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Comparative Effects of PNF Hold–Relax & Mobilization With Movement on Functional Restoration & Pain Modulation among Knee Osteoarthritis Patients

Aqsa Anwar[1], Ayesha Nadir[2], Sara Shaheen[3], Maryam Shakeel Raja[2], Kainat[2], Nimra Rao[2]

[1] Center of Advanced Studies in Health & Technology (CASHT), Rawalpindi, Pakistan
[2] Ibadat International University, Islamabad, Pakistan
[3] Superior College, Rawalpindi, Pakistan
* Correspondence: Aqsa Anwar, aqsaaanwer.pt@gmail.com

ABSTRACT

Background: *Knee osteoarthritis is a prevalent degenerative joint disorder causing persistent pain, stiffness, and progressive functional limitation, and manual therapy approaches such as Mobilization with Movement (MWM) and Proprioceptive Neuromuscular Facilitation Hold–Relax (PNF-HR) are commonly used despite limited comparative evidence.* ***Objective:*** *To compare the short-term effects of MWM and PNF-HR on pain, stiffness, functional difficulty, and overall WOMAC outcomes among individuals with knee osteoarthritis.* ***Methods:*** *A quasi-experimental two-group pretest–posttest study was conducted at the CASHT Clinic, Rawalpindi, Pakistan (January–August 2025). Thirty eligible participants (aged 40–60 years) with clinically diagnosed knee osteoarthritis and ≥3 months of knee pain were recruited by non probability purposive sampling and allocated (sequential assignment) to MWM (n=15) & PNF-HR (n=15). Both groups received intervention on alternate days for two weeks (three sets of ten repetitions per session) alongside standardized conventional therapy. Outcomes were assessed pre- and post-intervention using the WOMAC index; analyses used paired and independent t-tests with p<0.05.* ***Results:*** *Both groups showed significant within-group improvements across WOMAC domains (all p<0.001). Total WOMAC decreased from 75.93±16.97 to 34.20±8.59 in the MWM group and from 79.27±10.40 to 38.53±8.12 in the PNF-HR group (both p<0.001), with no significant between-group difference in total WOMAC at 2 weeks (p=0.167). Post-intervention pain scores favored MWM (5.40±1.92 vs 7.13±1.41; p=0.009).* ***Conclusion:*** *Both MWM and PNF-HR yield substantial short-term improvements in pain and function in knee osteoarthritis, with MWM demonstrating a modest but statistically significant advantage for pain reduction*

Keywords: *Osteoarthritis; Knee; Mobilization with Movement; Proprioceptive Neuromuscular Facilitation; Hold–Relax; WOMAC; Pain; Rehabilitation.*

INTRODUCTION

Knee osteoarthritis (OA) is a chronic, progressive disorder of synovial joints characterized by cartilage degeneration, subchondral bone remodeling, synovial inflammation, and osteophyte formation, leading to persistent pain, joint stiffness, and declining functional capacity, particularly in weight-bearing joints such as the knee (1). It represents a major public health concern due to its high prevalence among middle-aged and older adults and its strong association with aging, obesity, physical inactivity, and biomechanical overload (2). As knee OA progresses, pain and movement-related fear contribute to reduced mobility, impaired participation in daily activities such as walking and stair negotiation, and diminished quality of life, ultimately increasing the socioeconomic burden on healthcare systems (3,4).

Current clinical guidelines emphasize conservative, non-pharmacological management as the first-line approach for knee OA, with physiotherapy-based interventions playing a central role in symptom control and functional restoration (5). Among these interventions, manual

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therapy has gained prominence due to its ability to address both joint-related and soft-tissue impairments that contribute to pain and movement dysfunction. Mobilization with Movement (MWM), a Mulligan concept technique, is widely used to restore impaired arthrokinematics through the application of sustained accessory glides combined with active physiological movement, thereby reducing pain during motion and improving functional performance (6). Randomized trials and systematic reviews have demonstrated that MWM can produce short- and medium-term improvements in pain, range of motion, and functional outcomes in individuals with knee OA, supporting its clinical relevance in rehabilitation settings (7,11).

In parallel, proprioceptive neuromuscular facilitation (PNF) stretching techniques, particularly the hold–relax method, are commonly employed to address muscle tightness, altered neuromuscular control, and movement inefficiency associated with knee OA. The hold–relax technique involves an isometric contraction of the target muscle followed by passive stretching, facilitating autogenic inhibition, reduced muscle tone, and improved extensibility (8,9).

