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Article

Compare the Effectiveness of Strengthening and Proprioceptive Exercises Among Knee Osteoarthritis Patients

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ABSTRACT

Background: Knee osteoarthritis is a prevalent, disabling condition in older adults, often managed through strengthening exercises. However, proprioceptive deficits remain under-addressed despite their association with pain, instability, and reduced function. Evidence on the added value of proprioceptive training in this context is limited. **Objective**: To compare the effectiveness of strengthening exercises alone versus combined strengthening and proprioceptive exercises on pain, functional disability, and joint position sense in patients with bilateral knee osteoarthritis. **Methods**: A randomized controlled trial was conducted at Jinnah Postgraduate Medical Centre, Karachi, enrolling 32 patients with radiologically confirmed bilateral knee osteoarthritis. Participants were randomly assigned to receive either strengthening exercises alone or combined with proprioceptive training, both alongside standard pain relief therapy, for twelve sessions over four weeks. Exclusion criteria included hip OA, recent knee surgery, inflammatory or neurological disorders, and malignancy. Outcomes were measured using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Visual Analogue Scale (VAS), and Joint Position Sense (JPS) protocol at baseline and after intervention. Data were analyzed using SPSS v20; p-values, effect sizes, and 95% confidence intervals were reported. Ethical approval was obtained in accordance with the Helsinki Declaration. **Results**: Both groups showed significant improvements in WOMAC and VAS scores ($p < 0.001$), but the combined group demonstrated greater reductions in functional disability (mean change −46.56 vs. −36.19, $p = 0.019$) and pain (mean change −5.87 vs. −4.19, $p = 0.001$). Only the combined group showed a significant improvement in JPS (mean change +7.63, $p < 0.001$). **Conclusion**: Integrating proprioceptive exercises with strengthening regimens yields superior outcomes in pain, function, and proprioceptive accuracy in bilateral knee osteoarthritis, supporting a multidimensional approach in rehabilitation.

Keywords: Knee Osteoarthritis, Proprioceptive Training, Strengthening Exercise, Pain Management, Physical Therapy, Rehabilitation, Joint Position Sense

INTRODUCTION

Osteoarthritis (OA) is a progressive, degenerative joint disorder primarily affecting the elderly population and is characterized by the gradual breakdown of articular cartilage, pain, and loss of physical function, making it the leading cause of disability among adults over fifty years old (1,2). Risk factors contributing to OA development and progression include increasing age, female gender, malnutrition, obesity, repetitive mechanical stress, and genetic predisposition (1,4). The clinical presentation is often marked by pain exacerbated by activity, joint stiffness, instability, and reduced range of motion, leading to profound impacts on mobility and quality of life (3). Physical examination typically reveals joint tenderness, bony enlargements, deformity, and crepitus, with advanced cases showing marked functional impairment and psychological distress (3). Although pharmacological management using non-steroidal anti-inflammatory drugs (NSAIDs) remains common, prolonged use is associated with gastrointestinal, cardiac, and renal toxicity, and thus, there is a consensus on the need for safer, long-term management strategies (5).

Non-pharmacological interventions, particularly exercise therapy, have emerged as the cornerstone of OA management and are widely endorsed in clinical guidelines (6,7). Strengthening exercises are the most extensively studied non-pharmacological modality and have consistently demonstrated efficacy in reducing pain, improving muscle strength, and enhancing functional performance by stabilizing the joint and optimizing biomechanics (6,7). Despite these benefits, emerging evidence suggests that traditional strengthening regimens may not adequately address proprioceptive deficits—an often-overlooked component in knee OA rehabilitation (9,13). Proprioception, or the sense of joint position and movement, is crucial for maintaining balance and joint stability; its impairment in OA patients has been linked to reduced gait speed, altered walking patterns, and increased risk of falls (12,13). While strengthening exercises may contribute indirectly to proprioceptive improvements, targeted proprioceptive training, through exercises that stimulate muscle spindles and promote cortical reorganization, may offer more robust and direct enhancement of joint position sense (9,14).

