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RESEARCH ARTICLE

Effect of Weight Bearing Exercises on Pain, Leg Function, Balance and Bone Strength in Females of Postmenopausal Age with Osteoarthritis Knee

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Abstract

Background/Objectives: Osteoarthritis (OA) of the knee is prevalent among postmenopausal women (PMW), impacting their quality of life. This Randomized Controlled Trial (RCT) aimed to assess the effectiveness of conventional physiotherapy combined with joint-loading exercises on stable and unstable platforms in improving knee function, muscle strength, balance, and bone mineral density - an important strength of the study - in PMW with OA. **Methods**: Thirty PMWs with knee OA were randomly allocated to three groups (n=10): Group A got conventional physiotherapy, Group B got conventional physiotherapy plus joint-loading exercises on a stable platform, and Group C got conventional physiotherapy plus joint-loading exercises on an unstable platform. Key tools utilized in the study included the Knee Injury and Osteoarthritis Outcome Score (KOOS), Manual Muscle Test (MMT), Timed Up and Go Test (TUGT), and Dual Energy X-ray absorptiometry (DEXA) for assessing pain, function, balance, and bone strength. The interventions lasted six weeks, with pre-and post-test assessments. Mention how the analysis was done **Findings**: All groups showed significant improvements in KOOS (G-A: 10.9%, G-B: 18.0%, G-C: 9.3%), MMT (G-A: 3.4 to 4.2, G-B: 3.4 to 4.6, G-C: 3.5 to 4.6), TUGT (G-A: 7.5%, G-B: 6.1%, G-C: 9.9%) and DEXA (G-A at -0.077 $\pm$ 0.4, G-B at 0.225 $\pm$ 0.5, and G-C at -0.246 $\pm$ 0.5) no significant differences were found between groups, though G- B showed the highest improvements. **Novelty**: While all interventions effectively improved knee function, muscle strength, and balance in PMW with OA, joint-loading exercises on a stable platform demonstrated the greatest benefits.

Keywords: Osteoarthritis; Postmenopausal Women; Physiotherapy; Joint-loading exercises; Muscle Strength; Balance

1 Introduction

Weight-bearing exercises provide significant benefits for postmenopausal women with osteoarthritic knees by addressing pain, leg function, balance, and bone strength [1].

These exercises help reduce pain by improving joint mobility, strengthening muscles around the knee, and boosting circulation to decrease inflammation[2]. Strengthening the supporting muscles enhances leg function, allowing for better mobility and daily activity performance[3]. Regular weight-bearing activities also improve balance and postural stability, dropping the threat of falls, which is crucial for women at risk of osteoporosis. These exercises promote bone health by stimulating bone remodeling along with raising bone mineral density, making them essential for managing osteoarthritic symptoms and improving the quality of life in this demographic[4]. Key tools, including KOOS, MMT, TUGT, and DEXA, were used to gauge the bearing of these exercises on pain, function, balance, and bone strength in the study. These tools collectively enabled a comprehensive evaluation of the effectiveness of stable and unstable surface exercises in improving the physical condition of postmenopausal women with knee osteoarthritis[5]. This investigation's chief goal is to compare the effectiveness of a conventional exercise program with weight-bearing exercises performed on both firm and unstable surfaces in improving pain, lower limb function, balance, and bone mineral density within postmenopausal women having degenerative osteoarthritic knee joints.

2 Methodology

The investigation was designed as an RCT and conducted at the Co-operative Institute of Health Sciences' Physiotherapy Outpatient Department, Thalassery, Kerala, India. It targeted postmenopausal women (PMW) with osteoarthritis (OA) of the knee joint to assess the effectiveness of different interventions. In addition to the DEXA scan for bone mineral density (BMD), outcome measures included the Manual Muscle Test (MMT) for muscle strength, the Timed Up and Go Test (TUGT) for balance, and KOOS for pain and lower extremity function.

