

Effectiveness of Muscle Energy Technique and Neuromuscular Knee Strengthening Exercises in Patients with Knee Osteoarthritis: A Systematic Review

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Abstract: *Knee osteoarthritis (OA) is a progressive degenerative condition characterized by pain, reduced joint mobility, muscle weakness, and functional disability. The objective of this systematic review was to evaluate the effectiveness of non-surgical rehabilitation approaches for knee OA, including Muscle Energy Technique (MET), neuromuscular knee strengthening exercises, and physiotherapy-based interventions. A comprehensive literature search was conducted across PubMed, PEDro, Google Scholar, ResearchGate, and the Cochrane Library, following PRISMA guidelines. Of the 98 studies identified, 74 were excluded due to duplication, inaccessibility, or mismatch with eligibility criteria. Twenty-four full-text articles were screened, and six studies involving adults aged 40–75 years with Grade I–III knee OA met the inclusion criteria. The findings indicated that non-surgical interventions significantly reduced pain, improved knee range of motion, enhanced balance, proprioception, and functional outcomes. Combination therapies, such as neuromuscular strengthening exercises combined with MET, produced better results than single interventions. Muscle Energy Technique was consistently effective in reducing pain, improving hamstring flexibility, and increasing knee extension range of motion, with Post-Isometric Relaxation MET demonstrating superior results compared to Reciprocal Inhibition MET. Physiotherapy-based and individualized treatment approaches achieved greater functional improvement and pain reduction. Despite variations in study design and treatment duration, evidence supports non-surgical rehabilitation as a safe, effective, and cost-efficient first-line treatment for knee osteoarthritis. However, limited sample sizes and short follow-up durations highlight the need for further high-quality, long-term randomized controlled trials to validate these findings.*

Keywords: Knee Osteoarthritis, Muscle Energy Technique, Neuromuscular Training, Proprioception, Pain Reduction, Functional Mobility, Rehabilitation.

1. Introduction

Osteoarthritis (OA) is a prevalent degenerative joint disorder characterized by knee pain, swelling, stiffness, muscle weakness, and loss of joint function resulting from progressive cartilage degeneration¹. The prevalence of knee OA among older adults ranges from 30% to 45%, with females being more commonly affected than males². The knee joint is frequently involved due to its weight-bearing role and exposure to repetitive mechanical loading. Disease progression and severity vary among individuals but often result in long-term disability. Despite extensive research, the exact etiology and underlying mechanisms of OA remain unclear³.

Current management strategies for knee OA include surgical, non-surgical, pharmacological, and non-pharmacological interventions aimed at symptom relief and improving quality of life⁴. Muscle Energy Technique (MET) is an active manual therapy based on principles of autogenic and reciprocal inhibition. Post-Isometric Relaxation (PIR) and Post-Facilitation Stretch (PFS) are commonly used MET techniques targeting the hamstrings and quadriceps. PIR involves a brief submaximal isometric contraction followed by muscle relaxation and stretching, leading to reduced pain, increased range of motion, prevention of muscle spasm, and improved circulation and lymphatic

drainage¹². MET is widely used for managing muscle-related dysfunctions and enhancing overall muscle performance.

Neuromuscular Exercise (NEMEX) programs primarily aim to improve sensorimotor control and functional joint stabilization. These programs are designed to enhance postural control and functional performance in physically active middle-aged individuals with mild to moderate knee OA^{6, 7}.

The purpose of this systematic review was to evaluate the effectiveness of MET and neuromuscular knee strengthening exercises on pain reduction, knee range of motion, balance, proprioception, and functional mobility in individuals with knee OA, and to compare their outcomes with conventional physiotherapy approaches.

2. Literature Survey

Knee osteoarthritis (OA) is a prevalent degenerative joint disorder characterized by pain, reduced range of motion, muscle weakness, and functional limitations. Research indicates that non-surgical interventions such as neuromuscular knee strengthening exercises and Muscle Energy Technique (MET) play a central role in conservative management. Several randomized trials and systematic

reviews (Ganjave & Dabholkar, 2017; Khan & Rizvi, 2018; Kasani & Apparao, 2020; Sabharwal & Joshi, 2022; Ali et al., 2023; Tahir & Munir, 2024; Ashraf & Anwar, 2024; Komalasari & Handayani, 2024) have reported significant reductions in pain and improvements in functional outcomes, balance, proprioception, and knee range of motion following these treatments. MET appears particularly effective for reducing muscle tightness and improving knee extension (with Post-Isometric Relaxation outperforming Reciprocal Inhibition in some trials), while structured neuromuscular programs (NEMEX) consistently enhance dynamic stability, mobility, and activity performance. Many studies also demonstrate added benefit when MET is combined with conventional physiotherapy compared to physiotherapy alone.

