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An Anatomical Approach to Posterior Chain Dysfunction: Introducing Kinetic Chain Activation for Lower Back Pain Rehabilitation

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ABSTRACT

Background and Aims: Non-specific lower back pain (NSLBP) is a leading cause of disability worldwide, often associated with hamstring tightness, pelvic misalignment, and postural dysfunction. Conventional physiotherapy approaches typically include static hamstring stretching to relieve posterior chain stiffness. However, emerging strategies such as Kinetic Chain Activation (KCA) emphasize dynamic muscle recruitment and neuromuscular coordination. This study aims to compare the effectiveness of static stretching and KCA in individuals with NSLBP, highlighting the functional benefits of integrated movement-based interventions.

Materials and Methods: A randomized clinical trial conducted on 60 participants (aged 25–50 years) with NSLBP, equally divided into: Group A (static hamstring stretching) and Group B (KCA technique). Each group received three supervised sessions per week for four weeks. Pain intensity, functional disability, and hamstring flexibility were assessed pre- and post-intervention using the Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and Popliteal Angle Test, respectively. Statistical analysis included paired and unpaired t-tests, with significance set at $p < 0.05$.

Results: Both groups demonstrated significant within-group improvements in VAS, ODI, and popliteal angle ($p < 0.001$). Although intergroup comparisons revealed no statistically significant differences ($p > 0.05$), the KCA group exhibited slightly superior improvements in hamstring flexibility and functional recovery.

Conclusion: Static stretching and kinetic chain activation are both effective for managing NSLBP. However, the dynamic and integrative nature of KCA may provide additional functional advantages, particularly in addressing neuromuscular coordination and postural dysfunction in sedentary populations. Its simplicity and equipment-free design make it a promising addition to rehabilitation protocols.

Keywords: *Non-Specific Low Back Pain, Kinetic Chain Activation, Static Hamstring Stretching, Functional Disability, Flexibility, Proprioception*

1. INTRODUCTION

Non-specific lower back pain (NSLBP), characterized by the absence of a specific underlying pathology, represents a major global health burden. It accounts for significant functional limitations and economic costs, particularly in individuals with sedentary lifestyles. A growing body of research implicates postural imbalances and muscular tightness—especially in the hamstrings—as key contributors to mechanical dysfunction in the lumbopelvic region.

The hamstrings influence pelvic tilt and spinal curvature, and when tight or inhibited, they can alter normal biomechanics, leading to pain and restricted movement. Static hamstring stretching has traditionally been employed to alleviate muscle tension and improve range of motion. However, static methods may not fully address neuromuscular deficits such as proprioceptive impairment or poor intersegmental control.

In contrast, Kinetic Chain Activation (KCA) techniques emphasize coordinated movement patterns, muscle recruitment through full range, and fascial stimulation. These methods aim to restore dynamic control and correct length–tension imbalances—especially relevant in individuals with postural deconditioning due to prolonged sitting.

While both approaches are used in clinical practice, there remains a paucity of comparative data evaluating their relative effectiveness. This study was designed to compare static stretching and KCA interventions in individuals with NSLBP to determine their impact on pain relief, functional disability, and hamstring flexibility.

2. MATERIALS & METHODS

Study Design

A prospective, randomized clinical trial was conducted at the outpatient physiotherapy department of Pacific Medical College and Hospital, Udaipur, from September 2024 to March 2025. The study adhered to CONSORT 2010 guidelines and received institutional ethical clearance.

Participants

Sixty participants aged 25–50 years with clinically diagnosed NSLBP (pain duration ≥ 4 weeks, VAS > 5/10) were included. Participants with prior spinal surgery, neurological deficits, systemic joint disorders, or pregnancy were excluded. Written informed consent was obtained from all participants.

Inclusion Criteria

- Individuals aged **25-50** years
- Diagnosed with non-specific lower back pain for at least **4 weeks**
- VAS score > **5/10**
- Ability to participate in physiotherapy sessions
- Willingness to provide informed consent

Exclusion Criteria

- History of spinal surgery or structural abnormalities (e.g., scoliosis, spondylolisthesis)
- Presence of neurological deficits or radiculopathy
- Systemic conditions affecting mobility (e.g., rheumatoid arthritis, ankylosing spondylitis)
- Pregnancy.

Sample Size, Randomization and Allocation

60 participants were randomly assigned into two groups (n = 30 each):

- **Group A:** Static Hamstring Stretching
- **Group B:** Kinetic Chain Activation Technique (KCA)

Both groups were gender-balanced (15 males and 15 females each).

