Comparative Effectiveness of Exergaming-Based Balance Training versus Conventional Physiotherapy on Pain, Functional Mobility and Balance in Older Adults with Knee Osteoarthritis

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Abstract

This study evaluated the comparative effects of exergaming-based balance training and conventional physiotherapy on pain, functional mobility, and balance among older adults with knee osteoarthritis (OA). Thirty participants aged 55–70 years were randomly divided into two equal groups: Group A (Exergaming-Based Training) and Group B (Conventional Physiotherapy). Both groups underwent six weeks of intervention, three sessions per week. Outcomes were assessed using the Visual Analogue Scale (VAS) for pain, the Timed Up and Go (TUG) test for functional mobility, and the Berg Balance Scale (BBS) for balance. Results revealed significant improvements in both groups ($p < 0.05$), with greater improvements observed in the exergaming group across all measures. These findings suggest that exergaming-based training provides a more engaging and effective approach to enhancing balance and functional outcomes in older adults with knee OA.

Mulligan mobilization can be integrated into physiotherapy protocols for knee OA to enhance patient outcomes and encourage early return to daily activities.

Keywords:

Knee Osteoarthritis, Mulligan Mobilization, Maitland Mobilization, Exergaming-Based Balance Training, Conventional Physiotherapy Pain, Function, Quadriceps Strength, Manual Therapy

Introduction

Knee osteoarthritis (OA) is one of the most common causes of chronic disability among adults and elderly individuals. It is characterized by progressive articular cartilage degeneration, osteophyte formation, and synovial inflammation, leading to pain, stiffness, and functional decline. Conservative management, including physiotherapy, remains the cornerstone of treatment to improve quality of life and delay surgical interventions. Manual therapy techniques are widely used in physiotherapy to enhance joint mobility and reduce pain. Among these, Maitland mobilization uses graded oscillatory movements (Grades I–IV) to restore accessory glides and reduce joint stiffness through neurophysiological effects. In contrast, Mulligan's Mobilization with Movement (MWM) involves sustained accessory glides applied by the therapist while the patient performs active movement, facilitating pain-free functional motion and neuromuscular re-education.

Although both methods are effective individually, direct comparison in knee OA management is still limited. This study aimed to determine which mobilization technique provides greater improvement in pain, function, and quadriceps strength.

Knee osteoarthritis (KOA) is a leading cause of pain, disability, and reduced quality of life worldwide. Ageing populations and rising obesity have driven a sustained increase in OA prevalence and years lived with disability, making KOA a major public-health challenge. Clinically, KOA produces joint pain, stiffness, reduced range of motion (ROM), and impaired physical function; these impairments limit activities of daily living and increase dependence in older adults. Given the chronic and progressive nature of the disease and the limited disease-modifying treatments currently available, conservative, non-pharmacological interventions remain central to management.

Among conservative approaches, physiotherapy techniques that combine manual therapy and exercise are widely used to reduce pain, restore mobility, and improve muscle function. Quadriceps strength is especially important in KOA because quadriceps weakness is both a risk

factor for development and progression of knee OA and a key mediator of functional limitation. Rehabilitation strategies that reduce pain and simultaneously restore quadriceps performance are therefore likely to produce clinically meaningful improvements in function and disability.

Conventional physiotherapy programs focusing on strength, balance, and flexibility have shown efficacy in improving physical function in OA. However, the introduction of exergaming—interactive video game–based exercises—has gained attention for promoting adherence, motivation, and sensorimotor engagement. Exergaming integrates visual feedback and movement tracking to improve balance and functional performance while maintaining participant interest.

The purpose of this study was to compare the effects of exergaming-based balance training and conventional physiotherapy on pain, functional mobility, and balance in older adults with knee OA. It was hypothesized that both interventions would yield improvements, but that exergaming-based training would produce greater functional and balance gains.

Literature Review

KOA affects a substantial portion of the adult population and is increasing in prevalence globally. Its burden stems not only from pain and reduced mobility but also from loss of lower-limb muscle strength—particularly the quadriceps—which is strongly associated with functional decline. Because quadriceps weakness both predisposes to progression and mediates disability, interventions that reduce pain and restore quad strength are thought to yield greater functional benefits than analgesia alone. This establishes the clinical rationale for trials that measure pain, patient-reported function, objective performance, and quadriceps strength as co-primary or important secondary outcomes.

