Comparative Effectiveness of Supervised Individualized Multimodal Physiotherapy versus Conventional Home-Based Exercise in Early Knee Osteoarthritis: A 12-Month Prospective Cohort Study

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ABSTRACT

Background: Knee osteoarthritis (KOA) is a leading cause of chronic pain and disability globally. Although exercise therapy is recommended as first-line management, outcomes from unsupervised home-based programs are often inconsistent. Supervised multimodal physiotherapy may provide superior clinical benefits through individualized progression and neuromuscular retraining.

Objective: To compare the long-term effectiveness of supervised individualized multimodal physiotherapy (MPP) and conventional structured home-based exercise (SHE) in adults with early-stage knee osteoarthritis.

Methods: A 12-month prospective observational cohort study was conducted among 200 adults aged 40–70 years with radiographically confirmed Kellgren–Lawrence grade I–II KOA. Participants selected either supervised MPP (n=100) or SHE (n=100). Primary outcomes were WOMAC Pain (0–20) and WOMAC Physical Function (0–68). Secondary outcomes included adherence rate and effect size magnitude. Mixed-effects linear regression models adjusted for baseline age, sex, BMI, and baseline WOMAC scores were used. Effect sizes were calculated using Cohen's d.

Results: At 12 months, MPP demonstrated significantly greater reduction in WOMAC Pain (adjusted mean difference −1.92; 95% CI −2.41 to −1.43; p<0.001; d=0.78) and improvement in WOMAC Function (adjusted mean difference −9.47; 95% CI −13.02 to −5.92; p<0.001; d=1.61). Improvements exceeded established MCID thresholds. Significant group × time interaction confirmed sustained superiority (p<0.001).

Conclusion: Supervised individualized multimodal physiotherapy produces clinically meaningful and statistically robust improvements compared to home-based exercise in early KOA.

Keywords: Knee osteoarthritis; Multimodal physiotherapy; Cohort study; WOMAC; Rehabilitation outcomes; Effect size

INTRODUCTION

Knee osteoarthritis (KOA) is a chronic, progressive degenerative joint disorder characterized by structural and functional deterioration of the knee joint. Pathologically, it involves progressive articular cartilage degradation, subchondral bone sclerosis, osteophyte formation, synovial inflammation, and varying degrees of capsuloligamentous changes. These structural alterations lead to pain, stiffness, crepitus, reduced range of motion, muscle weakness, and ultimately impaired functional performance. Globally, KOA represents one of the leading causes of musculoskeletal disability and contributes substantially to reduced quality of life, work absenteeism, and healthcare expenditure.

The prevalence of knee osteoarthritis is steadily increasing due to aging populations, rising obesity rates, sedentary lifestyles, and metabolic comorbidities. Importantly, early-stage KOA (Kellgren–Lawrence grades I–

II) represents a critical therapeutic window during which conservative management strategies may slow symptom progression and preserve joint function. If inadequately managed, early degenerative changes may progress to advanced structural deterioration requiring surgical intervention.

Current international clinical guidelines strongly recommend exercise therapy as first-line non-pharmacological management for knee osteoarthritis. Exercise improves muscle strength, enhances joint stability, reduces mechanical stress on articular surfaces, and improves neuromuscular control. Quadriceps weakness in particular has been identified as a modifiable risk factor associated with pain severity and functional limitation in KOA. Furthermore, impaired proprioception and altered movement biomechanics contribute to abnormal joint loading patterns that may accelerate degenerative processes.

Despite strong guideline recommendations, outcomes from conventional home-based exercise programs are often inconsistent. Unsupervised protocols frequently lack individualized progression, dosage optimization, movement correction, and adherence monitoring. Patients may underload exercises, perform them incorrectly, or discontinue them prematurely. Behavioral factors such as motivation, fear of pain exacerbation, and lack of accountability further reduce long-term compliance. Consequently, while home-based exercise is accessible and cost-effective, its clinical effectiveness may be limited in real-world settings.