Interventions

Group A – Static Hamstring Stretching: Received passive static hamstring stretches (2-minute holds × 3 repetitions per leg, with 1-minute rest intervals), three times a week for four weeks (figure1).

Figure 1. Static Hamstring Stretch position is illustrated.

Group B – Kinetic Chain Activation Technique: received KCA-based exercises including:

- 7–8 seconds of fascial stimulation via posterior chain tapping (figure2)
- 15 repetitions of active prone knee flexion (figure 2)

Frequency: Three times a week for four weeks

Figure 2. Fascial stimulation by tapping the posterior chain area is shown.

Figure 3. Prone knee flexion performed during Kinetic Chain Activation.

Home Program for Both Groups: taught during the first session.

Participants were instructed to do basic isometric hamstring contractions, gluteal squeezes, transverse abdominal activation, and seated resisted knee flexion using the contralateral limb.

Outcome Measures

Measured at baseline and after 4 weeks:

- **Pain Intensity:** Measured using the **Visual Analog Scale (VAS)**, a 10-cm line representing pain severity from 0 (no pain) to 10 (worst possible pain).

- **Functional Disability:** Assessed using the **Oswestry Disability Index (ODI)**, a validated questionnaire measuring the degree of disability related to lower back pain.
- **Popliteal Angle:** Assessed using the inclinometer mobile application. Excellent interrater (ICC: 0.87) and intrarater reliability (ICC: 0.97) for assessing hamstring muscle flexibility with the popliteal angle test, which is performed easily by a single assessor.

Statistical Analysis

Data were analyzed using SPSS v26. Paired t-tests assessed within-group changes; unpaired t-tests evaluated between-group differences. Statistical significance was set at $p < 0.05$.

3. RESULT

Table 1: Gender wise Distribution

	Group A		Group B	
Gender	No.	%	No.	%
Female	15	50.00%	15	50.00%
Male	15	50.00%	15	50.00%
Total	30	100.00%	30	100.00%

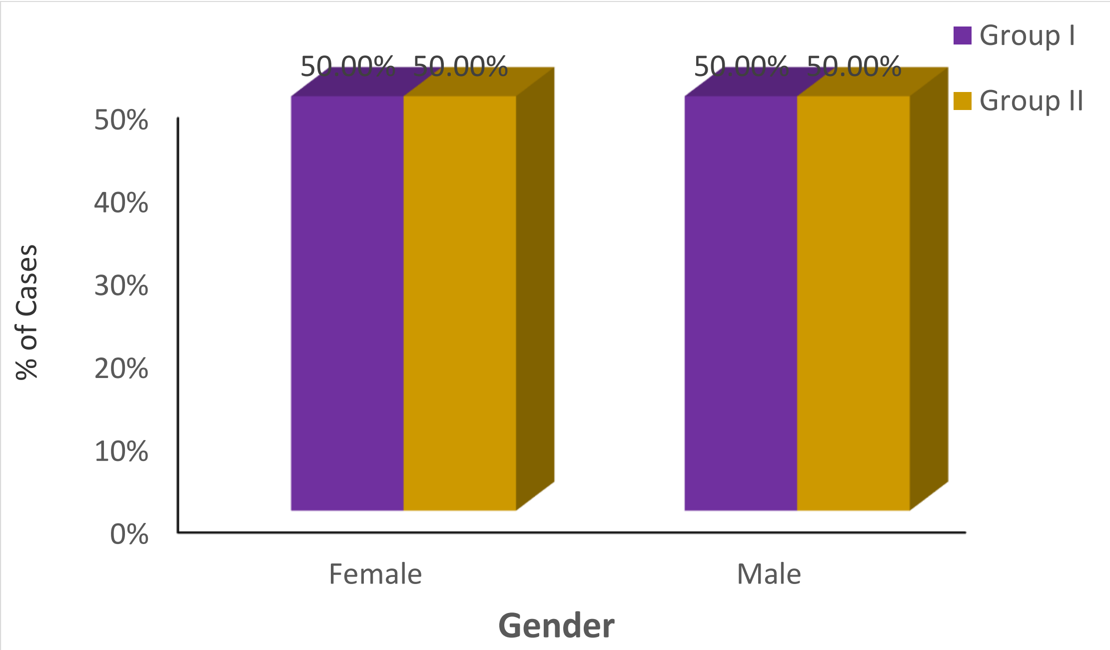


Table 2: Gender wise Pre Op VAS Score in Both Groups

VAS Score	Group A		Group B		
Gender	Mean	SD	Mean	SD	P value
Female	6.27	1.16	6.13	1.25	>0.05
Male	6.07	0.96	6.53	1.19	>0.05
Total	6.17	1.05	6.33	1.21	>0.05
P value	>0.05		>0.05		