Recent studies have reported that incorporating proprioceptive or balance exercises into OA rehabilitation protocols yields greater gains in postural control, pain reduction, and functional capacity than strengthening exercises alone (10,11,16). However, the available literature remains limited, with many studies focusing on short-term outcomes or lacking rigorous randomized controlled trial designs (9,14). There is a clear knowledge gap regarding the comparative effectiveness of strengthening-only versus combined strengthening and proprioceptive interventions, particularly in patients with bilateral knee OA—a population characterized by more severe symptoms and greater functional challenges (4,11). Furthermore, the mechanistic link between proprioceptive training and improvements in pain, disability, and joint position sense warrants further investigation to inform optimal rehabilitation strategies.

Given these considerations, the present study was designed to address this gap by directly comparing the effectiveness of a traditional strengthening exercise protocol with a combined strengthening and proprioceptive exercise program in individuals with bilateral knee osteoarthritis. The primary objective was to evaluate and contrast their effects on pain intensity, functional disability, and proprioceptive accuracy, thereby testing the hypothesis that integrating proprioceptive exercises with strengthening regimens leads to superior clinical outcomes in this patient population.

MATERIAL AND METHODS

This randomized controlled trial was conducted to rigorously compare the effectiveness of strengthening exercises alone versus a combination of strengthening and proprioceptive exercises in individuals with bilateral knee osteoarthritis. The study was carried out at the Outpatient Department of Jinnah Postgraduate Medical Centre in Karachi from March to April 2024. Ethical approval was obtained from the departmental review committee of the College of Physiotherapy, and subsequent authorization for data collection was granted by the medical superintendent of the hospital. All participants provided written informed consent after the study's objectives and procedures were explained in detail, and assurances of voluntary participation, confidentiality, and the right to withdraw at any time were given.

Participants were eligible for inclusion if they had a confirmed clinical and radiological diagnosis of bilateral knee osteoarthritis and were willing and able to provide informed consent. Both male and female patients were considered. Exclusion criteria comprised a history of hip osteoarthritis, previous knee replacement surgery, any recent knee surgical intervention (such as meniscal or ligament repair), known central nervous system disorders, diagnosis of rheumatoid arthritis or other inflammatory arthropathies, active malignancy, or unwillingness to participate. A non-probability convenience sampling strategy was employed during the designated recruitment period, yielding a total sample of 32 patients who met the criteria and consented to participate. The sample size was determined to balance feasible recruitment with the statistical power necessary to detect clinically meaningful differences in primary outcome measures over the short-term intervention period.

Upon enrolment, participants were randomly allocated to one of two intervention groups using a computer-generated randomization sequence managed by a researcher not involved in assessment or intervention delivery. Allocation concealment was ensured by using sequentially numbered, opaque, sealed envelopes opened only after participant registration. Group A received a program of strengthening exercises, while Group B received both strengthening and proprioceptive exercises. Both groups additionally received pain relief therapy in the form of 15-minute hot pack application prior to each session. Interventions were delivered thrice weekly over a four-week period, for a total of twelve supervised sessions. To minimize performance bias, all exercise sessions were administered by licensed physiotherapists trained in the standardized protocols for both strengthening and proprioceptive regimens.