However, most included studies report short-term benefits; small sample sizes, heterogeneous intervention protocols, and brief follow-up periods limit the ability to draw conclusions about long-term efficacy. Direct comparisons are further constrained by variability in outcome measures and moderate methodological quality across studies. Despite these limitations, conservative physiotherapy-based approaches are generally safe, non-invasive, and clinically beneficial for pain relief and functional restoration in knee OA. To strengthen the evidence base and determine optimal treatment combinations and dosing, future research should emphasize large-scale randomized controlled trials, standardized intervention protocols, and longer follow-up periods.

Problem Definition

Knee osteoarthritis (OA) is a progressive degenerative joint disorder characterized by pain, stiffness, reduced range of motion, muscle weakness, and functional limitations. It is highly prevalent in older adults and frequently leads to impaired mobility, reduced participation in daily activities, and decreased quality of life. Individuals with knee OA

often experience difficulty walking, climbing stairs, and performing routine functional tasks, which significantly affects their independence and overall well-being.

Although non-surgical rehabilitation approaches, including neuromuscular knee strengthening exercises and Muscle Energy Technique (MET), are widely used, there is no universally accepted protocol or consensus regarding their comparative effectiveness. Current studies demonstrate variable outcomes, short follow-up periods, and heterogeneity in treatment methods, limiting the ability to draw definitive conclusions regarding long-term efficacy.

Therefore, a systematic review is necessary to evaluate the effectiveness of MET and neuromuscular exercises in reducing pain, improving knee range of motion, enhancing balance and proprioception, and restoring functional performance in individuals with knee OA. This review aims to identify the most effective non-surgical interventions and highlight gaps in research to guide evidence-based clinical practice for knee osteoarthritis rehabilitation.

3. Methodology

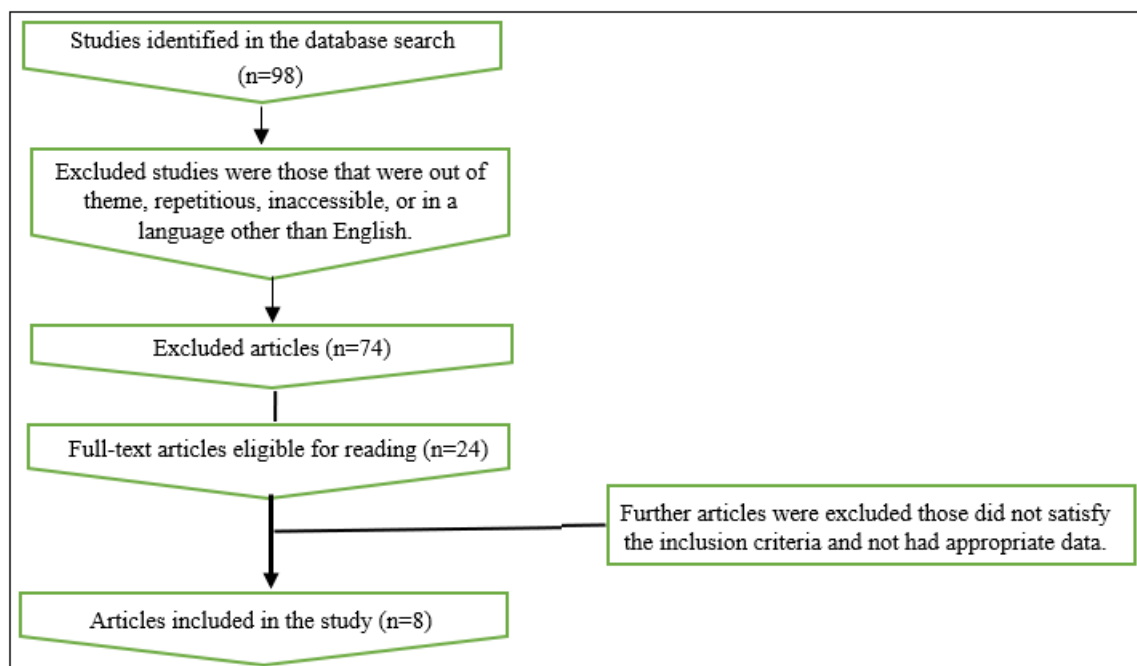
Study design

This systematic review was conducted based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines.

