

Efficacy of Kneel Marching and Kneel Walking Exercises on Pain and Joint Proprioception in Knee Osteoarthritis: A Randomized Controlled Trial

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Abstract

Background: Knee osteoarthritis (OA) is a prevalent degenerative joint disorder characterized by pain, functional limitations, and impaired proprioception. Conventional physiotherapy focuses mainly on strengthening and mobility, while proprioceptive deficits often remain under-addressed.

Methodology: This randomized controlled trial included 48 patients with knee OA who were randomly allocated into Group A (conventional physiotherapy) and Group B (conventional physiotherapy plus kneeling-based proprioceptive exercises on a soft mat). Interventions were provided for four weeks. Pain was assessed using the Numeric Pain Rating Scale (NPRS) and proprioception using Joint Position Sense Error (JPSE).

Results: Both groups showed statistically significant improvements in pain and proprioception ($p < 0.05$). However, Group B demonstrated significantly greater reductions in NPRS and JPSE scores compared to Group A ($p < 0.001$).

Conclusion: Incorporation of kneel marching and kneel walking exercises on a soft mat along with conventional physiotherapy is more effective in reducing pain and improving proprioception in patients with knee OA than conventional exercises alone.

Keywords: Knee osteoarthritis, Proprioception, Kneeling exercises, Pain, Physiotherapy

Introduction

Knee osteoarthritis (OA) is a chronic, progressive degenerative joint disorder involving articular cartilage degeneration, subchondral bone remodeling, osteophyte formation, and synovial inflammation. It is one of the leading causes of pain and disability among older adults worldwide [1,2]. Common risk factors include advancing age, obesity, previous joint injury, malalignment, muscle weakness, and occupational loading [3]. Clinically, patients present with pain, stiffness, reduced range of motion, crepitus, impaired balance, and functional limitations affecting quality of life.

Pain is the predominant symptom of knee OA and is multifactorial in origin, arising from periarticular structures such as synovium, ligaments, capsule, and subchondral bone, along with central sensitization mechanisms [4]. Exercise-based physiotherapy is strongly recommended as a first-line conservative intervention due to its proven effectiveness and safety [5].

Proprioception, defined as the sense of joint position and movement, is commonly impaired in individuals

with knee OA due to degeneration of joint mechanoreceptors, inflammation, and neuromuscular inhibition [6]. Proprioceptive deficits contribute to joint instability, abnormal loading, and functional decline. Recent evidence highlights the importance of neuromuscular and proprioceptive training in improving pain, stability, and functional outcomes in knee OA [7]. Kneeling-based activities on a soft surface may enhance proprioceptive input through closed kinetic chain loading and increased sensory feedback, yet evidence in this area remains limited. Therefore, this study aimed to evaluate the effectiveness of kneel marching and kneel walking exercises on pain and joint proprioception in individuals with knee OA.

Methodology

Study Design and Participants

This randomized controlled trial was conducted on **48 patients diagnosed with knee osteoarthritis** who fulfilled the inclusion and exclusion criteria. Participants were recruited from the outpatient physiotherapy department and provided written informed consent prior to participation

Outcome Measures

Assessments were performed at **baseline (pre-intervention)** and at the **end of 4 weeks (post-intervention)** by a blinded assessor.

1. Pain Intensity

Pain was assessed using the **Numeric Pain Rating Scale (NPRS)**, a 11-point scale ranging from 0 (no pain) to 10 (worst imaginable pain). The NPRS is a valid and reliable tool for assessing pain intensity in individuals with musculoskeletal conditions, including knee osteoarthritis (ICC = 0.95–0.96).

2. Proprioception

Knee joint proprioception was evaluated using **Joint Position Sense Error (JPSE)**. Participants were asked to actively reproduce predetermined knee joint angles, and the absolute error between the target angle and reproduced angle was recorded. JPSE has demonstrated good reliability and validity in individuals with knee osteoarthritis (ICC = 0.72–0.90), making it an appropriate measure of proprioceptive accuracy.

