SHORT COMMUNICATION

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Effectiveness of Mcgill's Big Three Exercises on Knee Osteoarthritis: A Randomized Controlled Trial

Siddesh Ganesan* and Humera Sultana

College of Physiotherapy, School of Health Sciences, Dayananda Sagar University, Kanakapura Road, Ramanagara District, Bengaluru - 562112, Karnataka, India; siddesh4544@gmail.com

Abstract

Background: Osteoarthritis (OA) is a degenerative joint condition causing pain, stiffness, and reduced mobility, significantly affecting quality of life. Knee OA is associated with gait and balance impairments, increasing fall risk in elderly individuals. Core stability exercises play a vital role in enhancing functional movement and reducing knee joint burden, yet evidence on their effectiveness in knee OA is limited. **Aim:** To determine the effectiveness of McGill's Big Three exercises in patients with knee OA. **Materials and Methods:** A pretest-posttest randomized controlled trial was conducted on 36 subjects meeting the inclusion criteria, randomly assigned into two groups (n = 18 each). Group A received McGill's Big Three exercises along with conventional management, while Group B received conventional management alone. Interventions were administered atleast 3 sessions/ week, 25-30 minutes per session, for 6 weeks. Outcome measures included WOMAC, Timed Up and Go (TUG) test and Step test. **Results:** Group A demonstrated statistically significant improvements across all WOMAC domains, including pain (mean difference: 3.22, $p = 0.001$), stiffness (mean difference: 1.39, $p = 0.039$), physical function (mean difference: 10.56, $p < 0.001$), and total WOMAC score (mean difference: 15.39, $p < 0.001$). Functional performance also improved markedly in Group A, shown by a 3.32-second reduction in TUG time ($p < 0.001$) and an increase of 3 repetitions in the Step Test ($p < 0.001$). In contrast, Group B showed no significant change in any WOMAC domain ($p > 0.05$), with minimal improvements observed in TUG (0.88 seconds, $p = 0.008$) and the Step Test (0.39 repetitions, $p = 0.004$). Between-group analyses confirmed that Group A achieved significantly greater improvements across all outcome measures ($p < 0.001$). **Conclusion:** Incorporating McGill's Big Three exercises into conventional physiotherapy significantly improves pain, reduces stiffness, and enhances physical function, mobility, and dynamic balance in individuals with knee osteoarthritis, demonstrating their effectiveness as an adjunct intervention.

Major Findings: McGill's Big Three exercises led to significant improvements in WOMAC pain (3.22, $p = 0.001$), stiffness (1.39, $p = 0.039$), physical function (10.56, $p < 0.001$), and total score (15.39, $p < 0.001$). Functional outcomes improved substantially, with TUG improving by 3.32 seconds ($p < 0.001$) and Step Test performance increasing by 3 repetitions ($p < 0.001$). Between-group comparisons confirmed the superior effectiveness of McGill's Big Three, with all key outcomes favouring Group A ($p < 0.05$).

Keywords: Core Stability, Functional Mobility, Knee OA, McGill's Big Three Exercises, Rehabilitation

1. Introduction

The World Health Organization (WHO) defines OA as a degenerative joint disease that leads to discomfort, inflammation and reduced flexibility, making movement difficult. According to the American College of Rheumatology, OA is a common joint disorder that predominantly affects middle-aged and elderly individuals. It involves the whole joint - cartilage, synovium, ligaments, and bone, and is often described as "wear-and-tear" arthritis.

**Author for correspondence*

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The global burden of OA has risen substantially: over 528 million people were estimated to suffer from OA in 2019, a 113% increase since 1990, with approximately 73% of affected individuals older than 55 years and about 60% being women[1]. In India, OA prevalence has also increased markedly: cases went up from 23.46 million in 1990 to 62.35 million in 2019, with an increase in age-standardized prevalence between these years[2]. Up to 28.7% of Indians with knee-related OA symptoms report difficulty performing activities of daily living[3]. Clinically, patients with knee OA commonly present with joint pain and stiffness and demonstrate reductions in mobility and functional capacity, resulting in decreased productivity and quality of life and a measurable socioeconomic impact[4].

