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Original Article

Comparative Effects of Calisthenic Exercises and Sensory-Motor Training in Patients with Knee Osteoarthritis: A Randomized Clinical Trial

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ABSTRACT

Background: Knee osteoarthritis (OA) is a prevalent musculoskeletal disorder leading to pain, limited mobility, and functional disability. Non-pharmacological interventions, including calisthenic and sensory-motor training, have demonstrated clinical utility, but direct comparative evidence for these modalities remains limited. Objective: To compare the effects of calisthenic exercises and sensory-motor training, both combined with conventional physical therapy, on pain, range of motion, balance, and functional disability in patients with grade III knee osteoarthritis. Methods: A single-blind, randomized controlled trial was conducted with 108 adults (aged 40–65) diagnosed with unilateral grade III knee OA. Participants were allocated to either calisthenic or sensory-motor training groups (n=54 each) and completed 8-week supervised interventions. Outcomes—Visual Analogue Scale (VAS) for pain, goniometric range of motion (ROM), Timed Up and Go (TUG) test, and WOMAC index—were assessed at baseline, 4 weeks, and 8 weeks. Data were analyzed using independent t-tests and repeated measures ANOVA. Results: Both interventions resulted in significant improvements in pain, ROM, balance, and disability (all p<0.01). Sensory-motor training was superior at 8 weeks, yielding greater reductions in pain (VAS difference: 1.41; Cohen's d=3.00) and disability (WOMAC difference: 19.78; Cohen's d=5.54), and larger improvements in ROM and TUG performance compared to calisthenic exercises. Conclusion: Sensory-motor training was more effective than calisthenic exercises in improving pain, range of motion, balance, and function in patients with moderate knee osteoarthritis, supporting its prioritization in conservative rehabilitation strategies.

Key Words: Knee osteoarthritis, calisthenic exercise, sensory-motor training, pain, range of motion, randomized controlled trial.

INTRODUCTION

This randomized controlled trial was conducted to evaluate and compare the effectiveness of calisthenic exercises and sensory-motor training in managing symptoms of knee osteoarthritis. The study was conducted at Gosha-e-Shifa Trust Hospital and Riaz Mansoor Trust Hospital, Lahore, Pakistan, over a period of eight weeks following recruitment and baseline assessments. Ethical approval for the study was obtained from the Institutional Review Board of Riphah International University, Lahore (REC/RCR&AHS/23/0141), and the trial was prospectively registered with the WHO-affiliated Iranian Clinical Trials Registry under registration number IRCT20190717044238N11. Written informed consent was obtained from all participants prior to enrollment, in accordance with the ethical standards of human subject research.

Eligible participants were males and females aged 40 to 65 years with a clinical diagnosis of unilateral grade III tibiofemoral osteoarthritis, confirmed through both radiographic and clinical criteria. Inclusion required symptom duration of more than three months and fulfillment of the Kellgren-Lawrence classification for moderate knee OA. Patients were excluded if they had systemic diseases, neurological deficits, psychiatric illnesses, a history of lower limb fracture or knee surgery, meniscal or ligamentous injuries, or metal implants in the lower extremity. Participant recruitment followed a non-probability convenience sampling method. A total of 108 participants meeting eligibility criteria were randomly allocated into two equal groups (n = 54 per group) using the fishbowl method to ensure randomization. This was a single-blind study where participants were unaware of group allocation, but the researcher administering the interventions was not blinded.

Group A received calisthenic exercises along with conventional physical therapy. The calisthenic protocol included exercises such as abductor leg raises, adductor leg raises, prone leg extensions, knee bends, alternate toe touches, lunges, calf raises, leg kicks, and jack twists. Each exercise was performed in one set of 10 repetitions, three times per week, over a period of eight weeks. Group B received sensory-motor training in addition to the same conventional physical therapy. The SMT protocol included exercises such as crossing steps, side-walking, abrupt direction changes, walking over varied surfaces like mattresses, and balance board training. Each SMT activity was performed for 10 to 20 steps or sustained for 30 seconds, repeated three to five times per session, with three sessions per week for eight weeks. Both groups received the same standard physical therapy, including a 20-minute heating pad, isometric quadriceps and hamstring exercises, Tendo-Achilles, hamstring, and vastus medialis stretches, each performed in 10 repetitions per session.

