Effectiveness of Mulligan mobilization versus proprioceptive exercises in knee osteoarthritis: a randomized controlled trial

Eficacia de la movilización de Mulligan frente a los ejercicios propioceptivos en la osteoartritis de rodilla: un ensayo clínico aleatorizado

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Abstract

Background. Knee osteoarthritis (KOA) is a common orthopedic disorder that causes chronic pain, limits the mobility, and reduces the overall quality of life. As much as efficacy of exercise therapy is supported by empirical evidence, relative effectiveness of Mulligan Mobilization Technique (MMT) by comparison with proprioceptive training is yet to be established.
Objective. The purpose of this study was to compare the impacts of MMT with proprioceptive exercises (PE) and standard physiotherapy in people with KOA on pain and functional status.
Methods. A randomized controlled trial including 60 participants (aged ≥40 years) was conducted over 10 weeks. Participants were allocated to MMT, PE and control physiotherapy groups. Pain intensity (NPRS) and knee function (KOOS Total Score) were assessed at baseline, 4th, 8th and 10th weeks. Repeated-measures ANOVA with Bonferroni-adjusted pairwise comparisons was used.
Results. The statistically significant improvements were observed in all the intervention groups ($p < 0.001$).
The most significant pain reduction and the maximum functional improvement was found in MMT. PE had an intermediate degree of improvement and traditional physiotherapy had the lowest degree of effect size.
Effect sizes were highest for MMT (NPRS $\eta^2 = 0.624$; KOOS $\eta^2 = 0.387$).
Conclusion. Among patients with KOA, Mulligan Mobilization with Movement was found to be better than proprioceptive exercises and traditional physiotherapy in reducing pain and improving the knee function. These results support the use of MMT as a conservative modality of first instance, which offers clinicians a powerful and effective alternative to achieve better patient outcomes.

Keywords

Knee osteoarthritis, Mulligan mobilization, proprioceptive exercises, physiotherapy, NPRS, KOOS, randomized controlled trial.

Resumen

Antecedentes. La osteoartritis de rodilla (OAR) es un trastorno ortopédico común que provoca dolor crónico, limita la movilidad y reduce la calidad de vida en general. Aunque la eficacia de la terapia con ejercicio está respaldada por evidencia empírica, la efectividad relativa de la Movilización con Movimiento de Mulligan (MMT), en comparación con el entrenamiento propioceptivo, aún no ha sido claramente establecida.
Objetivo. El objetivo del presente estudio fue comparar los efectos de la MMT, los ejercicios propioceptivos (PEG) y la fisioterapia estándar en personas con OAR, en relación con el dolor y el estado funcional.
Métodos. Se llevó a cabo un ensayo clínico aleatorizado con 60 participantes (edad ≥ 40 años) durante un período de 10 semanas. Los participantes fueron asignados a los grupos de MMT, PEG o fisioterapia convencional (grupo control). La intensidad del dolor (NPRS) y la función de la rodilla (puntuación total KOOS) se evaluaron al inicio del estudio y en la 4.ª, 8.ª y 10.ª semana. Se utilizó un ANOVA de medidas repetidas con comparaciones por pares ajustadas mediante Bonferroni.
Resultados. Se observaron mejoras estadísticamente significativas en todos los grupos de intervención ($p < 0.001$). La mayor reducción del dolor y la máxima mejora funcional se encontraron en el grupo MMT. El grupo PEG mostró un grado intermedio de mejoría, mientras que la fisioterapia convencional presentó el menor tamaño del efecto. Los tamaños del efecto fueron más altos en el grupo MMT (NPRS $\eta^2 = 0.624$; KOOS $\eta^2 = 0.387$).
Conclusión. En pacientes con osteoartritis de rodilla, la Movilización con Movimiento de Mulligan demostró ser superior a los ejercicios propioceptivos y a la fisioterapia tradicional para reducir el dolor y mejorar la función de la rodilla. Estos resultados respaldan el uso de la MMT como una modalidad conservadora de primera elección, ofreciendo a los clínicos una alternativa potente y eficaz para lograr mejores resultados en los pacientes.

Palabras clave

Osteoartritis de rodilla, movilización de Mulligan, ejercicios propioceptivos, fisioterapia, NPRS, KOOS, ensayo clínico aleatorizado.