Selection of studies

A total of 98 articles were obtained as a result of search using the key words and the articles were filtered and sorted according to the inclusion and exclusion criteria. The article which met the inclusion criteria and 8 articles were included in the study.

Study selection strategy:



Inclusion criteria and Exclusion criteria

This review comprised systematic reviews, meta-analyses, and randomized controlled trials on the non-surgical treatment of Osteoarthritis (OA) in persons aged 40 to 75 years. Eligible studies included therapies such as physiotherapy, exercise therapy and muscle energy techniques, with reported outcomes including pain relief, increased Knee range of motion and improved quality of

life. Only English-language publications from 2000-2025 were evaluated. Studies that focused on surgical or invasive treatments, included pediatric, animal or in vitro populations, or were case reports, editorials, or narrative reviews were all eliminated and the articles which did not contain appropriate data and in any other language other than English were excluded.

Summaries of studies included

Author	Study Design	Participants	Objective of the study	Results obtained	Conclusion
Ganjave Pranita D and Dabholkar Twinkle (2017)	Experimental study	Individuals diagnosed with Grade I and Grade II Knee Osteoarthritis	To determine the effectiveness of neuromuscular training in improving: Pain relief, Postural balance, Functional performance in patients with early-stage knee osteoarthritis	The neuromuscular training group showed significant improvement compared to the control group in: Reduction in pain (lower VAS scores), Better balance control (improved Berg Balance / Single Leg Stance scores), Enhanced functional mobility (improved WOMAC and TUG test outcomes)	Neuromuscular training is effective in reducing pain, improving balance, and enhancing functional performance in patients with Grade I and II knee osteoarthritis. It provides better outcomes than conventional exercise therapy alone
Amna Aamir Khan & Jaza Rizvi (2018)	Comparative Experimental Study	Individuals diagnosed with Knee Osteoarthritis (commonly Grades I–III)	To compare the effectiveness of Muscle Energy Technique (MET) and Static Stretching of the Gastrocnemius muscle in improving: Pain levels, Functional disability in patients with Knee OA	Both MET and static stretching significantly reduced pain and functional disability. However, the MET group showed greater improvement than static stretching in terms of pain reduction and functional performance.	Muscle Energy Technique was found to be more effective than static stretching of the gastrocnemius muscle in reducing pain and disability in knee OA patients. MET improves neuromuscular control, reduces muscle tightness, and enhances joint mobility more efficiently than simple static stretching.
Kasani Ravi Teja, Patchava Apparao (2020)	Experimental Study	Subjects diagnosed with Knee Osteoarthritis (Grades I–III)	To compare the effectiveness of: Neuromuscular Training, which emphasizes joint control, proprioception, and dynamic stability versus functional Task Training, which focuses on practicing real-life movement tasks and improving daily functional ability in reducing pain and improving functional outcomes in patients with knee osteoarthritis.	Neuromuscular Training group showed significantly greater improvement in: Pain reduction (greater decrease in VAS scores) Functional performance (better WOMAC improvement) Mobility and balance efficiency (better TUG test scores) This indicates better enhancement of joint proprioception, stability, and neuromuscular control compared to functional task training alone.	Neuromuscular training is more effective than functional task training in: Reducing pain, Improving function, Enhancing mobility and dynamic balance in individuals with knee osteoarthritis.
Jyoti Sabharwal & Shabnam Joshi (2022)	Systematic Review and Meta-analysis	Adults diagnosed with Knee Osteoarthritis (Grades I–III) based on clinical or radiological criteria.	To determine whether Neuromuscular Exercise Programs (NEMEX) are effective in improving: Pain Physical Function, Balance and Joint Stability in individuals with knee osteoarthritis, as compared to conventional physiotherapy or no intervention.	Improvement in physical function was greater in the NEMEX group than control groups (better WOMAC functional and stiffness scores). Balance and postural stability showed notable improvements due to proprioceptive and coordination emphasis. Results demonstrated that neuromuscular exercises produce clinically meaningful benefits in knee OA.	Neuromuscular Exercise (NEMEX) training is effective in reducing pain Improving physical function and mobility, enhancing balance and joint stability in patients with knee osteoarthritis.