The outcome variables were pain, active knee joint range of motion (flexion and extension), balance, and functional disability. Pain intensity was assessed using the Visual Analogue Scale (VAS), a 100 mm horizontal line with high test-retest reliability (ICC = 0.97–0.98), where patients marked their perceived pain (10). Range of motion was measured using a universal goniometer while the participant lay prone, with anatomical landmarks at the lateral femoral condyle. This method is known to have high interrater reliability (r = 0.97–0.98) and validity in measuring active knee flexion and extension (11). Balance and mobility were assessed using the Timed Up and Go (TUG) test, a widely used and reliable test for elderly individuals and patients with osteoarthritis (ICC > 0.96) (12). Functional disability was evaluated using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which includes three subscales for pain, stiffness, and physical function. The WOMAC index demonstrates strong internal consistency (α = 0.81–0.91) and test-retest reliability (ICC = 0.68–0.89) in OA populations (13).

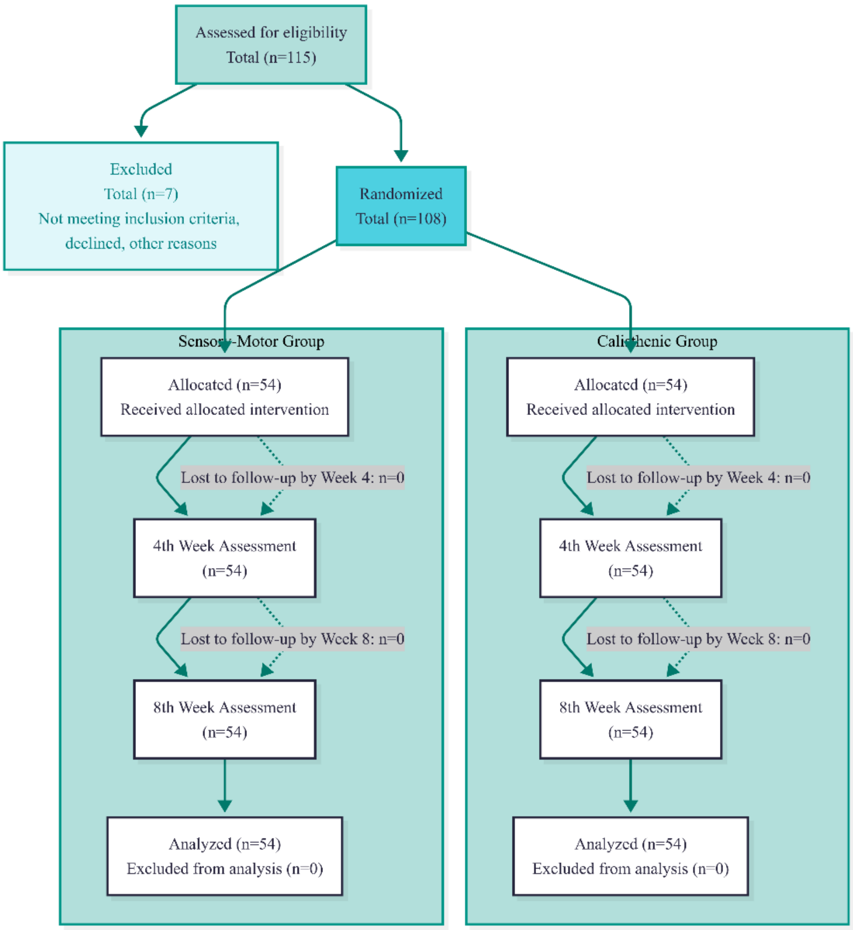

Figure 1 CONSORT Flowchart

The sample size was calculated using Epitool software, based on VAS as the primary outcome variable, with a 10% attrition rate included. A final sample of 108 participants (54 per group) provided sufficient power to detect statistically significant differences. All assessments were conducted at baseline, 4 weeks, and 8 weeks by trained assessors blinded to group allocation. Data were analyzed using SPSS version 26. Normality of continuous data was assessed using the Kolmogorov–Smirnov test. As data were normally distributed ($p > 0.05$), parametric tests were applied. Between-group comparisons at each time point were performed using independent-sample t-tests, while within-group comparisons across time points were analyzed using repeated-measures ANOVA. Statistical significance was set at $p \leq 0.05$ for all tests. Missing data due to dropouts or incomplete responses were handled using listwise deletion, and all analyses were conducted on a per-protocol basis.

RESULTS

The study recruited a total of 108 participants diagnosed with unilateral grade III knee osteoarthritis, who were evenly randomized into two groups: calisthenic exercise (Group A) and sensory-motor training (Group B). Baseline demographic and clinical characteristics were largely comparable between groups, with no statistically significant differences in age (mean 56.05 ± 5.20 years for Group A vs. 58.02 ± 5.19 years for Group B, p = 0.094), gender distribution (45.9% male and 54.1% female in Group A; 32.4% male and 67.6% female in Group B, p = 0.187), duration of pain, inciting injury, pain onset, or presence of sensory symptoms (all p > 0.05). The only significant difference observed was in the side affected: Group A had a higher proportion of right knee involvement (48.6%) compared to Group B (27.0%), while left knee involvement was more common in Group B (73.0%, p = 0.031), as shown in Table 1.