Knee OA is particularly associated with gait and balance impairments and an increased risk of falls among older adults[5]. Pathophysiologically, pain and joint dysfunction often lead to disuse, muscle weakness (especially of the quadriceps and hip stabilizers) and changes in neuromuscular control that further compromise joint stability and mobility[6]. Recognizing these mechanisms, international guidelines from organizations such as OARSI and ESCEO emphasize conservative management as the first line of care, highlighting weight management, patient education, and structured, land-based exercise programs targeting strength, cardiovascular fitness, balance, and neuromuscular function prior to pharmacologic or surgical options[7]. Knee buckling and reduced knee confidence are independently associated with declines in advanced functional activities, indicating that knee instability and knee confidence are important modifiable factors in disease progression[8].

Core stability is fundamental to many functional activities such as standing, walking, and transfers because it regulates pelvic position and trunk control, facilitates force transfer along the kinetic chain, and coordinates proximal stability with distal mobility[9-11]. Core exercises target the Lumbopelvic-Hip Complex (LPHC) and peri-articular musculature, enhancing coordination and stability of the hip, pelvis, trunk and knee and thereby potentially reducing knee loading during gait[12-15]. Anatomically, the "core" comprises a muscular box formed by the diaphragm superiorly, the abdominal wall anteriorly, paraspinals and gluteals posteriorly, and the pelvic floor and hip girdle inferiorly. Improving strength and endurance of these muscles improves trunk control, spinal mobility, and overall balance, that may relieve stress on the knee and reduce fall risk[14,15].

McGill's approach to core training, popularly known as "McGill's Big Three" (curl-up, side-bridge, and bird-dog) was developed to enhance core muscle endurance and spinal stability. Although McGill's Big Three exercises are well established in low back pain rehabilitation, there is limited randomized controlled evidence evaluating their specific effect on knee osteoarthritis when added to a conventional knee rehabilitation program. This study addresses that gap by testing whether the McGill Big Three, as an adjunct to routine conservative care, produces improvements in pain, self-reported function and objective mobility/balance in people with knee OA.

2. Materials and Methods

2.1 Study Design and Participants

This study was a randomized controlled trial with a pre-post intervention design conducted among individuals diagnosed with Knee Osteoarthritis (KOA) from urban and rural areas of Bangalore. Ethical clearance was obtained from the Institutional Scientific Committee (ISC), Dayananda Sagar University, Bangalore (Approval No: ISC/Intern/DSU/2025/692). Written informed consent was obtained from all participants prior to enrollment. A total of 58 individuals were screened, of whom 36 met the eligibility criteria and were randomized through simple random allocation into two equal groups (n = 18 each). Due to the nature of the exercise-based intervention, blinding of participants and therapists was not feasible. However, the outcome assessor was blinded to group allocation.

2.2 Eligibility Criteria

Eligible participants were aged 40–80 years, presented with clinical symptoms of knee OA (edema, stiffness, crepitus, and pain)[16] and had radiographic evidence of Grade II or III on the Kellgren–Lawrence scale. Both male and female participants were included. Exclusion criteria were history of knee fracture, prior knee joint replacement, intra-articular steroid injection within the preceding three months, systemic inflammatory arthritis, recent significant knee injury, or any physical restriction to perform exercise.

2.3 Intervention Protocol

Group A received McGill's Big Three Exercises along with conventional knee exercises, whereas Group B received

conventional knee exercises alone for 6 weeks. McGill's Big Three exercises included curl-ups, side planks, and Bird-dog exercises. The program began with 2 sets of 10 repetitions of isotonic exercises, followed by 2 sets of 8 repetitions of the isometric variant (each position held for 5 seconds). All unilateral exercises were performed on both sides to ensure balanced development. Pauses were incorporated strategically: 5 seconds between isometric contractions, 30 seconds between sets of isotonic exercises, and 1 minute between different exercises. Participants performed the exercises at least 3 times per week.