Selection Criteria[2,3]

Inclusion Criteria

1. Adults aged **40–70 years** of either sex.
2. Clinically and radiographically diagnosed **primary knee osteoarthritis** according to the **American College of Rheumatology (ACR) criteria**.
3. **Kellgren–Lawrence grade I–III** knee osteoarthritis.
4. Presence of **knee pain for at least 3 months** with an **NPRS score ≥ 3** at baseline.
5. Ability to **kneel and perform kneel-based activities** with or without mild discomfort.
6. Willingness to participate and comply with the study protocol for **4 weeks**, with regular attendance.
7. Provided **written informed consent** prior to participation.

Exclusion Criteria

1. **Secondary knee osteoarthritis** due to inflammatory arthritis (e.g., rheumatoid arthritis, gout, ankylosing spondylitis).
2. **Advanced knee osteoarthritis** (Kellgren–Lawrence grade IV).

3. History of **knee surgery**, intra-articular fracture, or total/partial knee arthroplasty in the affected knee.
4. **Intra-articular injection** (corticosteroid or viscosupplementation) within the past **3 months**.
5. Presence of **acute knee inflammation**, significant joint effusion, or active infection.
6. Neurological disorders affecting lower limb sensation, balance, or motor control (e.g., stroke, peripheral neuropathy).
7. Severe **cardiopulmonary, vestibular, or systemic conditions** limiting safe participation in exercise.
8. Skin conditions, wounds, or hypersensitivity around the knee preventing kneeling on a soft surface.
9. Participation in any **structured lower-limb strengthening or proprioceptive training program** within the last **6 weeks**.
10. Cognitive impairment or inability to understand instructions or outcome assessment procedures.

Participants were randomly allocated into **two groups (n = 24 each)** using a simple randomization method.

- **Group A (Control Group):** Conventional physiotherapy exercises
- **Group B (Experimental Group):** Conventional physiotherapy exercises combined with proprioceptive exercises performed on a soft mat (kneeling-based activities)

The intervention period was **4 weeks**, with sessions conducted **twice per week**, totaling **8 supervised treatment sessions**.

Intervention Protocol

Group A: Conventional Physiotherapy Exercise Program

Participants in Group A received a standardized conventional exercise program aimed at reducing pain and improving knee function. The program included:

- **Quadriceps strengthening:** Static quadriceps exercises (10 repetitions × 3 sets, 5-second hold)
- **Hamstring strengthening:** Isometric hamstring contractions (10 repetitions × 3 sets)
- **Straight leg raises:** 10 repetitions × 3 sets
- **Active range of motion exercises:** Knee flexion and extension (10–15 repetitions × 2 sets)
- **Stretching exercises:** Hamstring and calf stretches (10-second hold × 3 repetitions)

Each session lasted approximately **25–30 minutes**. Adequate rest intervals were provided between exercises.

Group B: Conventional Physiotherapy + Proprioceptive Training

In addition to the conventional exercise program described above, participants in Group B performed **proprioceptive exercises on a soft mat**, focusing on controlled weight-bearing and sensorimotor stimulation of the knee joint.[4,5]

Proprioceptive Exercise Protocol:

1. **Static Kneeling**
 - Position: Kneeling on a soft mat with hips extended and trunk upright
 - Duration: Hold for 20–30 seconds

- Repetitions: 5 holds
- Purpose: Stimulate joint mechanoreceptors and improve Knee joint position Sense

2. Kneel Marching

- Position: Kneeling on soft mat
- Procedure: Alternately lifting one knee slightly off the mat, weight was bearded on another knee while balance was maintained
- Repetitions: 10 repetitions per side × 2 sets
- Purpose: Enhance dynamic joint position sense and neuromuscular control

3. Kneel Walking

- Procedure: Forward and backward walking on knees over the soft mat
- Distance: Approximately 3–5 meters per trial
- Repetitions: 5–6 trials per session
- Purpose: Improve functional proprioception, balance, and knee joint stability

The total duration of the proprioceptive component was **15–20 minutes**, making the overall session duration **40–45 minutes**. Exercises were progressed gradually based on patient tolerance while maintaining safety and proper technique.