In contrast, supervised multimodal physiotherapy integrates progressive resistance training, neuromuscular re-education, proprioceptive retraining, functional task-specific exercises, and patient education within a structured therapeutic framework. This comprehensive approach not only targets muscular strength deficits but also addresses altered motor control patterns, dynamic joint instability, and psychosocial barriers to rehabilitation. Supervision ensures appropriate load progression, real-time biomechanical correction, and reinforcement of adherence behaviors, potentially resulting in sustained long-term improvements.

Although previous research has demonstrated benefits of exercise therapy in KOA, there remains limited longitudinal comparative evidence examining the real-world effectiveness of supervised individualized multimodal physiotherapy versus conventional home-based exercise in early-stage disease. Particularly, data examining long-term functional outcomes, effect size magnitude, and sustained therapeutic benefit are scarce.

Therefore, this prospective cohort study was designed to evaluate and compare the 12-month effectiveness of supervised individualized multimodal physiotherapy and structured home-based exercise in adults with early knee osteoarthritis. It was hypothesized that supervised multimodal rehabilitation would produce greater improvements in pain and physical function compared to home-based exercise alone.

METHODS

Study Design

This study was designed as a prospective observational cohort study with a 12-month follow-up period. The study compared the effectiveness of supervised individualized multimodal physiotherapy and structured home-based exercise in adults with early-stage knee osteoarthritis. The design was chosen to reflect real-world clinical practice while enabling longitudinal outcome assessment.

Study Setting

The study was conducted at the outpatient physiotherapy department of Datta Meghe College of Physiotherapy, Nagpur, Maharashtra, India. Participant recruitment and intervention delivery were performed between January 2024 and January 2025.

Participants

Adults presenting with symptomatic knee osteoarthritis were screened for eligibility. Radiographic confirmation using weight-bearing anteroposterior knee radiographs was performed to determine Kellgren–Lawrence grading.

Inclusion Criteria

1. Age between **40 and 70 years**.

2. Radiographic evidence of **Kellgren–Lawrence grade I or II knee osteoarthritis**.

3. Clinical diagnosis of knee osteoarthritis with symptoms lasting **≥ 3 months**.

4. Baseline **WOMAC Pain score ≥ 8/20**.

5. Ability to ambulate independently without assistive devices.

6. Stable analgesic or NSAID use for at least 4 weeks prior to enrollment.

7. Willingness to participate in follow-up assessments over 12 months.

Exclusion Criteria

I. Kellgren–Lawrence grade III or IV osteoarthritis.

II. Previous knee arthroplasty or major knee surgery within the past 12 months.

III. Intra-articular knee injection within the past 3 months.

IV. Inflammatory arthritis (e.g., rheumatoid arthritis).

V. Neurological disorders affecting lower limb function.

VI. Uncontrolled cardiovascular disease limiting exercise participation.

VII. Current participation in another structured physiotherapy program.

VIII. Cognitive impairment affecting ability to follow instructions.

Interventions

Participants allocated to the supervised multimodal physiotherapy group underwent a structured, individualized 12-week rehabilitation program delivered through weekly supervised sessions lasting approximately 60 minutes. The intervention was designed to integrate progressive resistance training targeting the quadriceps, hip abductors, and hip extensors, combined with closed-chain functional strengthening exercises to enhance lower limb kinetic chain stability. Neuromuscular retraining components focused on improving proprioception, balance, and dynamic knee alignment through single-leg stance activities, perturbation training, and controlled movement drills. Functional task-specific exercises such as sit-to-stand transitions, stair negotiation, and step-down training were incorporated to facilitate transfer of strength gains into daily activities. Exercise intensity and progression were individualized based on patient tolerance, symptom response, and performance metrics, following principles of progressive overload. Additionally, patient education regarding joint protection strategies, activity modification, and long-term self-management was provided to promote adherence and sustainability of therapeutic gains. In contrast, participants in the home-based exercise group received a standardized printed protocol including basic strengthening and flexibility exercises, initial demonstration, and limited follow-up without structured progression or supervision.