Conventional exercises included knee range-of-motion exercises, strengthening exercises (quadriceps and hamstring isometrics, leg press, semi-squats with partial weight bearing, and step-ups), and stretching exercises (standing calf stretch, hamstring stretch, and quadriceps stretch).

2.4 Outcome Measures

The primary outcome was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a validated instrument for evaluating pain, stiffness, and physical function in knee osteoarthritis, originally developed and validated by Bellamy *et al.*,[17] In accordance with the OARSI recommendations for standardized physical function assessment in hip and knee OA populations, two performance-based tests were used: the Timed Up and Go (TUG) test and the Step Test[18] . The TUG test assesses basic functional mobility and dynamic balance, while the Step Test evaluates lower-limb functional strength, dynamic balance, and the ability to control weight transfer during repeated stepping movements.. Measurement properties, including reliability and validity of commonly used clinical balance and functional tests, are well supported in the literature[19], and the psychometric robustness of pain scales in knee OA populations further strengthens outcome interpretation[20] . Additionally, the reliability of performance-based tests such as the TUG and Step Test in populations with lower-limb OA has been established in previous work[21] . Assessments were performed pre- and post-intervention. Demographic details and baseline measurements were recorded prior to intervention.

2.5 Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Continuous variables are presented as mean ± Standard Deviation (SD) and categorical variables as frequencies (percentages). Within-group comparisons were performed using paired t-tests (or Wilcoxon signed-rank tests where appropriate) and between-group comparisons of change scores were performed using independent samples t-tests (or Mann–Whitney U tests if non-parametric). Categorical variables were compared using chi-square or likelihood-ratio tests. Effect sizes (Cohen's d) were calculated for primary outcomes. A two-tailed p-value < 0.05 was considered statistically significant.

3. Results

Table 1 presents the descriptive statistics of age ranging from 40 to 80 years with mean: 55.67 $\pm$ 13.04

Table 2 presents the distribution of participants by gender, group allocation, and Kellgren-Lawrence grade.

Table 3 presents the within-group comparison for Group A (McGill Big Three + Conventional Exercises). Pre- and post-intervention values of the WOMAC Index, TUG test, and Step test were analyzed using paired t-tests. Significant improvements were observed in WOMAC pain, stiffness, physical function, total score, as well as in TUG and Step test performance ($p < 0.05$).

Table 4 presents the within-group comparison for Group B (Conventional Exercises). Paired t-tests showed significant improvements only in TUG and Step test

Table 1. Descriptive statistics for age

(n = 36)	Range	Mean	S.D.
Age (Years)	40 to 80	55.67	13.04

Table 2. Distribution of gender, groups, and Kellgren and Lawrence grading scale

		Frequency	%
Gender	Male	13	36.1
	Female	23	63.9
Groups	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	18	50
	Group B: Conventional exercise	18	50
Kellgren and Lawrence grading scale	Two	28	77.8
	Three	8	22.2

Table 3. Comparison of WOMAC osteoarthritis index, TUG test, and step test among Group A: Mc GILL BIG 3 Exercise + Conventional exercise

Within Group A Mean		Group A: Mc GILL BIG 3 Exercise + Conventional exercise							
		Standard Deviation	Mean Difference	95% C.I	Effect size	"t"	df	p value	
Pain	Pre	11.00	3.22	3.22	2.55 to 3.90	0.857	10.11	17	< 0.001*
	Post	7.78	3.08						
Stiffness	Pre	4.89	1.41	1.39	0.68 to 2.10	0.503	4.15	17	0.001*
	Post	3.50	1.30						
Physical function	Pre	52.67	5.77	10.56	7.45 to 13.66	0.752	7.17	17	< 0.001*
	Post	42.11	8.99						
Total score	Pre	68.56	8.76	15.39	12.17 to 18.61	0.856	10.07	17	< 0.001*
	Post	53.17	11.36						
TUG Test	Pre	14.87	2.83	3.32	2.35 to 4.29	0.754	7.22	17	< 0.001*
	Post	11.55	1.93						
Step test	Pre	3.50	1.30	3.00	2.55 to 3.45	0.920	14.03	17	< 0.001*
	Post	6.50	1.38						