Introduction

Knee osteoarthritis (KOA) is a worldwide public -health issue, as it affects about 10 to 15% of adults over 60 years and is disproportionately common in women (Zain et al., 2020; Sarallahi et al., 2020). The consecutive increase of the KOA prevalence is correlated with the aging of populations, increasing obesity rates, and sedentary lifestyles. As a result, the disease is a brutal burden to healthcare systems, expensive interventions, productivity at work, and, most tragically, quality of life of the impacted individuals (Sarallahi et al., 2020). These burdens are further enhanced by a lack of timely rehabilitation services in low- and middle-income environments, and there is a need to have scalable and evidence-based interventions.

KOA can be characterized by a progressive course of development that is characterized by cartilage destruction, subchondral bone alteration, inflammation of the synovium, and slow deterioration of joint functions. Symptomatically, patients have pain, stiffness, swelling, limited range of movement, poor balance, and difficulty in everyday activities (Zain et al., 2020; Sarallahi et al., 2020). Abnormal load distributions and a change in the biomechanics of the lower limbs due to the medial compartment implication, which is the most frequent in KOA, makes the progression of deterioration and functional loss accelerate (Zain et al., 2020).

KOA care is still based on conservative management. Pharmacologic interventions are supplemented by rehabilitation based on physiotherapy, during which exercise can be considered a core element. Routinely used exercises include strengthening, flexibility, aerobic, and sensorimotor training aimed at decreasing pain and increasing the functional capacity (Rosadi, 2023). The use of manual therapy, in particular of Mulligan Mobilization with Movement (MWM), is often viewed as an addition to having a significant impact on pain and joint mobility by using pain-free sustained glides and active movements (Anwer et al., 2018). Several studies have reported the immediate and short-term effects of MWM on pain, joint range, and functional performance; comparative data indicate that it could be as effective as other manual interventions in the treatment of KOA pain and gait-related (Westad, 2019). In addition to the effects of mechanical loading, MWM can regulate pain perceptions and motor control, which leads to the fact that movement efficiency and joint stability are improved (Kong et al., 2022; Ljubojevic et al., 2020; Subhani et al., 2024).

Proprioceptive training is aimed to address the lack of joint position sense, balance, and neuromuscular coordination, which are typical of KOA patients (Adhama et al., 2022). Such impairments lead to instability of joints, distortion of gait and risk of falls. It has been shown that balance training and unstable-surface exercising reduce pain and enhance balance and functional performance (Viswas et al., 2021; Wang et al., 2021). Besides, proprioceptual losses can appear at an early stage of KOA, which can lead to disease development (Kulkarni, 2017; Moitra & Sharma, 2016).

Recent evidence has shown significant support of both MWM and proprioceptive training, but there are still significant gaps in the literature. Most of the studies are performed to integrate these interventions with other modalities, which not only hides its individual effect but also is not representative of its pure effect (Hifza & Arif, 2023). The majority of evidences are based on short-term consequences, leaving no indication of long-term sustainability of benefits (Vrushali, 2019). Direct comparisons of the manual and sensorimotor methods in structured rehabilitation programs are few and have irregular results (Shaikh & Nabi, 2004; Aliyah & Usman, 2023).

The current study directly contrasts the efficacy of Mulligan Mobilization with Movement and proprioceptive exercises on pain, functional performance, and balance in people with mild to moderate KOA. These interventions are likely to be more clearly defined and their specific contributions to the overall effectiveness of the conservative treatment approach in the case of KOA patients can be explained by means of isolating them in the context of a controlled rehabilitation model and offering clinicians with practical evidence to achieve this objective.

Methodology

Study Design and Setting

This randomized controlled trial (RCT) was designed to investigate the effectiveness of such three treatments on knee osteoarthritis (KOA): Mulligan Mobilization Technique (MMT), Proprioceptive Exercises (PE), and Traditional Physical Therapy (Control). The research was centered on the variation of the level of pain and functional status of the persons in one of the three groups. The process of data collection occurred in the Physiotherapy Out-Patient Department of the National healthcare Centre in Karachi, Pakistan, in the interval of March 27, 2025, to June 13, 2025.