Result

Data analysis was done by using JAMOVI version 2.6.44 solid. Normality of Pre data was tested first (Table-1). As the data was normally distributed further Within-group analysis was done using paired t-test (Table-2) demonstrated statistically significant improvement in pain and proprioception in both groups ($p < 0.05$). However, Group B showed a greater magnitude of improvement with highly significant reductions in NPRS and JPSE scores ($p < 0.001$). Normality of Post data was checked (Table -3) as data was normally distributed further Between-group analysis using Unpaired t-test (Table-4) revealed that post-intervention pain intensity and joint position sense error were significantly lower in Group B compared to Group A ($p < 0.001$), indicating the superior effectiveness of proprioceptive training on a soft mat.

Table-1 Normality of Pre data

Group	Variable	Shapiro-Wilk p	Distribution
A	NPRS Pre	0.661	Normal
A	JPSE Pre	0.1069	Normal
B	NPRS Pre	0.9863	Normal
B	JPSE Pre	0.3698	Normal

Table-2 Within Group Comparison by Paired t test.

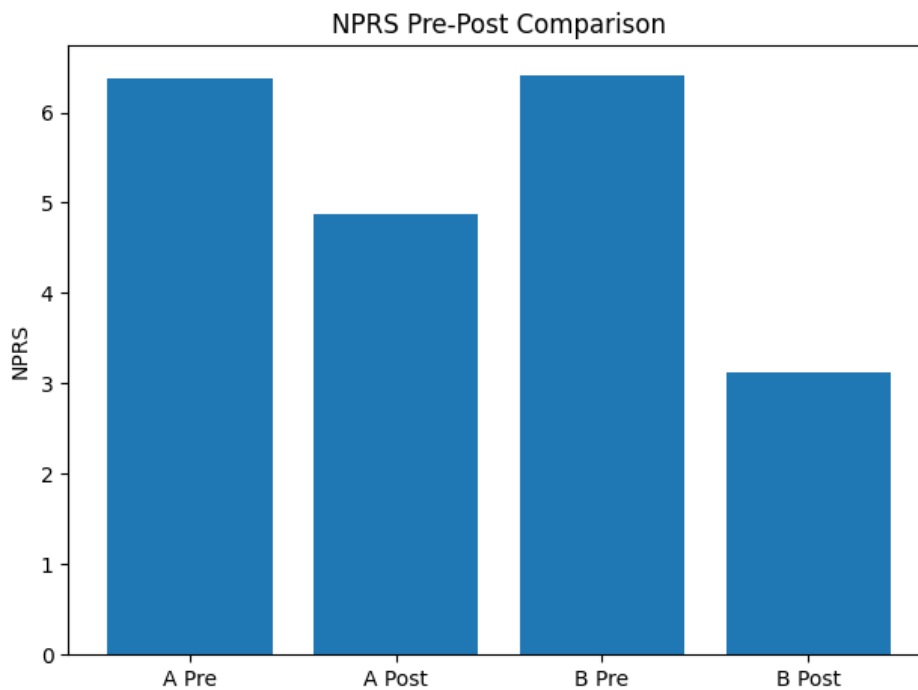
Group	Outcome	Pre Mean	Post Mean	p-value
A	NPRS	6.381889375	4.867779095	0
A	JPSE	5.545452513	4.348204572	0
B	NPRS	6.415930489	3.120451628	0
B	JPSE	5.528267732	2.917620066	0