Table 4. Comparison of WOMAC Osteoarthritis index, TUG test, and step test among Group B: Conventional exercise

Within Group B Mean		Group B: Conventional exercise							
		SD	Mean Difference	95% C.I for mean difference	Effect size	"t"	df	p value	
Pain	Pre	13.44	3.09	0.00	-1.72 to 1.72	0	0	17	1
	Post	13.44	3.01						
Stiffness	Pre	5.44	1.62	0.28	-0.55 to 1.11	0.028	0.70	17	0.491
	Post	5.17	1.62						
Physical function	Pre	56.22	3.62	0.72	-0.97 to 2.41	0.046	0.90	17	0.379
	Post	55.50	4.03						
Total score	Pre	75.11	7.36	1.00	-1.85 to 3.85	0.031	0.74	17	0.469
	Post	74.11	6.49						
TUG Test	Pre	18.10	3.05	0.88	0.26 to 1.49	0.348	3.01	17	0.008*
	Post	17.22	3.31						
Step test	Pre	1.72	0.67	0.39	0.14 to 0.64	0.389	3.29	17	0.004*
	Post	2.11	0.90						

performance ($p < 0.05$), with no significant changes in WOMAC scores.

Table 5 shows the between-group comparison of intervention effectiveness. Independent t-tests of pre-post difference scores revealed that Group A demonstrated significantly greater improvements than Group B in all outcome measures: WOMAC pain, stiffness, physical function, total score, TUG, and Step test ($p < 0.05$).

Table 5. Comparison of the intervention (Pre-Post) in WOMAC Osteoarthritis index, TUG test, and step test between the groups

Effectiveness (Pre - Post)		Mean	S.D.	Independent samples t test	Degree of freedom	p value
Pain	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	3.22	1.35	3.68	34	0.001*
	Group B: Conventional exercise	0.00	3.46			
Stiffness	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	1.39	1.42	2.15	34	0.039*
	Group B: Conventional exercise	0.28	1.67			
Physical function	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	10.56	6.24	5.87	34	< 0.001*
	Group B: Conventional exercise	0.72	3.39			
Total Score	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	15.39	6.48	7.06	34	< 0.001*
	Group B: Conventional exercise	1.00	5.73			
TUG Test	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	3.32	1.95	4.49	34	< 0.001*
	Group B: Conventional exercise	0.88	1.24			
Step Test	Group A: Mc GILL BIG 3 Exercise + Conventional exercise	3.00	0.91	10.68	34	< 0.001*
	Group B: Conventional exercise	0.39	0.50			