2.1 Inclusion and Exclusion Criteria (add information about consent of the participants)

Inclusion criteria involved women aged 50-65 who had experienced menopause, confirmed by the absence of menstruation for at least a year. Participants also needed radiographic evidence of OA based on the Kellegren-Lawrence grading system (II-III) and clinical signs of unilateral tibiofemoral primary OA. So, the exclusion criteria included individuals with secondary OA, additional musculoskeletal disorders, prior lower extremity surgeries, lower limb malformations, a BMI above 30, acute wounds, bone cancers, systemic inflammatory diseases, neurological or motion-related problems, metabolic diseases, surgical menopause, cardiovascular disorders, or kidney and liver conditions. Mention the clearance letter number and date

2.2 Treatment procedure

For isometric quadriceps exercises, participants were seated in a long-sitting position with a rolled towel under their knee, pressing the towel for 15 contractions, each held for 10 seconds, totaling 10 minutes. For isometric hamstring exercises, participants pressed a towel placed under the posterior tibia in the same position. Straight leg raises (SLR) were performed in a supine position, with graded resistance based on tolerance, lasting 10 minutes. Retro walking was conducted for 10 minutes, with five forward and five backward steps inside parallel bars, ensuring no discomfort. Interferential therapy (quadripolar method, 90-130 Hz, beat frequency 10-100 Hz) was administered for 10 minutes. This treatment for Group A (G-A) was conducted 5 days a week for 6 weeks, totaling 40 minutes per session. Group B (G-B) received 20 minutes of the same conventional exercises as Group A, followed by 20 minutes of joint-loading exercises (lateral and forward step-ups, and partial squats) on a stable platform, with each exercise performed for 10 repetitions per leg. The total treatment time for G-B was 40 minutes, 5 days a week for 6 weeks. Group C (G-C) underwent 20 minutes of conventional exercises, followed by 20 minutes of joint-loading exercises (lateral and forward step-ups, and partial squats) performed on a mini trampoline, with the support of a safety belt provided by a physiotherapist. The total treatment time for G-C was 40 minutes, 5 days a week for 6 weeks

2.3 Statistical Analysis

Data analysis was conducted utilizing two-way recurrent measures ANOVA to contrast the differences between groups and within pre- and post-test conditions. Bonferroni post hoc tests were applied for multiple comparisons. The interaction between group and test effects was also assessed. A p-value < 0.05 was deemed statistically noteworthy, and all statistical analyses were done utilizing Sigma Plot 14.5.

Table 1. Comparison of G-A, B and C on KOOS

S No.	Comparison of groups	Tests	Statistics
1	G-A	Pre-test	56.8 + 1.0
	G-A	Post-test	63.0 + 1.7
	G-B	Pre-test	54.5 + 1.4
	G-B	Post-test	64.3 + 1.4
	G-C	Pre-test	61.2 + 1.7
	G-C	Post-test	66.9 + 2.0
2	Significance across groups (G-A, B and C)		F = 2.917 P < 0.001
	Significance across tests (Pre-test and Post-test)		F = 181.655 P < 0.001
	Significance in the interaction (groups X tests)		F = 5.790 P = 0.008
3	Significance inside G-A (Pre-test and Post-test)		t = 6.670 P < 0.001
	Significance inside G-B (Pre-test and Post-test)		t = 10.543 P < 0.001
	Significance inside G-C (Pre-test and Post-test)		t = 6.132 P < 0.001
4	Significance across Pre-test (G-A and G-B)		t = 1.039 P = 0.919
	Significance across Pre-test (G-A and G-C)		t = 1.988 P = 0.166
	Significance across Pre-test (G-B and G-C)		t = 3.027 P = 0.014
5	Significance across Post-test (G-A and G-B)		t = 0.587 P = 1.0
	Significance across Post-test (G-A and G-C)		t = 1.762 P = 0.263
	Significance across Post-test (G-B and G-C)		t = 1.175 P = 0.746

G-A = Conventional exercise;
G-B = Conventional exercise + Joint loading exercise in stable platform;
G-C = Conventional exercise + Joint loading exercise in unstable platform.
The values are mean + SE;
n = 10 in each group.
The 'F', 't' and 'P values are by two-way RM ANOVA with Bonferroni 't' test for multiple comparisons.

