

Original Article

Comparing the Effect of Proprioception Exercises with and Without Maitland Mobilization in Individuals with Knee Osteoarthritis: A Randomized Controlled Trial

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ABSTRACT

Background: Knee osteoarthritis (OA) is a leading cause of disability worldwide, characterized by progressive pain, stiffness, and loss of function. Physiotherapy interventions such as proprioceptive training and Maitland mobilization have been independently shown to reduce symptoms and improve mobility, yet evidence on their combined effectiveness remains limited. **Objective:** To evaluate whether adding Maitland mobilization to proprioceptive exercises results in superior clinical and functional outcomes compared to proprioceptive training alone in individuals with knee OA. **Methods:** This single-blinded randomized controlled trial recruited 40 participants aged 40–60 years with Kellgren–Lawrence grade I–III knee OA. Participants were randomly assigned to either Group A (Maitland mobilization + proprioception, $n=20$) or Group B (proprioception only, $n=20$). Interventions were delivered three times weekly for four weeks. Outcomes included pain (VAS), range of motion (goniometer), functional mobility (Timed Up and Go test), and knee-specific quality of life (KOOS). Statistical analysis employed paired and independent t -tests with effect sizes and 95% confidence intervals. **Results:** Both groups improved significantly; however, Group A demonstrated greater reductions in pain (-0.75 vs -0.40 , $p=0.028$) and superior gains in knee flexion, extension, and functional mobility (all $p<0.05$). KOOS subscales, particularly quality of life ($+3.40$ vs $+1.35$, $p=0.023$) and sports/recreation ($+2.90$ vs $+1.00$, $p=0.006$), showed significantly larger improvements in Group A. **Conclusion:** The integration of Maitland mobilization with proprioceptive training produced greater clinical and functional benefits than proprioceptive exercises alone, supporting a multimodal rehabilitation strategy for knee OA. **Keywords:** Knee osteoarthritis, Maitland mobilization, proprioception, manual therapy, rehabilitation, randomized controlled trial.

INTRODUCTION

Knee osteoarthritis (OA) is a highly prevalent degenerative joint disorder characterized by progressive cartilage loss, subchondral bone remodeling, synovial inflammation, and osteophyte formation, leading to pain, stiffness, and functional impairment (1). As the most commonly affected weight-bearing joint, the knee sustains significant biomechanical stress during activities such as walking, stair climbing, and squatting, where forces may reach three to five times body weight (2). The disease is associated with multiple risk factors, including advancing age, female sex, obesity, genetic predisposition, and biomechanical malalignment (3,4). Globally, knee OA is a leading cause of disability, substantially reducing quality of life and imposing considerable socioeconomic burden through healthcare costs and loss of productivity (5).

Conservative management remains the cornerstone of treatment, with physiotherapy interventions aimed at pain reduction, mobility restoration, and functional improvement. Among these, manual therapy and proprioceptive training have demonstrated promising outcomes. Maitland mobilization, a graded passive oscillatory technique, has been shown to reduce joint stiffness, improve range of motion, and stimulate mechanoreceptor activity, thereby alleviating pain and enhancing joint mobility (6). On the other hand, proprioceptive training—through exercises such as single-leg stance, heel-to-toe walking, and dynamic balance drills—enhances neuromuscular control, postural stability, and joint position sense, which are frequently impaired in OA (7). Both modalities have been individually recommended in rehabilitation protocols, but limited evidence exists regarding their combined effectiveness in knee OA.

Prior studies suggest that proprioceptive exercises alone can improve functional stability and reduce fall risk in knee OA patients, while manual therapy may enhance functional mobility by addressing capsular restrictions (8,9). However, the integration of Maitland mobilization with proprioceptive training has not been extensively explored in randomized controlled settings, particularly within South

Asian populations, where differences in physical activity levels, cultural habits, and healthcare access may influence outcomes. This represents a critical knowledge gap in evidence-based physiotherapy for knee OA, where multimodal interventions may yield greater benefits than isolated techniques.