Table-3 Normality of Pre data

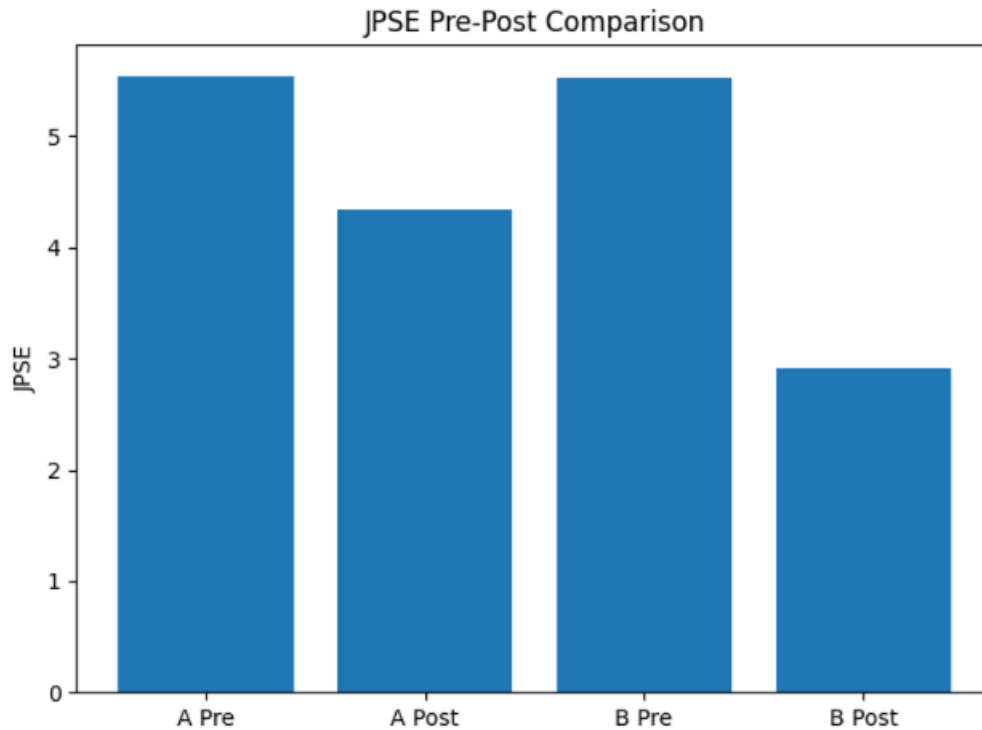
Group	Variable	Shapiro-Wilk p	Distribution
A	NPRS Post	0.7206	Normal
A	JPSE Post	0.1008	Normal
B	NPRS Post	0.4345	Normal
B	JPSE Post	0.1961	Normal

Table-4 Between Group Comparison by Unpaired t test

Outcome	Group A Post Mean	Group B Post Mean	p-value
NPRS	4.867779095	3.120451628	0
JPSE	4.348204572	2.917620066	0



Graph-1 between group NPRS Pre-Post Comparison



Graph-2 between group JPSE Pre-Post Comparison

Discussion

The present randomized controlled trial investigated the effectiveness of **kneel marching and kneel walking performed on a soft mat**, in addition to conventional exercises, on **pain and proprioception** in patients with knee osteoarthritis. The findings demonstrated that although both groups showed statistically significant improvements in pain intensity and joint position sense error (JPSE) following four weeks of intervention, **Group B exhibited significantly greater improvements** compared to Group A. These results support the hypothesis that **proprioceptive-focused weight-bearing activities on an unstable surface** provide superior outcomes compared to conventional exercise alone.

Effect on Pain

Pain reduction was observed in both groups, which can be attributed to the effects of conventional exercises such as strengthening, range-of-motion activities, and stretching. These exercises are known to improve joint nutrition, reduce stiffness, enhance muscular support around the knee, and modulate pain through neuromuscular and central mechanisms. Similar findings have been reported by **Bennell et al.** and **Fransen et al.**, who demonstrated that structured exercise programs significantly reduce pain in individuals with knee OA.