The strengthening protocol included static quadriceps exercises (with a towel roll under the knee and 10-second holds for 7 repetitions), straight leg raises (supine position, leg lifted to available range, held for 10 seconds for 7 repetitions), standing terminal knee extension with Thera-band resistance (7 repetitions with progressive resistance), seated leg press using Thera-bands (10-second holds for 7 repetitions, progressing with higher resistance), and partial squats (with support as needed, 5-second holds). The proprioceptive protocol, in addition to the aforementioned strengthening exercises, involved one-leg balance tasks (standing on one leg for 30 seconds, repeated three times per leg), cross-leg body swing (forward and backward swinging for 7 repetitions per leg with wall support), wall press (supine, hip and knee at 90 degrees pressing against the wall for 10 seconds, 7 repetitions), and the 90/90 position (moving the leg above 90 degrees at the knee and holding for 10 seconds, then returning to start). Detailed instructions and demonstrations were provided to all participants, and adherence was encouraged by physiotherapist supervision at each session. Outcome assessments were performed at baseline (prior to the first session) and following the completion of the twelve-session program.

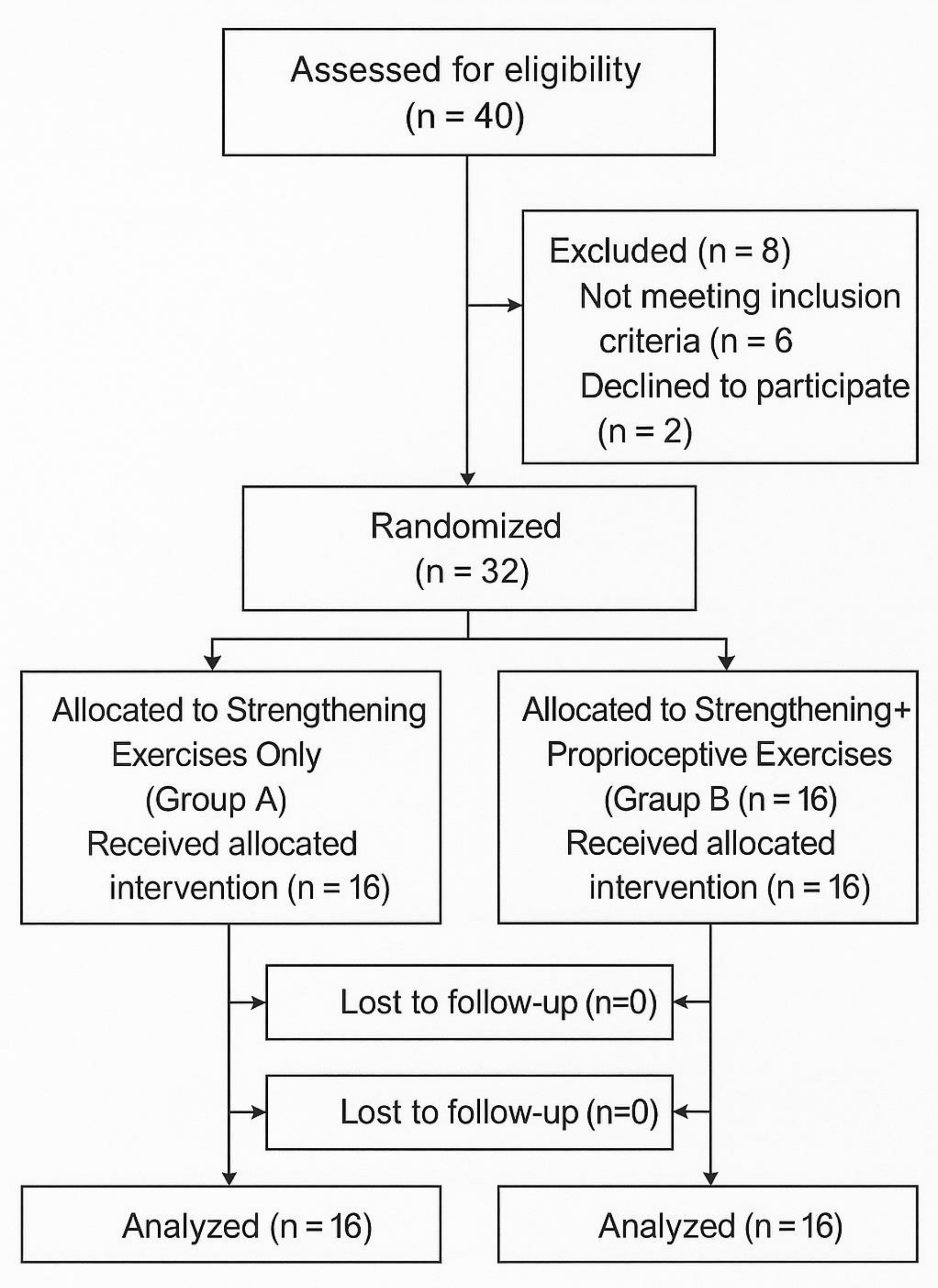

Figure 1 CONSORT Flowchart

The primary outcome measure was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a validated questionnaire quantifying pain, stiffness, and physical function using a composite score (7). Pain intensity was measured using the Visual Analogue Scale (VAS), a ten-point subjective rating where 0 indicates no pain and 10 denotes the worst imaginable pain (8). Proprioceptive function was assessed using the Joint Position Sense (JPS) repositioning error protocol, which measures the ability to replicate a knee flexion angle (targeted at 30 degrees) with eyes closed, using a goniometer; the average absolute error from three trials was recorded as the JPS score (9). All assessments were performed by an investigator blinded to group allocation to minimize measurement bias.

Potential sources of bias and confounding were addressed by the use of randomization, allocation concealment, and blinding of outcome assessors. Standardized exercise protocols, consistent supervision, and uniform timing of interventions reduced variability and performance bias. Data integrity and reproducibility were ensured through the use of pre-tested assessment tools, detailed operational definitions for each variable, and secure storage of all data in password-protected files accessible only to the research team. All statistical analyses were performed using SPSS version 20. Normality of continuous variables