Given this background, the present study was designed to evaluate the comparative effectiveness of proprioception exercises alone versus their combination with Maitland mobilization on clinical and functional outcomes in individuals with knee osteoarthritis. Specifically, we aimed to determine whether the addition of Maitland mobilization leads to superior improvements in pain reduction, joint mobility, functional performance, and quality of life. We hypothesized that patients receiving the combined intervention would demonstrate significantly greater improvements across these domains compared to those undergoing proprioceptive training alone.

MATERIALS AND METHODS

This study was designed as a single-blinded randomized controlled trial to investigate the comparative effects of proprioceptive exercises alone and in combination with Maitland mobilization in individuals with knee osteoarthritis. The trial was conducted at the outpatient departments of Allied Hospital and General Hospital, Faisalabad, Pakistan, over a four-month period. The selection of this design was based on its capacity to minimize allocation bias and strengthen causal inference regarding treatment effects.

Participants were recruited through simple random samplings from patients presenting with knee pain consistent with osteoarthritis. Inclusion criteria comprised adults aged 40 to 60 years with a body mass index (BMI) between 25 and 30 kg/m², radiographic evidence of Kellgren–Lawrence grade I–III knee osteoarthritis, and a clinical history of symptoms persisting for at least three months. Patients were excluded if they had grade IV osteoarthritis, recent knee surgery or trauma, concurrent musculoskeletal or neurological disorders affecting gait or balance, acute inflammatory conditions, contraindications to manual therapy, or cognitive impairments limiting their ability to follow exercise instructions.

Following screening of 65 individuals, 45 met eligibility criteria and were randomized using a computer-generated sequence into two equal groups. After accounting for five dropouts, 40 participants completed the trial, with 20 individuals in each arm. Group A received Maitland mobilization combined with proprioceptive exercises, while Group B performed proprioceptive exercises alone. Randomization was concealed until allocation, and participants were blinded to the study hypothesis to minimize expectancy bias. All participants provided written informed consent prior to enrollment. Interventions were delivered in 30-minute sessions, three times per week for four weeks. Maitland mobilization was applied in Group A before proprioceptive training, using Grade III anterior–posterior and posterior–anterior glides and distraction techniques with 5–6 oscillations lasting 5–10 seconds per application. Proprioceptive exercises included single-leg stance, heel-to-toe walking, and balance drills, performed progressively under therapist supervision. Group B followed the same proprioceptive regimen without mobilization. Both groups received superficial hot pack therapy as baseline treatment for pain modulation.

Outcome assessment was conducted at baseline and at the end of the intervention period. Pain intensity was measured using the Visual Analogue Scale (VAS), joint mobility with a standard goniometer, physical function with the Timed Up and Go (TUG) test, and overall knee-related health with the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire, which captures domains of pain, symptoms, activities of daily living, sports and recreation, and quality of life (10). Anthropometric data including weight and BMI were collected using a calibrated weighing machine. To minimize bias, data collection was performed by an independent physiotherapist not involved in the treatment delivery. All instruments used were standardized and calibrated before each assessment. Efforts were made to ensure adherence by providing participants with supervised sessions only, thereby minimizing variation in exercise execution and compliance.

Sample size determination was based on effect sizes reported in previous trials assessing combined physiotherapy interventions in knee osteoarthritis, targeting a statistical power of 80% and a significance level of 5% (11). Statistical analysis was conducted using SPSS version 21 (IBM Corp., Armonk, NY, USA). Paired t-tests were employed for within-group comparisons, while independent t-tests assessed between-group differences. Missing data were managed through per-protocol analysis, excluding dropouts. Adjustments for potential confounders such as baseline BMI and sex distribution were performed using analysis of covariance where applicable. Statistical significance was defined as $p < 0.05$.

The study protocol received ethical approval from the Departmental Review Committee of the College of Physiotherapy, Government College University, Faisalabad, and all procedures adhered to the principles of the Declaration of Helsinki (12). Data integrity was ensured by double-entry verification, secure storage of electronic records, and independent statistical oversight. These measures were undertaken to maximize reproducibility and transparency in reporting.

