

EFFECT OF OPEN AND CLOSED KINETIC CHAIN EXERCISE WITH OR WITHOUT ADDITIONAL HIP STRENGTHENING EXERCISES ON PAIN, KNEE FUNCTION AND Q ANGLE AMONG ATHLETES WITH PATELLOFEMORAL PAIN SYNDROMEMukesh Kumar R.*^{1,2}, Dr. Sandhiya M.³, Dr. Senthil Selvam P.⁴, Dr. Vadivelan K.⁵, Dr. Muthukumran J.⁶¹Research Scholar, School of Physiotherapy, Vels Institute of Science and Technology, Chennai, India.²Assistant Professor, College of Physiotherapy, Dayananda Sagar University, Bangalore, India.³Assistant Professor, School of Physiotherapy, Vels Institute of Science and Technology, Chennai, India.⁴Professor and Head of the Department, School of Physiotherapy, Vels Institute of Science and Technology, Chennai, India.⁵Professor, SRM College of Physiotherapy, SRMIST, Chennai.⁶Principal, School of Physiotherapy, Sri Balaji Vidyapeeth, Chennai.***Corresponding Author: Mukesh Kumar R.**

Research Scholar, School of Physiotherapy, Vels Institute of Science and Technology, Chennai, India.

DOI: <https://doi.org/10.5281/zenodo.20443510>**How to cite this Article:** Mukesh Kumar R.*^{1,2}, Dr. Sandhiya M.³, Dr. Senthil Selvam P.⁴, Dr. Vadivelan K.⁵, Dr. Muthukumran J.⁶. (2026). Effect of Open and Closed Kinetic Chain Exercise with or Without Additional Hip Strengthening Exercises On Pain, Knee Function and Q Angle Among Athletes With Patellofemoral Pain Syndrome. European Journal of Pharmaceutical and Medical Research, 13(6), 256–268.

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Article Received on 23/04/2026

Article Revised on 13/05/2026

Article Published on 01/06/2026

ABSTRACT

Introduction: Patellofemoral pain syndrome (PFPS), commonly referred to as runner's knee, poses a significant challenge in orthopaedic and sports medicine due to its prevalence and impact on individuals engaged in physical activities. This condition manifests as anterior knee pain and is often exacerbated during movements such as running, climbing stairs, or prolonged sitting. **Aim:** Aim of the study is to compare the effects of open and closed kinetic exercise with or without additional Hip strengthening exercises on pain, knee function and Q angle among the athletes with patellofemoral pain. **Method:** In this experimental study, 30 subjects diagnosed with PFPS were divided into two groups: Group A underwent open and closed kinetic chain exercises, while Group B performed the same exercises supplemented with hip strengthening exercises. Pre and post-test assessments were conducted using outcome measures such as the Numerical Pain Rating Scale (NPRS), Kujala Anterior Knee Pain Scale (KAKS), and Q angle measurement. **Results:** Both Group A and Group B showed significant improvements in NPRS, KAKS, and Q angle measurements after six weeks of intervention. However, Group B, which received hip strengthening exercises in addition to kinetic chain exercises, exhibited greater improvements in pain reduction and functional outcomes compared to Group A. **Conclusion:** The findings of this study highlight the effectiveness of incorporating hip strengthening exercises into rehabilitation protocols for individuals with PFPS. The combination of open and closed kinetic chain exercises with hip strengthening yielded superior outcomes in pain reduction and functional improvement compared to kinetic chain exercises alone.

KEYWORDS: Patellofemoral pain syndrome (PFPS), numerical pain rating scale(NPRS),kujala anterior knee pain scale(KAKS), Q Angle (Quadriceps Angle), open and closed kinetic exercise.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is a common cause of anterior knee pain and is known by several names such as runner's knee, patellofemoral pain syndrome, retro patellar pain syndrome, lateral facet compression syndrome, or idiopathic anterior knee pain. It emerges as a diagnosis of exclusion post the elimination of other

intra-articular and peripatellar pathologies. Manifesting with discomfort typically situated behind or surrounding the patella, the condition flares up upon loading a flexed knee joint. Understanding and addressing PFPS necessitate a cohesive interprofessional approach, wherein clinicians, physical therapists, and other healthcare stakeholders collaborate closely in-patient

evaluation and management. This collective effort underscores the importance of a holistic approach, emphasizing interdisciplinary communication, patient education, and the integration of evidence-based interventions to optimize outcomes and mitigate the impact of PFPS on affected individuals' daily lives.^[1] PFPS is described as anterior or retro patellar knee pain in the absence of other pathology.^[18]