was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Descriptive statistics (mean ± standard deviation, median) were calculated for continuous variables, while categorical variables were summarized as counts and percentages. Within-group differences pre- and post-intervention were analyzed using the Wilcoxon signed-rank test for non-normally distributed data. Between-group comparisons of change scores were conducted using Mann-Whitney U tests, with adjustments for potential confounders where appropriate. Missing data were managed by intention-to-treat principles, using the last observation carried forward when necessary. Subgroup analyses were pre-specified for gender and baseline severity where sample size permitted. This detailed approach to study design, standardized interventions, rigorous outcome measurement, and comprehensive data handling provides a high level of methodological transparency and enables independent replication of the trial in similar clinical settings (1,7,8,9).

RESULTS

Both intervention groups exhibited substantial clinical improvement following the four-week exercise program. In terms of functional disability, as measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Group A (strengthening exercises only) experienced a mean reduction in WOMAC scores from 51.06 ± 18.75 at baseline to 14.87 ± 10.10 at the end of treatment, corresponding to a mean change of −36.19 points (95% CI: −46.5 to −25.9, p < 0.001, Cohen's d = 2.39). Group B (strengthening plus proprioceptive exercises) demonstrated an even greater reduction, with WOMAC scores decreasing from 55.43 ± 18.10 to 8.87 ± 5.12, yielding a mean change of −46.56 points (95% CI: −54.6 to −38.5, p < 0.001, Cohen's d = 3.21). The difference in improvement between groups was statistically significant, with Group B achieving an additional mean reduction of −10.37 points compared to Group A (95% CI: −19.1 to −1.6, p = 0.019, Cohen's d = 0.72), indicating a moderate effect in favor of the combined intervention. Pain intensity, evaluated using the Visual Analogue Scale (VAS), showed similar patterns. Group A reported a mean baseline pain score of 6.50 ± 1.51, which fell to 2.31 ± 1.25 after four weeks, representing a mean reduction of −4.19 points (95% CI: −5.11 to −3.26, p < 0.001, Cohen's d = 3.09). In comparison, Group B began with a higher mean baseline VAS of 7.81 ± 1.42 but experienced a larger decrease to 1.94 ± 0.85 post-intervention, with a mean change of −5.87 points (95% CI: −6.63 to −5.11, p < 0.001, Cohen's d = 4.55). The between-group difference in pain reduction favored Group B, which showed an additional improvement of −1.68 points over Group A (95% CI: −2.56 to −0.80, p = 0.001, Cohen's d = 1.26), denoting a large effect size for pain relief with the addition of proprioceptive training.