Within-group analysis over the eight-week intervention period revealed significant improvements across all measured outcomes for both groups (all p < 0.01, Table 2). In Group A, mean Visual Analogue Scale (VAS) pain scores decreased from 8.08 ± 0.72 at baseline to 3.32 ± 0.47 at week 8, a mean reduction of 4.76 points (95% CI: –5.08, –4.44). Group B demonstrated an even greater mean pain reduction, from 8.16 ± 0.68 at baseline to 1.91 ± 0.54 at week 8, corresponding to a mean difference of 6.25 points (95% CI: –6.58, –5.92). Active knee flexion range of motion increased by 45.16 degrees (95% CI: 42.98, 47.34) in Group A and by 62.89 degrees (95% CI: 60.43, 65.35) in Group B from baseline to week 8. Active knee extension improved by 0.57 degrees (95% CI: –0.65, –0.49) in Group A and by 0.71 degrees (95% CI: –0.78, –0.64) in Group B. Time Up and Go (TUG) test scores, reflecting balance and mobility, improved by 4.29 seconds (95% CI: –4.62, –3.96) in Group A and 7.00 seconds (95% CI: –7.24, –6.76) in Group B. Similarly, WOMAC scores, representing functional disability, improved by 38.33 points (95% CI: –40.10, –36.56) in Group A and by 53.54 points (95% CI: –55.12, –51.96) in Group B.

Table 1. Baseline Characteristics of Study Participants

Variable	Calisthenic (n=54)	Sensory-Motor (n=54)	p-value
Age (years), Mean ± SD	56.05 ± 5.20	58.02 ± 5.19	0.094[1]
Gender, n (%)			
Male	17 (45.9%)	12 (32.4%)	0.187[2]
Female	20 (54.1%)	25 (67.6%)	
Duration of Pain			0.408[2]
1 week	3 (8.1%)	4 (10.8%)	
3 months	20 (54.1%)	15 (40.6%)	
1 year	14 (37.8%)	18 (48.6%)	
Inciting Injury			0.380[2]
Yes	26 (70.3%)	29 (78.4%)	
No	11 (29.7%)	8 (21.6%)	
Onset of Pain			0.672[2]
Morning stiffness	3 (8.1%)	2 (5.4%)	
Pain after work	34 (91.9%)	35 (94.6%)	
Weakness/Numbness/Tingling			0.722[2]
Yes	32 (86.5%)	33 (89.2%)	
No	5 (13.5%)	4 (10.8%)	
Affected Side			0.031[2]
Right	18 (48.6%)	10 (27.0%)	
Left	19 (51.4%)	27 (73.0%)	

[1]Independent t-test for age. [2]Chi-square test for categorical variables.

Table 2. Within-Group Comparison of Outcome Measures Over Time

Outcome Measure	Group	Baseline Mean ± SD	Week 4 Mean ± SD	Week 8 Mean ± SD	Mean Difference [95% CI]	p-value[1]
Visual Analogue Scale	A	8.08 ± 0.72	5.24 ± 0.64	3.32 ± 0.47	-4.76 [–5.08, –4.44]	<0.01
	B	8.16 ± 0.68	4.40 ± 0.49	1.91 ± 0.54	-6.25 [–6.58, –5.92]	<0.01
Active Knee Flexion (°)	A	59.35 ± 5.97	82.59 ± 4.67	104.51 ± 4.46	45.16 [42.98, 47.34]	<0.01
	B	59.81 ± 5.81	90.10 ± 2.58	122.70 ± 5.21	62.89 [60.43, 65.35]	<0.01
Active Knee Extension (°)	A	0.95 ± 0.70	0.59 ± 0.60	0.38 ± 0.40	-0.57 [–0.65, –0.49]	<0.01
	B	0.81 ± 0.10	0.33 ± 0.50	0.10 ± 0.20	-0.71 [–0.78, –0.64]	<0.01
Timed Up & Go (sec)	A	17.45 ± 1.16	15.70 ± 1.26	13.16 ± 1.34	-4.29 [–4.62, –3.96]	<0.01
	B	18.10 ± 0.80	14.67 ± 0.47	11.10 ± 0.73	-7.00 [–7.24, –6.76]	<0.01
WOMAC Score	A	79.54 ± 5.62	56.83 ± 6.39	41.21 ± 3.57	-38.33 [–40.10, –36.56]	<0.01
	B	74.97 ± 5.67	47.86 ± 3.30	21.43 ± 4.46	-53.54 [–55.12, –51.96]	<0.01

[1]Repeated-measures ANOVA, within each group.