3 Results

Table 1 assessed the bearing of different exercise intermediations on pain and knee function in post-menopausal women with OA using the KOOS. Three groups were compared: G-A (conventional exercise), G-B (conventional exercise + joint loading on a stable platform), and G-C (conventional exercise + joint loading on an unstable platform). All groups showed noteworthy progress from pre-test to post-test, with G-A improving KOOS scores by 10.9%, G-B by 18.0%, and G-C by 9.3%. Although all interventions were effective, G-B showed the greatest improvement, though the differences between the groups were not statistically significant.

Table 2. Comparison of G-A, B, and C by MMT

S. No.	Comparison of groups	Tests	Statistics
1	G-A	Pre-test	3.4±0.2
	G-A	Post-test	4.2±0.2
	G-B	Pre-test	3.4±0.2
	G-B	Post-test	4.6±0.2
	G-C	Pre-test	3.5±0.2
	G-C	Post-test	4.6±0.2
2	Significance across groups (G-A, B, and C)		F =0 .887 P =0.423
	Significance across tests (Pre-test and Post-test)		F = 85.634 P <.001
	Significance in the interaction (groups X tests)		F = 1.158 P = .329
3	Significance inside G-A (Pre-test and Post-test)		t = 4.136 P < 0.001
	Significance inside G-B (Pre-test and Post-test)		t = 6.204 P < 0.001

Continued on next page

Table 2 continued

	Significance inside G-C (Pre-test and Post-test)	t = 5.687 P < 0.001
4	Significance across Pre-test (G-A and G-B)	t = .000 P = 1.000
	Significance across Pre-test (G-A and G-C)	t = .415 P = 1.000
	Significance across Pre-test (G-B and G-C)	t = .415 P = 1.000
5	Significance across Post-test (G-A and G-B)	t = 1.659 P = .311
	Significance across Post-test (G-A and G-C)	t = 1.659 P = .311
	Significance across Post-test (G-B and G-C)	t = .000 P = 1.000

Table 2 used the Manual Muscle Test (MMT) to assess thebearing of different exercise interventions on muscle strength in postmenopausal women with osteoarthritis. Table 2 shows the comparison between three groups: G-A (conventional exercise), G-B (conventional exercise + joint loading exercise on a stable platform), and G-C (conventional exercise + joint loading exercise on an unstable platform). All groups showed noteworthy progress in muscle strength from pre-test right to post-test, with G-A improving from 3.4 ± 0.2 to 4.2 ± 0.2, G-B from 3.4 ± 0.2 to 4.6 ± 0.2, and G-C from 3.5 ± 0.2 to 4.6 ± 0.2. However, when comparing muscle strength across the groups, there were no noteworthy alterations between them (F = 0.887, p = 0.423), indicating that the different exercise interventions were similarly effective. The interaction between group type and test (pre- and post-test) also showed no significant interaction effect (F = 1.158, p = 0.329). In pre-test comparisons, no noteworthy alterations were found between groups (p = 1.000 for G-A vs. G-B and G-A vs. G-C), and post-test comparisons showed similar results with no significant group differences (p-values ranged from 0.311 to 1.000). Overall, the interventions improved muscle strength, but no particular exercise regimen was found to be superior.

Table 3. Comparison of G-A, B, and C on Timed Up and Go Test (TUGT)

S. No.	Comparison of groups	Tests	Statistics
1	G-A	Pre-test	16.1±0.4
	G-A	Post-test	14.9 +0 .4
	G-B	Pre-test	16.3 ± 0.5
	G-B	Post-test	15.3 ± 0.4
	G-C	Pre-test	16.1 ±0 .5
	G-C	Post-test	14.5 ± 0.4
2	Significance across groups (G-A, B and C)		F =0 .400 P =0.674
	Significance across tests (Pre-test and Post-test)		F = 81.225 P < 0.001
	Significance in the interaction (groups X tests)		F = 1.575 P = 0.225
3	Significance inside G-A (Pre-test and Post-test)		t = 4.930 P < 0.001
	Significance inside G-B (Pre-test and Post-test)		t = 4.108 P < 0.001
	Significance inside G-C (Pre-test and Post-test)		t = 6.573 P < 0.001
4	Significance across Pre-test (G-A and G-B)		t = 0.340 P = 1.00
	Significance across Pre-test (G-A and G-C)		t = 0 P = 1.00
	Significance across Pre-test (G-B and G-C)		t = .340 P = 1.00
5	Significance across Post-test (G-A and G-B)		t = 0.680 P = 1.0
	Significance across Post-test (G-A and G-C)		t = .680 P = 1.00
	Significance across Post-test (G-B and G-C)		t = 1.360 P = 0.550

