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Temporal Patterns of Pain and Function Recovery During Online and Offline Group Rehabilitation for Knee Osteoarthritis: Secondary Analysis of a Randomized Controlled Trial

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ABSTRACT

Background: Rehabilitation is effective for knee osteoarthritis, but the timing of pain and functional improvement within short-term programs remains unclear

Objective: This secondary analysis of a randomized controlled trial compared early (0–3 weeks) and later (3–6 weeks) changes in pain and function within online and offline group rehabilitation

Methods: One hundred sixty patients with knee osteoarthritis were randomized to online (n=76) or offline (n=84) group exercise for six weeks. Pain (VAS) and function (WOMAC) were measured at baseline, 3 weeks, and 6 weeks, and analyzed using piecewise linear mixed-effects models.

Results: Pain declined steadily across both phases in online (−0.92 vs −0.91 points/week; p=0.88) and offline (−1.12 vs −1.02 points/week; p=0.13) groups. Functional improvement was greater in the later phase, significantly so in the online group (−8.71 vs −6.69 points/week; p<0.001).

Conclusion: Pain relief occurs evenly across 6 weeks, while functional gains are more pronounced during weeks 3–6, highlighting the need to complete the full program to maximize recovery.

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1. INTRODUCTION

Background

Knee osteoarthritis (OA) is one of the leading causes of pain and disability among older adults worldwide. It is characterized by progressive degeneration of articular cartilage, pain, stiffness, and functional limitation, which together reduce quality of life and impose a significant burden on healthcare systems [1]. In India, the prevalence of knee OA is rising due to increasing life expectancy, obesity, and sedentary lifestyle, making it a major public health concern [2].

Conventional physiotherapy remains the cornerstone of non-pharmacological management for knee osteoarthritis [3]. However, patients—particularly in semi-urban and rural regions—face barriers such as long travel distances, lack of local physiotherapy facilities, transportation challenges, and associated costs [4].These obstacles frequently result in reduced compliance and premature discontinuation of therapy.

Telerehabilitation, which delivers physiotherapy interventions via digital platforms, has emerged as a promising alternative to overcome these limitations. Evidence suggests that web-based telerehabilitation provides outcomes comparable to in-person therapy for musculoskeletal and post-surgical conditions, including total knee arthroplasty, while reducing travel, cost, and improving continuity of care [4,5]. During the COVID-19 pandemic, digital health initiatives such as eSanjeevani in India demonstrated the feasibility and acceptance of telemedicine and telerehabilitation models [6].

While previous trials, including our own randomized controlled trial evaluating the effectiveness of online versus offline group rehabilitation for knee OA (manuscript under review), have demonstrated improvements in pain and function, the **timing of these benefits within the intervention period remains unclear**. Specifically, it is not known whether improvements occur predominantly in the **early phase (0–3 weeks)** or continue with equal or greater magnitude in the **later phase (3–6 weeks)**. Understanding these temporal patterns of recovery is essential for clinicians to design optimal program durations, counsel patients regarding expected outcomes, and

improve adherence to complete the full course of rehabilitation [7,8]. Therefore, the present study aimed to examine whether improvements in pain and function among patients undergoing online and offline group rehabilitation for knee osteoarthritis occur primarily in the early phase (0–3 weeks) or in the later phase (3–6 weeks) of the intervention

2. METHODOLOGY

Study design and participants

This was a secondary analysis of a randomized controlled trial (manuscript under review) conducted at Teerthanker Mahaveer Hospital involving 160 patients diagnosed with knee osteoarthritis according to the Kellgren–Lawrence clinical criteria. Patients aged 40–80 years with knee pain and functional limitations were eligible. Exclusion criteria included recent knee surgery, inflammatory joint disease, or inability to participate in exercise sessions. Written informed consent was obtained from all participants. Ethical approval for the primary study was obtained from the Institutional Ethics Committee of Teerthanker Mahaveer University (Approval No.: PM/ETHICAL/PT/2023/004).

Randomization and intervention

Participants were randomly allocated to either an online group rehabilitation program (n=76) or an offline group rehabilitation program (n=84) using computer-generated random numbers. Both groups received a standardized six-week physiotherapist-supervised exercise protocol consisting of stretching, strengthening, mobility, and functional exercises tailored for knee OA. Sessions lasted approximately 45 minutes and were delivered six days per week. Online sessions were conducted via a secure video-conferencing platform, while offline sessions were delivered in person at the TMU hospital's Physiotherapy department.

Outcome measures

Pain intensity was measured using the Visual Analog Scale (VAS, 0–10), and physical function was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC, 0–100). Assessments were performed at baseline, week 3, and week 6 of the program.