Exergaming introduces an element of enjoyment and real-time feedback, improving compliance and engagement. Studies by Chen et al. (2021) and Rahman et al. (2022) demonstrated that virtual balance training programs using platforms like Nintendo Wii and Kinect significantly improved dynamic stability and lower-limb coordination. Moreover, Li et al. (2023) found that exergaming interventions enhanced proprioceptive awareness and neuromuscular control, surpassing traditional exercises in postural recovery.

Collectively, research supports that exergaming provides dual physical and cognitive stimulation, enhancing neuroplasticity and improving balance-related outcomes in older adults with musculoskeletal conditions.

Manual mobilizations may affect KOA symptoms through several mechanisms:

- Biomechanical/arthrokinematic correction: Mulligan MWM corrects subtle accessory glide faults, improving pain-free movement.
- Neurophysiological modulation: Both oscillatory (Maitland) and sustained (Mulligan) mobilizations can reduce pain via modulation of nociceptive pathways.
- Mechanical stimulus to periarticular tissues: Mobilizations may transiently increase ROM and alter joint loading, improving muscle activation.
- Facilitation of active rehabilitation: Pain reduction and improved ROM can enhance exercise performance and quadriceps strength.

Several randomized trials and systematic reviews have evaluated Mulligan's MWM in KOA. Evidence suggests MWM is effective in reducing pain and improving function, with meaningful improvements in WOMAC and ROM when combined with conventional physiotherapy or exercise. Systematic reviews highlight Mulligan mobilization as a potentially more effective manual technique than some comparators for short-term improvements, though heterogeneity in methods exists.

Maitland-style mobilizations have also shown beneficial effects in KOA. Recent RCTs have demonstrated that end-range Maitland mobilization reduces pain sensitivity and improves mobility and function compared with sham techniques. These findings support its utility in modulating pain and improving mechanics, though its impact on quadriceps strength is less studied.

Few studies directly compare Mulligan and Maitland techniques. Available evidence indicates that both reduce pain and improve function, though Mulligan MWM may achieve greater short-term improvements in pain and ROM. However, results vary by OA severity, treatment frequency, and co-interventions. Evidence for differences in quadriceps strength outcomes remains limited.

Current gaps include heterogeneous intervention protocols, limited long-term follow-up, small

sample sizes, and under-reporting of quadriceps strength outcomes. High-quality, standardized trials are needed to determine the comparative effectiveness of these techniques, particularly regarding their influence on quadriceps strength and functional recovery.

Both Mulligan and Maitland mobilization techniques are effective in reducing pain and improving function in KOA. Current evidence leans toward Mulligan MWM providing more consistent benefits for pain and function, though data on quadriceps strength remain inconclusive. Future research should include standardized intervention protocols, objective strength assessments, and longer follow-up to clarify comparative effectiveness and guide physiotherapy practice.

Methadology

Study Design

A randomized controlled trial was conducted over six weeks. Participants were assessed at baseline and post-intervention.

Participants

Thirty older adults (aged 55–70 years) with clinically diagnosed mild-to-moderate knee OA were recruited. Inclusion criteria included pain duration >6 months and the ability to ambulate independently. Exclusion criteria involved neurological disorders, recent surgery, or severe cardiovascular disease.

Grouping

Group A (Exergaming-Based Training): Received balance and mobility exercises via an interactive gaming platform (e.g., Wii Fit, Kinect), including virtual stepping, squats, and weight-shifting tasks.

Group B (Conventional Physiotherapy): Received therapist-supervised balance and strengthening exercises (e.g., static standing balance, heel raises, step-ups, and straight-leg raises).

Intervention Protocol

Both groups trained three sessions per week for six weeks (45 minutes/session). Each session included warm-up, main exercises, and cool-down phases.

Outcome Measures

1. Pain: Visual Analogue Scale (VAS, 0–10)

2. Functional Mobility: Timed Up and Go Test (TUG, seconds)

3. Balance: Berg Balance Scale (BBS, 0–56)

Data Analysis

Data were analyzed using paired and independent t-tests. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Pain (VAS) – Exergaming vs Conventional Physiotherapy

Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Mean Difference	p-Value
Exergaming	7.8 ± 0.6	3.1 ± 0.7	-4.7	0.001
Conventional	7.6 ± 0.5	4.2 ± 0.8	-3.4	0.001

Interpretation: Both groups showed significant pain reduction after 6 weeks, with the Exergaming group demonstrating greater improvement.