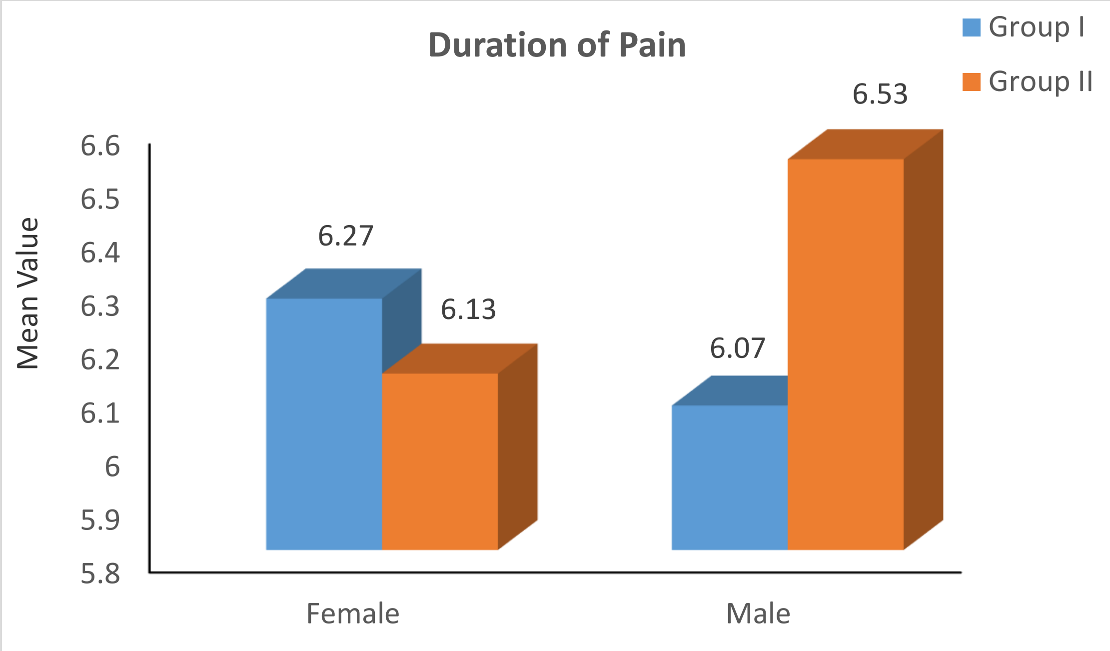


Table 3: Gender wise Post Op VAS Score in Both Groups

VAS Score	Group A		Group B		
Gender	Mean	SD	Mean	SD	P value
Female	2.60	1.06	2.80	1.57	>0.05
Male	2.93	1.22	3.13	1.46	>0.05
Total	2.77	1.14	2.97	1.50	>0.05
P value	>0.05		>0.05		