The implementation of comprehensive physical training programs tailored for adolescent female soccer players yields substantial benefits in injury reduction and long-term health outcomes. Research indicates that integrating various components such as sport-specific cardiovascular training, plyometrics, sport cord drills, strength, and flexibility training can significantly decrease lower body injury rates, fostering a conducive environment for athletes to maintain game readiness.^[2] While complete injury prevention remains elusive, practitioners play a pivotal role in mitigating certain injury types and minimizing the severity of injuries.^[3] Additionally, the concern surrounding anterior knee pain in adolescence and its potential correlation with patellofemoral osteoarthritis in later life underscores the necessity for proactive measures to preserve joint health and mitigate long-term complications.^[4] Ultimately, the overarching goal of sports medicine lies in nurturing the holistic well-being of athletes and patients, ensuring they remain healthy, pain-free, and capable of enjoying sustained participation in sports and physical activities throughout their lives. This comprehensive approach not only fosters physical resilience but also promotes a lifelong commitment to health and wellness within the athletic community. Patellofemoral Pain Syndrome (PFPS) presents as a condition characterized by both malalignment and muscular dysfunction.^[5]

PFPS, frequently emerges from overuse stress^[9], the condition inherently lends itself to prehabilitation strategies. It's crucial to acknowledge that anatomical variations in patellar and trochlear morphology can impose limitations on both rehabilitation and prehabilitation outcomes.^[10] Consequently, the efficacy of a prehabilitation regimen might be constrained by factors such as patellar shape and trochlear groove dimensions. Prehabilitation, grounded in a comprehensive understanding of anatomical, functional, and biomechanical dynamics preceding symptomatic PFPS, involves pre-emptive interventions in asymptomatic individuals. The Preparticipation Screening Evaluation (PPSE) emerges as a pivotal juncture for pre-emptive diagnosis and initiation of prehabilitation protocols.^[11] Through PPSE, healthcare practitioners can proactively identify individuals predisposed to PFPS, allowing for timely implementation of prehabilitative measures aimed at optimizing musculoskeletal function and pre-empting the onset of symptomatic PFPS.

Open kinetic and Closed Kinetic

Closed kinetic chain exercises, including squats and lunges, have emerged as pivotal tools in the management of patellofemoral pain syndrome (PFPS) due to their superior efficacy compared to open kinetic chain exercises in strengthening the quadriceps muscles and alleviating discomfort associated with PFPS. While open kinetic chain exercises, such as leg extensions, target the quadriceps, they often fail to address the underlying biomechanical imbalances and functional deficits inherent in PFPS. Research underscores the biomechanical advantages of closed kinetic chain exercises, emphasizing their ability to mimic real-life movements and distribute forces more evenly across the patellofemoral joint, thereby reducing excessive stress and minimizing pain exacerbation, particularly at the terminal ranges of motion where PFPS symptoms tend to intensify. The mechanics of closed kinetic chain exercises engage not only the quadriceps but also the entire lower extremity kinetic chain, promoting better neuromuscular coordination, dynamic stabilization, and functional integration, which are crucial components of PFPS rehabilitation and prevention strategies. However, the closed kinetic chain exercise group exhibited significantly better results in certain functional tests compared to the open kinetic chain group. This suggests that closed kinetic chain exercises may offer greater effectiveness in enhancing overall function and alleviating symptoms associated with PFPS.

Hip strengthening exercise

PFPS, a prevalent musculoskeletal disorder, often poses challenges in pain management and functional improvement. The review synthesized data from various studies, examining the effectiveness of hip strengthening exercises in comparison to knee strengthening exercises, and exploring the outcomes of combined approaches. While the review underscores the significance of both hip and knee strengthening modalities, it underscores the paramount importance of seeking guidance from healthcare professionals to devise a personalized exercise regimen tailored to individual needs and pain thresholds. This nuanced approach ensures that PFPS management strategies align with the unique physiological and biomechanical characteristics of each patient, optimizing treatment outcomes and fostering long-term relief and functional restoration. Isolated hip strengthening exercises provided the added advantage of greater pain relief.