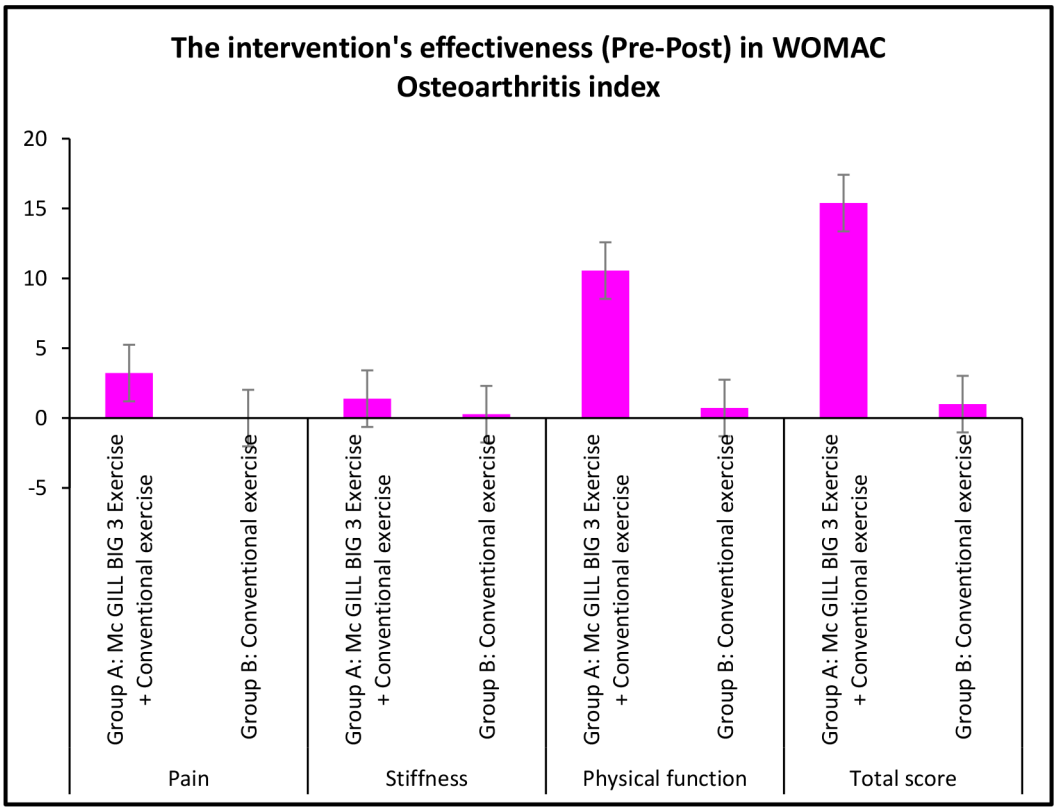


Figure 1. Effectiveness of intervention: WOMAC total score (pre vs post, Group A vs Group B).