Sample Size Calculation

G*Power software (version 3.1) was used to calculate the number of needed participants, and it was based on the repeated measures ANOVA in order to identify the differences between groups and over time. The calculation of the total sample size (f = 0.25, significance = 0.05, and the statistical power = 80) indicated the necessity to include 60 participants in the study. These respondents were randomly split into three equal groups (n = 20 each):

• Group A: Proprioceptive Exercise Group (PEG)

• Group B: Mulligan Mobilization Technique (MMT)

• Group C: Traditional Physical Therapy (Control)

Participants

Subjects and Recruitment

Adults aged 40 and older with mild to moderate KOA (based on Kellgren–Lawrence grades 2–3) were recruited from physiotherapy clinics using referral systems. A trained physiotherapist screened participants to confirm they met inclusion criteria and obtained written consent before conducting initial assessments.

Inclusion Criteria

• Age 40 or older

• Clinical diagnosis of KOA with KL grades 2–3

• Ability to walk at least 50 feet without using a walking aid

Exclusion Criteria

• KL grade less than 2 or greater than 3

• History of knee surgery or joint replacement

• Received corticosteroid injections in the knee within the last 6 months

• Any neurological or orthopedic issues affecting the lower limbs

• Autoimmune diseases, mental health conditions, or other disorders impacting balance

Randomization and Blinding Procedures

An independent researcher who was not involved in recruitment or treatment carried out the randomization and prepared the blinding protocol. Group allocation was concealed using sealed opaque envelopes (lucky draw method) until participants were assigned. Outcome assessors and the statistician were blinded to group assignments, and participants were instructed not to reveal their group to reduce bias.

Interventions

Interventions were given to all the three groups at three sessions per week over 10 weeks. Each session took about 40-45 minutes, comprising of warm up, intervention, and rest. Interventions were done by experienced physical therapists who had at least 5 years of clinical experience in musculoskeletal rehabilitation. Therapists who provided Mulligan Mobilization were also trained and certified in the Mulligan Concept.

Group A: Proprioceptive Exercise Group (PEG)

Participants first received pulsed ultrasound therapy, followed by a structured proprioceptive exercise program for a total of 30 sessions.

Pulsed Ultrasound Protocol:

• Frequency: 1 MHz

• Intensity: 2 W/cm^2

• Duty Cycle: 1:4

• Duration: 5 minutes

• Application: Circular motion using a 5 cm applicator on the inner and outer parts of the knee.

Exercise Components:

1. One-Leg Balance; Stand on one leg for 60 seconds, rest for 10–20 seconds, and repeat three times for each leg
2. Blind One-Leg Balance; Same as above, but with eyes closed. Three repetitions were performed for each leg with 10–20 seconds rest between trials.
3. Toe Walking; Walk 20 meters on toes in straight and outward directions. The exercise was performed for two repetitions, with 30 seconds rest between repetitions.
4. Heel Walking; Walk 20 meters on heels in straight, inward, and outward direction. Two repetitions were performed for each direction with 30 seconds rest between sets.
5. Cross-Body Leg Swings; 15 reps per leg using wall support. One set was performed initially and progressed to two sets from week 4 onward.

Group B: Mulligan Mobilization Technique (MMT)

Participants received the same ultrasound treatment followed by Mulligan Mobilization with Movement (MWM) three times per week for 10 weeks. Each session lasted approximately 25–30 minutes, excluding ultrasound.

Techniques Applied (2 sets of 10 reps, with 30–60 seconds rest between sets):

1. Medial Glide; A participant was in prone position and a mobilization belt was placed on the proximal tibia. There was a continuous medial glide with the participant flexing the knee actively.
2. Lateral Glide; This glide was applied to a sustained lateral glide with mobilization belt and the participant actively flexed and extended his knee.
3. Rotational Glide; A supine position was taken with the participant, and the tibia was gently rotated inwards. Active knee flexion was done with a sustained glide and slight overpressure was only applied within pain free limits.

Group C: Traditional Physical Therapy (Control)

Participants in this group received therapeutic ultrasound followed by conventional physical therapy exercises, with a session duration of approximately 30 minutes, excluding ultrasound.

Stretching Exercises:

- Calf muscles (gastrocnemius and soleus):

30-second hold × 3 repetitions, performed 3–5 days per week

- Hamstring stretch:

30-second hold × 3 repetitions, performed 3–5 days per week

- Strengthening Exercises:

Quadriceps strengthening exercises (e.g., isometric contractions and active knee extension)

2–3 sets of 10 repetitions, with 60 seconds rest between sets

Closed Kinetic Chain Exercises:

- Leg press
- Partial squats
- Step-up exercises

Each closed kinetic chain exercise was performed for 2 sets of 10 repetitions, with progression in resistance or step height introduced gradually after week 4 based on participant tolerance.

