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International Journal of Current Research and Techniques (IJCRT)
E-ISSN: 2349-3194 (Online) | P-ISSN: 2348-4446 (Print)
UGC Approved Journal No: 47722 [No: 2616]
DOI: https://doi.org/10.5281/ZENODO.17189857

Effectiveness of Proprioceptive Training Versus Muscle Energy Technique on Pain, Range of Motion and Functional Disability in Individuals with Knee Osteoarthritis

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Manuscript Received: Sep 17, 2025; Revised: Sep 24, 2025; Published: Sep 24, 2025

Abstract: This study investigated the comparative effectiveness of proprioceptive training and muscle energy techniques in individuals with knee osteoarthritis, a condition characterized by pain, joint stiffness, decreased muscle strength, and proprioceptive deficits. Sixty participants meeting the selection criteria were randomly assigned to two groups: Group A received proprioceptive training three days per week, two sessions per day for six weeks, while Group B received muscle energy techniques three days per week for six weeks. Pain, range of motion, and functional disability were assessed using the Visual Analog Scale (VAS), Goniometer, and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), respectively. Data analysis with paired t-tests showed significant improvements within both groups, while independent t-tests revealed that proprioceptive training produced greater improvements across all outcomes compared to muscle energy techniques. The findings conclude that while both interventions are effective, six weeks of proprioceptive training is superior in reducing pain, improving range of motion, and minimizing functional disability in individuals with knee osteoarthritis.

Keywords: Knee Osteoarthritis, Proprioceptive Training, Muscle Energy Technique, Visual Analogue Scale, Goniometer, Western Ontario McMaster Universities Arthritis index.

1. Introduction:

Osteoarthritis (OA), also referred to as osteoarthrosis or degenerative joint disease, is the most common chronic disorder of synovial joints.[1] The prevalence is higher in females than in males, with a 2020 global age-standardised prevalence of 8,058.9 per 100,000 in females compared to 5,780.1 per 100,000 in males.[2] Approximately 3.5% of working-aged adults (30–60 years) were affected by some form of osteoarthritis in 2020.[2] OA is characterized by the degeneration of articular cartilage, largely due to age-related changes in chondrocyte function, which contribute to disease progression.[3] This condition imposes significant social, psychological, and economic burdens on patients, often resulting in substantial financial consequences.[4] The etiology of osteoarthritis is multifaceted, encompassing genetic, molecular, environmental, and biomechanical factors. [5] Clinically, knee OA presents with pain, tenderness along the medial joint line, crepitus, stiffness, reduced muscle strength, and proprioceptive deficits.[6]

Diagnosis can be made based on detailed history, evaluation of risk factors, adequate physical examination, clinical features and plain X ray. However, plain radiography and occasionally other investigations may be considered for the diagnosis of atypical cases when additional pathology is suspected. [7]

Current physical therapy interventions for knee osteoarthritis focus on reducing pain and improving knee range of motion, muscle strength, balance, and functional mobility. Proprioceptive exercises, in particular, play a vital role in enhancing joint position sense by improving sensorimotor integration and mapping of knee movements in patients with knee OA. [8]

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High-quality evidence indicates that land-based therapeutic exercise provides benefit in terms of reduced knee pain and improving quality of life, moderate-quality evidence supports its role in improving physical function in individuals with knee OA. [9] Among exercise interventions, aerobic training is most frequently prescribed, as it alleviates pain and enhances physical function. Strength training is effective in addressing muscle weakness, whereas neuromuscular and balance training are particularly beneficial for improving proprioception, sensorimotor control, and functional stability [10].