Ali, Z., Zerish, Z., Hussain, M. N., Rahman, H. (2023)	Randomized clinical trial	Diagnosed with knee osteoarthritis Grade I or II	To determine and compare the effectiveness of the Mulligan Traction Straight Leg Raise (T-SLR) technique versus Muscle Energy Technique (MET) in improving: Pain intensity (measured by Visual Analogue Scale, VAS) Hamstring tightness (measured by Active Knee Extension Test) Functional knee disability (measured by Oxford Knee Score, OKS) in patients with knee osteoarthritis (Grade I & II).	Between groups: MET group was significantly better than Mulligan ($p=0.000$) in pain reduction	Muscle Energy Technique was more effective in reducing pain, improving hamstring flexibility and reduce functional disability in patient with knee Osteoarthritis
Iqra Tahir & Samiya Munir (2024)	Randomized Clinical Trial	Patients diagnosed with Knee Osteoarthritis (typically Grade I–III)	To compare the effectiveness of: Post-Isometric Relaxation MET and Reciprocal Inhibition MET in improving: Pain levels, and Knee joint extension range of motion in individuals with knee osteoarthritis	Both MET techniques resulted in significant reduction in pain and improvement in knee extension ROM compared to baseline. However, the Post-Isometric Relaxation (PIR) MET group showed greater improvement than the Reciprocal Inhibition group	Both Muscle Energy Techniques (PIR and RI) are effective in reducing pain and improving knee extension in patients with knee osteoarthritis. However, Post-Isometric Relaxation (PIR) is more effective than Reciprocal Inhibition for: Improving flexibility Increasing knee extension ROM reducing pain intensity Thus, PIR MET should be considered the preferred MET approach in physiotherapy rehabilitation for knee osteoarthritis patients
Fanila Ashraf & Kinza Anwar (2024)	Quasi-experimental study	Patients diagnosed with knee osteoarthritis	To examine whether adding Muscle Energy Technique to conventional physiotherapy provides additional benefits in improving: Pain levels, range of motion, Joint function and mobility	The experimental group showed significantly greater improvements compared to the control group	The study concluded that Muscle Energy Technique (MET) combined with conventional physiotherapy is more effective than conventional physiotherapy alone
Dwi Rosella Komalasari & Tri Mukti Handayani (2024)	Experimental study	Patients diagnosed with Knee Osteoarthritis (likely Grade I–III)	To determine the effect of Muscle Energy Technique on: Pain reduction, Improvement of Knee Range of Motion (ROM) in individuals with Knee Osteoarthritis	Post-Isometric Relaxation (PIR) applied to Quadriceps Femoris and Hamstring muscles	Significant decrease in pain scores after MET intervention. Significant improvement in knee ROM (increase in flexion range and reduced stiffness). MET helped reduce muscle tightness and improved joint mobility.

4. Results

A total of 98 studies were identified through the database search. After removing duplicates and screening titles and abstracts, 24 full-text articles were reviewed for eligibility. Based on the inclusion and exclusion criteria, 6 studies were finally included in this review.

The included studies involved adults aged 40–75 years diagnosed with Grade I–III knee osteoarthritis. Interventions analyzed included Neuromuscular Knee Strengthening Exercises and Muscle Energy Technique (MET) in

comparison with conventional physiotherapy or other exercise-based interventions.

Across the studies, neuromuscular training demonstrated:

- Significant reduction in pain levels, as measured by the Visual Analog Scale (VAS).
- Improved dynamic balance and postural stability, indicated by enhanced Berg Balance Scale and Single-Leg Stance outcomes.
- Better functional performance, reflected in improved WOMAC scores and reduced Timed Up and Go (TUG) times.

- Enhanced proprioception and joint control, showing improved movement coordination and stability during daily activities.