Outcome Measures

1. Numeric Pain Rating Scale (NPRS): The individuals were asked to rate their pain using a scale of 0 (never been in pain) to 10 (the worst pain ever). This scale is characterized by a high level of reliability, test-retest correlation was 0.73 to 0.78 (Euasobhon et al., 2022).

2. Knee Injury and Osteoarthritis Outcome Score (KOOS): This measure assesses five elements, which include symptoms, pain, daily activities, sports/recreation and quality of life with the knee. All the sections are based on Likert scale and transformed to a score between 0 and 100 with 0 being severe problems. The instrument is very robust, and the score is between 0.85 and 0.97(Roos, 2024; Phatama et al., 2021).

Statistical Analysis

The SPSS version 26 was used in analysis of data. Results were compared over time and in the three groups using repeated-measures ANOVA. Pairwise comparisons Pairwise comparisons were adjusted with the Holm Bonferonni method. Partial eta squared (η2) of ANOVA and Cohen d of group comparisons were used to determine effect sizes. The findings were presented in the form of mean differences with confidence intervals (CI). Normality as well as the assumption of sphericity were checked. Linear mixed models were used in case assumptions were not fulfilled. The p-value of below 0.05 was taken as significant.

Results

A total of sixty participants were recruited into the study and randomly assigned to either of the three treatment groups and completed the entire trial protocol. Everyone was incorporated into the analysis. Two major outcomes have been reported: pain intensity, measured with the help of the Numeric Pain Rating Scale (NPRS), and knee function, measured with the help of the Total Knee Injury and Osteoarthritis Outcome Score (KOOS).

Baseline Characteristics: Table 1 summarizes baseline demographic and clinical characteristics. The average age of the respondents was 55.35 ± 6.20 years with the age range of 42 to 67 years and 65% were females. Participants whose right knee was involved (53.3%) were slightly higher than the left knee (46.7%. About 36.7 percent of the participants gave symptoms that took more than three years. The average body mass index (BMI) was 29.22, with the standard of 5.27 kg/m2, which means that most of the study participants were overweight. At baseline, no statistically significant differences were found among groups, which confirms that the randomization process was practical and the predisposition to selection bias was reduced.

Table 1. Baseline Characteristics of Participants (N = 60)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean ± SD (Range)	55.35 ± 6.20 (42–67)
Gender	Male	21 (35.0%)
	Female	39 (65.0%)
Affected Knee Joint	Right	32 (53.3%)

	Left	28 (46.7%)
Duration of Pain	< 1 year	9 (15.0%)
	1–3 years	20 (33.3%)
	> 3 years	22 (36.7%)
	4 years	6 (10.0%)
	5 years	3 (5.0%)
Body Mass Index (BMI)	Mean ± SD (Range)	29.22 ± 5.27 (20.00–39.00)

Pain Intensity (NPRS Results): Table 2 and Figure 1 show the changes of the pain level in time and between groups. Mean NPRS scores were similar in all three groups at baseline (around 6.5), which means that there were no differences in the level of pain at baseline. The level of pain reduced significantly at the end of the intervention period (10 weeks) in all groups ($p < 0.001$). Nonetheless, the magnitude of improvement was lower in the control group than in the experimental groups, with a significant Time x Group interaction (η^2=0.550).