Between-group comparisons, summarized in Table 3, indicated no significant differences in baseline outcome measures. However, at week 4 and week 8, sensory-motor training resulted in significantly greater improvements across all outcomes compared to calisthenic exercise. At week 8, the mean VAS score was significantly lower in the sensory-motor group (1.91 ± 0.54) compared to the calisthenic group (3.32 ± 0.47), with a mean difference of 1.41 points (95% CI: 1.20, 1.62; p < 0.01; Cohen's d = 3.00).

The sensory-motor group achieved an 18.19-degree greater increase in active knee flexion (122.70 ± 5.21 vs. 104.51 ± 4.46; 95% CI: –20.08, –16.30; p < 0.01; Cohen's d = 4.07) and a 0.28-degree greater gain in knee extension (0.10 ± 0.20 vs. 0.38 ± 0.40; 95% CI: 0.17, 0.39; p < 0.01; Cohen's d = 4.58). TUG times improved more in the sensory-motor group by 2.06 seconds at week 8 (11.10 ± 0.73 vs. 13.16 ± 1.34; 95% CI: 1.62, 2.50; p < 0.01; Cohen's d = 1.53). Functional disability as measured by the WOMAC index was markedly reduced in the sensory-motor group (21.43 ± 4.46 vs. 41.21 ± 3.57), with a mean difference of 19.78 points (95% CI: 18.17, 21.39; p < 0.01; Cohen's d = 5.54). Overall, both interventions resulted in significant improvements in pain, range of motion, balance, and function, but sensory-motor training demonstrated consistently superior efficacy across all clinical outcomes by the end of the eight-week intervention.

Table 3. Across-Group Comparison of Outcome Measures at Each Time Point

Outcome Measure	Time Point	Calisthenic (Mean ± SD)	Sensory-Motor (Mean ± SD)	Mean Difference [95% CI]	Effect Size	p-value[1]
Visual Analogue Scale	Baseline	8.08 ± 0.72	8.16 ± 0.68	–0.08 [–0.33, 0.17]	0.11	>0.05
	4 weeks	5.24 ± 0.64	4.40 ± 0.49	0.84 [0.63, 1.05]	1.31	<0.01
	8 weeks	3.32 ± 0.47	1.91 ± 0.54	1.41 [1.20, 1.62]	3.00	<0.01
Active Knee Flexion (°)	Baseline	59.35 ± 5.97	59.81 ± 5.81	–0.46 [–2.76, 1.84]	0.07	>0.05
	4 weeks	82.59 ± 4.67	90.10 ± 2.58	–7.51 [–8.81, –6.21]	1.60	<0.01
	8 weeks	104.51 ± 4.46	122.70 ± 5.21	–18.19 [–20.08, –16.30]	4.07	<0.01
Active Knee Extension (°)	Baseline	0.95 ± 0.70	0.81 ± 0.10	0.14 [–0.07, 0.35]	0.06	>0.05
	4 weeks	0.59 ± 0.60	0.33 ± 0.50	0.26 [0.10, 0.42]	1.50	<0.01
	8 weeks	0.38 ± 0.40	0.10 ± 0.20	0.28 [0.17, 0.39]	4.58	<0.01
Timed Up & Go (sec)	Baseline	17.45 ± 1.16	18.10 ± 0.80	–0.65 [–1.10, –0.20]	0.56	<0.01
	4 weeks	15.70 ± 1.26	14.67 ± 0.47	1.03 [0.61, 1.45]	0.81	<0.01
	8 weeks	13.16 ± 1.34	11.10 ± 0.73	2.06 [1.62, 2.50]	1.53	<0.01
WOMAC Score	Baseline	79.54 ± 5.62	74.97 ± 5.67	4.57 [2.19, 6.95]	0.81	<0.01
	4 weeks	56.83 ± 6.39	47.86 ± 3.30	8.97 [7.04, 10.90]	1.40	<0.01
	8 weeks	41.21 ± 3.57	21.43 ± 4.46	19.78 [18.17, 21.39]	5.54	<0.01

[1]Independent t-test for between-group comparison at each time point.

