



Proprioceptive Training for Balance, Lower Extremity Function and Bone Mineral Density in Postmenopausal Women with Unilateral Knee Osteoarthritis

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Abstract Objectives: To compare conventional physiotherapy alone with conventional physiotherapy plus proprioceptive training for improving balance, lower extremity function and Bone Mineral Density (BMD) in postmenopausal women with unilateral Knee Osteoarthritis (KOA). **Methods:** This randomized pretest-posttest study included 30 postmenopausal women with unilateral KOA allocated to Group A (conventional physiotherapy) or Group B (conventional physiotherapy with proprioceptive training). Conventional physiotherapy comprised interferential therapy, stretching, quadriceps and hamstring isometrics, straight-leg raises, knee extension in high sitting and supervised retro-walking. Outcomes were assessed at baseline and after 8 weeks using the Knee injury and Osteoarthritis Outcome Score (KOOS), Timed Up and Go (TUG) test and Dual-energy X-ray Absorptiometry (DXA) T-score. Paired and unpaired t-tests were used, with $p < 0.05$ considered significant. **Results:** Both groups showed significant within-group improvement in KOOS and TUG scores ($p < 0.001$). Between-group post-test comparisons favored Group B for KOOS ($p = 0.046$) and TUG ($p < 0.001$), indicating superior improvement in function and balance with added proprioceptive training. Three participants in Group B were lost to follow-up. BMD did not change significantly within or between groups over the 8-week intervention period ($p > 0.05$). **Conclusion:** Adding proprioceptive training to conventional physiotherapy improved balance and lower extremity function more than conventional physiotherapy alone; however, no significant between-group change in BMD was observed over 8 weeks.

Key Words Conventional Exercise, DXA Scan, Knee Osteoarthritis, Postmenopausal Women, Proprioception

INTRODUCTION

Knee Osteoarthritis (KOA) is a common degenerative disorder of weight-bearing joints and a major cause of pain, stiffness, reduced mobility and disability in older adults [1]. Global estimates indicate a substantial disease burden and Indian women in the postmenopausal age group represent an especially relevant clinical population because menopause-related estrogen decline may adversely affect cartilage homeostasis, muscle performance, balance and skeletal health. In addition to pain and quadriceps weakness, impaired proprioception is increasingly recognized as an important contributor to activity limitation and postural instability in KOA [2]. Because proprioceptive deficits can alter neuromuscular control, patients may demonstrate poorer balance, slower mobility and reduced confidence during weight-bearing activities.

Exercise-based rehabilitation is therefore recommended as a first-line non-pharmacological strategy for KOA [3].

Although conventional physiotherapy improves symptoms, the additional value of structured proprioceptive training in postmenopausal women with unilateral KOA remains insufficiently clarified, particularly when balance and lower extremity function are considered as primary outcomes and Bone Mineral Density (BMD) is explored as a secondary outcome. The possible relationship between exercise and bone health is biologically plausible because repeated mechanical loading may stimulate bone adaptation; however, measurable BMD changes usually require longer intervention periods and careful control of nutritional and hormonal factors. On this basis, the present study aimed to compare conventional physiotherapy alone with conventional physiotherapy combined with proprioceptive training in postmenopausal women with unilateral KOA [4,5].

It was hypothesized that the combined program would produce greater improvement in balance and lower extremity function, whereas a significant short-term change in BMD over 8 weeks would be less likely.

METHODS

The investigation protocol was approved by the Institutional Ethics Committee and written informed consent was obtained from all participants. This randomized pretest-posttest study used simple random sampling to allocate 30 postmenopausal women with unilateral KOA into Group A (conventional physiotherapy exercises) and Group B (proprioceptive exercises in addition to conventional physiotherapy). Outcome measures were lower extremity function, balance and Bone Mineral Density (BMD), assessed using the Knee injury and Osteoarthritis Outcome Score (KOOS), Timed Up and Go (TUG) test and Dual-energy X-ray Absorptiometry (DXA) T-score, respectively. Baseline assessment was completed before initiation of therapy and post-test assessment was performed after 8 weeks of treatment. Sample size was estimated using G*Power version 3.1.9.7 (Heinrich Heine University Düsseldorf, Düsseldorf, Germany) based on an effect size of 1.3 reported previously, with alpha set at 0.05 and statistical power at 80%. The minimum sample required was 22 participants; this was increased by 20% to compensate for possible attrition, resulting in 15 participants per group.

Participants were women aged 55-65 years with KOA and Body Mass Index (BMI) <35 kg/m², without valgus or varus deformity, limb length discrepancy, or any condition limiting regular participation in the exercise program. Exclusion criteria included skin disorders, fracture within the preceding 6 months, major neurological disorders, open injuries, severe balance disturbance, severe asthma, uncontrolled hypertension, active malignancy, poor vision and recent intra-articular steroid injection. OA severity grade, menopause duration, calcium/vitamin D status, osteoporosis medication history and the exact DXA scan site were not available in the source dataset and should therefore be considered when interpreting the bone-related findings.

Group A received 15 minutes of interferential therapy for pain relief followed by passive hamstring and quadriceps stretching (10 repetitions; 5 minutes each).

Quadriceps and hamstring isometric exercises were then performed for 15 repetitions in one set over 5 minutes each. Straight-leg raises were given for 15 repetitions in two sets for 10 minutes, followed by knee extension in high sitting performed 15 times in two sets over 10 minutes. Treatment concluded with 5 minutes of therapist-supervised retro-walking in parallel bars. Group B received the same conventional physiotherapy program together with proprioceptive exercises comprising step-up and step-down on a footstool (15 repetitions, one set), lunges (15 repetitions, one set), mini-squats (15 repetitions) and marching on the spot. Each session lasted 60 minutes and was supervised by the therapist.