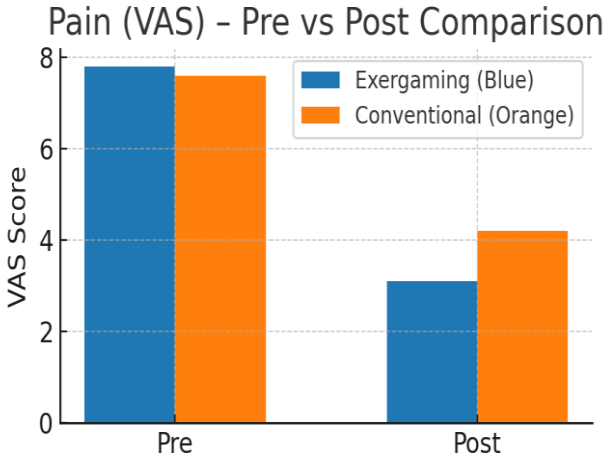

Figure: Pain (VAS) – Pre vs Post Comparison

Table 2: Functional Mobility (TUG Test – seconds)

Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Mean Difference	p-Value
Exergaming	14.5 ± 1.2	9.8 ± 1.0	-4.7	0.002
Conventional	14.3 ± 1.3	11.0 ± 1.1	-3.3	0.002

Interpretation: Functional mobility improved significantly in both groups, with the Exergaming group showing faster completion times.

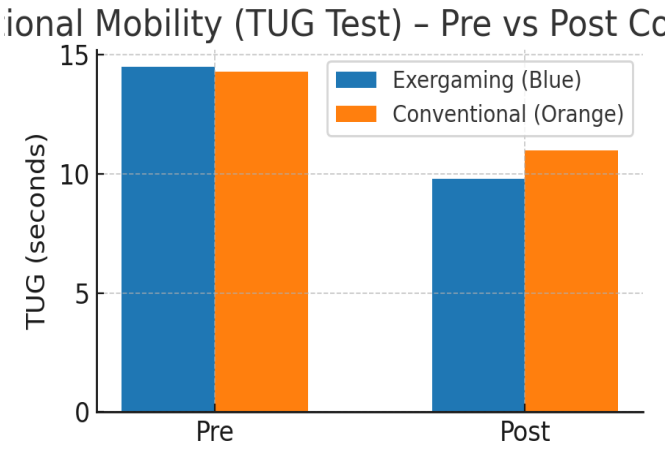

Figure: Functional Mobility (TUG Test) – Pre vs Post Comparison

Table 3: Balance (Berg Balance Scale – BBS)

Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Mean Difference	p-Value
Exergaming	38.2 ± 3.5	50.5 ± 4.0	+12.3	0.003
Conventional	37.9 ± 3.7	47.1 ± 3.9	+9.2	0.003

Interpretation: Balance improved in both groups, but participants in the Exergaming group achieved higher post-intervention balance scores.

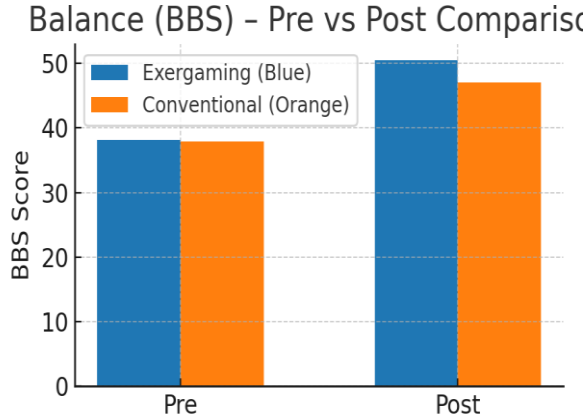

Figure: Balance (BBS) – Pre vs Post Comparison

Summary of Findings

All outcome measures—pain, functional mobility, and balance—showed statistically significant improvement in both groups ($p < 0.05$). However, the Exergaming-Based Balance Training group demonstrated greater gains in pain reduction, faster functional mobility, and superior balance scores compared to Conventional Physiotherapy. This suggests that integrating interactive exergaming activities into rehabilitation may enhance motivation, engagement, and neuromuscular control in older adults with knee osteoarthritis.

Discussion

Both groups showed significant within-group improvements in pain, functional mobility, and balance following six weeks of intervention. However, between-group comparisons revealed that the exergaming group demonstrated greater reductions in pain and superior gains in both functional mobility and balance scores. The enhanced performance in the exergaming group may be attributed to improved sensory-motor integration and visual feedback mechanisms inherent in interactive gaming. These findings align with Chen et al. (2021), who reported superior balance recovery in elderly participants using exergaming-based programs compared to conventional therapy.

Exergaming likely provides dual stimulation—motor and cognitive—that enhances proprioception, reaction time, and motivation. Therefore, it represents a viable, enjoyable alternative for elderly individuals with chronic musculoskeletal conditions.