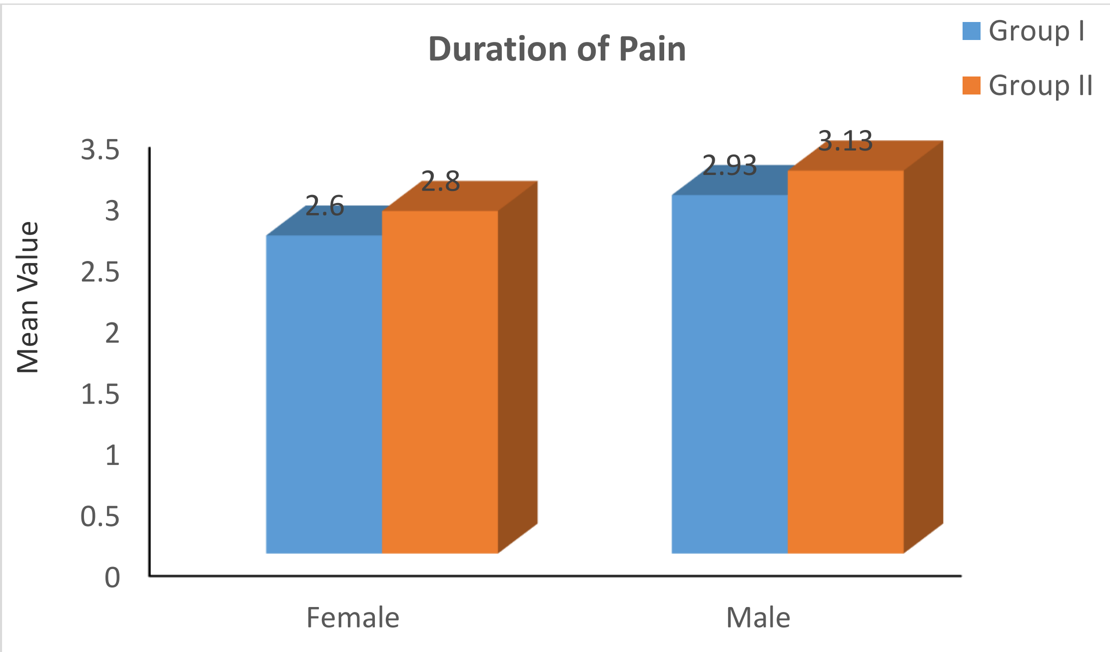


Table 4: VAS in Both Groups

VAS	Group A		Group B		
	Mean	SD	Mean	SD	P value
Pre Op	6.17	1.05	6.33	1.21	>0.05
Post Op	2.77	1.14	2.97	1.50	>0.05
P value	<0.001		<0.001		

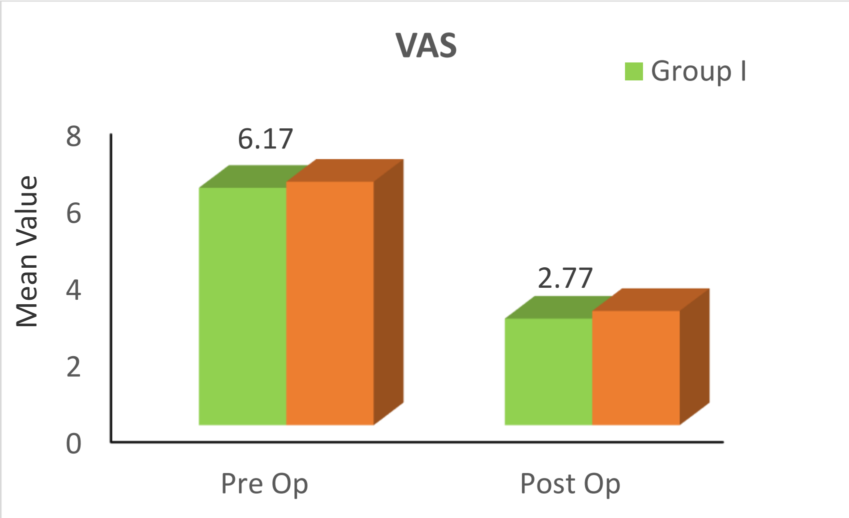


Table 5: ODI Score in Group A

ODI	Group A		
	Mean	SD	P value
Pre Op	20.97	5.92	<0.001 (HS)
Post Op	7.43	5.37	

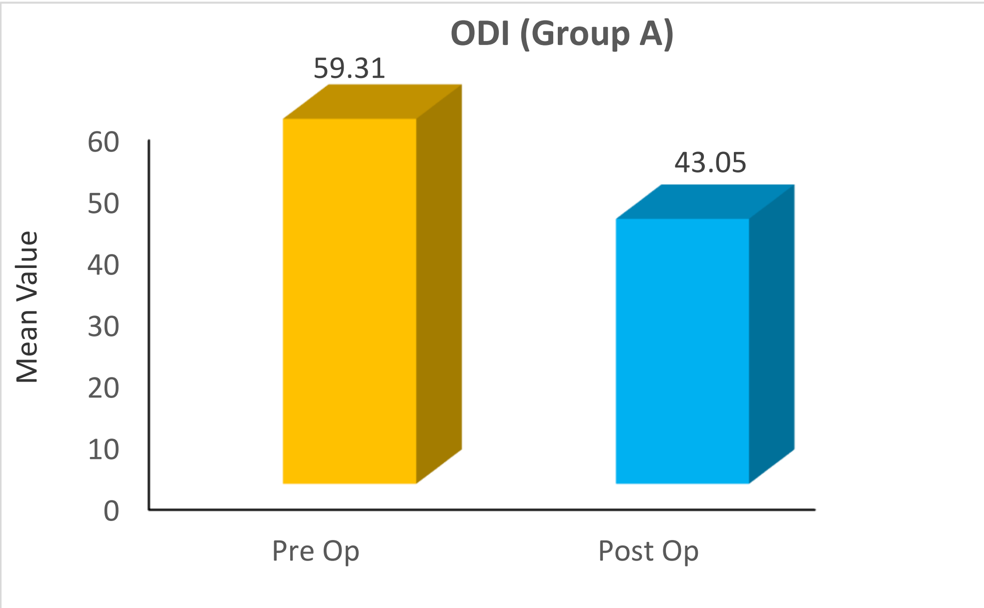


Table 6: ODI Score in Group B

ODI Score	Group B		
	Mean	SD	P value
Pre Op	19.17	6.74	<0.001 (HS)
Post Op	6.60	4.34	