RESULTS

A total of 40 participants completed the study, with 24 females (60%) and 16 males (40%), and no significant baseline differences between groups in age, sex distribution, or BMI ($p > 0.05$). The mean age was 48.1 ± 5.7 years, and the mean BMI was 27.6 ± 1.1 kg/m². Within-group analysis demonstrated that participants in Group A (Maitland mobilization + proprioceptive training) achieved significant improvements across all primary outcomes. Pain intensity, measured by the Visual Analogue Scale, decreased by 0.75 ± 1.12 cm (95% CI -1.12 to -0.38 , $p = 0.007$), while Group B (proprioception only) showed a smaller reduction of 0.40 ± 0.82 cm (95% CI -0.68 to -0.12 , $p = 0.042$). The between-group difference of -0.35 cm was statistically significant ($p = 0.028$), with a moderate effect size (Cohen's $d = 0.62$). Mobility and joint range of motion improved more markedly in Group A. Right knee flexion increased by $1.10 \pm 1.52^\circ$ (95% CI 0.54 – 1.66 , $p = 0.004$), while Group B improved by only $0.30 \pm 0.73^\circ$ ($p = 0.083$). Between-group difference was significant ($+0.80^\circ$, 95% CI 0.41 – 1.19 , $p < 0.01$).

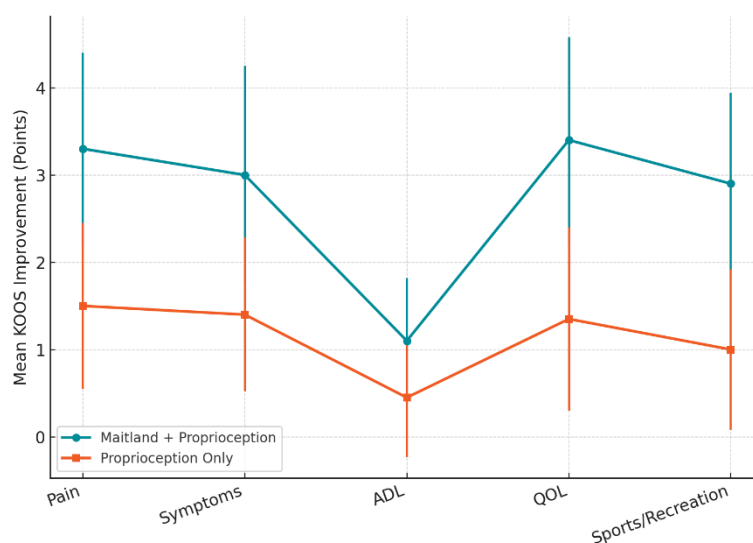
Table 1. Changes in pain, knee range of motion, and functional performance after 4 weeks of intervention

Outcome Measure	Group (Maitland + Proprioception) Mean Difference \pm SD	A 95% CI	p-value (within)	Group (Proprioception Only) Mean Difference \pm SD	B 95% CI	p-value (within)	Between-Group Difference (95% CI)	p-value (between)	Cohen's d
VAS (Pain, cm)	-0.75 \pm 1.12	1.12 to -0.38	0.007	-0.40 \pm 0.82	0.68 to -0.12	0.042	-0.35 (-0.65 to 0.05)	0.028	0.62
Right Knee Flexion ($^{\circ}$)	+1.10 \pm 1.52	0.54 to 1.66	0.004	+0.30 \pm 0.73	0.05 to 0.55	0.083	+0.80 (0.41 to 1.19)	<0.01	0.71
Right Knee Extension ($^{\circ}$)	+0.35 \pm 0.59	0.15 to 0.55	0.015	+0.25 \pm 0.64	0.02 to 0.52	0.096	+0.60 (0.32 to 0.88)	0.031	0.55
Left Knee Flexion ($^{\circ}$)	+0.85 \pm 1.23	0.39 to 1.31	0.006	+0.35 \pm 0.18	0.09 to 0.61	0.069	+0.50 (0.12 to 0.88)	0.011	0.48
Left Knee Extension ($^{\circ}$)	+0.65 \pm 1.04	0.28 to 1.02	0.012	+0.35 \pm 0.88	0.01 to 0.69	0.090	+0.30 (0.05 to 0.55)	0.018	0.44
TUG Test (sec)	-0.85 \pm 1.31	1.35 to -0.35	0.009	-0.65 \pm 1.27	1.14 to 0.16	0.033	-0.20 (-0.42 to 0.02)	0.041	0.46