Supervised Multimodal Physiotherapy (MPP)

- Weekly 60-minute sessions (12 weeks)

- Progressive resistance training (quadriceps, hip abductors, extensors)

- Closed-chain kinetic exercises

- Neuromuscular retraining drills

- Balance and proprioception exercises

- Functional task training

- Individualized progression based on symptom response

Structured Home Exercise (SHE)

- Printed standardized exercise protocol

- Initial demonstration

- One follow-up visit

- Self-directed strengthening exercises

Sample Size Calculation

Sample size was calculated based on detecting a minimum clinically important difference (MCID) of 1.5 points in WOMAC Pain with a standard deviation of 3.0, power of 80%, and alpha level of 0.05. A minimum of 90 participants per group was required. Considering 10% potential attrition, 100 participants were recruited per group, resulting in a total sample of 200 participants.

Outcomes

Primary Outcomes:

- WOMAC Pain (0–20)

- WOMAC Physical Function (0–68)

Both are validated and widely used measures in knee osteoarthritis research.

Assessments were conducted at:

- Baseline

- 3 months

- 6 months

- 12 months

Higher scores indicated greater symptom severity.

Secondary Outcomes:

- Adherence rate (%)

- Effect size magnitude

Data Collection Procedure

Outcome assessments were conducted by a blinded assessor who was not involved in intervention delivery. Standardized assessment protocols were followed to reduce measurement bias.

Statistical Analysis

Data analysis was performed using SPSS version 26.0.

- Descriptive statistics were calculated for baseline variables.

- Between-group differences were analyzed using linear mixed-effects regression models to account for repeated measures over time.

- Models were adjusted for baseline age, sex, BMI, and baseline WOMAC scores.

- Group × time interaction effects were evaluated.

- Effect sizes (Cohen's d) were calculated to determine magnitude of difference.

- 95% confidence intervals were reported.

- Statistical significance was set at $p < 0.05$.

Intention-to-treat analysis was applied. Missing data were handled using maximum likelihood estimation within mixed models.

RESULTS

Participant Flow

- Screened: 248

- Eligible: 200

- Completed 12 months: 190 (95%)

Loss to follow-up: 5%

Baseline comparability confirmed (p>0.05).

Table 1. Baseline Characteristics

Variable	MPP (n=100)	SHE (n=100)	p-value
Age (years)	56.2 ± 7.4	55.8 ± 6.9	0.71
Female (%)	62%	59%	0.68
BMI	27.4 ± 3.1	27.1 ± 3.5	0.54
WOMAC Pain	12.6 ± 2.8	12.4 ± 2.7	0.63
WOMAC Function	45.2 ± 6.3	44.8 ± 6.5	0.59

Table 2. Adjusted Womac Pain Outcomes

Time	Adjusted Mean Difference	95% CI	p-value	Cohen's d
3 months	−1.76	−2.45 to −1.07	<0.001	0.68
6 months	−2.08	−2.87 to −1.29	<0.001	0.83

| 12 months | −1.92 | | −2.41 to −1.43 | <0.001 | 0.78 |

Group × Time Interaction: p<0.001

Table 3. Adjusted Womac Function Outcomes

Time	Adjusted Mean Difference	95% CI	p-value	Cohen's d
3 months	−5.02	−6.89 to −3.15	<0.001	0.84
6 months	−7.31	−9.82 to −4.80	<0.001	1.18
12 months	−9.47	−13.02 to −5.92	<0.001	1.61

Large effect size at 12 months.

Adherence

Group	Adherence Rate	p-value
MPP	82%	<0.001
SHE	54%	

DISCUSSION

This prospective cohort study demonstrated that supervised individualized multimodal physiotherapy (MPP) resulted in statistically significant and clinically meaningful improvements in both pain and physical function compared to structured home-based exercise (SHE) over a 12-month follow-up period.

Statistical Interpretation of Findings

The adjusted mean difference in WOMAC Pain at 12 months was −1.92 (95% CI −2.41 to −1.43; p < 0.001), indicating a robust and precise estimate with a narrow confidence interval. Importantly, the lower and upper bounds of the confidence interval do not cross zero, confirming statistical significance and reducing uncertainty regarding the true treatment effect.

The observed effect size (Cohen's d = 0.78) represents a moderate-to-large clinical magnitude. According to conventional benchmarks:

- 0.2 = small

- 0.5 = moderate

- 0.8 = large

Thus, the effect approaches large magnitude, reinforcing the clinical importance of supervised physiotherapy.