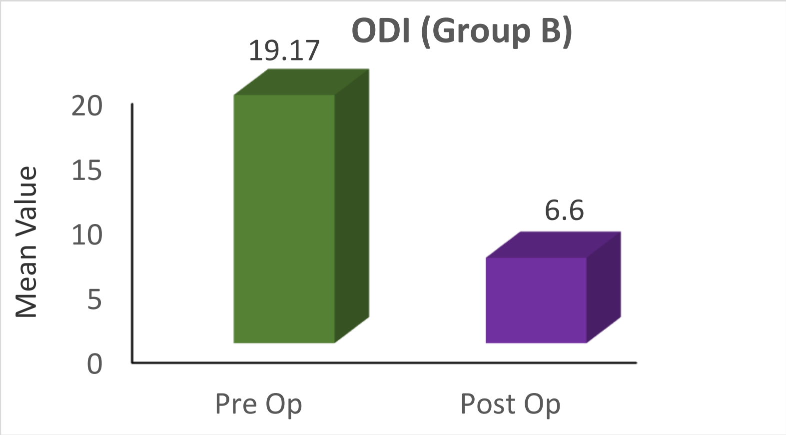


Table 7: Pre and Postop Popliteal Angle Distribution in Group A Patients

Popliteal Angle	Pre Op		Post Op		
Side	Mean	SD	Mean	SD	P value
Right	125.83	13.40	138.83	13.43	<0.05
Left	126.07	13.02	139.23	13.60	<0.05
P value	>0.05		>0.05		

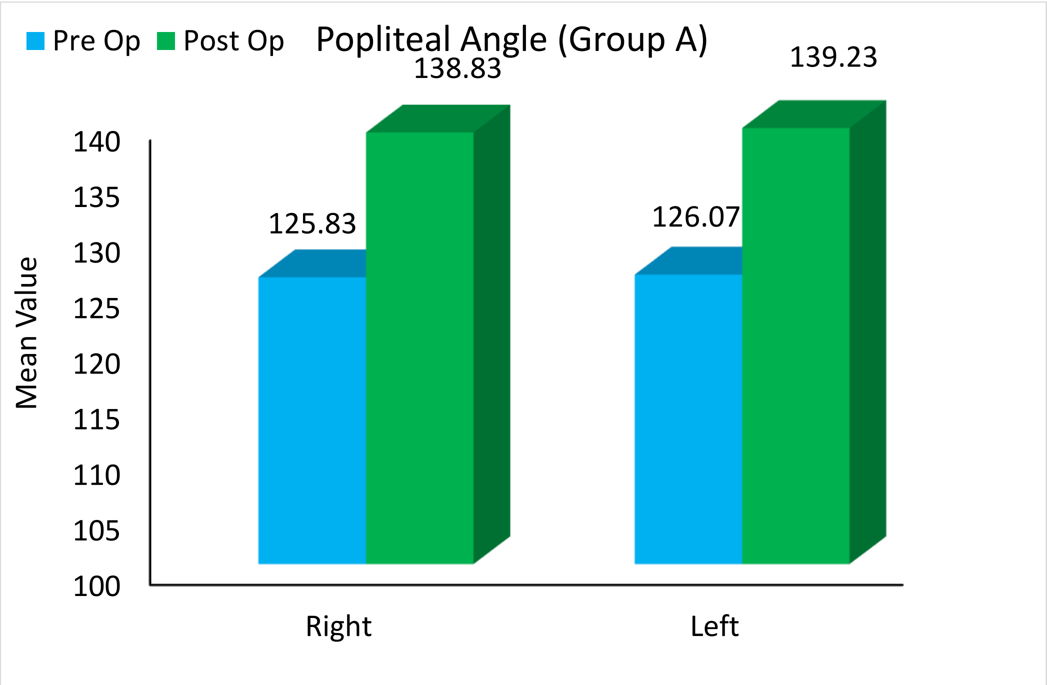


Table 8: Pre and Postop Popliteal Angle Distribution in Group B Patients

Popliteal Angle	Pre Op		Post Op		
Side	Mean	SD	Mean	SD	P value
Right	130.17	14.53	145.17	14.29	<0.05
Left	128.83	13.50	144.50	14.22	<0.05
P value	>0.05		>0.05		