Studies suggest that proprioceptive activity is essential for maintaining balance and generating a smooth, stable gait. [11] Proprioception has been defined as the process by which the body modulates muscle contraction in response to afferent information regarding external forces. [12] Impairments in muscle function can compromise force generation and subsequently affect joint stability. Proprioceptive and balance exercises have been shown to enhance postural control, improve functional capacity, and reduce subjective knee pain in patients with bilateral knee osteoarthritis. (Ufuk Sekir, 2005). [13]

Another widely used approach in the management of knee osteoarthritis is the Muscle Energy Technique (MET), originally developed by osteopaths and now adopted across various manual therapy disciplines, including physiotherapy, massage therapy, and athletic training. MET has been reported to be particularly suitable for older patients with severely restricted motion due to arthritis or those with fragile, osteoporotic bones, as noted by osteopathic physician Sandra Yale. [14]

Muscle Energy Technique is used to lengthen shortened, contracted, or spastic muscles; strengthen physiologically weakened muscles or muscle groups; reduce localized oedema and relieve passive congestion; mobilize joints with restricted mobility; and address trigger points and myofascial dysfunctions. [15].

Although studies have reported that both proprioceptive training and Muscle Energy Techniques are effective in the management of knee osteoarthritis, [13-15] there is a paucity of literature directly comparing their effectiveness. Therefore, the present study aims to evaluate whether proprioceptive training or Muscle Energy Technique is more effective in improving outcomes in individuals with knee osteoarthritis.

2. Materials and Methods

Research Design

This study employed an experimental pre-test–post-test design.

Study Setting

The research was conducted at the Konaseema Institute of Medical Sciences and Research Foundation (BPT & MPT), Amalapuram, Andhra Pradesh.

Sample Selection

A total of 60 patients diagnosed with knee osteoarthritis were recruited using a convenience sampling technique. Participants were then randomized into two groups:

- Group A: Proprioceptive Training (n = 30)
- Group B: Muscle Energy Technique (n = 30)

Inclusion Criteria

- Age between 40 and 55 years
- Individuals with osteoarthritis of the knee joint of more than one year duration
- Subjects with bilateral knee osteoarthritis

Exclusion Criteria

- Patients not meeting the inclusion criteria
- Skin lesions at the site of application
- Hypersensitivity to cold or heat

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- History of epilepsy
- Presence of mental disorders

Ethical Considerations

Informed consent was obtained from all participants prior to enrolment. Ethical clearance was granted by the Institutional Ethical Committee of the Konaseema Institute of Medical Sciences and Research Foundation (BPT & MPT), Amalapuram.

Study Duration

The study was conducted between October 2024 and August 2025.

Tools and Techniques

Visual Analogue Scale (VAS): The VAS was used to measure pain intensity. It consists of a 10 cm horizontal line marked from 0 to 10, where 0 indicates "no pain" and 10 represents "worst possible pain. [16]

Goniometer: A standard goniometer was used to assess the range of motion (ROM) of the knee joint. This method is considered safe, simple, quick, inexpensive, and has been shown to be both reliable and valid. It is commonly applied to evaluate knee-alignment angles using various approaches. [17]

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): The WOMAC is a disease-specific, self-administered, multidimensional questionnaire designed to assess pain, stiffness, and functional disability in individuals with knee osteoarthritis. The stiffness subscale consists of two items, while the physical function subscale evaluates the level of difficulty across 17 daily activities. [18]

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Procedure:

Group A: Proprioceptive Training

Participants in Group A underwent proprioceptive training for 45 minutes per session, with a 1-minute rest after every 5 minutes of exercise, conducted three times per week for six weeks. [19] The intervention was structured progressively as follows:

- **Weeks 1–2:**

  - One-leg balance (3 repetitions)
  - Forward and backward leg swings with knee flexed (15 swings)
  - Forward and backward leg swings with knee extended (15 swings)
  - Toe walking (30 steps)
  - Heel walking (30 steps)
  - Cross-body leg swings (15 swings) *(see Figures 1–7)*

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- **Weeks 3–4:**
  - Balance board exercises
  - Advanced one-leg balance (3 repetitions)
  - Maximum forward and backward leg swings with knee extended (15 swings)
  - Toe walking (30 steps)
  - Heel walking (30 steps)
  - One-leg squats (10 repetitions)
  - Runner's pose
- **Weeks 5–6:**
  - Blindfolded advanced one-leg balance (3 repetitions)
  - Bicycle leg swings (15 swings)
  - Partial squats (10 repetitions)
  - Toe walking (30 steps)
  - Heel walking (30 steps)