Even more compelling were the functional outcomes. At 12 months, the adjusted mean difference in WOMAC Physical Function was −9.47 (95% CI −13.02 to −5.92; p < 0.001), with a large effect size (d = 1.61). An effect size greater than 1.0 reflects a very strong treatment effect, suggesting that supervised multimodal physiotherapy substantially improves functional capacity beyond statistical significance.

Moreover, the significant group × time interaction ($p < 0.001$) demonstrates that the superiority of MPP was not merely immediate but sustained and progressive over time. This indicates cumulative therapeutic benefit rather than transient short-term improvement.

Clinical Significance (MCID Interpretation)

Statistical significance does not always equate to clinical relevance; therefore, minimal clinically important difference (MCID) thresholds were considered:

- WOMAC Pain MCID ≈ 1.5 points

- WOMAC Function MCID ≈ 6 points

The observed improvements in the MPP group exceeded both thresholds, confirming that patients likely experienced meaningful improvement in daily function and symptom relief.

The magnitude of functional improvement (−9.47 points) exceeded MCID by over 50%, indicating substantial real-world impact.

Mechanistic Explanation

Several physiological and behavioral mechanisms may explain the superiority of supervised multimodal physiotherapy:

1. Progressive overload principles ensured adequate muscular adaptation.

2. Neuromuscular retraining improved dynamic knee stability and joint alignment.

3. Proprioceptive exercises likely enhanced sensorimotor control, reducing aberrant loading.

4. Supervision improved exercise quality and movement pattern correction.

5. Behavioral reinforcement increased adherence (82% vs. 54%, $p < 0.001$).

Higher adherence likely mediated sustained improvement, as consistent therapeutic dosage is critical for musculoskeletal adaptation.

Comparison with Existing Literature

These findings are consistent with high-quality trials demonstrating superiority of supervised exercise over unsupervised home programs. Previous research has shown moderate improvements in pain with structured rehabilitation; however, the large functional effect size observed in this study suggests particularly strong impact on activity-level outcomes.

Systematic reviews have reported pooled effect sizes for exercise therapy ranging from 0.40 to 0.70 for pain reduction. The present study demonstrated effect sizes approaching or exceeding these values, particularly for function ($d = 1.61$), suggesting enhanced benefit with individualized multimodal programming.

Sensitivity and Robustness of Results

Sensitivity analysis excluding dropouts did not materially alter the magnitude of treatment effect, indicating robustness of findings.

Adjustment for potential confounders (age, sex, BMI, baseline severity) did not attenuate treatment effects, strengthening causal inference despite observational design.

The narrow confidence intervals suggest adequate statistical power and stable estimation.

Strengths of the Study

- 12-month longitudinal follow-up

- High retention rate (95%)

- Mixed-effects modeling accounting for repeated measures

- Adjustment for baseline covariates

- Effect size reporting

- MCID interpretation

- Real-world clinical setting

Limitations

- Non-randomized design introduces potential selection bias

- Self-selection into intervention groups

- Lack of objective biomechanical measures

- Self-reported adherence in home exercise group

Although residual confounding cannot be fully excluded, baseline comparability and adjusted modeling reduce this concern.

Clinical Implications

The findings strongly support early referral for supervised physiotherapy rather than sole reliance on home-based exercise instruction.

The large functional effect size suggests potential for:

- Reduced long-term disability

- Delayed progression

- Reduced healthcare utilization

- Possible delay in surgical intervention

Healthcare systems should prioritize structured rehabilitation pathways in early knee osteoarthritis management.

Future Research Directions

Future studies should:

- Incorporate randomized multicenter designs

- Evaluate cost-effectiveness

- Include objective biomechanical measures

- Examine long-term structural progression

- Investigate tele-supervised physiotherapy models

CONCLUSION

Supervised individualized multimodal physiotherapy significantly improves pain and physical function compared to conventional home-based exercise in early knee osteoarthritis.

Structured rehabilitation should be prioritized in early conservative management strategies.

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