AIM OF THE STUDY

Aim of the study is to compare the effects of open and closed kinetic exercise with or without additional Hip strengthening exercises on pain, knee function and Q angle among athletes with patellofemoral pain.

OBJECTIVE OF THE STUDY

PRIMARY OBJECTIVE

- To investigate the effect of open and closed kinetic with or without additional Hip strengthening

exercise on pain knee function & Q-angle among Athletes with Patellofemoral pain syndrome.

SECONDARY OBJECTIVE

- To investigate the effect of open and closed kinetic on pain, strengths and function in patellofemoral pain syndrome.
- To investigate the effect of Open and closed kinetic chain exercises with additional Hip strengthening on pain, strength and function in patellofemoral pain syndrome.

METHODOLOGY

- Study design: Randomized controlled trial, with two parallel group of allocation ratio 1:1
- Type of study setting: Physiotherapy clinic-Outpatient
- Source of data: Physio Pulze, Chennai
- Population: Subjects with Patellofemoral pain syndrome
- Sampling: Simple random sampling
- Sample size: It is calculated by using the following formula

$$n = \frac{2(Z_{\alpha} + Z_{1-\beta})^2 \sigma^2}{\Delta^2}$$

Where n is the required sample size. For Z_{α} , Z is a constant, α -error = 5%, 2 sided=1.96³⁸

For $Z_{1-\beta}$, β , Z is a constant set by convention according to power of the study

Power = 80%, Value = 0.8416, The standard deviation would be approximately 0.7, The effect size is 0.15. Therefore, the calculated sample size is 15 in each group.

Sample size: 30

- Recruitment: Subjects were recruited from the physiotherapy clinic and explained about the purpose and usefulness of the study.
- Allocation: Subjects were allocated to one of the two groups according to the selection criteria.
- Study duration: 6 Weeks

SELECTION CRITERIA

INCLUSION CRITERIA

- Age between 18 – 30 years of age
- Both male and female participants
- Clinical diagnosis of PFPS from an orthopaedical
- NPRS during activity of daily living at a minimum 3-8 on 10 scale
- Atraumatic anterior knee pain that aggravated with at least two of the following activities: stair ascent, stair descent, squatting, prolonged sitting, kneeling or isometric quadriceps contraction.

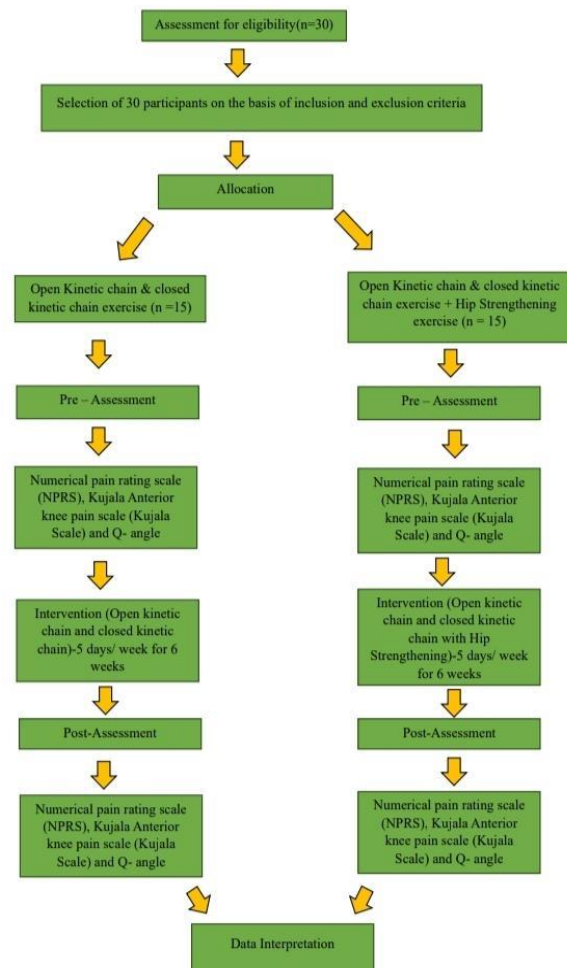
EXCLUSION CRITERIA

- Ligamentous instability or suspected meniscal injury
- Pregnancy

- Osteoarthritis
- Patellar subluxation, dislocation or tendinitis
- Knee surgery in last 3 years