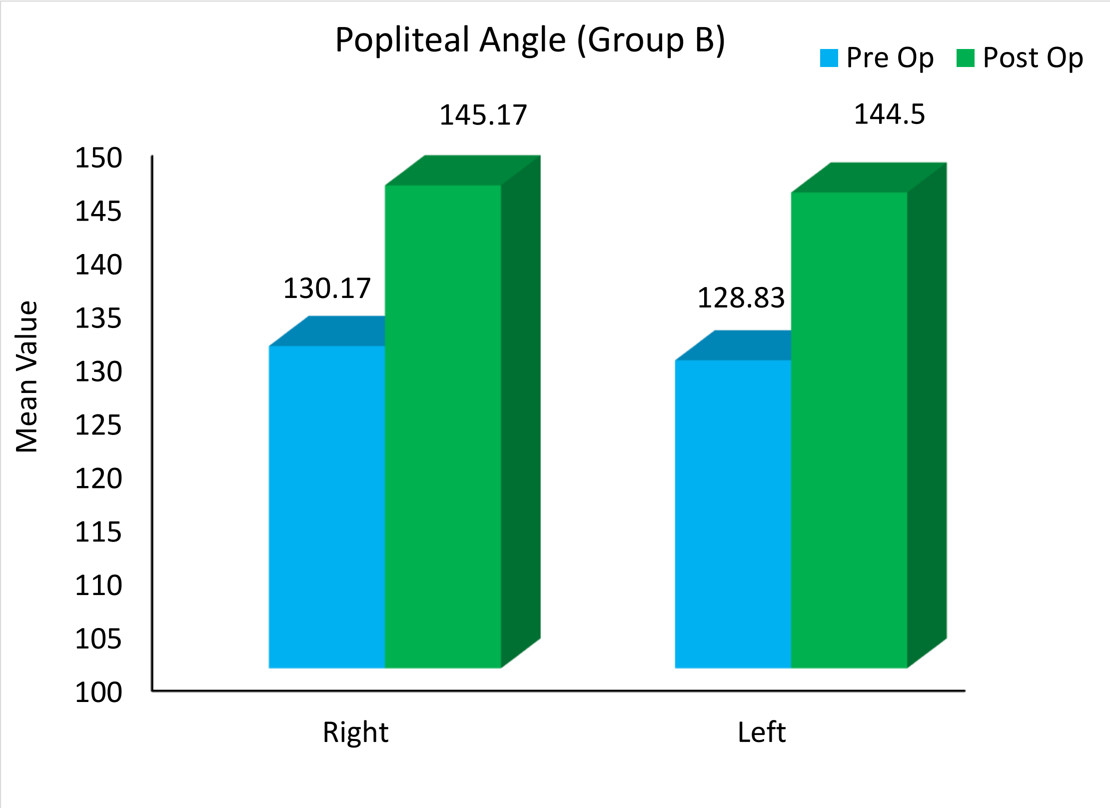


Table 9: Gender and ODI Score Distribution in Groups

		Group A		Group B		P value	
ODI Score	Gender	Female	Male	Female	Male	Female	Male
Pre Op	Mean	21.6	20.33	18.27	20.07	>0.05 (NS)	>0.05 (NS)
	SD	5.69	6.26	7.92	5.43		
Post Op	Mean	6.2	8.67	6.33	6.87	>0.05 (NS)	>0.05 (NS)
	SD	5.63	4.98	4.75	4.05		