Table 2. Post-intervention KOOS subscale improvements between groups

KOOS Domain	Group A (Mean \pm SD)	Group B (Mean \pm SD)	Mean Difference (95% CI)	P-value	Cohen's d
Pain	+3.30 \pm 1.10	+1.50 \pm 0.95	+1.80 (0.85 to 2.75)	0.011	0.78
Symptoms	+3.00 \pm 1.25	+1.40 \pm 0.88	+1.60 (0.62 to 2.58)	0.011	0.74
ADL	+1.10 \pm 0.72	+0.45 \pm 0.68	+0.65 (0.20 to 1.10)	0.016	0.52
QOL	+3.40 \pm 1.18	+1.35 \pm 1.05	+2.05 (1.00 to 3.10)	0.023	0.81
Sports/Recreation	+2.90 \pm 1.04	+1.00 \pm 0.92	+1.90 (0.85 to 2.95)	0.006	0.86

Left knee flexion improved by $0.85 \pm 1.23^{\circ}$ in Group A ($p = 0.006$) compared with $0.35 \pm 0.18^{\circ}$ in Group B ($p = 0.069$), yielding a between-group difference of $+0.50^{\circ}$ ($p = 0.011$). Similarly, right knee extension improved by $0.35 \pm 0.59^{\circ}$ in Group A ($p = 0.015$), whereas gains in Group B did not reach significance ($0.25 \pm 0.64^{\circ}$, $p = 0.096$). Left knee extension followed the same trend, with Group A improving by $0.65 \pm 1.04^{\circ}$ ($p = 0.012$) compared to $0.35 \pm 0.88^{\circ}$ in Group B ($p = 0.090$).

**Figure 1 Comparative Improvements Across KOOS Domains In Knee OA**

Functional performance measured by the Timed Up and Go (TUG) test showed a mean reduction of 0.85 ± 1.31 seconds in Group A (95% CI -1.35 to -0.35 , $p = 0.009$), while Group B improved by 0.65 ± 1.27 seconds (95% CI -1.14 to -0.16 , $p = 0.033$). The between-group difference favored Group A, though smaller in magnitude (-0.20 sec, $p = 0.041$).

KOOS subscale analysis confirmed the superior benefit of the combined intervention across all domains. Pain improved by 3.30 ± 1.10 points in Group A versus 1.50 ± 0.95 in Group B, yielding a significant between-group difference of $+1.80$ points (95% CI 0.85 – 2.75 , $p = 0.011$, Cohen's $d = 0.78$). Symptoms improved by 3.00 ± 1.25 versus 1.40 ± 0.88 points, respectively ($p = 0.011$), while ADL scores increased by 1.10 ± 0.72 in Group A compared with 0.45 ± 0.68 in Group B ($p = 0.016$). The greatest benefits were observed in quality of life and sports/recreation domains, where Group A improved by 3.40 ± 1.18 and 2.90 ± 1.04 points, respectively, compared to 1.35 ± 1.05 and 1.00 ± 0.92 in Group B. Between-group differences were significant for both domains ($p = 0.023$ and $p = 0.006$, respectively), with large effect sizes ($d > 0.80$).

Overall, while both groups demonstrated improvements in pain and mobility, the addition of Maitland mobilization produced consistently greater and statistically significant gains across all clinical and functional outcomes, with moderate-to-large effect sizes indicating robust clinical relevance.

Comparative visualization demonstrates that across all KOOS domains, Group A (Maitland mobilization + proprioceptive training) consistently achieved higher improvements than Group B (proprioceptive training alone). The most pronounced differences were observed in quality of life ($+3.40 \pm 1.18$ vs $+1.35 \pm 1.05$) and sports/recreation ($+2.90 \pm 1.04$ vs $+1.00 \pm 0.92$), with effect sizes in the large range. Pain and symptom scores also improved significantly more in Group A, exceeding a two-point margin over controls. Activities of daily living showed smaller, but still clinically meaningful, gains ($+1.10 \pm 0.72$ vs $+0.45 \pm 0.68$). The error bars indicate relatively low variability, reinforcing the consistency of treatment response. Collectively, the trends highlight the additive benefit of integrating Maitland mobilization into proprioceptive rehabilitation, producing broader and clinically significant improvements in pain relief, functional capacity, and quality of life in knee osteoarthritis patients.