OUTCOME MEASURES

- Pain – Numeric Pain Rating Scale (NPRS)
- Kujala Anterior Knee Pain Scale (KAKS)
- Q Angle Measurement



In this experimental study, 30 subjects with PFPS who fulfilled the inclusive and exclusive criteria were selected. then the participants were allocated to one of the two groups, according to the inclusion criteria and exclusion criteria, either group A (open and closed kinetic chain exercise) with 15 players (n=15) or group B (open and closed kinetic chain exercise with hip strengthening exercise) with 15 players (n=15). Both of the group perform the exercise five days in a week for a duration of 6 weeks. the pre and post-test was taken by using the outcome measures like pain - numerical pain rate scale, kujala anterior knee pain scale (KAKS) and Q Angle measurement.

GROUP A

In the experimental group, pre and post-test data of the players with patellofemoral pain was recorded before the first session. The players were asked to undergo the NPRS, KAKS, Q Angle measurement.

The players were asked to do the open and closed kinetic exercise such as maximal static quadriceps with knee full extension, straight leg raising, short arc movement, leg adduction exercise, seated leg press, partial squat exercise, step up and step-down exercise, terminal knee extension with elastic band.

OPEN KINETIC EXERCISE

1. STRAIGHT LEG RAISING

POSITION OF THE PATIENT: Supine lying.

PROCEDURE



Fig. 7: (Straight Leg Raise).

2. SHORT ARC MOVEMENT

POSITION OF THE PATIENT: Supine lying.

PROCEDURE: Ask the patient to flex the knee to 10 degree and place the towel roll under the knee and ask

PROCEDURE: Knee should be extended with a heel on the floor. one of the hip and knee should be flexed to stabilize the pelvis. leg is lifted to above 45 degree of hip flexion.

HOLD TIME: 5-10 seconds

DURATION: 2 sets of 10 repetition.

the patient to extend the knee fully (terminal knee extension).

DURATION: 2 sets of 10 repetition.



Fig. 8: Short Arc Movement.

3. LEG ADDUCTION EXERCISE

POSITION OF THE PATIENT: Side Lying

PROCEDURE: The patient must be in side lying and make the top of the leg in flexed position (hip and knee flexion) then do the adduction in the bottom of the leg.

DURATION: 2 sets of 10 repetition





FIG. 9: (Leg Adduction).

CLOSED KINETIC EXERCISE

1. PARTIAL SQUAT EXERCISE

POSITION OF THE PATIENT: Standing

PROCEDURE: Ask the patient to simultaneously flex the knee and hip to perform partial squat.

DURATION: 2 sets of 10 repetition.



FIG. 10: (Partial Squat).

2. STEP UP AND STEP-DOWN EXERCISE

POSITION: Standing.

PROCEDURE: Ask the patient to step up and step down on the stool.

DURATION: 2 sets of 10 repetition.



FIG. 11: (Step Up and Step Down).

3. TERMINAL KNEE EXTENSION WITH ELASTIC BAND

POSITION: Standing

PROCEDURE: Hook a resistance band to a pole that is about knee high. Face the pole that the band is hooked up

to and place the other side of the band around your hamstring right about your knee. Straight with your knee slightly bent. Straighten your leg drawing more tension on resistance band and causing your hamstring to work.

DURATION: 2 sets of 10 repetition



FIG. 12: (Terminal Knee Extension With Elastic Band).

GROUP B

In the experimental group, pre and post-test data of the players with patellofemoral pain was recorded before the first session. The players were asked to undergo the NPRS, KAKS, Q Angle measurement.

The players were asked to do the open and closed kinetic exercise (as performed by the group A) with hip strengthening exercises such as side lying clam exercise, unilateral pelvic bridging, leg extension while sitting, wall sits, squats.