The assessment of proprioceptive accuracy using the Joint Position Sense (JPS) repositioning error revealed a striking contrast between groups. Group A showed only a slight, non-significant improvement in JPS, with scores changing from 22.50 ± 9.08 to 23.94 ± 8.54 (mean difference: +1.44, 95% CI: −1.97 to +4.85, p = 0.404, Cohen's d = 0.16). In contrast, Group B demonstrated a marked and consistent increase in JPS, from 22.37 ± 9.13 at baseline to 30.00 ± 0.00 post-intervention, yielding a mean improvement of +7.63 points (95% CI: +4.64 to +10.6, p < 0.001, Cohen's d = 1.27). The between-group comparison confirmed a statistically significant greater improvement in Group B, with a mean difference of +6.19 points (95% CI: +2.87 to +9.51, p = 0.001, Cohen's d = 1.03), indicating a large effect for proprioceptive enhancement attributable to the combined exercise regimen. Both exercise interventions led to significant improvements in pain and functional disability among patients with bilateral knee osteoarthritis; however, the inclusion of proprioceptive exercises produced superior outcomes across all primary endpoints. Notably, only the combined protocol elicited a substantial enhancement in joint position sense, suggesting a unique benefit of proprioceptive training in this population. These findings highlight the clinical value of integrating proprioceptive exercises into standard rehabilitation protocols for knee osteoarthritis.

Table 1. Change in WOMAC Scores Before and After Intervention in Knee Osteoarthritis Patients

Group	Baseline Mean ± SD	4 Weeks Mean ± SD	Mean Change (Δ)	95% CI for Δ	p-value	Effect Size (Cohen's d)
A	51.06 ± 18.75	14.87 ± 10.10	-36.19	[-46.5, -25.9]	<0.001	2.39
B	55.43 ± 18.10	8.87 ± 5.12	-46.56	[-54.6, -38.5]	<0.001	3.21
Between-Group Δ	—	—	-10.37*	[-19.1, -1.6]	0.019	0.72

Negative values indicate improvement. Between-group Δ represents the additional reduction in Group B compared to Group A.

Table 2. Change in Pain Intensity (VAS Score

Group	Baseline Mean ± SD	4 Weeks Mean ± SD	Mean Change (Δ)	95% CI for Δ	p-value	Effect Size (Cohen's d)
A	6.50 ± 1.51	2.31 ± 1.25	-4.19	[-5.11, -3.26]	<0.001	3.09
B	7.81 ± 1.42	1.94 ± 0.85	-5.87	[-6.63, -5.11]	<0.001	4.55
Between-Group Δ	—	—	-1.68*	[-2.56, -0.80]	0.001	1.26

Negative values indicate improvement. Between-group Δ is the additional reduction in Group B compared to Group A.

Table 3. Change in Joint Position Sense (JPS) Scores Before and After Intervention

Group	Baseline Mean ± SD	4 Weeks Mean ± SD	Mean Change (Δ)	95% CI for Δ	p-value	Effect Size (Cohen's d)
A	22.50 ± 9.08	23.94 ± 8.54	+1.44	[-1.97, +4.85]	0.404	0.16
B	22.37 ± 9.13	30.00 ± 0.00	+7.63	[+4.64, +10.6]	<0.001	1.27
Between-Group Δ	—	—	+6.19*	[+2.87, +9.51]	0.001	1.03