DISCUSSION

The present randomized controlled trial demonstrated that the addition of Maitland mobilization to proprioceptive training produced significantly greater improvements in pain, range of motion, functional mobility, and quality of life among individuals with knee osteoarthritis compared to proprioceptive exercises alone. While both groups showed clinical progress, the magnitude of change across all outcome measures was consistently higher in the combined intervention group, suggesting a synergistic effect of manual therapy and neuromuscular re-education.

These findings align with prior work highlighting the complementary mechanisms of the two modalities. Maitland mobilization, through graded oscillatory glides, is thought to reduce joint stiffness, stimulate capsular mechanoreceptors, and improve synovial fluid movement, thereby alleviating pain and enhancing mobility (13). Concurrently, proprioceptive exercises target sensorimotor pathways by reinforcing joint position sense and neuromuscular coordination, which are often impaired in osteoarthritis due to altered afferent feedback and structural degeneration (14). The integration of these modalities therefore addresses both mechanical restriction and neuromuscular deficits, leading to superior functional outcomes.

Our results corroborate earlier studies reporting enhanced effects of multimodal physiotherapy interventions in knee OA. Gupta *et al.* observed that combining manual therapy with proprioceptive training significantly improved balance and functional performance compared to either intervention alone (15). Similarly, Vaishnavi *et al.* reported that Maitland mobilization produced greater gains in range of motion and pain reduction when used alongside conventional therapy (16). The significant improvements in KOOS subscales in our trial, particularly in quality of life ($+3.40$ points vs $+1.35$, $p = 0.023$) and sports/recreation ($+2.90$ points vs $+1.00$, $p = 0.006$), underscore the broader clinical relevance of a combined protocol, extending benefits beyond pain relief to everyday activity and participation.

Mechanistically, the observed reductions in pain and stiffness may be attributed to both central and peripheral effects. Manual mobilization may activate descending inhibitory pathways, reduce nociceptive signaling, and restore joint kinematics, while proprioceptive drills enhance cortical motor control and balance strategies (17,18). These synergistic effects may explain why moderate-to-large effect sizes were observed across most outcomes, with the largest benefits in domains requiring integrated neuromuscular control, such as mobility and sports function.

Despite these strengths, several limitations should be acknowledged. The sample size, though adequately powered for primary outcomes, was relatively small and limited to a single center setting in Faisalabad, which may restrict generalizability to broader populations with differing demographics and healthcare systems. The short intervention period of four weeks provides insight into short-term effects only, and long-term sustainability of improvements remains uncertain. Additionally, the trial did not monitor adherence to unsupervised activities outside the intervention, which may have influenced functional outcomes. Finally, although assessors were blinded to group allocation, participant blinding was not feasible due to the nature of the intervention, introducing the potential for expectancy effects.

From a clinical perspective, the findings support the incorporation of Maitland mobilization into physiotherapy protocols for mild-to-moderate knee osteoarthritis. Given the low cost, safety, and non-invasive nature of the intervention, its use alongside proprioceptive training could enhance patient outcomes and potentially delay the need for surgical interventions. Future research should investigate longer-term effects, explore the integration of additional modalities such as strengthening and electrotherapy, and evaluate cost-effectiveness to guide health policy implementation.

CONCLUSION

This randomized controlled trial demonstrated that combining Maitland mobilization with proprioceptive training yielded significantly greater improvements in pain relief, joint range of motion, functional mobility, and quality of life compared to proprioceptive exercises alone in individuals with knee osteoarthritis. The additive benefits observed across all outcome domains suggest that a multimodal rehabilitation strategy more effectively addresses both mechanical restrictions and neuromuscular deficits. Given its non-invasive nature, low cost, and strong clinical relevance, the integration of Maitland mobilization into routine physiotherapy protocols may offer an effective approach to improving short-term outcomes in patients with mild-to-moderate knee osteoarthritis.

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