1. SIDE LYING CLAM EXERCISE**POSITION:** Side lying**PROCEDURE:** Ask the players to side lying, keep the upper body straight. rest the head on your arm. place the top leg and foot on the top of the other, and bend the legs so the thigh and lower leg are 90 degrees. Now slowly

lift the top leg toward the ceiling and lower it again to keep feet together the whole time. only lift the knee as far as you can without moving the rest of your body.

DURATION: 2 sets of 10 repetition.**FIG. 12: (Side Lying Clam Exercise).****2. LEG EXTENSION WHILE SITTING****POSITION:** Sitting**PROCEDURE:** Ask the player to sit on a chair and wear a light weight cuff on lower leg (above the ankle). Now, slowly extended the knee and flex the knee.**DURATION 2:** Sets of 10 repetition.**FIG. 13: (Leg Extension While Sitting).**

3. WALL SITS

POSITION: Standing

PROCEDURE: Ask the player to stand with back against a wall. Place the feet about 60 cm away from the wall. Feet should be shoulder-width apart and flat on the floor, facing forward. fold arms and slowly slide the

upper body down the wall until the thigh level and lower legs are at a 90 degree. Thighs are horizontal, kneecaps are facing forward and back should be flat pressed against the wall. Hold the position for 20 to 30 seconds.

DURATION 2: Sets of 10 repetition.



FIG 14: (Wall Sits).

DATA ANALYSIS AND INTERPRETATION

The study conducted on 30 subjects with patellofemoral pain syndrome to compare the open and closed kinetic exercise and open and closed kinetic exercise with hip strengthening exercise. The data was carefully collected

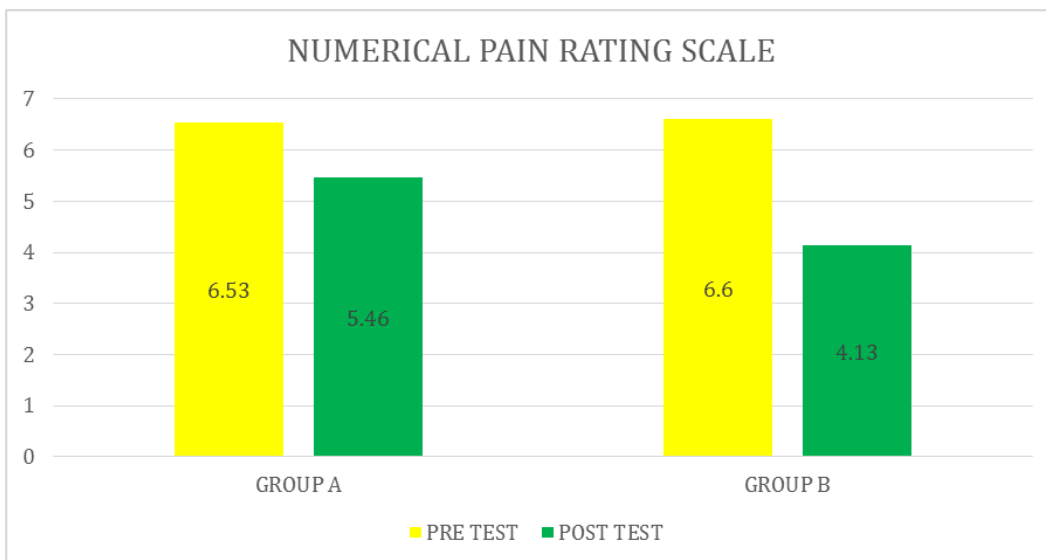
and calculated. All the parameters were assessed using the statistical package for social science (SPSS). The descriptive statistics (mean and standard deviation) and inferential statistics (paired sample t-test and independent samples t-test).

Table 1: Comparison of Numerical Pain Rating Scale Score Between Group -A and Group -B In Pre-Test and Post Test.

NPRS	GROUP A		GROUP B		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
PRE-TEST	6.53	0.743	6.60	0.828	0.244	0.809
POST TEST	5.46	0.990	4.13	0.915	3.821	0.001

The above table reveals the Mean, standard deviation (S.D), t-test and p value of the numerical pain rating scale score between (Group A) and (Group B) in pre-test and post-test. This table shows that there is no significant difference in pre-test values of the numerical pain rating scale scoring between Group A and Group B (*P >0.05).