Figure 1. Group comparison NPRS over time

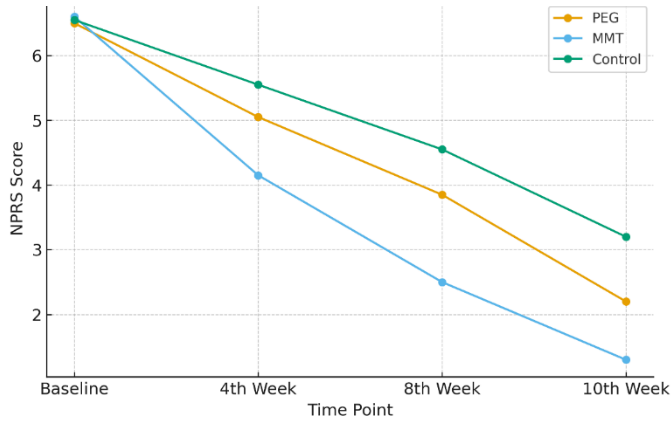


Table 2. Comparison of Numeric Pain Rating Scale (NPRS) Scores Across Groups

Time Point	PEG (n=20) M±SD	MMT (n=20) M±SD	CG (n=20) M±SD	Mean Difference (95% CI)	p-value	Effect Size (η^2)
Baseline	6.50 ± 0.688	6.60 ± 0.503	6.55 ± 0.510	Non-significant differences	0.101–0.439	—
4th Week	5.05 ± 0.605	4.15 ± 0.366	5.55 ± 0.510	MMT vs PEG: −0.90 (−1.22,−0.58) MMT vs CG: −1.40 (−1.68,−1.11) PEG vs CG: −0.50 (−0.77,−0.23)	<0.001	0.550
8th Week	3.85 ± 0.587	2.50 ± 0.688	4.55 ± 0.510	MMT vs PEG: −1.35 (−1.68,−1.02) MMT vs CG: −2.05 (−2.39,−1.71) PEG vs CG: −0.70 (−0.97,−0.43)	<0.001	0.550
10th Week	2.20 ± 0.523	1.30 ± 0.470	3.20 ± 0.410	MMT vs PEG: −0.90 (−1.13,−0.67) MMT vs CG: −1.90 (−2.12,−1.68) PEG vs CG: −1.00 (−1.22,−0.78)	<0.001	0.550
Overall Mean	4.40 ± 0.097	3.64 ± 0.097	4.96 ± 0.097	MMT vs PEG: −0.76 (−1.04,−0.49) MMT vs CG: −1.33 (−1.60,−1.05)	<0.001	0.624

The participants of MMT group showed the most stable and significant improvement of the pain intensity. Week 4, the average NPRS scores had lower to 4.15 in the MMT group, 5.05 in the proprioceptive exercise group (PEG), and 5.55 in the control group. During Week 8, the pain scores reduced further to 2.50 in the MMT group because the PEG and control groups reported mean scores of 3.85 and 4.55, respectively. In the end of evaluation (Week 10), MMT group scored the least in pain (mean 1.30), then PEG, then the control (3.20).

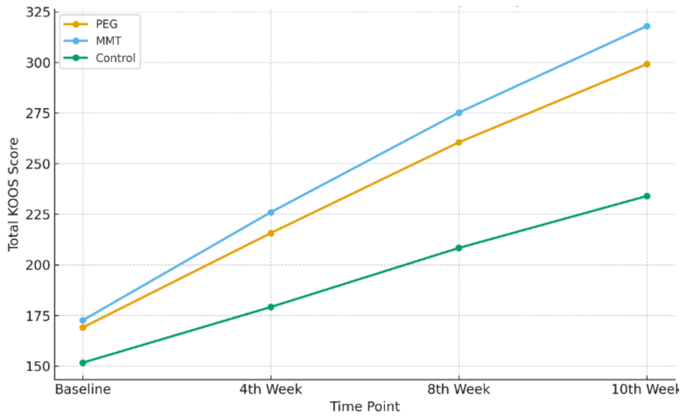
Comparisons between groups showed that MMT led to a much larger decreasing of pain as compared to PEG and control at all follow-up periods ($p < 0.001$). The total mean of NPRS during the intervention period also supported the benefit of MMT (mean 3.64) over PEG (4.40) and control (4.96). Table 4 revealed that pain reduction in the MMT group was significantly increase than in the PEG group (mean difference =-0.76; 95%CI= -1.04-0.49) and the control group (mean difference= -1.33; 95%CI= -1.60-1.05) showing larger and sustained analgesic effect of MMT.

Knee Function (KOOS Total Score Results): Table 3 and Figure 2 provide changes in knee functioning with time. There were no significant differences in baseline KOOS scores in the MMT and PEG groups (around 169-172) compared to the control group (151.65) but this was not significantly different. There were large improvements in the knee functioning with time ($p < 0.001$); although the extent of improvements was significant, as reflected by a large Time × Group interaction ($\eta2 = 0.682$).

