathomechanics of contracture of the extensor mechanism of the knee; *journal of bone and joint surgery*.
15. Escamilla, Rafael F.; Fleisig, Glenn S; Zheng, Nigel; Barrentinr, Steven W; Wilk, Kevine E; Andrews, James R. Biomechanics of the knee during closed kinetic chain and open kinetic chain exercises; *medicine and science in sports and exercise*: April 1998- volume 30 –Issue 4 – P556-569.
16. Aru Daskapan, BaharAnaforoglu, NihanOzunluPekyavas, Emine Handan Tuzun, SacideNurCosar, MetinKaratas; Comparison of mini squats and straight leg raise in patients with knee osteoarthritis: a randomized controlled clinical trial; *Turk J Rheumatol* 2013;28(1):1626.