This table shows that there is significant difference in pre-test and post-test values of numerical pain rating scale score between Group A and Group B (*P<0.001). Both the groups shows significant decrease in the post-test Means but (Group B) which has the lesser mean value is more effective than (Group-A).



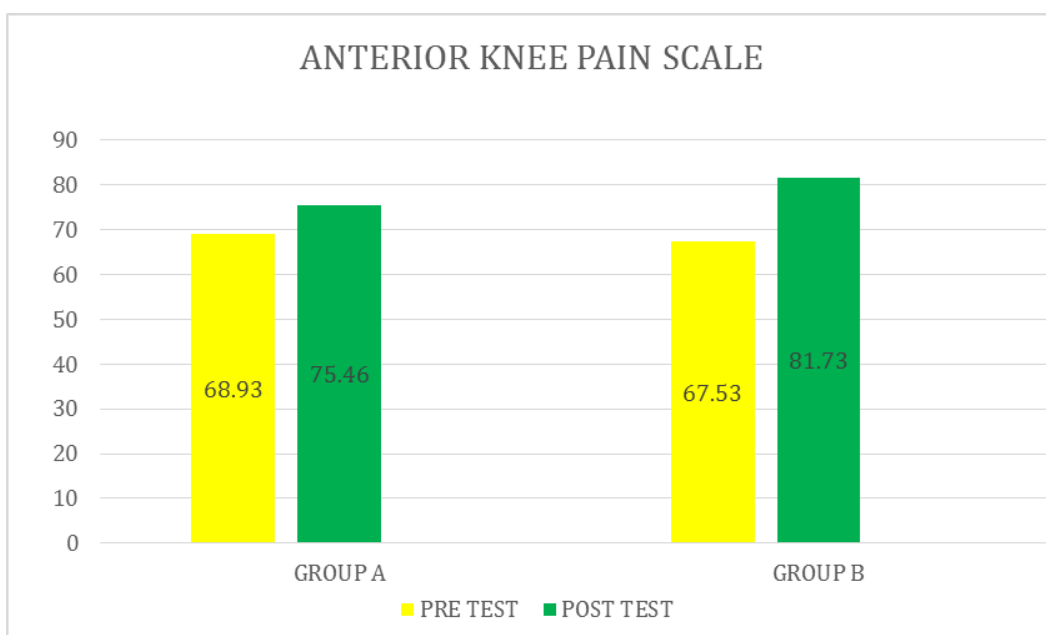
Graph 1: Comparison of Numerical Pain Rating Scale Score Between Group -A and Group -B In Pre-Test and Post Test.

Table 2: Comparison of Kujala Anterior Knee Pain Scale Score Between The Group-A and Group -B In Pre-Test And Post Test.

KAPS	GROUP A		GROUP B		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
PRE-TEST	68.93	2.890	67.53	3.661	1.163	0.255
POST TEST	75.46	2.972	81.73	3.011	5.740	0.000

The above table reveals the Mean, standard deviation(SD), t- test and p value of the kujala anterior knee pain scale score between the (Group A) and (Group B) in pre-test and post test. This table shows that there is no significant difference in pre-test values of the kujala anterior knee pain scoring between Group A and Group B (*P >0.05). This table shows that there is significant

difference in pre-test and post-test values of kujala anterior knee pain scale score between Group A and Group B (*P<0.001). Both the groups shows significant increase in the post-test Mean but (GROUP B) which has the higher mean value is more effective than (GROUP A).