Table 3. Comparison of Total KOOS Scores Across Groups

Time Point	PEG (n=20) M±SD	MMT (n=20) M±SD	CG (n=20) M±SD	Mean Difference (95% CI)	p-value	Effect Size (η^2)
Baseline	169.05 ± 41.69	172.60 ± 42.61	151.65 ± 22.18	Non-significant differences	0.018–0.130	—
4th Week	215.70 ± 38.08	226.00 ± 31.41	179.15 ± 20.67	MMT vs PEG: +10.30 MMT vs CG: +46.85 PEG vs CG: +36.55	<0.001	0.682
8th Week	260.55 ± 36.46	275.25 ± 27.19	208.35 ± 19.97	MMT vs PEG: +14.70 MMT vs CG: +66.90 PEG vs CG: +52.20	<0.001	0.682
10th Week	299.20 ± 34.67	318.00 ± 25.42	234.00 ± 20.11	MMT vs PEG: +18.80 MMT vs CG: +84.00 PEG vs CG: +65.20	<0.001	0.682
Overall Mean (EMM)	249.88	272.46	193.88	MMT vs PEG: −11.84 (NS) MMT vs CG: +54.67 PEG vs CG: +42.84	<0.001	0.387

Figure 2. Group comparison KOOS Total Score over time



The MMT group had the highest increases in knee functioning, in other hand PEG group and the control group had less increases. By Week 4, the KOOS scores raise to 226.00 in MMT group, 215.70 in PEG group, and 179.15 in control group. Week 10 showed further improvement in functional outcomes to a point of 318.00 in the MMT group, 299.20 in the PEG group, and 234.00 in the control group.

Pairs comparisons showed that MMT resulted in significant increased functional improvement in comparison with PEG and control at all follow-up points ($p < 0.001$). PEG group also exhibited improve functional results as compared to the control group. As the overall KOOS scores, the maximum functional results were duly noted in the MMT group (272.46) then PEG (249.88), and the few results in the control group (193.88). As shown in Table 4, the functional improvement was 54.67 points increase in MMT than in control, whilst PEG was showing an improvement of 42.84 points higher than in control. The MMT and PEG difference were not significantly different, which means that the variability of the two active interventions is similar.

The overall effect of the intervention on knee function was large and statistically significant, particularly in the MMT group ($\eta^2 = 0.387$).

Table 4 summarizes the comparisons of both the pain and the function. The effect size for pain reduction ($\eta^2 = 0.624$) and functional improvement ($\eta^2 = 0.387$) indicates that MMT produced clinically meaningful and sustained benefits compared with proprioceptive exercises and traditional physical therapy.

Table 4. Pairwise and Overall Group Comparisons for KOOS and NPRS Outcomes

Outcome	Group Comparison	Mean Difference	95% CI (Lower–Upper)	p-value	Overall F-value (df)	Effect Size (η^2)
KOOS Total Score	PEG vs. MMT	−11.84	−35.50 to +11.82	0.667	17.99 (2, 57)	0.387
	PEG vs. CG	+42.84	+19.18 to +66.50	p < 0.001		
	MMT vs. CG	+54.67	+31.02 to +78.33	p < 0.001		
	Overall Between-Group Comparison	—	—	p < 0.001	17.99 (2, 57)	0.387
NPRS Score	PEG vs. MMT	+0.762	0.489 to 1.036	p < 0.001	47.37 (2, 57)	0.624
	PEG vs. CG	−0.562	−0.836 to −0.289	p < 0.001		
	MMT vs. CG	−1.325	−1.599 to −1.051	p < 0.001		
	Overall Between-Group Comparison	—	—	p < 0.001	47.37 (2, 57)	0.624

Discussion

The current randomized controlled trial was a comparison of effect of Mulligan Mobilization Technique (MMT), proprioceptive exercises (PE) and Traditional physiotherapy in patients with knee osteoarthritis (KOA). Even though all interventions were statistically significant in terms of changes in pain and knee function, the changes were different in magnitude across groups. The MMT group showed improvement in pain reduction and increase in functional outcomes than the PE and control groups. These results show that there is a relationship between the intervention type and the clinical outcomes as opposed to the direct causal relationship.

The perceived advantages of traditional physiotherapy in the control group are in line with the available data about the importance of exercise-based physiotherapy as a viable, non-pharmacological method of KOA management. Randomized trials and systematic reviews performed in the past have shown that strengthening and aerobic exercise may result in the modest-to-moderate improvement of pain and function (Fransen et al., 2015; Brosseau et al., 2017). The changes that were detected in the control group can thus be attributed probably to established therapeutic effects of exercise and not exactly intervention-related mechanisms.