Statistical Analysis

Statistical analysis was performed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Data were summarized as mean±standard deviation. Paired t-tests were used for within-group comparisons and unpaired t-tests for between-group comparisons. A p-value <0.05 was considered statistically significant. Because 3 participants in Group B did not report for the final assessment, post-treatment findings reflect the analyzed available data. Effect sizes and adjusted analyses were not available and are acknowledged as reporting limitations.

RESULTS

The mean age was 57.33±2.06 years in Group A and 57.93±2.87 years in Group B, with no statistically significant baseline difference between the groups (p = 0.52). After 8 weeks of therapy, 3 participants in Group B were lost to follow-up. Within-group comparisons demonstrated significant improvement in KOOS and TUG scores in both groups (p<0.001). Baseline comparisons between Groups A and B were not significant for KOOS (p = 0.39) or TUG (p = 0.90), suggesting initial comparability. However, post-test comparisons showed significant differences in favor of Group B for KOOS (p = 0.046) and TUG (p<0.001), indicating that the addition of proprioceptive exercises was more effective than conventional exercises alone for improving lower extremity function and balance. In contrast, BMD showed no statistically significant within-group or between-group difference over the study period (p>0.05) (Table 1).

Table 1: Comparisons of Lower Extremity Function, Balance and Bone Mineral Density between the Groups

	Group A		t-test	p-value	Group B		t-test	p-value
	Pre-test	Post-test			Pre-test	Post-test		
KOOS test	58.2±4.23	66.47±3.89	-5.57	<0.001**	59.67±4.95	70.42±5.85	-5.17	<0.001**
Groups A Vs B (pre-test)			-0.87	0.39				
Groups A Vs Group B (post-test)			-2.10	0.046*				
TUGT	16.53±1.25	14.93±0.96	3.93	<0.001**	16.47±1.36	13.17±1.34	6.31	<0.001**
Groups A Vs B (pre-test)			0.13	0.90				
Groups A Vs B (post-test)			3.98	<0.001**				
Dexa scan-T score	-0.01±1.34	0.28±1.20	-0.62	0.54	-0.2±1.63	-0.23±1.58	0.05	0.96
Groups A Vs B (pre-test)			0.35	0.73				
Groups A Vs B (post-test)			0.95	0.35				

**Highly significant, *Significant

DISCUSSION

The present study showed that adding proprioceptive exercises to conventional physiotherapy produced better functional and balance outcomes than conventional physiotherapy alone in postmenopausal women with unilateral KOA. This finding is clinically relevant because proprioceptive exercise challenges postural control, stimulates neuromuscular responses and may improve joint position awareness during weight-bearing tasks. Such mechanisms may help explain the superior post-intervention KOOS and TUG outcomes observed in Group B. These findings are in line with previous studies showing that proprioceptive or sensorimotor exercise can improve pain, mobility and functional performance in patients with knee osteoarthritis.

Qiu *et al.* [6] reported that vibration-based exercise protocols improved pain and physical function compared with exercise alone, while Viswas *et al.* [7] observed better balance and activities of daily living after strengthening and proprioceptive exercises. Gupta and Heggannavar also showed benefit from combining proprioceptive interventions with mobilization-based therapy in osteoarthritis of the knee. Taken together, these comparisons support the practical role of proprioceptive training as a low-cost adjunct in physiotherapy-based rehabilitation programs for KOA. From a clinical standpoint, simple weight-bearing drills such as step-up/step-down training, lunges, mini-squats and marching can be incorporated progressively under supervision to enhance mobility and postural control in postmenopausal women at risk of functional decline and falls.

In contrast, the BMD findings were not statistically significant either within or between groups. This result should be interpreted cautiously and should not be overstated. Although exercise can positively influence bone through repeated mechanical loading, measurable changes in bone mass generally require longer duration, greater loading intensity and tighter control of nutritional, hormonal and medication-related confounders than were available in this study. Earlier work using tibial or peripheral bone measures has suggested that longer-term resistive or vibration-supported exercise may improve bone parameters in postmenopausal women, but the present 8-week program was probably too short to demonstrate a distinct BMD response. Therefore, in this manuscript the bone outcome is treated as exploratory rather than as evidence of proven skeletal benefit [8-10].

Several limitations should be considered while interpreting the findings. The sample size was small and the follow-up period was short, which restricts generalizability and is particularly important for a slow-changing outcome such as BMD. Three participants in Group B were lost to follow-up and the analysis reflects the available post-treatment data. OA severity grading, menopause duration, baseline physical activity, dietary calcium/vitamin D status, osteoporosis medication use, blinding details and the exact DXA scan site were not available in the source manuscript, which limits interpretation of the bone-related findings and the precision of risk adjustment. Nevertheless, the exercise protocol was clearly described and the functional findings

provide a useful basis for larger randomized controlled trials with longer follow-up, assessor blinding and more robust bone-health characterization.

CONCLUSION

Adding proprioceptive training to conventional physiotherapy appears to be an effective strategy for improving balance and lower extremity function in postmenopausal women with unilateral knee osteoarthritis. No significant change in bone mineral density was demonstrated over the 8-week intervention period. Larger and longer-duration randomized studies are required before any firm conclusion can be made regarding bone outcomes.

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