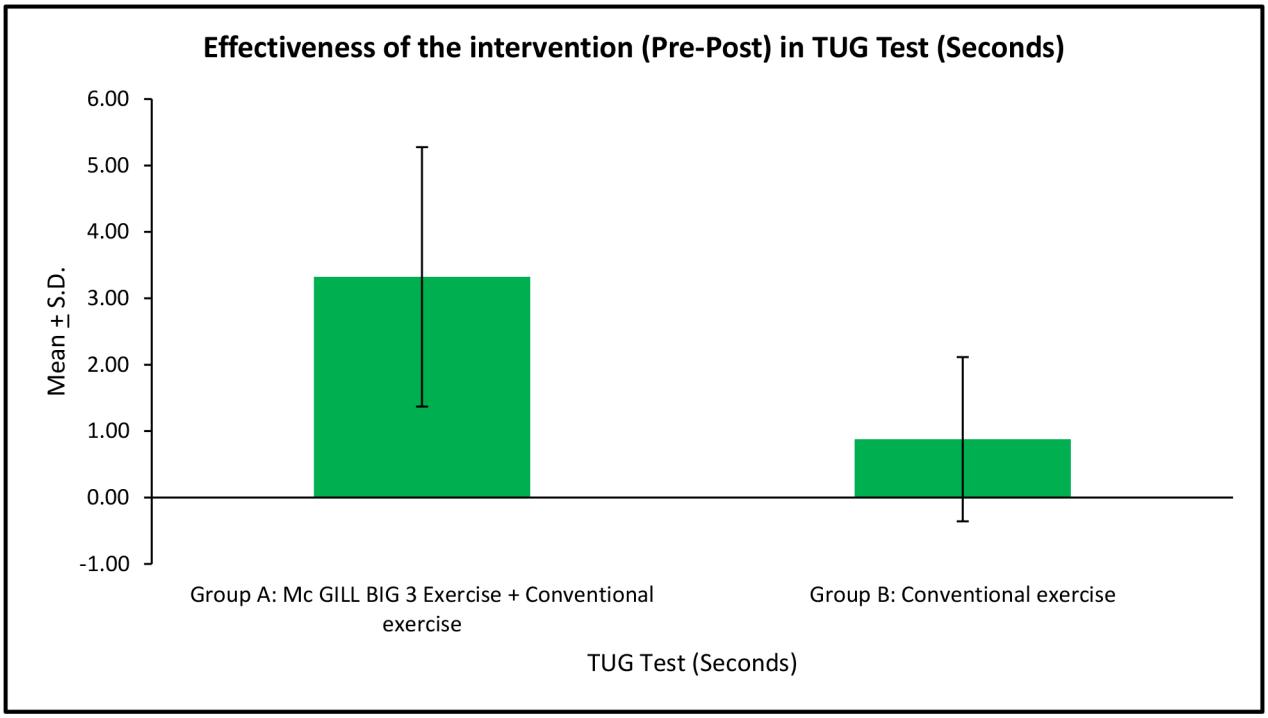


Figure 2. Timed Up and Go (TUG) test - mean times (seconds) pre and post by group.

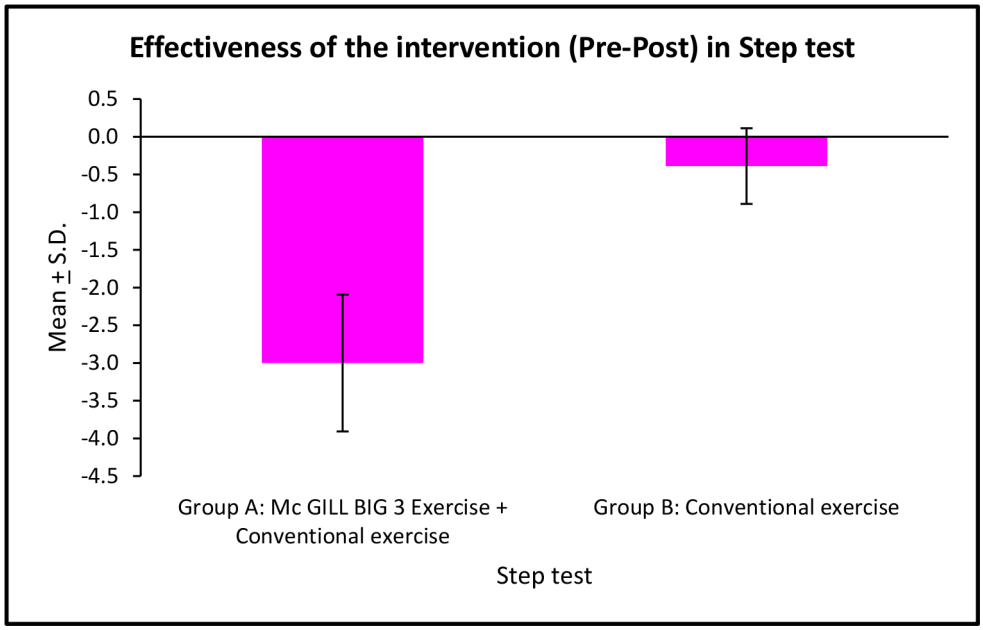


Figure 3. Step test - mean number of steps (pre vs post) by group.

4. Discussion

The primary aim of this randomized controlled trial was to evaluate whether adding McGill's Big Three core stabilization exercises to a conventional knee rehabilitation program produces improvements in pain, self-reported function and objective mobility/balance in people with Knee Osteoarthritis (KOA). Group A showed statistically significant reductions in WOMAC pain, stiffness, and physical function scores,



Figure 4. Curl-up (exercise demonstration).



Figure 5. Side bridge / Side plank (exercise demonstration).

along with marked improvements in TUG and Step Test performance. Between-group comparisons confirmed that these improvements were significantly greater than those observed in Group B (Tables 3 and 5).

