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Mulligan Mobilization Technique and Proprioceptive Exercises in Knee Osteoarthritis Rehabilitation: A Scoping Review

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ABSTRACT

***Background**: Knee osteoarthritis (KOA) is a leading cause of chronic pain and disability, and growing interest has emerged in manual therapy and sensorimotor training as adjuncts to standard physiotherapy. Mulligan Mobilization with Movement (MWM/MMT) and proprioceptive training target complementary biomechanical and neuromuscular deficits, yet evidence regarding their individual and combined effects remains fragmented. **Objective**: To map and synthesize available research on the application, outcomes, and limitations of MWM/MMT and proprioceptive training in adults with KOA across conservative rehabilitation settings. **Methods:** A scoping review was conducted following the Arksey–O'Malley framework and PRISMA-ScR guidelines. Searches of PubMed, MEDLINE, PEDro, CINAHL, Scopus, Google Scholar, and ScienceDirect (2014–March 2025) identified randomized trials, controlled studies, systematic reviews, meta-analyses, guidelines, and protocols. Two reviewers independently screened and charted data, with narrative thematic synthesis used to organize findings. **Results**: Forty-three studies met inclusion criteria. Both MWM/MMT and proprioceptive training demonstrated consistent short-term improvements in pain, physical function, proprioceptive acuity, balance, and range of motion. Comparative trials showed similar effectiveness to other manual therapies and combined or multimodal interventions often produced additive benefits. Evidence gaps included heterogeneous protocols, small samples, short follow-ups, and limited evaluation of combined approaches. **Conclusion**: MWM/MMT and proprioceptive training are promising adjuncts to physiotherapy for KOA, but high-quality long-term trials are urgently needed.*

Keywords
Knee osteoarthritis; Mulligan mobilization; Proprioceptive training; Manual therapy; Rehabilitation

INTRODUCTION

Knee osteoarthritis (KOA) is one of the leading causes of chronic pain, functional limitation, and loss of independence worldwide. Its burden is amplified by population ageing, rising obesity, and sedentary lifestyles, which collectively increase the prevalence and progression of degenerative joint disease and place sustained pressure on health and social care systems (1,2). While pharmacological agents and surgical procedures have an established role in advanced disease, contemporary clinical practice guidelines emphasize non-pharmacological strategies—particularly structured exercise and manual therapy—as first-line interventions because of their safety, accessibility, and potential to delay or reduce the need for surgery (1,3,4). Within this conservative framework, interventions that can simultaneously reduce pain, restore joint mechanics, and enhance neuromuscular control are of particular interest to physiotherapists and rehabilitation teams.

Proprioceptive training has emerged as a key component of multimodal KOA rehabilitation because it targets joint position sense, sensorimotor control, and postural stability, all of which are compromised in degenerative knee conditions and contribute to abnormal loading, pain, and functional decline (5,6). Randomized trials have shown that targeted proprioceptive and balance exercises can improve lower-limb alignment, reduce surrogate markers of medial knee loading such as the knee adduction moment, and enhance muscle performance and functional capacity in patients with early to moderate KOA (11–14,35–37). Meta-analyses and systematic reviews support these findings, reporting significant benefits of proprioceptive training on pain, function, balance, and joint repositioning accuracy when added to or compared with conventional physiotherapy (5,6,15,22,33,41–43). However, protocols vary widely in terms of exercise type, intensity, supervision, duration, and use of adjunct technologies such as biofeedback platforms, and not all trials demonstrate robust or sustained improvements (16–18,24,44–48). This heterogeneity makes it difficult to identify optimal dosage, delivery models, and patient subgroups most likely to benefit.

Mulligan mobilization with movement (MWM), often grouped under Mulligan Mobilization Techniques (MMT), represents another widely used manual therapy approach in KOA that combines sustained accessory glides applied by the therapist with concurrent active movement by the patient (7,35). The technique is designed to correct perceived positional faults, normalize arthrokinematics, and leverage pain-free movement to achieve rapid gains in range of motion and symptom relief (7,35,40). Multiple randomized and controlled trials suggest that MWM can produce immediate

or short-term reductions in pain, improvements in joint range, better balance, and enhancements in functional status, both in clinic-based and community-based samples, including household women and older adults (7,8,19–22,25,26,31,34,36,39,47). Systematic reviews and meta-analyses focused on MWM and joint mobilization more broadly also conclude that these techniques are effective adjuncts to usual care in KOA, particularly for pain and disability outcomes (9,10,22,23,35,38,44,45). At the same time, comparative studies often report similar overall benefits for Mulligan and other mobilization paradigms such as Maitland or McKenzie-based approaches, raising questions about whether outcomes are driven by Mulligan-specific mechanisms or by more general features common to manual therapy and active engagement (24,25,27–30,38).

Despite this growing body of work, several important uncertainties remain. First, most primary trials of proprioceptive training and MWM in KOA are small, single-centre studies with short follow-up, diverse outcome measures, and limited blinding, which constrains the strength and generalizability of conclusions (7,8,11–14,19–22,26,31,34,36,39,47,48). Second, existing systematic reviews tend to examine either proprioceptive training or Mulligan techniques in isolation, or to focus on generic joint mobilization or generic exercise, without mapping how these two complementary modalities are distributed across disease stages, clinical settings, and health-system contexts (5,6,9,10,22,23,33,38,41–43). Third, although both interventions target distinct but interrelated aspects of KOA pathophysiology—mechanical restriction and neuromuscular dysfunction—very few studies have directly evaluated combined protocols that integrate MWM with structured proprioceptive training, and evidence on long-term maintenance, stage-specific effects, and cost-effectiveness is sparse (19,30–32,36,42,48). These gaps make it difficult for clinicians and policymakers to determine how best to prioritize, sequence, or integrate MWM and proprioceptive exercises within comprehensive KOA rehabilitation pathways.