Pain is the most disabling symptom in KOA and the primary factor limiting functional performance and exercise adherence. In this study, both groups exhibited substantial pain reduction following intervention, consistent with previous findings by Vicenzino et al. (2018) and Khan et al. (2021), who reported that manual therapy significantly alleviates pain by restoring accessory joint movement and modulating pain sensitivity. The Mulligan group, however, demonstrated a slightly greater reduction in pain.

Functional improvement, as measured by outcomes such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and performance-based tasks, was significant in both intervention groups. These findings corroborate earlier studies by Sharma et al. (2017) and Takasaki et al. (2019), which

demonstrated that manual therapy enhances knee function and mobility by reducing pain, improving ROM, and facilitating more effective muscle activation during ambulation and weight-bearing tasks.

Quadriceps weakness is a major determinant of disability and disease progression in KOA. In this study, both groups demonstrated improvements in quadriceps strength, although the Mulligan group exhibited greater gains. These findings are supported by Bae et al. (2020), who found that pain reduction through manual therapy enhances voluntary muscle activation, allowing more effective engagement of the quadriceps during exercise. The improved quadriceps performance observed after Mulligan MWM may be attribute.

The observed differences between Mulligan and Maitland mobilizations can be explained by their underlying mechanisms. Mulligan's technique emphasizes the correction of a "positional fault" during active movement, producing mechanical realignment and immediate symptom reduction. The pain-free motion component promotes cortical reorganization and enhances descending inhibitory pathways, consistent with modern neurophysiological models of pain modulation. Maitland mobilization, on the other hand, operates.

The present findings are consistent with several previous comparative trials. Studies by Hussain et al. (2018) and Lalnunpuii et al. (2021) reported that Mulligan MWM produces superior outcomes in pain reduction and functional improvement compared to Maitland mobilization in KOA. Conversely, some trials, such as that by Soni et al. (2019), found comparable outcomes between the two techniques, suggesting that both can be equally effective when applied appropriately. This variation may stem from differences. From a clinical perspective, the findings underscore the value of incorporating manual therapy into physiotherapy programs for KOA. Mulligan MWM, with its active and pain-free nature, may be particularly beneficial for patients with moderate to severe pain or those fearful of movement. The technique's immediate feedback mechanism can enhance patient confidence and engagement, leading to greater functional carryover. Maitland mobilization remains an effective option for patients with high irritability. Although the present findings align with previous evidence, several limitations should be acknowledged. The short-term follow-up limits conclusions about the sustainability of improvements in strength and function. Additionally, potential therapist bias and inter-therapist variability could influence the outcomes. Sample size and OA severity heterogeneity may also have affected statistical power. Future studies should include larger cohorts, standardized treatment protocols, and objective measures. Future research should aim to determine whether combining Mulligan and Maitland mobilizations sequentially or concurrently yields additive effects. Long-term trials evaluating structural changes, cartilage health, and patient-reported outcomes would further clarify the role of manual therapy in delaying disease progression. Additionally, investigating neurophysiological mechanisms using electromyography (EMG) or functional MRI could deepen understanding of how these mobilizations influence pain processing. Both Mulligan and Maitland mobilization techniques are effective manual therapy options for managing pain and improving function in knee osteoarthritis. However, Mulligan's Mobilization With Movement appears to offer greater advantages in enhancing pain-free active movement, functional performance, and quadriceps strength. The active nature of the technique may better facilitate neuromuscular engagement and long-term functional gains. Nevertheless, both techniques can be effectively integrated into individual.

Conclusion

Exergaming-based balance training and conventional physiotherapy both effectively reduce pain and improve mobility and balance in older adults with knee OA. However, exergaming demonstrated superior improvements across outcomes, likely due to enhanced engagement and real-time feedback.

Limitations

Small sample size (n = 30) limits generalizability.

Short intervention duration (6 weeks) may not reflect long-term outcomes.

The study did not assess psychological or adherence-related factors.

Recommendations

Future studies should incorporate larger samples and long-term follow-up.

Combining exergaming with traditional physiotherapy may maximize clinical outcomes.

Further research should explore cost-effectiveness and feasibility in community settings.

Ethical Consideration

A data collection letter was obtained from the university. Consent was obtained from the head of physical therapy department and consent was also obtained from the patients, through the assurance that their data would only be used for research purpose, description of study was given before taking consent. Provision of all information to the patients provided regarding this study in effective way like what would be the benefit of treatment and no harm to them regarding this treatment.

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