

Muscle Strength and Joint Protection: Evaluating Effect of Isometric Quadriceps Exercise in Osteoarthritis of the Knee

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Abstract

Background: Osteoarthritis (OA) of the knee is a leading cause of pain, disability, and reduced quality of life among the elderly population. Quadriceps weakness is an important contributing factor to joint instability and symptom progression in knee OA. Strengthening exercises, particularly isometric exercises, may improve joint stability and functional outcomes. This study aimed to evaluate the effect of isometric quadriceps strengthening on pain, joint stability, and quality of life in patients with early-stage knee OA. **Methods:** This prospective study was conducted at IMS and SUM Hospital, Phulnakhara from January 2023 to January 2025 among 185 patients aged below 65 years with Grade I and II knee OA. Participants were randomly allocated into a case group (isometric exercises with pharmacotherapy and lifestyle advice) and a control group (pharmacotherapy and lifestyle advice alone). The intervention was administered for 8 weeks. Outcomes were assessed at baseline and at weeks 2, 4, 6, and 8 using the Knee Injury and Osteoarthritis Outcome Score (KOOS). **Results:** The case group demonstrated statistically significant improvement in pain, symptoms, activities of daily living, and quality of life compared to the control group from week 2 onward ($p < 0.001$). At 8 weeks, substantial improvement was observed in KOOS pain, symptom, ADL, and QOL scores in the intervention group, whereas the control group showed comparatively lesser improvement. The findings indicate that isometric quadriceps strengthening significantly enhances clinical and functional outcomes in knee OA patients. **Conclusion:** Isometric quadriceps strengthening is an effective adjunct to pharmacotherapy in reducing pain and improving functional capacity and quality of life in patients with early-stage knee osteoarthritis. Incorporating structured exercise programs into routine management may provide substantial clinical benefits.

Keywords: Knee osteoarthritis, Isometric exercises, Quadriceps strengthening, KOOS, Pain reduction, Quality of life, Conservative management



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INTRODUCTION

Osteoarthritis (OA) is the most common degenerative musculoskeletal disorder affecting the elderly population worldwide, characterized by progressive cartilage degeneration, joint space narrowing, osteophyte formation, and varying degrees of synovial inflammation. In India, a recent study reported a prevalence of 32.6% in rural populations and 60.3% in metropolitan populations, reflecting a substantial public health burden [1]. OA was documented as the 10th leading cause of non-fatal disease burden in 2009, significantly contributing to pain, disability, and reduced functional independence. Among the different types, primary OA—where no specific underlying cause is identified—is more frequently encountered in outpatient departments compared to secondary OA.

In recent decades, the rapid shift toward sedentary lifestyles has been recognized as a major modifiable risk factor for the rising incidence of knee OA. Physical inactivity leads to reduced lower extremity muscle strength, impaired joint biomechanics, and decreased shock-absorbing capacity during routine activities such as walking, climbing stairs, and rising from a chair. A study conducted in India in 2016 reported that OA affected approximately 36.8% of individuals with sedentary habits, compared to 26% among physically active individuals [2]. This highlights the protective role of regular physical activity in maintaining joint health and delaying degenerative changes.

Muscle strength and balance around the knee joint are crucial determinants of joint stability and load distribution. The quadriceps muscle, in particular, plays

a vital role in controlling knee extension and absorbing forces transmitted across the joint. It has been documented that a normal hamstring-to-quadriceps strength ratio greater than 0.6 is protective against the development and progression of OA, as it ensures optimal load sharing and reduces excessive stress on articular cartilage [3,4]. Weakness of the quadriceps not only increases joint instability but also contributes to pain, functional limitation, and progression of structural damage.

The Osteoarthritis Research Society International recommends non-pharmacological interventions, including structured exercise programs, as a core component of knee OA management [5]. Exercise therapy has been shown to reduce pain, improve muscle strength, enhance proprioception, and improve overall quality of life. Among various modalities, isometric exercises are particularly beneficial in early and moderate stages of OA because they generate muscle contraction without joint movement, thereby minimizing inflammation, intra-articular pressure, and further cartilage wear. Additionally, they are simple, cost-effective, and can be performed independently at home without continuous supervision. Therefore, this study aims to evaluate the effectiveness of quadriceps strengthening through isometric exercises in improving pain, joint stability, and quality of life in patients with knee OA.