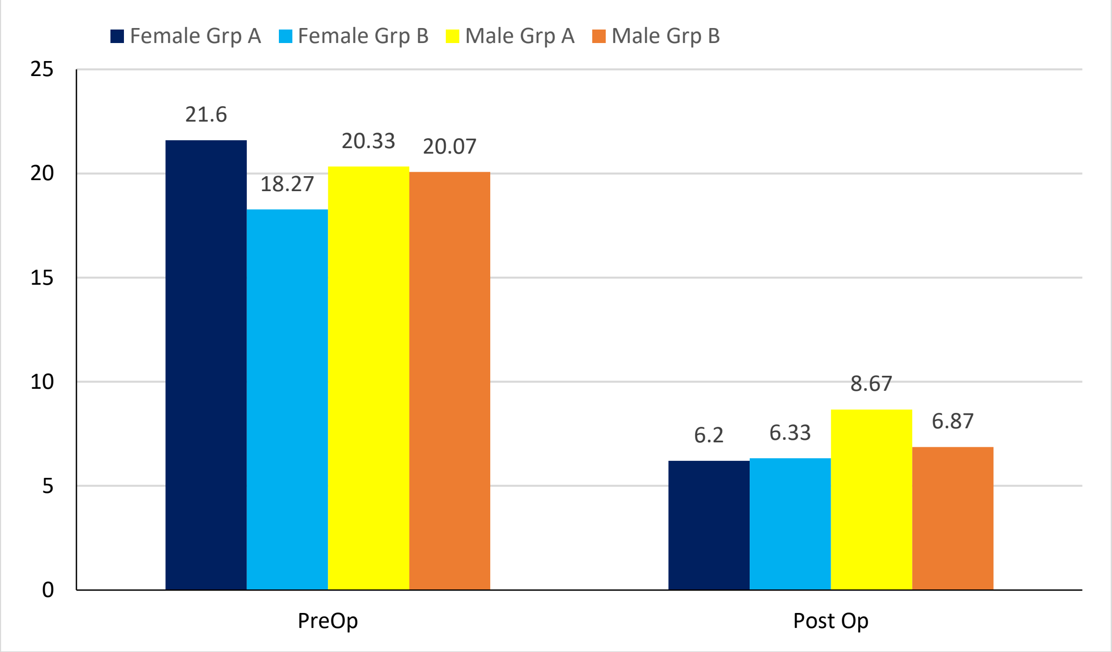
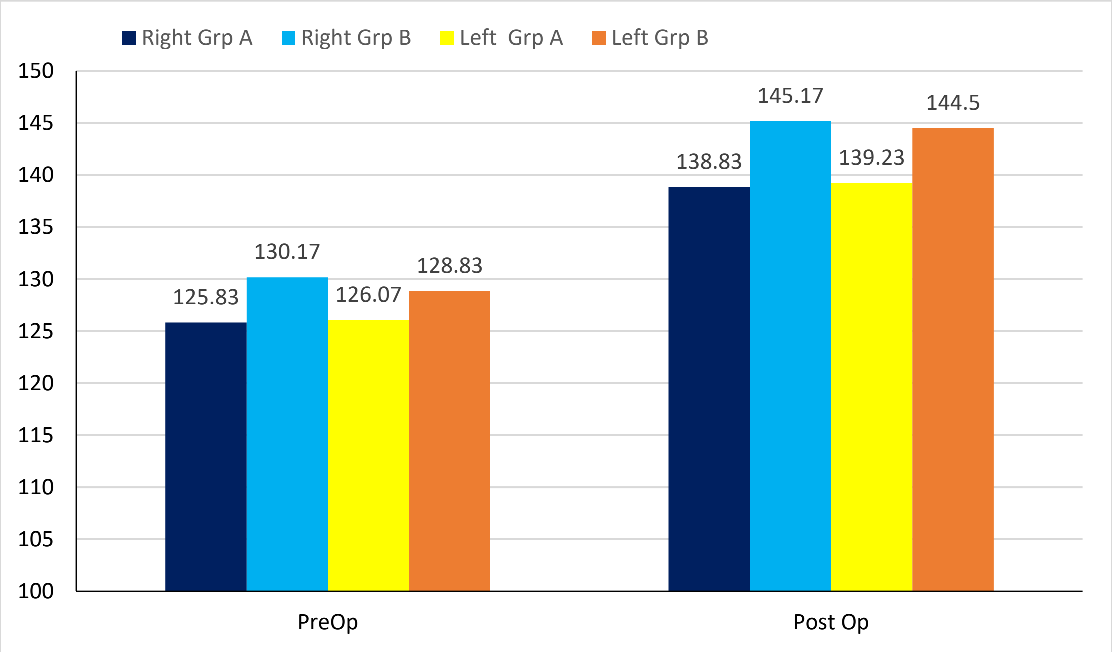


Table 10: Pre and Postop ODI Score with Popliteal Angle Among Groups

		Group A		Group B		P value	
	Popliteal Angle	Right	Left	Right	Left	Right	Left
Pre Op	Mean	125.83	126.07	130.17	128.83	>0.05 (NS)	>0.05 (NS)
	SD	13.4	13.02	14.53	13.5		
Post Op	Mean	138.83	139.23	145.17	144.5	>0.05 (NS)	>0.05 (NS)
	SD	13.43	13.6	14.29	14.22		



4. RESULT

Demographics

As shown in Table 1, both Group A and Group B had an equal distribution of males and females, with 15 males (50%) and 15 females (50%) in each group. This ensured that gender-based differences in outcomes could be reliably compared across groups.