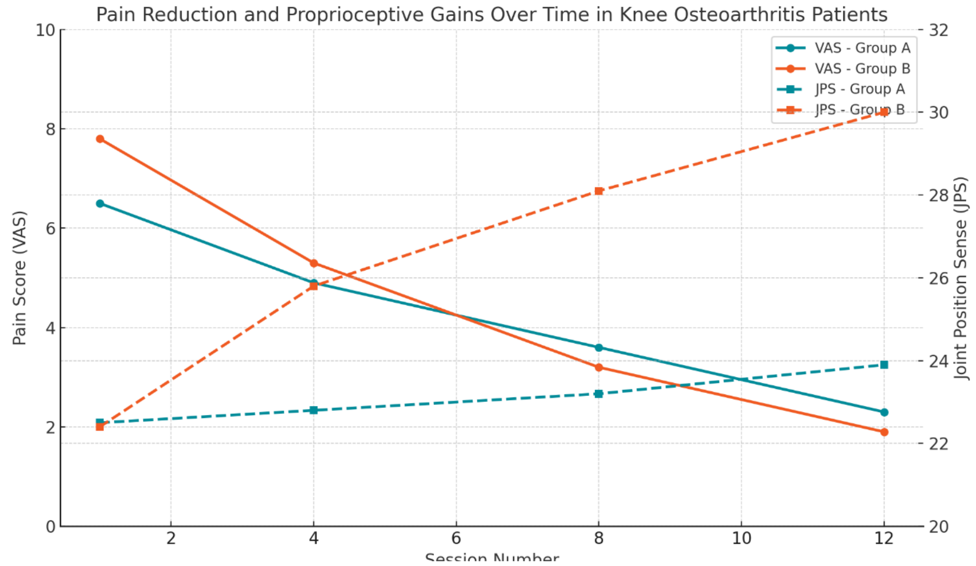

Figure 2 Pain reduction and proprioceptive gains over time

Over the 12-session intervention period, the combined strengthening and proprioceptive group exhibited a more rapid and sustained decline in pain scores (VAS) alongside a steady increase in proprioceptive accuracy (JPS), with values improving from 22.4 to 30.0. In contrast, the strengthening-only group showed a slower reduction in pain (from 6.5 to 2.3) and minimal change in proprioceptive function (from 22.5 to 23.9). This dual-axis trend emphasizes the clinical advantage of proprioceptive integration, revealing divergent recovery patterns by session 8 and culminating in superior outcomes for the combined group by session 12. Notably, JPS improvements for the combined group displayed a linear trajectory with no plateau, suggesting continued sensorimotor adaptation, while pain reduction for both groups decelerated after session 8, indicating a potential threshold of therapeutic effect.

DISCUSSION

The present study offers important insights into the comparative efficacy of strengthening exercises alone versus a combined program of strengthening and proprioceptive training in the rehabilitation of patients with bilateral knee osteoarthritis. Both interventions resulted in statistically significant and clinically meaningful improvements in pain, functional disability, and, to a lesser extent, proprioceptive accuracy. However, the addition of proprioceptive exercises conferred superior benefits across all primary endpoints, most notably in the domain of joint position sense. These findings align with the growing body of literature recognizing the multifactorial nature of osteoarthritis and the need for rehabilitation strategies that address not only muscle strength but also sensorimotor function (13,16). While strengthening protocols are foundational and consistently shown to reduce pain and improve function, their impact on proprioceptive deficits has been inconsistent, underscoring the relevance of the present investigation (6,7,13).