In Table 3 the pre-test phase, all groups showed similar scores, with G-A at 16.1 ± 0.4, G-B at 16.3 ± 0.5, and G-C at 16.1 ± 0.5. After the intervention, there was a significant reduction in time taken to complete the TUGT within all groups: G-A improved to 14.9 ± 0.4, G-B to 15.3 ± 0.4, and G-C to 14.5 ± 0.4 ($p < 0.001$ for each group). This indicates that all exercise interventions positively impacted mobility.

However, when comparing across the groups, no noteworthy alterations were observed in performance improvement (F = 0.400, p = 0.674), meaning that none of the interventions were statistically superior to the others. Similarly, the interaction across group type and test (pre- and post-test) was not noteworthy (F = 1.575, p = 0.225), showing that the type of exercise did not influence the extent of improvement. Overall, all groups demonstrated significant within-group improvements, but the type of exercise intervention did not make a marked difference across groups. The G-A exhibited a 7.5 % decrease, G-B exhibited a 6.1 % decrease and the G-C exhibited a 9.9 % decrease in time. This exhibits that in all the three groups there is a decrease in the time. This time taken was lesser in G-B likened to G-A alongside G-C.

Table 4. Comparison of G-A, B and C on Dual Energy X Ray Absorptiometry (DEXA) T Score Values

S. No.	Comparison of groups	Tests	Statistics
1	G-A	Pre-test	-0.127±0.4
	G-A	Post-test	-.0770±0.4
	G-B	Pre-test	.193±0.5
	G-B	Post-test	.225±0.5
	G-C	Pre-test	-.300±0.5
	G-C	Post-test	-0.246±0.5
2	Significance across groups (G-A, B and C)		F = .269 P =.766
	Significance across tests (Pre-test and Post-test)		F = 8.761 P =.006
	Significance in the interaction (groups X tests)		F = .195 P = 0.824
3	Significance inside G-A (Pre-test and Post-test)		t = 1.885 P =.070
	Significance inside G-B (Pre-test and Post-test)		t = 1.206 P =0.238
	Significance inside G-C (Pre-test and Post-test)		t = 2.036 P =.052
4	Significance across Pre-test (G-A and G-B)		t =0 .480 P = 1.00
	Significance across Pre-test (G-A and G-C)		t = 0.260 P = 1.00
	Significance across Pre-test (G-B and G-C)		t =0 .740 P = 1.00
5	Significance across Post-test (G-A and G-B)		t =0 .453 P = 1.0
	Significance across Post-test (G-A and G-C)		t = 0.254 P = 1.00
	Significance across Post-test (G-B and G-C)		t =0 .707 P = 1.00

In Table 4 utilized DEXA to gauge changes in bone mineral density, as shown in pre-test phase, T-scores for G-A, G-B, along with G-C were -0.127 ± 0.4, 0.193 ± 0.5, and -0.300 ± 0.5, respectively. Post-test values improved slightly within each group: G-A improved to -0.077 ± 0.4, G-B to 0.225 ± 0.5, and G-C to -0.246 ± 0.5.

A noteworthy difference was observed in bone mineral density improvement across pre- and post-test values across the groups (F = 8.761, p = 0.006), indicating an overall effect of the interventions. However, no noteworthy difference was observed in T-score changes across the groups themselves (F = 0.269, p = 0.766), proposing that the type of exercise did not impact the outcomes. Within-group analysis showed that G-C approached significance in bone density improvement (t = 2.036, p = 0.052), while G-A and G-B did not show significant changes from pre-right to post-test. Additionally, the interaction across group type and test phase was not noteworthy (F = 0.195, p = 0.824), further confirming that all three interventions had similar effects on bone mineral density. The G-A exhibited an improvement of 0.05 T score, the G-B exhibited 0.032 T score and the G-C exhibited 0.05 T score. This exhibits that in all three groups, there is minimal change in the mineral density.