Pain Intensity (VAS)

Table 2 presents the pre-intervention VAS scores across genders. In Group A, females had a mean VAS score of 6.27 ± 1.16 and males 6.07 ± 0.96, whereas Group B showed 6.13 ± 1.25 for females and 6.53 ± 1.19 for males. There was no statistically significant difference between genders ($p > 0.05$).

Post-intervention values (Table 3) indicated substantial reduction in pain: Group A females reduced to 2.60 ± 1.06 and males to 2.93 ± 1.22, while Group B females reduced to 2.80 ± 1.57 and males to 3.13 ± 1.46. The within-group improvements were significant (Table 4, $p < 0.001$), but intergroup and gender-wise comparisons remained non-significant ($p > 0.05$).

Functional Disability (ODI)

Group A's ODI scores improved from 20.97 ± 5.92 to 7.43 ± 5.37 (Table 5), and Group B improved from 19.17 ± 6.74 to 6.60 ± 4.34 (Table 6). Both changes were statistically significant ($p < 0.001$).

Gender-wise ODI comparisons (Table 9) showed that in Group A, females improved from 21.60 ± 5.69 to 6.20 ± 5.63, and males from 20.33 ± 6.26 to 8.67 ± 4.98. Group B showed similar reductions: females from 18.27 ± 7.92 to 6.33 ± 4.75, and males from 20.07 ± 5.43 to 6.87 ± 4.05. All within-group differences were significant, though no gender-based differences were statistically relevant ($p > 0.05$).

Hamstring Flexibility (Popliteal Angle)

Table 7 shows that in Group A, the right popliteal angle increased from 125.83° ± 13.40 to 138.83° ± 13.43 and the left from 126.07° ± 13.02 to 139.23° ± 13.60 ($p < 0.05$). Group B (Table 8) showed a more marked increase: right from 130.17° ± 14.53 to 145.17° ± 14.29 and left from 128.83° ± 13.50 to 144.50° ± 14.22 ($p < 0.05$).

Table 10 compares the ODI and Popliteal Angle scores, showing consistent improvements in flexibility across both groups, with Group B maintaining slightly higher post-intervention popliteal angles. However, the intergroup differences remained statistically non-significant ($p > 0.05$).

5. DISCUSSION

The findings from this randomized clinical trial validate the effectiveness of both static hamstring stretching and Kinetic Chain Activation (KCA) in managing non-specific lower back pain. Significant within-group improvements were observed in pain intensity, functional disability, and hamstring flexibility for both groups. These results suggest that targeting posterior chain tightness—particularly the hamstrings—plays a crucial role in reducing lumbar discomfort and restoring functional mobility.

Pain reduction, as indicated by VAS scores, was substantial across genders and both interventions. While both male and female participants responded well, Group A showed slightly better pain reduction, though this difference was not statistically significant. The uniform gender distribution enhanced the reliability of these comparisons.

ODI outcomes also revealed marked improvements in both groups, with Group A demonstrating a greater absolute reduction in disability index. Despite this, Group B showed slightly better post-intervention flexibility outcomes. Gender-based improvements within each group were consistent and not statistically different, affirming the interventions' generalizability.

Hamstring flexibility, assessed via the popliteal angle test, improved significantly in both groups. Group B, however, demonstrated superior gains, aligning with the theoretical advantage of KCA in promoting dynamic muscle recruitment and fascial mobility. These findings support integrating functional movement-based therapies into physiotherapy practice for NSLBP.

Although the differences between interventions were not statistically significant, the trend favors KCA for functional gains, and static stretching for pain relief. This nuanced understanding encourages clinicians to tailor interventions based on specific patient needs.

6. CONCLUSION

This study confirms that both static hamstring stretching and kinetic chain activation techniques are effective in reducing pain, improving functional ability, and enhancing hamstring flexibility in individuals with NSLBP. KCA showed marginally better outcomes in flexibility, whereas static stretching yielded slightly superior pain relief. Gender and intergroup analyses revealed no significant disparities, underscoring the general efficacy of both techniques across demographic lines.

Given the practical advantages of KCA—dynamic engagement, no equipment requirement, and emphasis on neuromuscular control—it may be particularly suitable for sedentary individuals with postural dysfunction. Nonetheless, both approaches remain valid and should be selected based on individual assessment and therapeutic goals.

7. SUMMARY

- Both static stretching and kinetic chain activation significantly improved VAS, ODI, and popliteal angle scores.
- No significant differences were found gender-wise within groups.
- KCA slightly outperformed in enhancing hamstring flexibility, while static stretching offered marginally better pain relief.

These findings support integrating both approaches into physiotherapy protocols for NSLBP management.

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