Studies evaluating Muscle Energy Technique (MET) reported:

- Significant reduction in pain intensity when compared to conventional therapy or Mulligan Traction techniques.
- Improved hamstring flexibility and increased knee extension range of motion, particularly in the Post-Isometric Relaxation (PIR) MET group.
- Better functional ability and reduced disability, as indicated by higher Oxford Knee Scores (OKS).
- PIR MET was consistently more effective than Reciprocal Inhibition MET in improving flexibility and reducing pain.

Studies combining MET with conventional physiotherapy demonstrated greater improvements than physiotherapy alone, confirming a synergistic therapeutic benefit.

Overall, the evidence suggests that both neuromuscular strengthening and MET are effective non-surgical interventions for knee osteoarthritis. Neuromuscular training primarily improves functional movement and balance, while MET is highly effective for pain reduction and flexibility enhancement.

5. Discussion

Ganjave Pranita D. & Dabholkar Twinkle (2017). This study demonstrated that neuromuscular training significantly improves pain, postural balance, and functional performance in patients with Grade I and II knee osteoarthritis. The improvements in Berg Balance and TUG scores indicate enhanced proprioceptive feedback and joint stability. The findings highlight the importance of neuromuscular re-education in early OA, where muscle weakness and altered joint mechanics are dominant contributors. The study supports neuromuscular training as a valuable addition to standard physiotherapy to optimize joint loading and movement control. More evidence is needed on whether task-oriented neuromuscular drills outperform traditional isotonic strengthening for functional recovery.

Amna Aamir Khan & Jaza Rizvi (2018) This study demonstrated that both Muscle Energy Technique (MET) and static stretching of the gastrocnemius muscle were effective in reducing pain and improving functional ability in individuals with knee osteoarthritis. However, the findings indicated that MET produced greater improvements compared to static stretching.

In knee osteoarthritis, tightness of the gastrocnemius can contribute to altered lower limb biomechanics, restricted knee extension, and increased joint load during gait, all of which exacerbate pain and disability. MET promotes controlled isometric contraction followed by muscle relaxation, which reduces alpha motor neuron excitability, decreases muscle tone, and enhances muscle length more effectively than passive stretching. Static stretching helps lengthen the muscle, which can reduce stiffness, but its effect is primarily mechanical. The study mostly included

Grade I–III OA. The effectiveness of MET in severe or late-stage OA (Grade IV) remains unknown

Kasani Ravi Teja & Patchava Apparao (2020). In this study, neuromuscular training was found to be more effective than functional task training. While functional task training focuses on performing daily movement patterns, neuromuscular training improves motor control, joint alignment, and movement precision. The superior improvement in WOMAC and TUG scores in the neuromuscular training group suggests that enhancing proprioception and coordinated muscle activation can provide stronger long-term functional benefits. This highlights the importance of addressing neuromuscular deficits rather than simply practicing functional movements. Standardized guidelines for load progression, frequency, and intensity are still underdeveloped important for both research and clinical translation.

Jyoti Sabharwal & Shabnam Joshi (2022). The systematic review and meta-analysis provided broader evidence supporting neuromuscular exercise (NEMEX) programs. The review emphasized improvements not only in pain and functional mobility but also in postural control and joint stability, which are often compromised in knee OA due to quadriceps weakness and mechanoreceptor deficits. The findings reinforce the clinical recommendation of incorporating structured neuromuscular exercise into standard OA rehabilitation, demonstrating its superiority over general strengthening alone.

Ali, Z. et al. (2023) This randomized clinical trial compared Muscle Energy Technique (MET) with the Mulligan Traction Straight Leg Raise. MET showed greater reductions in pain and hamstring tightness, as well as improved knee functional scores. MET's ability to modify neuromuscular tone and stretch tolerance explains these outcomes. The study also highlights that muscular tension and limited hamstring extensibility can directly influence knee joint biomechanics, making MET an effective tool for OA patients with soft tissue restrictions. Many studies focus on short-term gains; future work should assess retention of neuromuscular adaptations and re-injury rate

Iqra Tahir & Samiya Munir (2024) This study compared two types of MET: Post-Isometric Relaxation (PIR) and Reciprocal Inhibition (RI). Both techniques reduced pain and improved knee extension range, but PIR demonstrated more pronounced benefits. PIR is known to produce greater relaxation of hyper-tonic muscle fibers following isometric contraction, which likely accounts for superior outcomes. These findings support the selective use of PIR MET when the primary impairment is reduced flexibility and joint mobility due to adaptive muscle shortening. Future research should investigate how factors such as baseline muscle tightness, proprioceptive acuity, and neuromuscular control influence responsiveness to MET.