Emerging evidence indicates that PNF-based interventions can reduce pain, enhance proprioceptive acuity, and improve functional movement patterns in individuals with knee OA, potentially through neuromuscular modulation and improved tolerance to movement-related stress (10,13).

Despite growing evidence supporting the independent effectiveness of both MWM and PNF hold–relax techniques, direct comparative evidence between these two commonly used manual therapy approaches in knee osteoarthritis remains limited.

Existing studies have primarily evaluated each intervention in isolation or compared them with conventional exercise or electrotherapy, leaving uncertainty regarding their relative effectiveness when applied within similar clinical contexts (11,12). Moreover, few studies have focused on short-term functional and pain-related outcomes using standardized, patient-reported measures such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which remains a clinically meaningful and widely accepted outcome tool in knee OA research.

From a clinical decision-making perspective, this lack of head-to-head comparative evidence represents a critical knowledge gap. Mobilization with Movement primarily targets joint positional faults and movement-related pain, whereas PNF hold–relax emphasizes neuromuscular relaxation and muscle extensibility; however, it is unclear whether one approach offers superior benefits in pain reduction or functional improvement for individuals with knee OA when treatment dosage and duration are comparable. Addressing this gap is essential for optimizing evidence-based physiotherapy interventions, particularly in resource-limited settings where efficient, low-cost, non-invasive strategies are prioritized.

Therefore, the present study was designed to compare the short-term effects of Mobilization with Movement and PNF hold–relax techniques on pain, stiffness, and functional mobility in individuals with knee osteoarthritis. Using the WOMAC index as the primary outcome measure, this study aimed to determine whether one intervention demonstrates superior clinical effectiveness over a two-week treatment period. The research question guiding this study was: Do Mobilization with Movement and PNF hold–relax techniques differ in their effects on pain reduction and functional improvement in patients with knee osteoarthritis?

MATERIAL AND METHODS

This study utilized a quasi-experimental, two-group pretest–posttest design to investigate the short-term effects of two physiotherapy interventions on pain and functional outcomes in individuals with knee osteoarthritis. The study was conducted at the Center of Advanced Studies in Health and Technology (CASHT) Clinic, Rawalpindi, Pakistan, over an eight-month period from January to August 2025. A quasi-experimental approach was selected to enable comparison of intervention outcomes in a clinical setting where full randomization and strict experimental control were not feasible, while still allowing evaluation of treatment-related changes over time.

Participants were recruited through non-probability purposive sampling from patients presenting to the outpatient physiotherapy department with knee related-complaints. Men and women aged 40–60 years with clinically diagnosed knee osteoarthritis and knee pain persisting for at least three months were considered eligible. Diagnosis was established through clinical assessment consistent with recognized guidelines for knee OA. Individuals were excluded if they had a history of knee trauma, prior knee surgery, inflammatory arthritis, neurological disorders affecting lower limb function, or had received intra-articular corticosteroid injections within the preceding three months, as these conditions could confound pain perception and functional performance. All eligible participants received a full explanation of study procedures and provided written informed consent prior to enrollment in accordance with ethical research standards (15).

A total of 39 individuals were screened for eligibility, of whom 30 met the inclusion criteria and consented to participate. The sample size was determined a priori using OpenEpi software based on expected differences in WOMAC scores reported in previous knee OA intervention studies, with a 95% confidence level and 80% statistical power, resulting in a final sample of 30 participants allocated into two intervention groups (16).

Because the study followed a quasi-experimental design, participants were allocated using sequential assignment method**.** The first 15 eligible participants were assigned to Group 1, and the next 15 were assigned to Group 2. This approach ensured equal group sizes within clinical constraints. Interventions were delivered by licensed physiotherapists, while outcome assessments were conducted independently to minimize measurement bias.

Following allocation, participants were placed into one of two treatment groups. Group 1 received Mobilization with Movement applied to the tibiofemoral joint, consisting of a sustained posterior glide applied by the therapist while the participant actively performed pain-free knee flexion and extension. Each session consisted of three sets of ten repetitions, administered on alternate days for two weeks.