Given the heterogeneity of interventions, outcomes, comparators, and study designs, and the emerging but fragmented nature of this literature, a scoping approach is well suited to map the extent, characteristics, and gaps in evidence rather than to generate pooled effect estimates. This scoping review therefore aims to synthesize and organize current research on Mulligan Mobilization Techniques and proprioceptive training in the rehabilitation of adults with knee osteoarthritis. Specifically, it seeks to describe how these interventions have been applied across different KOA populations and settings; to summarize their reported effects on pain, function, balance, proprioception, and quality of life when used alone or in combination; and to identify key methodological limitations and research gaps that should inform the design of future randomized trials, implementation studies, and economic evaluations

MATERIALS AND METHODS

This review was designed and conducted as a scoping review to systematically map the existing evidence on the use of Mulligan Mobilization with Movement (MWM/MMT) and proprioceptive training in the rehabilitation of adults with knee osteoarthritis (KOA). The methodological approach followed the framework proposed by Arksey and O'Malley, with subsequent refinements by Levac and colleagues, and reporting was guided by the PRISMA-ScR checklist (1). A scoping review method was chosen because of the substantial heterogeneity in interventions, study designs, outcome measures, and populations, and because the primary aim was to map key concepts, summarize the range and nature of available evidence, and identify gaps for future research rather than to calculate pooled effect sizes in a meta-analysis.

A PCC (Population–Concept–Context) structure was used to frame the review question. The population of interest was adults diagnosed with KOA based on clinical or radiographic criteria. The central concepts were Mulligan Mobilization with Movement (MWM/MMT) and proprioceptive training used as therapeutic interventions. The context comprised conservative physiotherapy and rehabilitation settings, including clinic-based, community-based, outpatient, and exercise-therapy environments. On this basis, the review question was formulated as: "What is the extent, nature, and range of evidence describing the use, effects, and limitations of Mulligan Mobilization Techniques and proprioceptive training in adults with knee osteoarthritis across conservative rehabilitation settings?"

A comprehensive search strategy was implemented across seven electronic databases: PubMed, MEDLINE, PEDro, CINAHL, Scopus, Google Scholar, and ScienceDirect. The search covered the period from January 2014 to March 2025, thereby encompassing approximately a decade of contemporary research and allowing inclusion of recently published trials from 2025. Medical Subject Headings (MeSH) and free-text terms were combined using Boolean operators. Core terms included "Osteoarthritis, Knee," "Mulligan Mobilization with Movement," "Mobilization, Joint," "Mulligan Technique," "Proprioception," "Proprioceptive training," "Balance training," "Rehabilitation," and "Physical therapy modalities." An example search strategy for PubMed was: ("Osteoarthritis, Knee"[MeSH] OR knee osteoarthritis) AND ("Mulligan mobilization" OR MWM OR "mobilization with movement") AND (proprioception OR "proprioceptive training" OR "balance exercises"). To ensure completeness, the reference lists of relevant systematic reviews, meta-analyses, and clinical practice guidelines were also screened manually to identify additional eligible studies.

Eligibility criteria were defined a priori according to the PCC framework. Studies were included if they involved adults aged 18 years or older with clinically or radiographically confirmed KOA, and if they evaluated Mulligan Mobilization with Movement, proprioceptive training, or combined or comparative interventions involving these methods. Eligible study designs comprised randomized controlled trials, controlled clinical trials, quasi-experimental studies, systematic reviews, meta-analyses, clinical practice guidelines, and study protocols directly relevant to KOA rehabilitation. Only peer-reviewed, full-text articles published in English between 2014 and March 2025 were considered. Exclusion criteria encompassed case reports, editorials, letters, and conference abstracts without full text, as well as non-English publications, studies exclusively examining surgical techniques, and studies on non-KOA populations unless they were clearly and directly relevant to understanding theoretical mechanisms of proprioceptive or Mulligan-based interventions.

All search results were imported into EndNote for management and duplicate removal. Study selection was conducted in two stages by two independent reviewers. In the first stage, titles and abstracts were screened against the eligibility criteria. In the second stage, full texts of potentially relevant articles were retrieved and assessed for inclusion. Any disagreements at either stage were resolved through discussion and, when necessary, consultation with a third reviewer. The search initially identified 1,214 records. After removal of 312 duplicates, 902 records remained for title and abstract screening. Of these, 830 were excluded as clearly irrelevant to the PCC framework. Seventy-two full-text articles were then assessed for eligibility, and 43 studies met the inclusion criteria and were retained for data charting. This selection process is summarized in the PRISMA-ScR flow diagram (Figure 1).

Data from the included studies were extracted using a predefined data-charting template that was developed in advance, piloted on five randomly selected studies, and refined before full application. For each study, the charting form captured the author and year of publication, study design,

characteristics of the population, details of the intervention (classified as MWM/MMT, proprioceptive training, or combined), the comparator or control condition, outcome measures (including pain, physical function, balance, proprioception, range of motion, and quality of life), the direction and summary of the main findings, key methodological features, and any explicitly noted or inferable gaps relevant to the scoping aims. Two reviewers independently charted the data, and discrepancies were resolved by consensus.