Fanila Ashraf & Kinza Anwar (2024) This quasi-experimental study reported that combining MET with conventional physiotherapy produced better outcomes than physiotherapy alone. These findings suggest that MET provides additional therapeutic benefit when integrated with

strengthening, stretching, and functional training programs. The study reinforces the concept of multimodal rehabilitation, where addressing both neuromuscular control and soft tissue impairments yields optimal clinical results. Further studies should include long follow up. Current studies vary in MET application (contraction intensity, duration, repetitions). Standardizing protocols could improve reproducibility and meta-analytical power.

The study by Dwi Rosella Komalasari & Tri Mukti Handayani (2024) showed that applying Muscle Energy Technique (MET) using the Post-Isometric Relaxation (PIR) approach to the Quadriceps Femoris and Hamstring muscles significantly helped in reducing pain and improving knee joint range of motion (ROM) in patients with Knee Osteoarthritis (OA). In knee OA, tightness in the quadriceps and hamstrings increases abnormal joint compression and limits mobility, contributing to pain and functional disability. MET works through a gentle isometric contraction followed by muscle relaxation and stretching. The study did not evaluate whether pain relief and ROM improvement are maintained over weeks or months, which is crucial for chronic conditions like OA.

6. Conclusion

This systematic review demonstrates that both Muscle Energy Techniques (MET) and neuromuscular knee strengthening exercises are effective non-surgical rehabilitation strategies for individuals with knee osteoarthritis. Neuromuscular exercises primarily enhance proprioception, balance, joint stability, and overall functional performance, making them valuable in improving movement efficiency and preventing further joint degeneration. On the other hand, MET shows superior benefits in reducing pain, decreasing muscle tightness, and improving knee range of motion, particularly when Post-Isometric Relaxation techniques are applied.

The findings further indicate that combining MET with conventional physiotherapy produces better outcomes than exercise therapy alone, supporting a multimodal, patient-centered approach to osteoarthritis management. Although the studies reviewed demonstrated positive therapeutic effects, limitations such as small sample sizes and short follow-up durations highlight the need for high-quality randomized controlled trials to determine long-term effectiveness and establish standardized treatment protocols. However, it was noted that the number of available high-quality studies focusing specifically on neuromuscular knee strengthening exercises is limited. This restricts the ability to draw stronger conclusions regarding optimal dosage, progression parameters, and long-term functional effects of neuromuscular training.

Therefore, although current findings are supportive, future research should include larger sample sizes, longer follow-up periods, and standardized neuromuscular exercise protocols to establish clearer evidence-based guidelines. Overall, integrating both neuromuscular strengthening and MET into routine physiotherapy practice appears beneficial in improving pain relief, enhancing joint mobility, and

restoring functional independence in patients with knee osteoarthritis.

Overall, the evidence strongly supports incorporating both neuromuscular strengthening and MET into routine physiotherapy practice to improve pain relief, enhance joint mobility, and restore functional independence in patients with knee osteoarthritis.

7. Future Scope

According to the findings of this systematic review, future research should aim to improve the quality and consistency of studies on non-surgical rehabilitation of knee osteoarthritis. Many existing studies are limited by small sample sizes, short follow-up periods, and variability in intervention protocols, which restrict the strength and generalizability of the conclusions. To establish definitive evidence on the long-term benefits of Muscle Energy Technique (MET) and neuromuscular knee strengthening exercises, future investigations should employ large-scale randomized controlled trials with standardized treatment protocols. Further studies are needed to compare single-modality versus combined multimodal approaches to determine the most effective strategies for pain relief, functional improvement, and quality of life enhancement. Incorporating objective outcome measures, such as biomechanical assessments, gait analysis, or imaging, can improve the precision of results. Additionally, stratifying participants based on OA severity, baseline muscle tightness, or proprioceptive deficits will enable more personalized rehabilitation strategies. Collaborative research involving physiotherapists, orthopedic specialists, and clinical researchers is essential to develop standardized, evidence-based guidelines for non-surgical management of knee osteoarthritis.

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musculoskeletal physiotherapy, neuro-rehabilitation, exercise therapy, and evidence-based physiotherapy practice

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