Statistical analysis

Piecewise linear mixed-effects models were used to estimate rates of change in VAS and WOMAC during the early (0–3 weeks) and later (3–6 weeks) phases. Random intercepts accounted for individual variability. Slopes were expressed as points of change per week, and early versus later slopes were compared using contrasts. Results are presented as mean estimates with 95% confidence intervals. All statistical analyses were performed using Stata version 17.0 (StataCorp LLC, College Station, TX, USA). Statistical significance was set at $p < 0.05$.

Study flow

The flow of participants from enrollment to allocation and analysis is summarized in Figure 1.

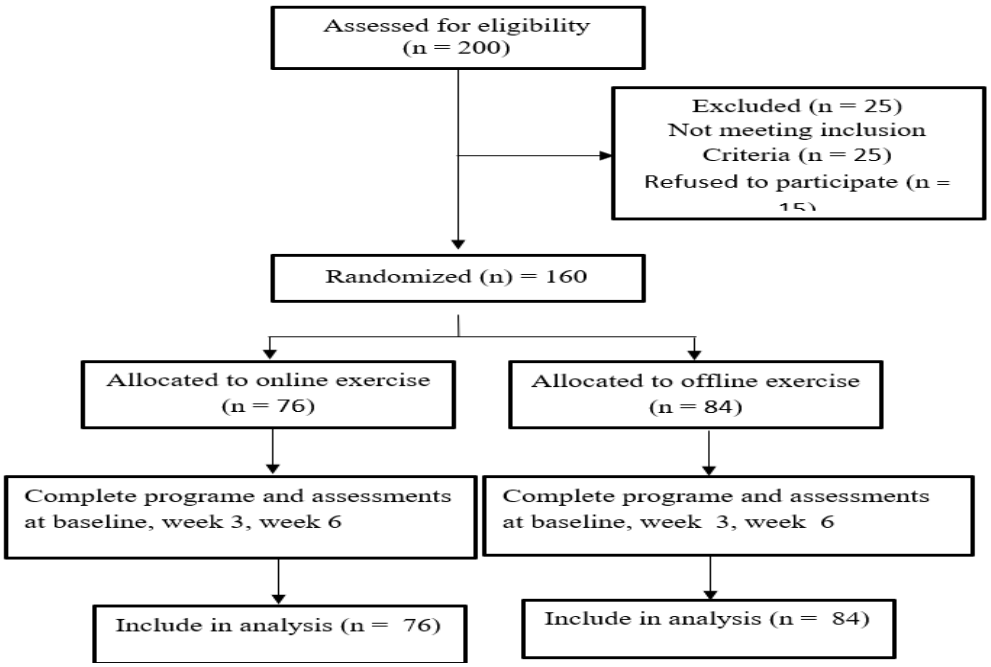

Fig 1 CONSORT flow diagram of participant enrollment, allocation, and analysis.

3. RESULTS

Participant characteristics

A total of 160 patients with knee osteoarthritis were randomized to group rehabilitation programs and completed assessments at baseline, week 3, and week 6 (Figure 1). The study population had a mean age of 58 years, with a balanced distribution of men and women. Table 1 summarizes the estimated slopes and within-outcome comparisons between the early (0–3 weeks) and later (3–6 weeks) phases.

Table 1 Slopes of change in VAS pain and WOMAC function during the early (0–3 weeks) and later (3–6 weeks) phases. Values are expressed as points/week with within-group p-values comparing phases. Negative slopes indicate improvement (reduction in scores).

Outcome	Phase	Online slope (points/week)	Offline slope (points/week)	p-value (Online: early vs later)	p-value (Offline: early vs later)
VAS	0–3 weeks	-0.92	-1.12	0.88	0.13
VAS	3–6 weeks	-0.91	-1.02	0.88	0.13
WOMAC	0–3 weeks	-6.69	-6.68	<0.001	0.22
WOMAC	3–6 weeks	-8.71	-7.44	<0.001	0.22

Pain outcomes (VAS)

Pain intensity, measured by VAS, declined steadily throughout the 6-week program. Piecewise mixed-effects models showed no significant difference between the early (0–3 weeks) and later (3–6 weeks) slopes, indicating consistent pain reduction across both phases (Table 1)

Functional outcomes (WOMAC)

Functional outcomes, measured by WOMAC, improved significantly across both phases. The later slope (3–6 weeks) was significantly steeper than the early slope (0–3 weeks) ($p < 0.001$), indicating accelerated functional recovery during the second half of the program (Table 1)