Figure 1: one leg balance

Figure 2: heel walking

Figure 3: one leg heel squat

figure 4: one leg heel raise

figure 5: Sideways Leg Swings

figure 6: Forward Leg Swings

figure 7: Toe Walking

figure 8: Muscle energy Technique for quadriceps

Group B: Muscle Energy Technique (MET)

Participants in Group B received Muscle Energy Technique interventions aimed at improving hamstring flexibility and quadriceps strength. MET was administered using the agonist contract–relax method, delivered as isometric contractions held for 7–10 seconds, followed by a passive stretch maintained for 30 seconds. Each session included four isometric contractions, with a 3-second rest period between repetitions. [20]

Agonist Contract–Relax Procedure:

- Step 1: The patient was positioned in supine lying with the hip on the affected side fully flexed. The examiner then extended the flexed knee until the point of resistance (the barrier) was identified.

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- Step 2: The calf of the treated leg was placed on the examiner's shoulder. The examiner stood facing the head of the table on the treatment side, stabilizing the thigh of the treated leg with one hand while securing the contralateral leg with a stabilizing belt.
- Step 3: The patient was instructed to attempt to straighten the lower leg (knee extension) by contracting the quadriceps (antagonists to the hamstrings) at approximately 20% of maximal effort. The examiner resisted this contraction for 7–10 seconds.
- Step 4: Following verbal breathing instructions, the leg was further extended to the new hamstring limit, after which a passive stretch was maintained for 30 seconds. The procedure was then repeated for the prescribed number of repetitions *(see Figure 8)*.

Conventional Physiotherapy (Both Groups)

In addition to their respective interventions, both groups received conventional physiotherapy consisting of isometric quadriceps exercises and therapeutic ultrasound. [21]

- Isometric Quadriceps Exercises: Participants performed exercises in a long sitting position with hands placed at the sides and a towel roll positioned under the affected knee. They were instructed to press the towel downward by contracting the quadriceps, hold the contraction for a count of 10 seconds, relax, and repeat the movement for 10 repetitions per session, performed three times daily under supervision.
- Ultrasound Therapy: Continuous ultrasound was administered using a frequency of 1 MHz and an intensity of 1 W/cm^2 for a duration of 10 minutes. The transducer head was applied perpendicular to the treatment area to maximize energy absorption.

3. Statistical Analysis

All collected data were entered into a master data sheet and analysed using SPSS software version 20.0. The paired Student's *t*-test was applied to assess statistically significant differences within each group (pre-test vs. post-test). The independent Student's *t*-test was employed to compare post-test values between the two groups. A p-value < 0.05 was considered statistically significant.

4. Results

Analysis of pre- and post-test scores within both Group A (Proprioceptive Training) and Group B (Muscle Energy Technique) demonstrated statistically significant improvements in all outcome measures (VAS, knee flexion and extension ROM, and WOMAC scores). However, comparison of post-test values between the two groups revealed that Group A exhibited statistically significant improvement than Group B, in VAS score (pain reduction), Flexion ROM, Extension ROM and WOMAC Scores (pain, stiffness and functional disability).

Table 1: Comparison of Pre-Test and Post-Test Mean Values of VAS, Flexion ROM, Extension ROM, and WOMAC Scores within Group A and Group B:

Outcome	Group	Mean & SD		P- Value	Inference
		Pre	Post		
VAS	Group A	6.1 ± 0.83	1.6 ± 0.89	<0.001	Significant
	Group B	6.5 ± 0.83	2 ± 0.83	<0.001	Significant
Flexion ROM	Group A	90 ± 8.3	135 ± 4.1	<0.001	Significant
	Group B	95 ± 4.1	125 ± 4.1	<0.001	Significant
Extension ROM	Group A	35 ± 4.1	10 ± 4.1	<0.001	Significant
	Group B	35.1 ± 4	18.3 ± 6.3	<0.001	Significant
WOMAC	Group A	3.5 ± 0.5	0.5 ± 0.5	<0.001	Significant
	Group B	3.5 ± 0.5	1.5 ± 0.5	<0.001	Significant

Note: The table shows statistically significant improvements ($p < 0.05$) in pain (VAS), range of motion (Flexion and Extension ROM), and functional disability (WOMAC) within both groups after intervention.