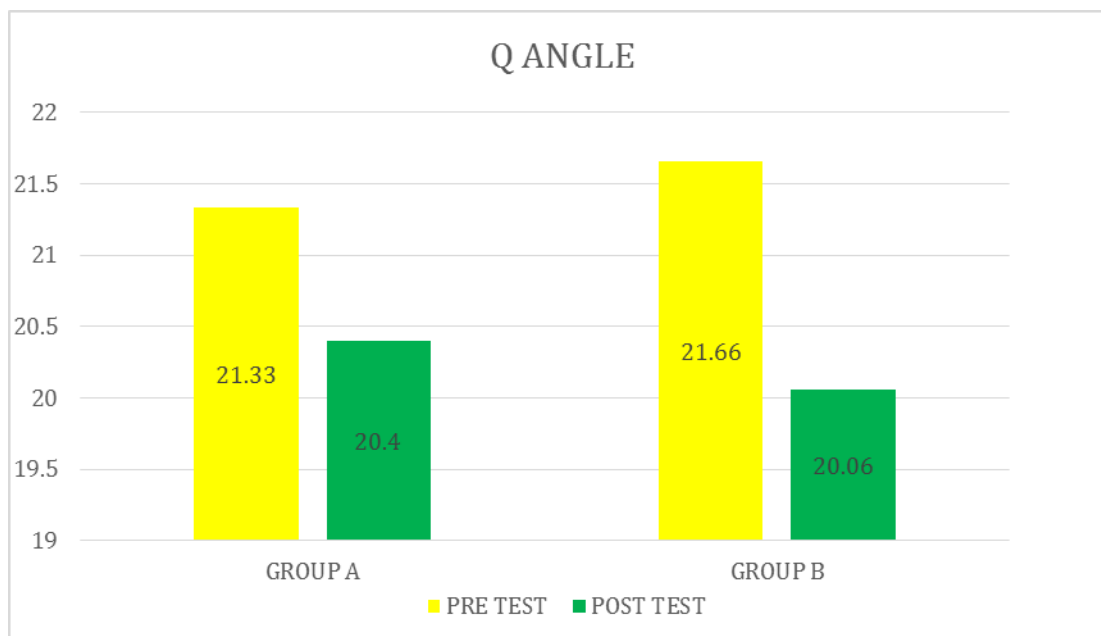
GRAPH-2: Comparison of Kujala Anterior Knee Pain Scale Score Between Group-A and Group -B In Pre-Test And Post Test.

Table 3: Comparison of Q Angle Score Between Group-A and Group -B In Pre-Test and Post Test.

Q-ANGLE	GROUP A		GROUP B		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
PRE-TEST	21.33	2.225	21.66	2.257	0.403	0.690
POST TEST	20.40	2.292	20.06	2.491	1.161	0.255

The above table reveals the Mean, standard deviation (S.D), t-test and p value of the Q ANGLE score between (Group A) and (Group B) in pre-test and post-test. This table shows that there is no significant difference in pre-test values of the Q ANGLE scoring between Group A and Group B (*P > 0.05). This table shows that there is

significant difference in pre-test and post-test values of Q ANGLE score between Group A and Group B (*P < 0.001). Both the groups shows significant decrease in the post test Means but (Group B) which has the lesser mean value is more effective than (Group-A).

**GRAPH 3: Comparison of Kujala Q Angle Score Between Group-A and Group -B In Pre-Test And Post Test.**

RESULTS

30 Subjects were included in this study. The statistics were done by using the statistical package for social science (SPSS) version 24.0 to see the effectiveness of both the intervention open and closed kinetic exercise and open and closed kinetic exercise with hip strengthening exercise among patellofemoral pain syndrome. There is an evidence of significant difference within the group A (open and close kinetic exercise) was noted on NPRS score p-value is 0.000, KAKS score p-value is 0.000 Q angle score value is 0.269 and the Group B (open and closed kinematic exercise with hip strengthening exercise) was noted on NPRS score p-value is 0.000, KAKS score p-value is 0.000 Q angle score value is 0.76. There was significant difference when compared between pre-test and post-test difference in Group A and Group B on NPRS score was 1.07 and 2.47 respectively, at the duration of 6 weeks. The result suggests that there is difference in NPRS scoring when compared between the groups, and it's also found statistically significant p-value 0.001. when compared pre-test and post-test difference in Group A and Group B for KAKS score was 6.59 and 14.2 respectively, at the duration of 6 weeks. The result suggests that there is

difference in KAKS scoring when compared between the groups, and it's also found statistically significant p-value 0.000. when compared pre-test and post-test difference in Group A and Group B for Q angle score was 0.93 and 1.6 respectively, at the duration of 6 weeks. The result suggests that there is difference in Q angle scoring when compared between the groups, and it's also found statistically significant p-value 0.000. Hence, this study proves that there is statistical difference when compared between the groups and open and closed kinetic exercise with hip strengthening is superior to the other.