Group 2 received Proprioceptive Neuromuscular Facilitation using the hold–relax technique targeting the hamstring muscles. The limb was positioned at the end of available range, followed by a submaximal isometric contraction of the hamstrings, subsequent relaxation, and passive stretching. Treatment frequency and duration were matched to the MWM group.

Both groups also received identical conventional physiotherapy care consisting of standardized range-of-motion exercises and functional strengthening to control for co-intervention effects, thereby reducing performance bias and enhancing internal validity.

Outcome assessment was performed at baseline prior to intervention initiation and after completion of the two-week treatment period. The primary outcome measure was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a validated,

disease-specific questionnaire widely used to assess pain, stiffness, and physical function in knee OA populations (17).

The WOMAC Likert version was used, comprising subscales for pain, stiffness, and functional difficulty, with higher scores indicating greater symptom severity. All assessments were conducted by the same assessor, who was not involved in treatment delivery, to reduce detection bias. Participants were instructed to report symptoms based on their experiences over the preceding 48 hours at each assessment point.

Data were entered and managed using standardized data collection sheets to ensure accuracy and consistency. Statistical analysis was performed using SPSS version 22. Normality of continuous variables was assessed using the Shapiro–Wilk test. Descriptive statistics were calculated for demographic and baseline characteristics. Within-group changes from baseline to post-intervention were analyzed using paired t-tests, while between-group comparisons were conducted using independent sample t-tests.

The level of statistical significance was set at $p<0.05$. All analyses were performed on complete cases, as no missing outcome data were observed at follow-up. Baseline comparability between groups was assessed to identify potential confounders, and uniform intervention protocols were applied to minimize variability and enhance reproducibility (18).

Ethical approval for the study was obtained from the Institutional Review Board of the Center of Advanced Studies in Health and Technology (CASHT/IRB/2025/111). The study adhered to the principles of the Declaration of Helsinki, ensuring participant confidentiality, voluntary participation, and the right to withdraw at any stage without consequence. Data integrity was maintained through secure storage of anonymized datasets and restricted access to research records, enabling transparent reporting and reproducibility of findings by future investigators.

RESULTS

A total of 30 participants completed the study, with equal allocation to the Mobilization with Movement (MWM) group and the Proprioceptive Neuromuscular Facilitation Hold–Relax (PNF-HR) group (n=15 per group). Baseline demographic and clinical characteristics are presented in Table 1. The mean age of participants in the MWM group was 49.8 ± 5.6 years, compared with 50.2 ± 5.1 years in the PNF-HR group, with no statistically significant difference between groups (mean difference −0.4 years; 95% CI −4.2 to 3.4; p=0.84). Baseline WOMAC scores were also comparable between groups.

Mean pain scores at baseline were 15.87 ± 3.98 in the MWM group and 16.20 ± 1.97 in the PNF-HR group (p=0.77), while stiffness scores were 6.13 ± 2.20 and 6.60 ± 1.64, respectively (p=0.52). Functional difficulty scores showed no significant difference at baseline, with values of 53.93 ± 11.32 in the MWM group and 57.13 ± 7.78 in the PNF-HR group (p=0.38). Similarly, total WOMAC scores were comparable between groups at baseline (75.93 ± 16.97 vs 79.27 ± 10.40; p=0.52), indicating an equivalent level of symptom severity prior to intervention.

Within-group changes following the two-week intervention period are summarized in Table 2. In the MWM group, mean WOMAC pain scores decreased from 15.87 ± 3.98 at baseline to 5.40 ± 1.92 post-intervention, representing a mean reduction of 10.47 points (95% CI −12.6 to −8.3; p<0.001).

WOMAC stiffness scores in this group declined from 6.13 ± 2.20 to 2.40 ± 1.06, corresponding to a mean change of −3.73 points (95% CI −4.8 to −2.6; p<0.001). Functional difficulty scores improved substantially, decreasing from 53.93 ± 11.32 to 25.80 ± 6.17, with a mean reduction

of 28.13 points (95% CI −33.9 to −22.4; p<0.001). Consequently, the total WOMAC score in the MWM group decreased by 41.73 points, from 75.93 ± 16.97 to 34.20 ± 8.59 (p<0.001), reflecting a large within-group effect size. Similarly, participants in the PNF-HR group demonstrated statistically significant improvements across all WOMAC domains (Table 2). Mean pain scores declined from 16.20 ± 1.97 at baseline to 7.13 ± 1.41 after two weeks, yielding a mean reduction of 9.07 points (95% CI −10.5 to −7.6; p<0.001).