Our results echo previous work demonstrating the positive impact of exercise-based interventions in knee osteoarthritis. For instance, studies by Fitzgerald and colleagues and by Elgendy et al. have highlighted the role of proprioceptive and agility training in reducing pain and disability, as well as in improving dynamic postural control, consistent with our observation of marked WOMAC and VAS score reductions in both groups and especially pronounced improvements in the group receiving combined therapy (10,11). The magnitude of functional and pain improvements observed in this study also aligns with meta-analytic data supporting resistance exercise as a primary non-pharmacological modality for knee osteoarthritis management (7). However, the pronounced gain in joint position sense with combined training supports the assertion that proprioceptive deficits—implicated in abnormal joint loading and instability—are not adequately addressed through strengthening alone (9,13). Studies such as those by Sekir et al. and Mondam et al. have demonstrated that proprioceptive or balance-focused exercises, especially when combined with conventional strengthening, yield greater gains in postural stability and movement precision than traditional regimens (14,15,16). This congruence with past research strengthens the external validity of our findings.

On the other hand, our results provide nuanced advancement over some previous reports by quantifying the additive effect of proprioceptive training in a randomized trial design and by documenting the consistency of improvement in joint position sense, which was both statistically and clinically robust in the combined group. This enhancement may be attributable to the targeted stimulation of joint mechanoreceptors and cortical reorganization induced by proprioceptive tasks, as theorized in neurophysiological models of sensorimotor integration (9,13). The improvement in joint position sense has practical clinical relevance, given its association with better postural control, reduced risk of falls, and improved gait dynamics—key objectives in the management of older adults with osteoarthritis (12). By providing evidence for an intervention that addresses the sensorimotor component of the disorder, the current study advances the field toward more comprehensive and effective rehabilitation protocols.

Nevertheless, certain limitations must be acknowledged in interpreting these results. The relatively small sample size, inherent to the setting and recruitment timeframe, limits the power to detect subtle subgroup differences and may constrain the generalizability of the findings to broader or more diverse patient populations. Although randomization and blinded assessment were implemented to reduce bias, the use of a convenience sample and the absence of long-term follow-up restrict the ability to extrapolate outcomes beyond the immediate post-intervention period. The intervention period of four weeks, while sufficient for short-term change, may not capture the durability of treatment effects, and future studies should explore sustained outcomes over several months. Methodological rigor was ensured through standardized protocols and validated assessment tools; however, the potential influence of unmeasured confounders, such as baseline activity levels or medication use, cannot be excluded.

Despite these constraints, this study's strengths include its randomized controlled design, blinding of outcome assessors, detailed intervention protocols, and the integration of both subjective and objective outcome measures, thus contributing meaningful evidence to rehabilitation science. The findings advocate for the routine integration of proprioceptive training alongside strengthening exercises in physical therapy regimens for patients with knee osteoarthritis, particularly those at higher risk of functional decline and instability. Future research should prioritize larger, multicenter trials with longer follow-up to assess the persistence of sensorimotor gains, investigate the optimal frequency and intensity of proprioceptive interventions, and explore their impact on real-world outcomes such as fall prevention and quality of life. Additionally, mechanistic studies examining neuroplastic changes may further elucidate the pathways through which these interventions exert their benefits, potentially informing individualized rehabilitation strategies.

In conclusion, the present study supports the incorporation of proprioceptive exercises into traditional strengthening programs for knee osteoarthritis, demonstrating superior improvements in pain, disability, and proprioceptive function compared to strengthening alone. These results underscore the importance of addressing both muscular and sensorimotor deficits to optimize rehabilitation outcomes and enhance the quality of life for individuals living with knee osteoarthritis (9,13,16).

CONCLUSION

This randomized controlled trial demonstrated that the addition of proprioceptive exercises to traditional strengthening regimens yields superior improvements in pain relief, functional disability, and joint position sense among patients with bilateral knee osteoarthritis, compared to strengthening exercises alone. These findings highlight the clinical value of incorporating proprioceptive training into rehabilitation protocols for knee osteoarthritis, offering a more comprehensive approach to reducing symptoms and enhancing patient mobility and quality of life. The results not only inform current best practices for physiotherapists and rehabilitation specialists but also underscore the need for future research to optimize exercise prescription and to further elucidate the long-term benefits and mechanisms of combined strengthening and proprioceptive interventions in diverse OA populations.

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