However, the **greater pain reduction in Group B** suggests an additional analgesic effect of proprioceptive training involving kneeling, kneel marching, and kneel walking on a soft mat. These activities impose **controlled compressive and shear forces** across the knee joint while engaging multiple mechanoreceptors, including muscle spindles, Golgi tendon organs, and joint receptors. The enhanced afferent input may activate spinal and supraspinal inhibitory pathways, contributing to pain modulation through the **gate control mechanism**. Moreover, repetitive exposure to controlled loading may reduce pain-related fear and improve movement confidence, thereby decreasing central sensitization commonly observed in chronic OA pain.

These findings are consistent with studies by **Hurley et al.** and **Sharma**, who reported that neuromuscular and sensorimotor training improves pain outcomes by optimizing joint loading patterns and improving dynamic knee stability.

Effect on Proprioception

Proprioceptive deficits are a well-documented feature of knee OA and are believed to result from **degenerative changes in articular cartilage, ligamentous laxity, muscle weakness, synovial inflammation, and reduced mechanoreceptor sensitivity**. In the present study, both groups demonstrated improvements in JPSE, indicating that exercise-based interventions positively influence proprioceptive acuity.

Notably, **Group B showed significantly greater improvement in joint position sense** compared to Group A. This finding highlights the superiority of incorporating **kneeling-based proprioceptive exercises on a soft mat**, which create an unstable and sensory-rich environment. Soft mat surfaces increase postural demand and require continuous joint repositioning, thereby enhancing **afferent feedback from periarticular structures**. Kneel marching and kneel walking further challenge dynamic joint control by requiring coordinated activation of quadriceps, hamstrings, and hip stabilizers while maintaining knee alignment.

Previous studies by **Diracoglu et al.** and **Fitzgerald et al.** have demonstrated that proprioceptive and balance training significantly improves joint position sense and functional stability in individuals with knee OA. The present findings align with these studies and extend the evidence by highlighting the effectiveness of **closed-chain kneeling activities**, which are relatively underexplored in OA rehabilitation.

Mechanisms Underlying the Superiority of Kneeling-Based Proprioceptive Training

The enhanced outcomes observed in Group B can be explained through several interrelated mechanisms. First, kneeling activities promote **closed-kinetic-chain loading**, which increases co-contraction of agonist and antagonist muscle groups, thereby improving joint stability and reducing aberrant knee movements associated with pain and degeneration. Second, the soft mat introduces surface instability, compelling the neuromuscular system to rely more heavily on proprioceptive input for postural control and movement accuracy.

Additionally, repeated exposure to controlled knee flexion in kneeling positions may improve **tolerance to joint compression**, normalize sensory processing, and reduce pain-avoidance behaviors. Over time, this may lead to improved motor planning and reduced joint stress during functional activities such as walking and stair climbing. These mechanisms are supported by the work of **Ageberg and Roos**, who emphasized the role of sensorimotor training in restoring neuromuscular control and joint confidence in degenerative knee conditions.

Conclusion

The present study concludes that the incorporation of kneel marching and kneel walking exercises on a soft mat along with conventional physiotherapy is more effective in reducing pain and improving proprioception in patients with knee osteoarthritis than conventional exercises alone. Kneeling-based proprioceptive training is a simple, safe, and cost-effective intervention that can be recommended as an adjunct in conservative physiotherapy management of knee osteoarthritis.

Clinical Implications

The findings of this study suggest that incorporating **kneel marching and kneel walking on a soft mat** into conventional physiotherapy programs can provide **clinically meaningful improvements in pain and**

proprioception in patients with knee OA. These exercises are cost-effective, require minimal equipment, and can be safely progressed based on patient tolerance. Given the central role of proprioceptive impairment in OA progression and functional decline, such interventions may contribute to improved long-term joint health and reduced disability.

Limitations and Future Directions

Despite the positive findings, the study was limited by a relatively short intervention duration and the absence of long-term follow-up. Future studies should examine the **sustainability of proprioceptive gains**, include functional and biomechanical outcomes, and explore dose-response relationships of kneeling-based training. Incorporating imaging or neuromuscular assessments may further elucidate underlying mechanisms.

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