DISCUSSION

In this present study, the main objective of the clinical trial was to find out the effectiveness of open and closed kinetic exercise versus open and closed kinetic exercise with hip strengthening on pain and improvement of the function in patellofemoral pain. The study result was interpreted on the basis on outcome measure were used in this study. According to the result, the average changes obtained on self-reported outcome obtained by the subjects in the both groups (NPRS, KUJALA, Q-ANGLE scale) group A (open and closed kinetic chain

exercise) and group B (open and closed chain kinetic exercise with hip strengthening). There is a significant difference on decrease the pain and improvement the function in patellofemoral pain syndrome receiving the intervention. The results of the present study indicates a significant decrease in pain and improvement of function in both groups. However, the open and closed kinetic exercise with hip strengthening exercise were more effective in decreasing the pain and improvement in the functions in subjects with PFPS more than open and closed kinetic exercise alone

Changes in pain intensity between Group A (open and closed kinetic exercise) versus Group B (open and closed kinetic exercise with hip strengthening)

The result of this present study showed that comparatively significant improvement in pain intensity between the group A versus group B. the pre and post mean difference was found to be 1.07 and 2.47 from the baseline to 6 th week for group A and group B respectively. These results suggest that there is difference in pain intensity when compared between the groups, and it is also found to be statistically significant $p=0.001$.

Boling et al., who concluded that active hip adduction during dynamic mini squat increases the quadriceps activity but without significant changes in vastus medialis obliques. **Natri et al.**, identified a strong correlation between quadriceps muscle strength and the long-term outcome in patient with patellofemoral pain. The effect of closed kinetic chain exercise was combined with the effect of hip abduction and lateral rotators strengthening exercise in decreasing the pain and improving function.

Improvement in function between Group A (open and closed chain kinetic exercise) versus Group B (open and closed chain kinetic exercise with hip strengthening exercise)

The result of this present study showed that comparatively significant improvement in quality of life between the group A versus group B. the pre and post mean difference was found to be 6.53 and 14.2 from the baseline to 6 th week for group A and group B respectively. These results suggest that there is difference in quality of life when compared between the groups, and it is also found to be statistically significant $p=0.001$.

According to **Grossi et al.**, the closed kinetic chain exercises in the first 60° of knee flexion is better tolerated by individuals with DFP. Increasing knee flexion using the technique of the squat that provides higher electrical activation of the VMO and VL. This occurs because of the rectus femoris to be more active in this chain and, consequently, the VMO increases its electrical activity to keep the patella in its proper alignment.

The conclusion of this study was started that both the open and close chain kinetic exercise and open and

closed kinetic exercise with hip strengthening was found to be improve the function equivalently but the open and closed kinetic chain exercise with hip strengthening superior to other. Hence, according to the statistical analysis this study rejected null hypothesis and accepted the alternative hypothesis.

Changes in Q angle between Group A (open and closed chain kinetic exercise) versus Group B (open and closed chain kinetic exercise with hip strengthening exercise)

The result of this present study showed that comparatively significant improvement in Q angle between the group A versus group B. the pre and post mean difference was found to be 0.93 and 1.6 from the baseline to 6 th week for group A and group B respectively. These results suggest that there is difference in quality of life when compared between the groups, and it is also found to be statistically significant $p=0.255$.

De Oliveira Silva et al. (2015), the authors evaluated individuals with PFPS in dynamic and static conditions and found out that in the dynamic condition the majority of individuals presented excessive subtalar pronation, however, the same individuals showed no change in the clinical trial for the posture of the subtalar pronation.

CONCLUSION

This study concludes that, GROUP B (OPEN AND CLOSED KINETIC EXERCISE WITH HIP STRENGTHENING EXERCISE) is effective in reducing the knee pain, improve Range of Motion and maintain Q angle. Thus, this study hereby accepts the alternative hypothesis is that there is significant difference between the open and closed kinetic chain exercise versus open and closed kinetic exercise with hip strengthening among the patellofemoral pain syndrome.

LIMITATION OF THE STUDY

- Duration of study is only 6 weeks.
- The study has a small sample size.
- This study has not measured body mass index of participants.
- Selected age group of 18 to 30 years (both male and female)

RECOMMENDATION

- Quadriceps strengthening can be measuring using EMG studies.
- Multiple group can be included for the study.
- Duration of the study can be longer to see the long-term effectiveness.

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