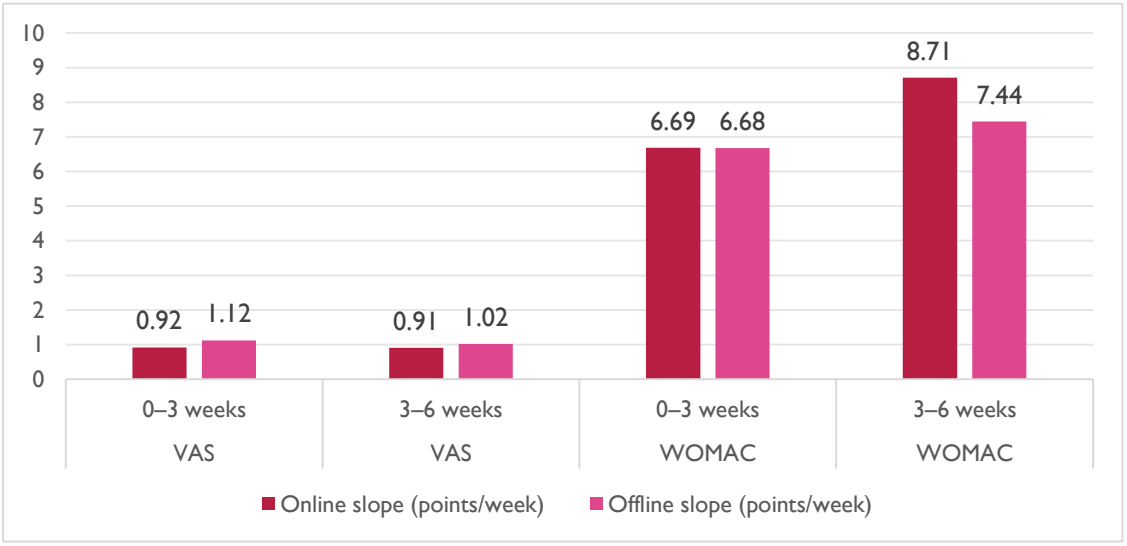

Figure 2. **Absolute improvements during early (0–3 weeks) and later (3–6 weeks) phases in (A) VAS pain and (B) WOMAC function. Positive values indicate improvement (reduction in scores). Bars represent mean change over each 3-week phase; higher bars reflect greater improvement.**

4. DISCUSSION

Principal findings

This secondary analysis of a randomized controlled trial demonstrated that pain reduction in knee osteoarthritis occurred steadily across both early (0–3 weeks) and later (3–6 weeks) phases of rehabilitation, while functional recovery accelerated significantly during the later phase. These findings suggest that although patients may experience rapid relief from pain in the initial weeks, continued participation is essential for achieving greater improvements in function.

Comparison with existing literature

Previous trials and systematic reviews have established that exercise-based rehabilitation is effective for reducing pain and improving function in knee osteoarthritis [9,6]. However, most studies have reported overall pre–post outcomes without examining the temporal sequence of recovery. Pisters et al. reported heterogeneous recovery trajectories in osteoarthritis, noting that adherence plays a key role in sustaining improvements [11]. Our findings extend this work by demonstrating that while pain improves steadily, functional gains may require longer exposure to exercise and are more evident in the later weeks. This aligns with the concept that neuromuscular and functional adaptations lag behind analgesic effects [12,13]. Furthermore, programs such as GLA:D™ have emphasized the importance of structured and supervised exercise to optimize adherence and long-term outcomes [14].

Clinical implications

Clinically, these results underscore the need for physiotherapists to counsel patients that early pain relief should not be interpreted as completion of therapy. Instead, patients should be motivated to complete the full duration of rehabilitation to maximize functional benefit and reduce dropout risk. This is particularly relevant for telerehabilitation, where convenience may tempt patients to discontinue prematurely. Reinforcing the expectation of continued functional gains in later weeks may help sustain adherence and improve overall outcomes.

Strengths and limitations

Strengths of this study include the randomized design, structured group-based interventions, and the use of piecewise mixed-effects models to capture phase-specific improvements. Limitations include the relatively short follow-up (6 weeks), restriction to a single trial population, and the fact that this is a secondary analysis rather than a priori trial aim. Future studies with longer follow-up are warranted to determine whether later-phase acceleration in function persists beyond 6 weeks and whether similar patterns are observed in diverse clinical settings.

5. CONCLUSION

This secondary analysis shows that pain relief in knee osteoarthritis occurs steadily throughout a 6-week rehabilitation program, while functional recovery accelerates during the later phase. These findings highlight the need for patients to complete the full duration of therapy to achieve maximum functional benefit.

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