Table 3 (Group A) demonstrates large and clinically meaningful changes in both patient-reported and performance-based outcomes after six weeks of combined core and knee-focused rehabilitation. Pain decreased by 3.22 points ($p = 0.001$) and physical function improved by 10.56 points ($p < 0.001$) on the WOMAC index, while TUG time and Step Test repetitions also improved markedly (TUG: 3.32 s; Step Test: 3 steps). These changes reflect improved trunk and pelvic stability and more efficient force transfer across the Lumbopelvic-Hip Complex



Figure 6. Bird-dog (exercise demonstration).

(LPHC), helping to reduce abnormal knee loading during functional activities[22,23]. The observed subjective and objective improvements suggest that McGill's Big Three exercises, targeting core endurance and neuromotor control, acted synergistically with conventional knee exercises to produce rapid functional gains.

By contrast, Table 4 (Group B) shows that conventional knee exercises alone produced no significant change in WOMAC pain, stiffness or total score over the same 6-week period, although statistically significant improvements were observed in the TUG (mean change 0.88 s; p = 0.008) and Step Test (mean change 0.39 steps; p = 0.004). The between-group analysis (Table 5) further emphasize that augmenting conventional programs with core training yields additional benefits than those with knee-focused exercises alone.

The greater reductions in WOMAC pain and function in Group A suggest that improving trunk–pelvic control may directly influence knee symptoms, possibly by optimizing load distribution during dynamic tasks, minimizing maladaptive compensatory patterns, and improving balance confidence, thereby translating into improved self-reported function[22,23] . Superior TUG and Step Test improvements in Group A indicate that combined core and knee training enhances dynamic balance, stepping ability, and lower-limb power.

These findings are consistent with earlier work demonstrating benefits of core strengthening for balance and functional mobility in musculoskeletal populations[15,22,24,-26]. For example, Mokhtar et al. (2023) reported improvements in balance and mobility after core-focused interventions, while Hernandez *et al.*,(2019) found that adding core activation to conventional therapy enhanced short-term pain relief in knee OA[22]. Our results extend this literature by providing randomized evidence that a brief program of McGill's Big Three, when combined with standard knee rehabilitation, improves both subjective and objective outcomes in people with grade II-III KOA. (KL Scale)

Strengths of the study include randomized allocation, a pragmatic exercise protocol deliverable in typical clinical settings (3 sessions/week, 25–30 min/session), and the use of both patient-reported (WOMAC) and performance-based (TUG, Step Test) outcomes recommended by OARSI[18]. Effect sizes for primary outcomes were moderate to large (Table 3), indicating meaningful benefits.

The study has several limitations. First, the sample size was modest (n = 36), which may limit precision and generalizability; larger trials are needed to confirm these findings. Second, the intervention period was short (6 weeks) and the study did not include long-term follow-up, so the durability of observed improvements is unknown. Third, full participant blinding to the specific exercise content was not feasible because of the nature of the interventions. Participants were, however, not informed of the study hypothesis. Finally, we did not include objective

biomechanical measures (e.g., gait kinetics or muscle activation patterns) that could more directly demonstrate mechanisms of change; future studies should consider incorporating such assessments.

Clinical implications of this trial are that incorporating McGill's Big Three core exercises into routine knee rehabilitation may produce greater reductions in pain and improvements in mobility and balance than conventional knee exercises alone. Clinicians may consider incorporating targeted core exercises into standard knee rehabilitation for symptomatic KOA. Future research should investigate optimal dosing, whether benefits are maintained long term, and whether improvements translate into reduced fall risk and delay in disease progression.

5. Conclusion

This randomized controlled trial demonstrates that adding McGill's Big Three exercises to conventional knee rehabilitation results in greater improvements in pain, stiffness, physical function, and functional mobility compared to conventional exercises alone. These findings support the inclusion of targeted core training as an adjunct to standard conservative management.

6. Conflict of Interest

The authors declare no conflict of interest.

7. Data Availability

The datasets generated and/or analysed during the current study are available from either of the authors upon reasonable request.

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Author Contribution

All authors contributed to study conception and design. Material preparation, data collection and analysis were performed by both authors. All authors read and approved the final manuscript.

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