4 Discussion

This investigation looked to compare the effectiveness of various exercise interventions on pain, lower limb function, balance, and bone mineral density within postmenopausal women with degenerative OA knee joints. The interventions included conventional exercises (G-A), conventional exercises combined with joint loading on a stable platform (G-B), and conventional exercises combined with joint loading on an unstable platform (G-C). The results from the various assessments—KOOS, MMT, TUGT, and DEXA—provide insights into the efficacy of these interventions as suggested in previous studies[6].

The KOOS results (Table 1) demonstrated noteworthy progress in all groups from pre-test right to post-test, with G-B showing the most considerable improvement of 18.0%, compared to 10.9% in G-A and 9.3% in G-C. Although these improvements were statistically significant within each group, the differences between the groups were not significant. This indicates that while all interventions led to improvements in knee function, adding joint loading exercises—whether on a stable or unstable platform—did not result in a statistically superior outcome compared to conventional exercises alone[7]. Previous studies suggest that while various exercise interventions significantly improve knee function, the type of exercise may not significantly impact the extent of improvement[8] [9].

The MMT results (Table 2) showed significant improvements in muscle strength in all groups. Both G-B and G-C exhibited an increase in muscle strength comparable to G-A, with no significant differences among the groups. This suggests that while all exercise regimens effectively enhanced muscle strength, no single approach was superior[10]. These results are consistent with research indicating that both conventional and additional joint loading exercises improve muscle strength in osteoarthritis patients, although the specific type of exercise may not lead to differential benefits[11].

Table 3 presents TUGT results, which highlight significant reductions in the time taken to complete the test across all groups, reflecting improved mobility. G-C showed the greatest decrease in time (9.9%), compared to 7.5% in G-A and 6.1% in G-B. Despite these improvements, there were no significant differences between groups. This indicates that while all interventions positively affected mobility, the type of exercise did not result in a significant variation in the extent of improvement.A similar study reported that both conventional and combined exercise regimens improved functional mobility without distinct superiority[12]. DEXA results (Table 4) revealed modest improvements in bone mineral density (BMD) across all groups, with no significant differences between groups. G-C and G-A showed the greatest improvements in T-score values, though these changes were minimal. The lack of significant differences between groups suggests that the addition of joint loading exercises did not significantly impact bone mineral density compared to conventional exercises alone. This aligns with literature suggesting that while exercise can positively influence bone health, the specific type of exercise regimen may not result in significantly different outcomes[12]. Future investigations should explore the long-run effects and include larger, more diverse populations to validate these findings and better understand the benefits of joint loading exercises.

5 Conclusion

The results of this study reveal significant improvements in pain, knee function, muscle strength, and mobility in post-menopausal women with osteoarthritis (OA) after undergoing different exercise interventions. The study compared three groups: G-A (conventional exercise), G-B (conventional exercise + joint loading on a stable platform), and G-C (conventional exercise + joint loading on an unstable platform). All groups showed meaningful progress from the pre-test to the post-test, with G-B showing the most improvement in KOOS scores (18%) and muscle strength (4.6 ± 0.2). However, statistical analysis indicated that the differences between groups were not significant, suggesting that all interventions were equally effective.

The novelty of this study lies in the evaluation of joint loading exercises on different platforms, which, although beneficial, did not outperform conventional exercise alone in terms of statistical significance. Previous studies have not explored this specific comparison in such depth, particularly in post-menopausal women, making this study unique in its approach.

Strengths of the study include its rigorous randomized controlled trial (RCT) design and the use of multiple outcome measures (KOOS, MMT, TUGT, and DEXA) to assess improvements. However, a limitation is the small sample size (n = 10 per group), which may have dropped the power to spot significant variances across groups. Additionally, the study did not explore the long-term sustainability of the improvements seen.

Future studies could increase the sample size and explore other variables, such as the impact of longer intervention periods or different age groups. Open questions remain regarding the precise mechanisms through which joint loading exercises influence OA outcomes and whether a combination of therapies might yield more robust benefits.

In conclusion, the study delivers valuable insights directly into the efficacy of joint loading exercises in improving OA symptoms. However, further research is needed to explore the nuances of these interventions and their broader applicability in clinical practice.

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