MATERIALS AND METHODS

Study Design and Setting

This prospective study was conducted at IMS and SUM Hospital, Phulnakhara over two-year period from January 2023 to January 2025. The study population comprised 185 patients attending the orthopedic outpatient department with complaints of non-traumatic knee pain. Ethical approval was obtained from the Institutional Ethics Committee prior to commencement of the study, and written informed consent was obtained from all participants. The total duration of follow-up for each participant was two months.

Participants and Eligibility Criteria

All patients were evaluated by the principal investigator through detailed clinical examination and radiological assessment to confirm the diagnosis of osteoarthritis.

Inclusion criteria:

- Patients diagnosed with Grade I or Grade II osteoarthritis according to the American College of Rheumatology criteria
- Patients with Grade III or less osteoarthritis on the Kellgren–Lawrence scale

RESULTS

The comparison of KOOS pain scores between the case and control groups showed a statistically significant improvement in the intervention group over time. Although baseline scores were comparable ($p = 0.005$), the case group demonstrated a marked increase in pain scores from 13.80 ± 0.901 at baseline to 85.43 ± 1.237 at 8 weeks, indicating substantial pain reduction. In contrast, the control group showed only modest improvement, reaching 56.00 ± 0.00 at 8 weeks. From week

- Patients aged below 65 years
- Patients presenting with non-traumatic knee pain

Exclusion criteria:

- Patients with inflammatory arthritis
- Patients with post-traumatic arthritis
- Patients with knee deformity
- Patients with meniscal tear

A total of 185 patients who satisfied the eligibility criteria were enrolled and randomly allocated into two groups using the card method: Group A (case group) and Group B (control group).

Intervention Protocol

Patients in Group A received isometric exercise therapy in addition to pharmacotherapy and lifestyle advice. The exercise program included isometric quadriceps exercises, straight leg raising, and isometric hip adduction exercises. Each exercise was performed as 10 repetitions per set. During the first week, one set of all exercises was performed twice daily, and the regimen was progressively increased to three sets twice daily by the end of the fifth week. Isometric quadriceps exercises were performed in a recumbent position with a towel placed beneath the knee, holding the contraction for 5 seconds. Straight leg raising was performed in the supine position, lifting the leg approximately 10 cm above the plinth and maintaining contraction for 10 seconds. Isometric hip adduction was carried out in the supine position by pressing a pillow between the knees and sustaining the contraction for 5 seconds.

Control Group and Outcome Measures

Patients in Group B (control group) received only pharmacotherapy and lifestyle advice without any structured exercise intervention. Assessments were conducted at baseline and at weeks 2, 4, 6, and 8 to evaluate pain intensity, joint stability, and quality of life using the KOOS (Knee Injury and Osteoarthritis Outcome Score). The KOOS evaluates five domains—pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life—with scores ranging from 0 (worst symptoms) to 100 (no symptoms) [6].

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 23.0 and Microsoft Excel. Numerical variables between the case and control groups were compared using the unpaired t-test. A p -value of <0.05 was considered statistically significant.

2 onward, the differences between groups were highly significant ($p < 0.001$), confirming the effectiveness of isometric exercises in reducing pain (Table 1).

Table 1: Comparison of KOOS Pain Scores Between Case and Control Groups (n = 185)

Sl. No.	Time Interval	Case (Mean $\pm$ SD)	Control (Mean $\pm$ SD)	p-value
1	0 weeks	13.80 $\pm$ 0.901	14.00 $\pm$ 0.00	0.005
2	2 weeks	46.91 $\pm$ 0.289	19.00 $\pm$ 0.00	0.001**
3	4 weeks	66.19 $\pm$ 2.005	33.00 $\pm$ 0.00	0.001**
4	6 weeks	80.40 $\pm$ 1.290	50.00 $\pm$ 0.00	0.001**
5	8 weeks	85.43 $\pm$ 1.237	56.00 $\pm$ 0.00	0.001**