The improvement between the PE and the control group was more significant, which can be supported by the contributions of the proprioceptive training to sensorimotor control. It has been already reported that proprioceptive deficits are widespread in KOA, and they correlate with compromised balance and functional limitations (Kulkarni et al., 2019; Wang et al., 2021). Proprioceptive training was found to enhance the sense of joint position and postural stability, which could be associated with functional improvement (Jeong et al., 2019; Sheikhhoseini et al., 2023). Nonetheless, it is still yet to be established how far these improvements can be associated with structural or biomechanical changes in the long-term and none of the current findings can be used to establish causality.

The fact that the MMT group has shown higher improvements could have been due to a mixture of the biomechanical and neurophysiological factors. The positional fault theory, as formulated by Mulligan, is mainly a theoretical approach, according to which pain and movement limitation could be caused by minor joint dysplasia, which is fixed through pain-free mobilization during active motion (Hing et al., 2015). Although this model offers a conceptual framework, there is limited direct empirical evidence to support the argument that positional faults are the major mechanism.

Conversely, some of the suggested mechanisms behind MMT can be backed using empirical data. Mobilization techniques and other forms manual therapy intervention have been demonstrated to have an effect on central pain modulation by reducing nociceptive input, and modifying spinal and supraspinal processing (Bhagat et al., 2020; Elbasti and Yentur, 2025). Neurophysiological evidence indicates that mobilization methods could stimulate descending inhibitory processes and this could be one of the reasons of pain intensity reduction realized. Also, it has been suggested that mechanoreceptor stimulation at the time of joint mobilization is linked with increased proprioceptive acuity and neuromuscular control, but it has not been demonstrated to date that Mulligan techniques have this effect (Subramanian and Rajesh, 2021; Mostamand et al., 2023).

The motor learning and the confidence in movements may also be promoted through the active movement component of Mobilization with Movement. The theoretical models of motor control support this hypothesis and empirical results confirm the ability of active and painless movement to decrease fear avoidance and enhance functional performance (Aman et al., 2015; May et al., 2015). Nevertheless, psychological or neurocognitive outcomes were not directly evaluated in the current study and thus such interpretations must be treated as a speculation.

Clinically, the results indicate that the three interventions are not only useful but MMT can be linked to greater short-term effects on pain and functions. These should not be perceived as evidence of the intervention in favor or causation. Possible personal patient attributes, pre-test impairments and compliance may also have played a role in the outcome and were not formally considered as effect modifiers. Further research that includes biomechanical tests, neurophysiological tests, and more extensive follow-ups is needed to explain causal relationships and show how the identified benefits would be sustained.

Strengths and Limitations

The strengths of this research were that it was based on the randomized controlled design, well-validated outcome measures (NPRS and KOOS), and direct comparisons of two active treatments to conventional physiotherapy. The reason is that the repeated measurements were carried out during 10 weeks, which enabled the researchers to monitor short- and medium-term results.

Nevertheless, there were also limitations of the study. It was done in one center that could restrict the generalizability of the findings. In addition, participants and therapists could not be blinded and this could have generated performance bias. The participants were not assessed on long-term effects, and there were no objective biomechanical and proprioception tests, and the duration was 10 weeks. As well, the enrollees were not categorized according to such factors as the severity of X-rays or their psychological condition, which might affect the way they reacted to treatment.

Future Directions

Major multi-centres studies with extended follow-ups are required to know the duration of the benefits of MMT and its cost-effectiveness. Possible combined effects of MMT should also be tested as a future study should determine the effects of MMT when used in combination with proprioceptive or strengthening exercises. The objective tests of proprioception, joint loading, and balance would also be worthwhile to implement, as well as to develop specific programs to determine which of the patients works best with each treatment.

Conclusions

It was found that even though both traditional physiotherapy and proprioceptive exercises will be useful, Mulligan Mobilization with Movement provides the most predictable and quickest pain and function enhancement among KOA patients. Proprioceptive training is not only a useful addition to the typical physiotherapy, but it is also well-rounded and so it is a part of a comprehensive KOA rehab program. These results indicate the significance of a patient-based integrated rehabilitation process, and MMT is a particularly useful solution.

Ethical Approval & Clinical Trial Registration

Ethical approval was obtained from the Institutional Review Board (Ref. No. LUC/MKT/IND/SP/03/327. The main study clinical trial has already been registered at the PRS clinical trial registry USA (ID: NCT06971016)

Conflict of Interest

Authors declare no conflict of interest.

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