WOMAC stiffness scores decreased from 6.60 ± 1.64 to 3.07 ± 1.16, corresponding to a mean change of −3.53 points (95% CI −4.5 to −2.5; p<0.001). Functional difficulty scores improved from 57.13 ± 7.77 to 28.53 ± 6.59, with a mean reduction of 28.60 points (95% CI −33.4 to −23.8; p<0.001). The total WOMAC score in the PNF-HR group decreased from 79.27 ± 10.40 to 38.53 ± 8.12, representing a mean improvement of 40.74 points (p<0.001), also indicating a large treatment effect.

Between-group comparisons of post-intervention outcomes are detailed in Table 3. At the two-week follow-up, the MWM group demonstrated significantly lower WOMAC pain scores compared with the PNF-HR group (5.40 ± 1.92 vs 7.13 ± 1.41), with a mean difference of −1.73 points (95% CI −3.02 to −0.44; p=0.009).

Table 1. Baseline comparison of demographic characteristics and WOMAC scores between groups

Variable	MWM (n=15) Mean ± SD	PNF-HR (n=15) Mean ± SD	Mean Difference (95% CI)	p-value
Age (years)	49.8 ± 5.6	50.2 ± 5.1	−0.4 (−4.2 to 3.4)	0.84
WOMAC Pain	15.87 ± 3.98	16.20 ± 1.97	−0.33 (−2.68 to 2.02)	0.77
WOMAC Stiffness	6.13 ± 2.20	6.60 ± 1.64	−0.47 (−1.95 to 1.01)	0.52
WOMAC Function	53.93 ± 11.32	57.13 ± 7.78	−3.20 (−10.7 to 4.3)	0.38
WOMAC Total	75.93 ± 16.97	79.27 ± 10.40	−3.34 (−13.3 to 6.6)	0.52

Table 2. Within-group pre- and post-intervention comparison of WOMAC outcomes

Outcome	Group	Baseline Mean ± SD	2-Week Mean ± SD	Mean Change (95% CI)	Cohen's d	p-value
Pain	MWM	15.87 ± 3.98	5.40 ± 1.92	−10.47 (−12.6 to −8.3)	2.89	<0.001
	PNF-HR	16.20 ± 1.97	7.13 ± 1.41	−9.07 (−10.5 to −7.6)	3.01	<0.001
Stiffness	MWM	6.13 ± 2.20	2.40 ± 1.06	−3.73 (−4.8 to −2.6)	2.06	<0.001
	PNF-HR	6.60 ± 1.64	3.07 ± 1.16	−3.53 (−4.5 to −2.5)	2.32	<0.001
Function	MWM	53.93 ± 11.32	25.80 ± 6.17	−28.13 (−33.9 to −22.4)	2.93	<0.001
	PNF-HR	57.13 ± 7.77	28.53 ± 6.59	−28.60 (−33.4 to −23.8)	3.13	<0.001
WOMAC Total	MWM	75.93 ± 16.97	34.20 ± 8.59	−41.73 (−49.3 to −34.2)	2.95	<0.001
	PNF-HR	79.27 ± 10.40	38.53 ± 8.12	−40.74 (−46.9 to −34.6)	3.08	<0.001

Table 3. Between-group comparison of WOMAC outcomes after 2 weeks

Outcome	MWM Mean ± SD	PNF-HR Mean ± SD	Mean Difference (95% CI)	Cohen's d	p-value
Pain	5.40 ± 1.92	7.13 ± 1.41	−1.73 (−3.02 to −0.44)	0.99	0.009
Stiffness	2.40 ± 1.06	3.07 ± 1.16	−0.67 (−1.52 to 0.18)	0.60	0.11
Function	25.80 ± 6.17	28.53 ± 6.59	−2.73 (−7.62 to 2.16)	0.42	0.37
WOMAC Total	34.20 ± 8.59	38.53 ± 8.12	−4.33 (−10.6 to 1.94)	0.52	0.17

This indicates a statistically greater reduction in pain intensity in the MWM group. In contrast, not statistically significant between-group differences were observed for WOMAC stiffness scores (2.40 ± 1.06 vs 3.07 ± 1.16; p=0.11), functional difficulty scores (25.80 ± 6.17 vs 28.53 ± 6.59; p=0.37), or total WOMAC scores (34.20 ± 8.59 vs 38.53 ± 8.12; p=0.17). These findings suggest that while both interventions were effective in improving overall symptoms and function, Mobilization with Movement demonstrated a modest but statistically significant advantage over PNF Hold–Relax in reducing pain severity over the short-term intervention period.