** $p < 0.001$ considered statistically significant

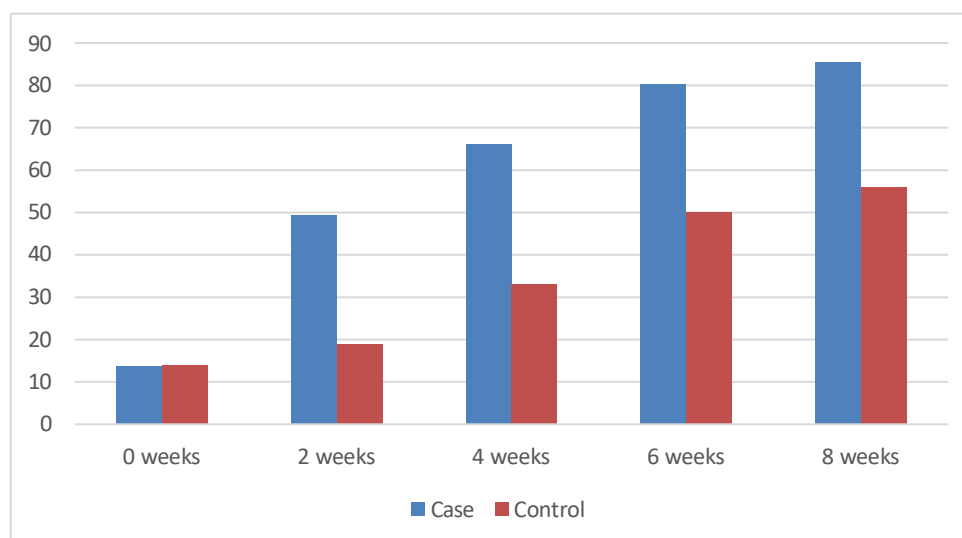


Figure 1: Comparison of KOOS Pain Scores across the study population.

Analysis of KOOS symptom scores revealed significant improvement in the case group compared to the control group. Baseline scores were similar between groups; however, the case group showed progressive improvement from 10.64 $\pm$ 0.767 at 0 weeks to 67.62 $\pm$ 0.880 at 8 weeks. The control group demonstrated comparatively limited improvement, with a final score of 43.00 $\pm$ 0.00 at 8 weeks. The intergroup differences were statistically highly significant ($p < 0.001$) at all follow-up intervals, indicating better symptom relief with the exercise intervention (Table 2).

Table 2: Comparison of KOOS Symptom Scores Between Case and Control Groups (n = 185)

Sl. No.	Time Interval	Case (Mean $\pm$ SD)	Control (Mean $\pm$ SD)	p-value
1	0 weeks	10.64 $\pm$ 0.767	11.00 $\pm$ 0.00	0.001**
2	2 weeks	45.65 $\pm$ 0.765	11.00 $\pm$ 0.00	0.001**
3	4 weeks	53.54 $\pm$ 1.145	21.00 $\pm$ 0.00	0.001**
4	6 weeks	63.73 $\pm$ 0.857	21.00 $\pm$ 0.00	0.001**
5	8 weeks	67.62 $\pm$ 0.880	43.00 $\pm$ 0.00	0.001**

** $p < 0.001$ considered statistically significant

The KOOS ADL scores showed a significant functional improvement in the case group throughout the study period. The case group improved from 21.65 $\pm$ 0.862 at baseline to 80.63 $\pm$ 0.879 at 8 weeks, reflecting enhanced ability to perform daily activities. Although the control group exhibited some improvement, the final score was lower (49.00 $\pm$ 0.00) compared to the intervention group. The differences between groups were statistically significant at all measured intervals ($p < 0.001$), highlighting the positive impact of quadriceps strengthening on functional capacity (Table 3).

Table 3: Comparison of KOOS Activities of Daily Living (ADL) Scores Between Case and Control Groups (n = 185)

Sl. No.	Time Interval	Case (Mean $\pm$ SD)	Control (Mean $\pm$ SD)	p-value
1	0 weeks	21.65 $\pm$ 0.862	21.00 $\pm$ 0.00	0.001**
2	2 weeks	48.73 $\pm$ 0.608	22.00 $\pm$ 0.00	0.001**
3	4 weeks	48.72 $\pm$ 0.614	40.00 $\pm$ 0.00	0.001**
4	6 weeks	56.82 $\pm$ 0.572	40.00 $\pm$ 0.00	0.001**
5	8 weeks	80.63 $\pm$ 0.879	49.00 $\pm$ 0.00	0.001**

** $p < 0.001$ considered statistically significant

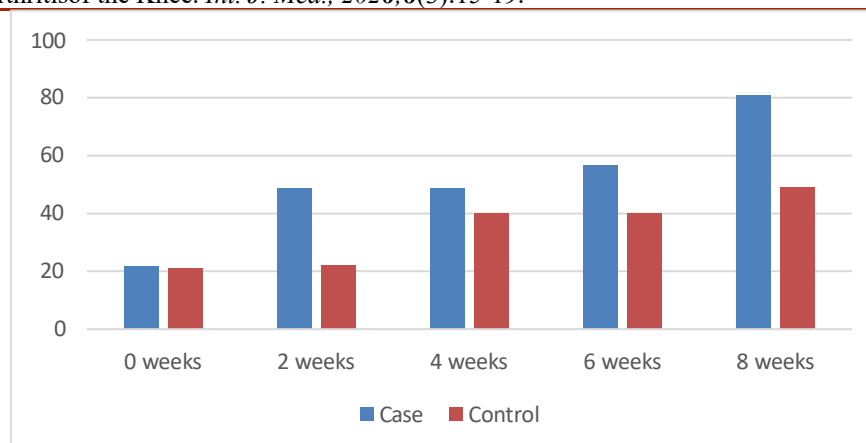


Figure 2: Comparison of KOOS Activities of Daily Living (ADL) Scores across the two groups