Given the diversity of methodologies, interventions, and outcome domains, a narrative thematic synthesis approach was adopted. Rather than pooling effect sizes, studies were grouped into predefined analytic categories to facilitate comparison and mapping of the evidence base. These categories included primary randomized and controlled studies of proprioceptive training in KOA, systematic reviews and meta-analyses on proprioceptive interventions, primary trials of Mulligan Mobilization with Movement, systematic reviews and meta-analyses of Mulligan or related joint mobilization methods, comparative studies contrasting Mulligan with other manual or exercise-based approaches such as Maitland or McKenzie, combined or multimodal interventions integrating MWM and exercise (including proprioceptive training), and clinical practice guidelines or conceptual sources addressing conservative KOA rehabilitation. Within and across these groups, patterns in reported outcomes, populations, intervention protocols, and follow-up durations were examined to identify areas of consistency, uncertainty, and gaps in literature.

In keeping with the objectives and conventions of scoping review methodology, no formal risk-of-bias assessment or quantitative grading of evidence quality was undertaken. The intent was to provide a broad and structured overview of the extent and nature of existing evidence on Mulligan Mobilization Techniques and proprioceptive training in KOA, rather than to generate definitive estimates of treatment efficacy or to support guideline-level recommendations (1).

RESULTS

This scoping review included 43 records published between 2014 and March 2025. Of these, 29 were primary experimental or quasi-experimental studies (mostly randomized controlled or controlled clinical trials), 11 were systematic reviews or meta-analyses, one was a clinical practice guideline, and two were randomized trial protocols (Table I). The majority of primary studies directly involved adults with knee osteoarthritis, while a small number examined related conditions (e.g. periarthritis shoulder or broader proprioceptive training contexts) and were included to inform mechanistic and conceptual understanding (1,3,5,9,15,21–23,33,35,37,39,42,43). Across studies, KOA severity ranged from early or mild radiographic disease to moderate and severe stages, with some trials explicitly stratifying by radiological grade and others including mixed-stage cohorts.