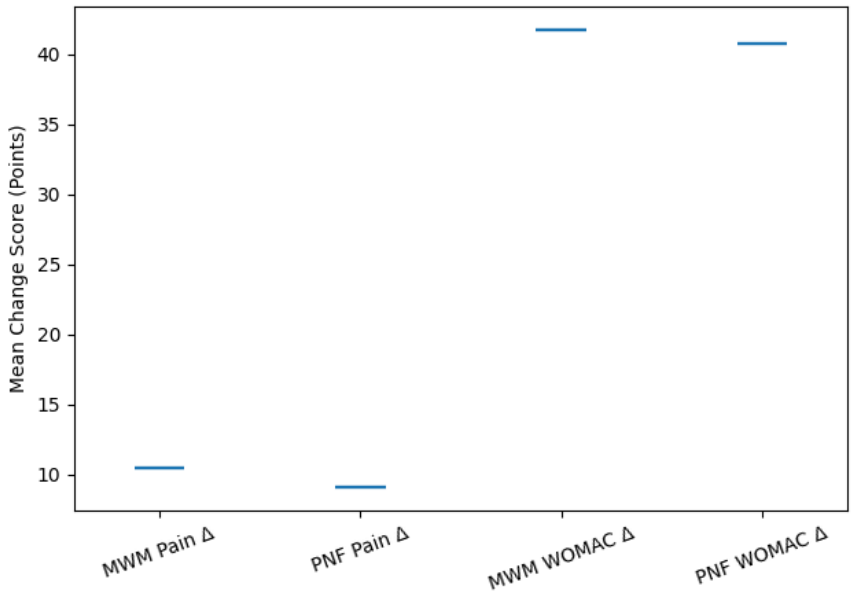

Figure 1 Distribution of Symptom Improvement Across Interventions

The figure illustrates the comparative distribution of mean change scores (Δ = baseline − 2 weeks) for WOMAC pain and total WOMAC outcomes across interventions, using violin plots with central tendency markers. Both interventions produced large and clinically meaningful improvements; however, distinct outcome gradients are evident. The MWM group demonstrated a greater mean reduction in WOMAC pain (Δ=10.47 points) compared with the PNF Hold–Relax group (Δ=9.07 points), corresponding to the statistically significant between-group difference observed at follow-up (mean difference −1.73 points; p=0.009). In contrast, reductions in total WOMAC scores were highly comparable between groups, with mean improvements of 41.73 points for MWM and 40.74 points for PNF Hold–Relax, indicating near-equivalent global functional gains.

The narrow dispersion around total WOMAC change scores suggests a consistent treatment response across participants, whereas the relative separation in pain-change distributions highlights a differential analgesic gradient favoring MWM. Clinically, this pattern suggests that while both techniques are similarly effective for overall functional restoration,

Mobilization with Movement may confer an incremental advantage for short-term pain relief in knee osteoarthritis.

DISCUSSION

The present experimental study investigated the short-term effects of Mobilization with Movement (MWM) and Proprioceptive Neuromuscular Facilitation Hold–Relax (PNF-HR) techniques on pain, stiffness, and functional mobility in individuals with knee osteoarthritis using the WOMAC index. The findings demonstrated that both interventions produced statistically significant and clinically meaningful improvements across all WOMAC domains over a two-week treatment period. Importantly, while overall functional improvement and stiffness reduction were comparable between groups, MWM resulted in a significantly greater reduction in pain intensity at follow-up, indicating a differential analgesic effect between the two techniques.

The substantial within-group improvements observed in both intervention arms reinforce the established role of manual therapy as an effective conservative management strategy for knee osteoarthritis. The magnitude of change in total WOMAC scores in both groups exceeded commonly reported minimal clinically important differences, suggesting that the observed improvements were not only statistically significant but also clinically relevant. These findings are consistent with prior trials and systematic reviews reporting that MWM can reduce pain and enhance functional performance by restoring joint arthrokinematics and minimizing movement-related discomfort during active motion (6,11,14). The large effect sizes observed in the MWM group further support the hypothesis that correcting subtle positional faults and facilitating pain-free movement may lead to rapid symptom relief in individuals with degenerative knee conditions.