The KOOS QOL scores demonstrated notable improvement in the case group compared to the control group. Both groups had a baseline score of 0.00; however, the case group showed steady improvement, reaching 68.47 ± 0.00 at 8 weeks. The control group also improved but to a lesser extent, with a final score of 50.00 ± 0.00 . The differences between the groups from week 2 onward were statistically highly significant ($p < 0.001$), indicating that isometric exercise therapy significantly enhanced knee-related quality of life (Table 4).

Table 4: Comparison of KOOS Quality of Life (QOL) Scores Between Case and Control Groups (n = 185)

Sl. No.	Time Interval	Case (Mean ± SD)	Control (Mean ± SD)	p-value
1	0 weeks	0.00 ± 0.00	0.00 ± 0.00	—
2	2 weeks	50.00 ± 0.00	0.00 ± 0.00	0.001**
3	4 weeks	50.00 ± 0.00	25.00 ± 0.00	0.001**
4	6 weeks	56.00 ± 0.00	25.00 ± 0.00	0.001**
5	8 weeks	68.47 ± 0.00	50.00 ± 0.00	0.001**

** $p < 0.001$ considered statistically significant

DISCUSSION

The findings of the present study involving 185 patients demonstrate that an 8-week isometric quadriceps strengthening program resulted in a statistically significant reduction in knee pain ($p < 0.001$) and marked improvement in functional outcomes and quality of life in the intervention group compared to the control group. The progressive increase in KOOS pain, symptom, ADL, and QOL scores suggests that structured exercise therapy produces clinically meaningful benefits within a relatively short duration. These improvements may be attributed to enhanced quadriceps muscle strength, improved neuromuscular control, and better dynamic stabilization of the knee joint, thereby reducing abnormal joint loading and mechanical stress.

The reduction in pain observed in the present study is likely related to improved shock absorption and joint alignment secondary to strengthened quadriceps musculature. Quadriceps weakness has been consistently associated with knee instability and increased joint compressive forces, contributing to symptom progression in osteoarthritis. Although Messier et al. reported no significant correlation between quadriceps strengthening and improvement in pain or joint stability [7], the current findings demonstrate a clear association between targeted strengthening and symptomatic relief. The discrepancy may be due to differences in study design, intervention intensity, or duration of follow-up.

The results of this study are consistent with prior evidence supporting exercise as a cornerstone in the management of knee osteoarthritis. The Fitness Arthritis and Seniors Trial (FAST) reported an 8–10% improvement in pain and functional scores following 18 months of aerobic or resistance exercise among patients with knee OA [8]. Similarly, Deyle et al. [9], Falconer et al. [10], and Fisher et al. [11] documented significant reductions in pain and improvements in physical function following structured exercise interventions. These findings collectively reinforce current clinical recommendations advocating non-pharmacological strategies, particularly exercise therapy, as first-line management for knee OA [12-14].

In the present study, the substantial improvement observed over 8 weeks may be attributed not only to increased quadriceps strength but also to enhanced proprioception, improved joint stability, and reduced fear-avoidance behaviors. Improved muscular support around the knee likely contributed to better load distribution across the joint surfaces, thereby decreasing nociceptive input and improving overall functional capacity. Consequently, isometric quadriceps strengthening appears to be a simple, cost-effective, and clinically beneficial intervention for reducing pain,

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enhancing stability, and improving quality of life in patients with early-stage knee osteoarthritis.

CONCLUSION

The present study concludes that an 8-week structured isometric quadriceps strengthening program, combined with pharmacotherapy and lifestyle modification, significantly reduces pain and improves symptoms, functional ability, and quality of life in patients with early-stage knee osteoarthritis. Compared to pharmacotherapy alone, the addition of targeted exercise demonstrated superior outcomes across all KOOS domains. Isometric quadriceps exercises are simple, safe, cost-effective, and feasible for home-based practice, making them an effective non-pharmacological intervention in the conservative management of knee osteoarthritis.

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