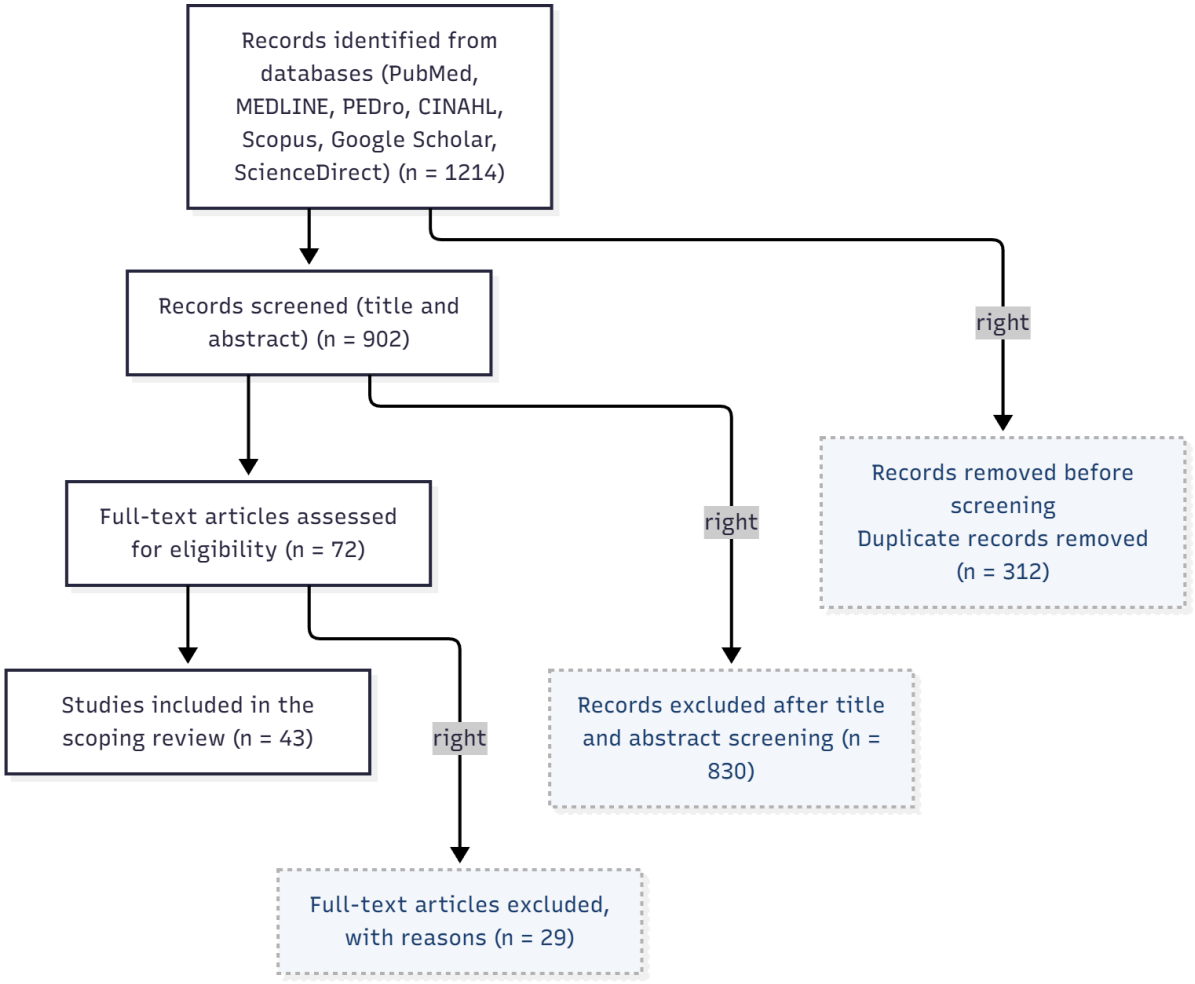

Figure 1 PRISMA-ScR Flowchart

Evidence on proprioceptive training in KOA came predominantly from randomized or controlled trials supplemented by several recent meta-analyses (5,6,11–18,24,32,34,40,41,42,48). Early trials demonstrated that circuit-based or balance-oriented proprioceptive programmes reduced knee pain and improved muscle function and joint position sense compared with conventional exercises or home programmes in patients with degenerative KOA (11,12,16,17). Subsequent work extended these findings to female-only samples and bilaterally affected patients, reporting

better balance, functional capacity, and muscle performance when proprioceptive elements were added to standard rehabilitation (13,14,36). In stage-stratified designs, benefits were observed across mild to more advanced radiographic grades, although effect sizes tended to be larger in early and moderate KOA than in severe disease, suggesting that responsiveness may decline with structural progression (8,13,14). Studies incorporating biofeedback platforms, such as Equiboard, reported greater gains in proprioceptive accuracy and associated reductions in pain and functional limitation than conventional programmes without feedback, indicating that mode of delivery and supervision may influence outcomes (18,32,40). Overall, most proprioceptive trials reported superior short-term improvements in pain, function, balance, or joint repositioning error in the intervention groups compared with usual care or strengthening alone, though a few studies found more modest or transient effects, particularly when programmes were of low intensity or limited duration (16,17,24,48).

These trial-level observations were reinforced by several systematic reviews and meta-analyses focused on proprioceptive or exercise-based training. Pooled analyses consistently showed that proprioceptive training, either as a stand-alone modality or embedded within multimodal exercise programmes, produces clinically relevant improvements in pain, physical function, balance, and knee repositioning sense compared with control conditions in KOA (5,6,15,22,33,41–43). Recent meta-analyses highlighted that interventions specifically targeting proprioceptive acuity yielded greater gains in joint repositioning accuracy and postural control than generic strengthening or range-of-motion exercises alone, supporting a targeted sensorimotor approach (15,22,33,43). At the same time, authors noted substantial heterogeneity in exercise content, supervision, intensity, frequency, and follow-up duration, and emphasised that long-term durability of effects and optimal programme parameters remain uncertain (5,6,15,22,41,42).

Evidence for Mulligan Mobilization with Movement (MWM/MMT) in KOA was similarly anchored in a cluster of randomized and controlled clinical trials spanning mild to moderate–severe disease (7,8,19–22,25,27,29–32,34–36,38,39,44–47). Multiple RCTs reported that adding MWM to conventional physiotherapy led to more pronounced short-term reductions in pain, greater increases in knee range of motion, and better functional scores on WOMAC or activity-based measures than exercise or usual care alone (7,19,21,27,31,38,39). Several studies documented immediate pain relief and mobility gains following a single or brief course of MWM sessions compared with control interventions, findings that were replicated in community-dwelling women and household females, suggesting applicability beyond strictly supervised clinic populations (2,7,20,21,25,31,47). Trials in moderate to severe KOA also showed improvements in static and dynamic balance, indicating that MWM may favourably influence postural control as well as pain and mobility even in more advanced disease, though follow-up durations were often short (8,25,36).

A number of comparative trials directly contrasted Mulligan techniques with other manual therapy or exercise approaches. Studies comparing MWM with Maitland mobilization or McKenzie-based exercises generally found that all active interventions improved pain, range of motion, and function, with Mulligan techniques sometimes associated with faster short-term pain relief or slightly greater functional gains, but without consistent evidence of clear long-term superiority (20,24,27,29,30,34,38). Trials examining different Mulligan glide directions (e.g. medial versus internal rotation) suggested that both variations were beneficial, and that technique selection might be tailored to individual patient response rather than guided by robust evidence of one glide being superior (34,45). Early pilot studies and smaller controlled trials reported modest but positive effects of MWM on pain, disability, and pressure-pain thresholds, supporting its feasibility and potential value but also underscoring the need for larger, methodologically rigorous trials (26,31,36,39,46).

Several studies explored combined or multimodal interventions, integrating Mulligan mobilization with other exercise components. Adding MWM to core or trunk stabilization exercises, or to conventional physiotherapy, generally yielded larger improvements in pain, function, and quality of life than exercise alone in short-term follow-up, suggesting additive or synergistic effects (4,19,30,31,32,38,42). Likewise, pairing MWM with dry needling in KOA resulted in greater reductions in pain and better gains in range of motion compared with dry needling alone, indicating that manual joint techniques may enhance the impact of soft-tissue or needling interventions (11,32). Proprioceptive training was also evaluated as part of combined packages that included strengthening or aquatic resistance training, with such multimodal programmes achieving better functional outcomes than standard care However, very few trials directly and explicitly examined the integration of Mulligan MWM with structured proprioceptive training as the main combined intervention, and evidence on optimal sequencing, dose, or interaction effects between these two modalities remains sparse.