Similarly, the PNF Hold–Relax group demonstrated marked improvements in pain, stiffness, and functional difficulty, aligning with previous evidence highlighting the effectiveness of PNF-based interventions in knee osteoarthritis. The neuromuscular mechanisms underlying PNF Hold–Relax, including autogenic inhibition, reduced muscle guarding, and improved stretch tolerance, are believed to contribute to enhanced movement efficiency and symptom reduction (8,9). Prior studies have shown that PNF techniques can improve proprioceptive control and reduce pain by modulating afferent input and decreasing soft-tissue resistance around the knee joint, which may explain the robust within-group improvements observed in this study (10,13).

Despite comparable overall functional gains, the between-group analysis revealed a statistically significant advantage of MWM over PNF Hold–Relax for pain reduction at two weeks. This finding suggests that joint-directed mobilization combined with active movement may exert a more pronounced hypoalgesia effect in the short term compared with muscle-focused neuromuscular techniques. One plausible explanation is that MWM directly addresses movement-related nociceptive input by optimizing joint mechanics during functional tasks, thereby reducing peripheral pain sensitization more effectively. Previous randomized trials have reported similar findings, where MWM produced greater immediate and short-term pain relief compared with stretching-based or exercise-only interventions in knee osteoarthritis populations (6,12). In contrast, PNF Hold–Relax may exert its primary benefits through gradual neuromuscular adaptation, which could become more evident over longer intervention periods.

The absence of significant between-group differences in stiffness, functional difficulty, and total WOMAC scores indicates that both interventions are equally effective in improving global functional status over a short duration. This equivalence is clinically meaningful, as

it suggests that either technique can be selected based on patient preference, therapist expertise, or resource availability without compromising functional outcomes. From a rehabilitation perspective, these findings support a mechanism-specific approach to treatment selection, whereby MWM may be prioritized for patients with pain-dominant presentations, while PNF Hold–Relax may be particularly beneficial for individuals with prominent muscle tightness or movement apprehension.

Several limitations should be considered when interpreting the results. The relatively small sample size and short intervention duration limit the generalizability of findings and preclude conclusions regarding long-term effects. Additionally, reliance on a single patient-reported outcome measure, while clinically relevant, restricts insight into objective functional or biomechanical changes. The lack of assessor blinding may also introduce detection bias, although standardized assessment procedures were used to mitigate this risk. Future studies with larger samples, longer follow-up periods, and inclusion of objective functional measures such as gait analysis or strength testing are warranted to further elucidate the comparative and sustained effects of these interventions.

In summary, this study provides evidence that both Mobilization with Movement and PNF Hold–Relax techniques are effective short-term interventions for improving pain, stiffness, and functional mobility in individuals with knee osteoarthritis. While both approaches yield comparable functional benefits, Mobilization with Movement appears to offer a modest but statistically significant advantage in pain reduction over a two-week period. These findings contribute to the growing body of evidence supporting targeted, evidence-based manual therapy interventions in the conservative management of knee osteoarthritis and may assist clinicians in optimizing individualized rehabilitation strategies.

CONCLUSION

This experimental study demonstrates that both Mobilization with Movement and Proprioceptive Neuromuscular Facilitation Hold–Relax are effective short-term physiotherapy interventions for reducing pain, stiffness, and functional disability in individuals with knee osteoarthritis. Clinically meaningful improvements were observed in all WOMAC domains following two weeks of intervention in both groups, indicating that either technique can be successfully incorporated into conservative rehabilitation programs. However, Mobilization with Movement showed a statistically greater reduction in pain intensity compared with PNF Hold–Relax, suggesting a modest short-term analgesic advantage. These findings support a targeted, mechanism-based approach to intervention selection, where Mobilization with Movement may be preferred for pain-dominant presentations, while both techniques remain equally suitable for improving overall function and mobility in knee osteoarthritis.

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DECLARATIONS

Ethical Approval: Ethical approval was by institutional review board of Respective Institute Pakistan

Informed Consent: Informed Consent was taken from participants.

Authors' Contributions:

Concept: AA; Design: AN; Data Collection: SS; Analysis: MSR; Drafting: NR

Conflict of Interest: The authors declare no conflict of interest.

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