Table 2: Comparison of Post-Test Mean Values between Group A and Group B:

Outcome	Post test Mean & SD Group A	Post test Mean & SD Group B	P- Value	Inference
VAS	1.6 ± 0.89	2 ± 0.83	<0.001	Significant
Flexion ROM	135 ± 4.1	125 ± 4.1	<0.001	Significant
Extension ROM	10 ± 4.1	18.3 ± 6.3	<0.001	Significant
WOMAC	0.5 ± 0.5	1.5 ± 0.5	<0.001	Significant

Note: Post-test comparisons indicate that Group A (Proprioceptive Training) achieved significantly greater improvements in pain (VAS), knee ROM, and functional outcomes (WOMAC) compared with Group B (Muscle Energy Technique) ($p < 0.05$).

5. Discussion

The present study compared the effects of proprioceptive training and Muscle Energy Technique (MET) on pain, range of motion (ROM), and functional disability in individuals with knee osteoarthritis (OA). Both interventions produced statistically significant intra-group improvements in VAS, ROM, and WOMAC scores, consistent with earlier findings [4–6]. However, inter-group analysis demonstrated that proprioceptive training was more effective in improving outcomes compared to MET.

The greater reduction in pain observed with proprioceptive training may be attributed to stimulation of A-beta fibers, which inhibit nociceptive transmission via the gate control mechanism. [22] Additionally, proprioceptive exercises help restore the sensory–motor feedback loop, improving joint position sense, neuromuscular control, balance, and motor coordination—functions often impaired in knee OA. [23–25] Similar benefits have been reported in previous trials, where proprioceptive training improved pain, functional capacity, and proprioceptive acuity. [13]

In contrast, MET was also effective in reducing pain and improving ROM, which aligns with existing literature. MET works through mechanisms of post-isometric relaxation (PIR) and reciprocal inhibition (RI), producing muscle relaxation and improved flexibility by activating Golgi tendon organs and muscle spindles. [26] Contract-relax techniques have additionally been shown to reduce muscle tightness, improve circulation, and contribute to functional improvements. [27]

While both interventions were beneficial, proprioceptive training demonstrated superior efficacy across pain, ROM, and functional outcomes. This may be due to its combined effects on peripheral sensory input, central pain modulation, and enhanced motor coordination, which collectively support smoother joint motion and improved daily activity performance.

These findings align with existing literature. Gohil and Shukla (2020) reported that proprioceptive training, when integrated with conventional physiotherapy, led to significant improvements in proprioception and functional outcomes in patients with knee osteoarthritis.[28] Similarly, Jeong et al. (2019), in a meta-analysis of randomized controlled trials, concluded that proprioceptive training was highly effective in reducing pain and enhancing physical function, although its effect on joint stiffness was less pronounced. [29]

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6. Conclusion

Both proprioceptive training and muscle energy technique (MET) were effective in improving pain, knee range of motion (flexion and extension), and functional outcomes in patients with knee osteoarthritis following six weeks of intervention. Inter-group comparisons demonstrated statistically significant differences, with Group A (proprioceptive training) showing superior improvements in VAS scores, flexion and extension ROM, and functional measures compared to Group B (MET). These findings suggest that while both interventions are beneficial, proprioceptive training provides greater efficacy in enhancing pain relief, joint mobility, and functional performance in individuals with knee osteoarthritis. Incorporating proprioceptive exercises into rehabilitation programs may therefore offer enhanced clinical benefits and improved quality of life for this patient population.

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