The trial-level data were framed and contextualised by a set of systematic reviews, meta-analyses, and guidelines. Reviews focusing on Mulligan techniques or joint mobilization more broadly concluded that MWM is an effective adjunctive therapy for KOA, particularly for pain and disability outcomes, while also highlighting heterogeneity in protocols and limitations in sample size and trial quality (9,10,22,23,28,35,37,44,45). Systematic reviews of peripheral joint applications of MWM and of its effects on proprioception provided indirect support for its wider neuromuscular and functional benefits, though KOA-specific data were less abundant in these broader analyses (22,35,37,39). Proprioceptive and exercise-based reviews, as noted, reinforced the value of sensorimotor training within conservative KOA management (5,6,15,22,33,41–43). The Ottawa Panel and other clinical practice guidelines emphasized aerobic exercise, strengthening, and manual therapy as core components of non-pharmacological KOA care, positioning both exercise-based and mobilization strategies as key elements of comprehensive rehabilitation pathways (1,3,4,38). Collectively, these secondary and guideline sources support the integration of MWM and proprioceptive training as promising adjuncts to standard physiotherapy, while at the same time repeatedly calling for higher-quality, longer-term, and more standardized research to clarify their comparative effectiveness, stage-specific indications, and cost-effectiveness in diverse clinical settings.

Table I. Evidence Included in the Scoping Review

Study No.	Author (Year)	Title	Study Design	Purpose	Intervention	Comparator	Outcome Measures	Main Findings
1	Aman et al. (2015)	The effectiveness of proprioceptive training for improving motor function	Systematic review	Evaluate proprioceptive training across clinical conditions	Proprioceptive training	Various controls	Motor function, balance	Proprioceptive training improves motor function; supports its use in KOA contexts

Study No.	Author (Year)	Title	Study Design	Purpose	Intervention	Comparator	Outcome Measures	Main Findings
2	Bhagat et al. (2020)	Immediate effects of Mulligan's techniques on pain and mobility in KOA	Randomized controlled trial	Test immediate effects of MWM	Mulligan MWM	Conventional therapy	VAS pain, WOMAC, mobility tests	MWM produced immediate reductions in pain and mobility improvement
3	Brosseau et al. (2017)	Ottawa panel guidelines for KOA – Aerobic exercise	Clinical practice guideline	Provide KOA exercise recommendations	Aerobic exercise	Usual care	Pain, function, QoL	Aerobic exercise recommended; complements strengthening/manual therapy
4	Buke et al. (2024)	MWM + core stabilization in female KOA patients	RCT (single blind)	Compare combined vs core-only training	MWM + core stabilization	Core stabilization only	VAS, WOMAC	Combined program superior for pain and function
5	Chen et al. (2024)	Joint mobilization effects in KOA	Systematic review & meta-analysis	Quantify mobilization effects including MWM	Joint mobilization (incl. MWM)	Sham/usual care	Pain, ROM, function	Mobilization significantly improved pain and function
6	Cho et al. (2015)	Proprioceptive training and knee loading metrics	RCT	Evaluate alignment/loading changes	Proprioceptive training	Conventional exercises	Alignment, KAM, function	Improved alignment and reduced loading metrics
7	Elbasti & Yentür (2025)	Immediate effects of MWM ± taping in KOA	RCT	Evaluate acute effects	MWM ± taping	Usual care	VAS pain, WOMAC	Immediate pain and function improvement
8	Gayretli Atan et al. (2025)	Proprioceptive training by radiological stage	Controlled clinical study	Assess stage-specific effects	Proprioceptive training	Conventional therapy	Pain, function, balance	Benefits observed across KOA stages; magnitude varied by severity
9	Ghafoor et al. (2023)	Exercise vs MWM in household females with KOA	RCT	Compare MWM vs exercise	Mulligan MWM	Exercise therapy	VAS pain, ADL	MWM achieved greater short-term pain and ADL improvement
10	Gohil & Shukla (2020)	Biofeedback-assisted proprioceptive training	Controlled trial	Test biofeedback effects	Biofeedback proprioception training	Conventional rehab	Pain, function, proprioception	Biofeedback improved proprioception and pain/function
11	Habib et al. (2025)	Dry needling ± MWM two-leg rotation in KOA	RCT	Examine additive effects	Dry needling + MWM	Dry needling alone	VAS pain, ROM, dysfunction	Combined technique superior for pain and ROM
12	İnce et al. (2023)	Balance and proprioception exercises in female KOA	RCT	Assess balance/proprioception training	Balance + proprioceptive exercises	Conventional therapy	Pain, function, balance	Significant improvements in balance and function
13	Jadhav & Anap (2019)	Mulligan vs McKenzie exercises in KOA	RCT (single blind)	Compare MWM vs McKenzie	MWM	McKenzie exercises	Pain, ROM, function	Both effective; MWM produced faster short-term relief
14	Jain & Shinde (2025)	Aquatic resistance + proprioceptive training	Controlled trial	Evaluate multimodal training	Aquatic + balance + proprioception	Conventional therapy	Muscle performance, function	Multimodal program improved strength and function
15	Jeong et al. (2019)	Proprioceptive training in KOA: Meta-analysis	Systematic review & meta-analysis	Quantify effects	Proprioceptive training	Controls	Pain, function, balance	Significant improvements across outcomes
16	Ju et al. (2015)	Proprioceptive circuit exercise in KOA	RCT	Assess circuit exercises	Proprioceptive circuit training	Home/conventional program	Pain, muscle function	Reduced pain and improved muscle function
17	Kiran et al. (2018)	MWM vs Maitland mobilization	RCT	Compare two manual therapies	MWM + conventional therapy	Maitland + conventional	Pain, ROM, function	Both effective; MWM slightly superior
18	Kirthika et al. (2018)	Combined proprioceptive + conventional PT	Controlled pretest–posttest	Evaluate additive value	Proprioceptive + conventional PT	Conventional PT	Pain, function	Added proprioception improved outcomes
19	Kulkarni et al. (2019)	Proprioceptive exercises in KOA	Controlled trial	Assess proprioception/balance	Proprioceptive exercises	Conventional exercises	JPS, balance	Improvement seen; modest magnitude
20	Lalnunpuii et al. (2017)	MWM vs Maitland in female KOA	Double-blind RCT	Compare two mobilizations	MWM	Maitland mobilization	Pain, ROM, function	Comparable benefits; no clear superiority