DISCUSSION

The results of this randomized clinical trial demonstrated that both calisthenic exercises and sensory-motor training, when combined with conventional physical therapy, led to significant improvements in pain, range of motion, balance, and functional disability among patients with grade III knee osteoarthritis over an eight-week intervention period. Notably, the sensory-motor training group experienced greater clinical benefits across all measured outcomes compared to the calisthenic exercise group. These findings highlight the importance of proprioceptive and neuromuscular-focused interventions in the management of knee OA, particularly for patients with moderate disease severity who are seeking non-surgical solutions to improve their quality of life.

The baseline comparability of the two groups ensured that observed differences were attributable to the interventions rather than confounding factors. The sensory-motor training group achieved a mean reduction in pain intensity (VAS) of 6.25 points, compared to a 4.76-point reduction in the calisthenic group, yielding a between-group difference of 1.41 points at week 8 ($p < 0.01$; Cohen's $d = 3.00$). This substantial decrease in pain aligns with previous studies that have underscored the efficacy of proprioceptive and neuromuscular interventions for symptomatic relief in OA populations (14,15). Furthermore, improvements in active knee flexion were markedly higher in the sensory-motor group, which gained 62.89 degrees from baseline compared to 45.16 degrees in the calisthenic group, resulting in an 18.19-degree between-group difference at week 8 ($p < 0.01$). This difference supports the notion that interventions challenging balance and postural stability may facilitate greater motor unit recruitment and joint mobility gains (16).

Functional improvements were also more pronounced in the sensory-motor group, which exhibited a 53.54-point decrease in WOMAC disability scores versus a 38.33-point decrease in the calisthenic group, corresponding to a 19.78-point between-group difference at week 8 ($p < 0.01$; Cohen's $d = 5.54$). These gains are clinically meaningful and suggest that proprioceptive retraining addresses functional limitations beyond what is achieved through strength and flexibility exercises alone. The Timed Up and Go (TUG) test further substantiated these findings, with the sensory-motor group demonstrating a 7.00-second improvement compared to 4.29 seconds in the calisthenic group, indicating enhanced dynamic balance and mobility.

The superior outcomes associated with sensory-motor training are consistent with previous randomized controlled trials reporting the benefits of targeted proprioceptive exercises in OA populations. Gurudut et al. (2018) found that proprioceptive training was more effective than calisthenic exercises for pain reduction and functional improvement, mirroring the present findings (17). Likewise, recent evidence by Kuş et al. (2023) suggests that sensory-motor training is at least as effective as resistance training for OA symptom management, and may provide unique benefits for balance and neuromuscular coordination (18). The magnitude of improvement observed in this study underscores the value of incorporating balance and sensory-focused components into standard OA rehabilitation protocols.

Several factors may explain the superiority of sensory-motor interventions. OA is associated with proprioceptive deficits, altered joint loading, and impaired neuromuscular control, which are inadequately addressed by isolated strengthening exercises (19). Sensory-motor training challenges postural reflexes, improves joint position sense, and stimulates compensatory neuromuscular adaptations, resulting in greater functional gains and symptom relief (20). The findings of this study therefore support the integration of sensory-motor training into conservative management programs for moderate knee OA.

Limitations of this study include its single-blind design, restriction to a single geographic region, and reliance on self-reported measures, which may introduce reporting bias or limit generalizability. The study also did not assess long-term maintenance of benefits beyond eight weeks, nor did it stratify outcomes by gender or OA severity subgroups. Despite these limitations, the randomized design, robust sample size, and use of validated outcome measures enhance the reliability and relevance of the results.

In summary, both calisthenic and sensory-motor training protocols significantly improved pain, joint range of motion, balance, and function in patients with moderate knee OA, but sensory-motor training provided consistently superior results across all outcomes. These findings provide compelling evidence for clinicians to prioritize proprioceptive and neuromuscular strategies in conservative OA management and justify further research into the long-term benefits and optimal implementation of such interventions.

CONCLUSION

The present randomized clinical trial demonstrated that both calisthenic exercises and sensory-motor training, when integrated with conventional physical therapy, led to significant improvements in pain, range of motion, balance, and functional disability among patients with grade III knee osteoarthritis. However, sensory-motor training was consistently more effective than calisthenic exercises in reducing pain intensity, enhancing knee flexion and extension, improving balance, and minimizing disability scores over the eight-week intervention. These results support the prioritization of sensory-motor training as a preferred conservative management strategy for moderate knee osteoarthritis and highlight the value of proprioceptive and neuromuscular approaches in routine clinical rehabilitation. Further research is recommended to explore the long-term effects, optimal training protocols, and applicability to broader OA populations.

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