Study No.	Author (Year)	Title	Study Design	Purpose	Intervention	Comparator	Outcome Measures	Main Findings
21	Li et al. (2022)	Maitland vs Mulligan mobilization	Systematic review & meta-analysis	Compare modalities	Mulligan mobilization	Maitland mobilization	Pain, ROM, function	Both effective; no consistent superiority
22	Lin et al. (2025)	Proprioceptive exercise in KOA	Systematic review & meta-analysis	Evaluate proprioceptive training	Proprioceptive exercise	Controls	Pain, function, proprioception	Improved proprioception and functional outcomes
23	Madhumita et al. (2024)	Mulligan techniques in shoulder periarthritis	Interventional study (non-KOA)	Examine Mulligan effects in shoulder	MWM	Conventional therapy	Pain, function	Improved outcomes; indirect KOA relevance
24	Moitra & Sharma (2016)	Proprioceptive training in early KOA	RCT	Assess early-stage KOA	Proprioceptive training	Home program	JPS, balance	Improvements present but small; dose dependent
25	Mostamand et al. (2023)	MWM in moderate–severe KOA	RCT	Evaluate MWM in advanced KOA	MWM	Conventional therapy	Static/dynamic balance, pain	Improved balance and pain
26	Nazir et al. (2020)	MWM + trunk stabilization (Protocol)	RCT protocol	Describe planned combined intervention	MWM + trunk stabilization	Isometric strengthening	Planned pain/function	Protocol suggests potential superiority
27	Prabhakar et al. (2020)	Proprioceptive training vs conventional exercise (Protocol)	RCT protocol	Planned proprioception comparison	Proprioceptive training	Conventional exercise	Postural sway	Protocol predicts reduced sway
28	Qureshi et al. (2023)	Meta-analysis of MWM in KOA	Systematic review & meta-analysis	Quantify short-term effects	MWM	Controls	Pain, function, emotional scores	Supports short-term benefits of MWM
29	Rangparia & Singh (2025)	McKenzie vs Mulligan	RCT	Compare two exercise approaches	MWM	McKenzie exercises	ROM, function	Similar outcomes; MWM faster pain relief
30	Rao et al. (2018)	Maitland vs MWM – immediate effects	Randomized crossover trial	Direct comparison	MWM	Maitland mobilization	Pain, ROM	Both effective; minor differences
31	Razek & Shenouda (2014)	MWM pilot study in KOA	Pilot RCT	Preliminary evaluation	MWM	Conventional therapy	Pain, disability, ROM	Modest but positive improvements
32	Richhariya et al. (2023)	Proprioception + core + PT	Controlled trial	Evaluate multimodal rehab	Proprioception + core + PT	Conventional PT	Pain, QoL	Greater improvements in pain and QoL
33	Sheikhhoseini et al. (2023)	Exercise training and JPS	Systematic review & meta-analysis	Assess repositioning sense	Exercise (incl. proprioception)	Controls	JPS	Exercise improves JPS accuracy
34	Solanki & Kage (2015)	Medial vs IR Mulligan glide	RCT	Compare two glides	Medial glide	Internal rotation glide	Pain, ROM, function	Both glides beneficial; patient-specific selection
35	Stathopoulos et al. (2019)	MWM across peripheral joints	Systematic review & meta-analysis	Evaluate peripheral joint MWM	MWM	Controls	Pain, ROM, function	Supports MWM effectiveness; heterogeneous data
36	Subbiah (2023)	MWM effects on PPT and function	Controlled trial	Examine sensory and functional effects	MWM	Conventional therapy	PPT, pain, function	Increased PPT and improved function
37	Subramanian & Rajesh (2021)	Mulligan mobilization & proprioception	Systematic review	Evaluate proprioceptive effects	MWM	Not applicable	JPS/proprioception	Suggests proprioception improves; evidence limited
38	Tabassum et al. (2024)	MWM + conventional PT	Controlled clinical study	Evaluate additive benefits	MWM + PT	PT alone	Pain, function	MWM + PT superior to PT alone
39	Ughreja & Shukla (2017)	MWM in KOA	Controlled trial	Examine MWM effects	MWM	Conventional therapy	Pain, function	Significant reductions in pain and improved function
40	Vamsidhar et al. (2017)	Proprioceptive + strengthening training	Controlled trial	Evaluate combined exercises	Proprioceptive + strengthening	Standard care	Pain, function	Combined training improved outcomes
41	Vishnupriya (2017)	Foam balance vs proprioceptive exercise	Comparative study (thesis)	Compare two balance strategies	Foam balance training	Proprioceptive exercise	Balance, function	Both improved balance; protocol-dependent variations
42	Wang et al. (2021)	Proprioceptive training in KOA	Systematic review & meta-analysis	Quantify efficacy	Proprioceptive training	Controls	Pain, function, balance	Significant benefits; supports integration in rehab
43	Weleslassie et al. (2021)	MWM for KOA – review of RCTs	Systematic review	Summarize RCTs on MWM	MWM	Various controls	Pain, disability	Supports MWM as adjunct therapy

DISCUSSION

This scoping review mapped and synthesized a decade of research on Mulligan Mobilization with Movement (MWM/MMT) and proprioceptive training in the conservative rehabilitation of knee osteoarthritis (KOA). Across 43 records, including randomized and controlled trials, systematic reviews, meta-analyses, guidelines, protocols, and a small number of conceptually relevant non-KOA studies, the overall pattern of evidence is cautiously supportive of both modalities as adjuncts to standard physiotherapy rather than as stand-alone replacements for established exercise and education programmes. The evidence base consistently suggests short-term improvements in pain, function, balance, and joint position sense when either MWM or targeted proprioceptive training is integrated into KOA rehabilitation, but it remains too heterogeneous and methodologically limited to support strong conclusions about long-term outcomes or clear superiority over alternative manual therapy or exercise strategies (5–7,9,10,15,19–23,28,33,35,37,41–43).

Proprioceptive training emerged as a particularly relevant strategy for addressing sensorimotor deficits that contribute to abnormal joint loading and functional decline in KOA. Randomized and controlled trials demonstrated that proprioceptive and balance-oriented circuits can reduce pain, improve muscle performance, and enhance joint position sense and postural stability compared with conventional exercise or home programmes alone (11–14,16–18,19,24,32,36,40,48). These benefits were observed across different radiological stages, with some evidence that patients with early to moderate KOA may experience larger functional gains than those with more advanced disease (8,13,14). Meta-analyses reinforced these findings, reporting pooled improvements in pain, function, balance, and knee repositioning accuracy when proprioceptive training is added to or compared with usual care (5,6,15,22,33,41–43). At the same time, effect sizes were not uniformly large, and several trials reported modest or transient benefits, particularly when interventions were brief, of low intensity, or delivered with limited supervision (16,17,24). Heterogeneity in exercise content, progression, frequency, and use of adjunct technologies such as biofeedback platforms complicates attempts to define an "optimal" proprioceptive protocol and suggests that individualization and adherence are likely to be critical determinants of outcome.

Evidence for Mulligan MWM/MMT in KOA showed a broadly similar pattern of promising but context-dependent benefits. Numerous randomized and controlled trials reported that the addition of MWM to conventional physiotherapy resulted in greater reductions in pain, larger improvements in range of motion, and better functional scores than exercise or usual care alone, often with clinically noticeable change observed immediately or within a small number of treatment sessions (7,19–22,25–27,29–32,34,36,38,39,44–47). These rapid analgesic and mobility effects were seen not only in outpatient clinic settings but also in community-dwelling and household female populations, supporting the feasibility of MWM in diverse contexts (2,7,9,20,21,31,47). In moderate–severe KOA, MWM was associated with improvements in static and dynamic balance as well as pain, indicating that even structurally advanced knees may respond favorably in the short term (8,25,36). Systematic reviews and meta-analyses focusing on MWM and broader joint mobilization strategies concluded that MWM is an effective adjunct for pain and disability reduction in KOA, while also underscoring limitations in trial quality and reporting (9,10,22,23,28,35,37,44,45).

However, the comparative evidence tempers any assumption that Mulligan techniques are uniquely superior to other manual therapies. Trials directly comparing MWM with Maitland mobilization or McKenzie-based interventions generally found that all active treatment arms improved pain, range of motion, and function, with only small and sometimes inconsistent advantages for MWM, typically in terms of faster short-term pain relief or slightly greater functional gains (20,24,27,29,30,34,38). Similarly, studies comparing different Mulligan glides suggested that both medial and internal rotation glides can be beneficial, implying that manual therapy effects may be driven at least partly by shared mechanisms such as graded movement, therapist–patient interaction, and active participation rather than by a single specific technique (34,45). These findings align with wider discussions in the manual therapy literature about non-specific effects and reinforce the need for well-designed, adequately powered head-to-head trials if claims of technique-specific superiority are to be substantiated.

A key conceptual strength of this review is its concurrent consideration of proprioceptive training and MWM within a unified framework of conservative KOA care. Proprioceptive interventions target neuromuscular control, joint position sense, and balance, whereas MWM is designed to restore more normal arthrokinematics and reduce pain during movement (7,35,40). In theory, these modalities should be complementary: manual mobilization may create a "window of opportunity" by reducing pain and stiffness, while proprioceptive training may help consolidate gains in movement quality and load distribution. Indeed, several multimodal studies showed that combining MWM with core or trunk stabilization, conventional physiotherapy, or dry needling produced better short-term improvements in pain, function, and quality of life than single-modality programs (4,11,19,30–32,38,42). Similarly, packages integrating proprioceptive and strengthening exercises, or aquatic resistance with balance and proprioception components, tended to outperform standard care (14,18,32,36,40,48). Yet, despite this suggestive pattern, very few trials explicitly and systematically evaluated protocols that deliberately integrate MWM and structured proprioceptive training as the central combined intervention. As a result, the optimal sequencing, dosing, and interaction effects between these two approaches remain largely undefined.

From a scoping perspective, the mapped evidence highlights several important gaps. First, the majority of primary studies were small, single-centre trials with short follow-up periods, often limited to immediate or short-term outcomes. This constrains the ability to draw conclusions about the sustainability of benefits, the prevention of functional decline, or the impact on time to surgery. Second, there was substantial heterogeneity in patient populations (including variation in age, sex distribution, radiographic severity, and comorbidity profiles), intervention content and progression, comparator conditions, and outcome measures. Pain was typically assessed with VAS or similar scales and function with WOMAC or task-based tests, but balance, proprioception, and quality of life were operationalized in multiple ways, limiting comparability across trials. Third, most studies did not systematically stratify outcomes by KOA stage, obesity, or other relevant clinical subgroups, leaving uncertainty about which patients are most likely to benefit from MWM, proprioceptive training, or their combination. Fourth, virtually no trial provided robust cost-effectiveness data, despite the importance of low-cost, scalable interventions in resource-constrained settings where access to surgery is limited.

The findings of this review should also be interpreted in light of its own methodological limitations. As a scoping review, the primary aim was to map the breadth and characteristics of the evidence rather than to conduct formal risk-of-bias assessment or produce pooled effect estimates. No quantitative quality grading was undertaken, and it is likely that some of the included trials suffer from risks of selection, performance, or detection bias, particularly given the inherent challenges of blinding in manual therapy and exercise research. The search was restricted to English-language publications and to peer-reviewed full texts, which may introduce language and publication bias and underrepresent data from non-indexed or regional journals. In addition, although an effort was made to distinguish KOA-specific trials from broader or non-KOA studies, some conceptual sources (e.g. peripheral joint MWM, shoulder periarthritis, or general proprioceptive training literature) were included to inform mechanisms and context rather than to provide direct clinical evidence in KOA, and their findings should be extrapolated with caution.

Despite these caveats, the scoping approach provides a useful integrative perspective on how MWM and proprioceptive training currently fit within conservative KOA management. For clinicians, the available evidence supports the use of both modalities as adjuncts to guideline-recommended interventions such as aerobic exercise, strengthening, weight management, and education (1,3,4,38). MWM appears particularly valuable for achieving rapid pain relief and mobility gains that may enhance patient engagement with longer-term exercise programmes, whereas proprioceptive training offers targeted improvements in balance, joint position sense, and functional stability that may help address sensorimotor deficits and reduce fall risk (5,6,11–15,22,33,41–43). For researchers and policymakers, the mapped gaps highlight priorities for future work: large, multicentre randomized trials with longer follow-up; explicit evaluation of combined MWM–proprioceptive protocols; stage-specific and phenotype-specific analyses; integration of objective biomechanical and sensorimotor measures alongside patient-reported outcomes; and rigorous economic evaluations, especially in low- and middle-income settings.

In summary, current evidence suggests that Mulligan Mobilization Techniques and proprioceptive training are promising, safe, and adaptable components of multimodal rehabilitation for knee osteoarthritis, offering consistent short-term improvements in pain, function, and sensorimotor outcomes when added to standard physiotherapy. However, variations in study quality, small sample sizes, short follow-up durations, and heterogeneous protocols limit the strength of inferences that can be drawn. Future research should focus on clarifying the long-term effectiveness, optimal implementation strategies, and cost-effectiveness of these interventions, with particular emphasis on combined approaches that may leverage the complementary mechanisms of manual mobilization and proprioceptive retraining to deliver more durable and clinically meaningful benefits.

CONCLUSION

This scoping review indicates that Mulligan Mobilization with Movement (MWM/MMT) and proprioceptive training are promising adjunctive strategies within conservative rehabilitation for knee osteoarthritis, consistently demonstrating short-term improvements in pain, range of motion, proprioceptive acuity, balance, and functional performance when integrated with standard physiotherapy. Evidence across randomized and controlled trials, systematic reviews, and multimodal intervention studies supports their applicability across varying KOA severity levels, though methodological heterogeneity, small sample sizes, inconsistent protocols, and limited long-term follow-up restrict the certainty and generalizability of these findings. Comparative studies reveal that while MWM may offer faster early analgesia, its advantages over other manual therapies are modest, and proprioceptive training outcomes vary depending on intensity, supervision, and delivery mode. Very few studies directly evaluate combined MWM–proprioceptive protocols, highlighting a critical research gap. Future investigations should prioritize adequately powered, multicenter trials with extended follow-up, standardized intervention parameters, biomechanical and neuromuscular outcome measures, subgroup analyses by KOA stage, and rigorous economic evaluations to confirm long-term efficacy, refine clinical decision-making, and guide incorporation of these interventions into evidence-based rehabilitation pathways.

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