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Comparison of Static Hamstring Stretching and Kinetic Chain Activation Technique on Individuals with Non-Specific Lower Back Pain: A Randomized Clinical Trial

Prachi Doshi[*1], Dr. Jafar khan[2], Dr. KM. Annamalai[3], Dr. Renuka Pal[4], Dr. Vardhman Jain[5], Dr. Richa Hirendra Rai[6], Dr. Preksha Jain[7], Dr. Parneet Kaur Bedi[8], Dr. Vaibhav Choubey[9], Dr. Shilpi Kapoor[10]

[*1]M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[2]Dean & HOD, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[3]Consultant Senior Physiotherapist & Director Physio Alliance Apollo Hospital, Ahmedabad, Gujarat, India

[4]Associate Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[5]Consultant Senior Physiotherapist & Director Synergy Health Point, Bombay, Maharashtra, India

[6]Professor, School of Physiotherapy, Delhi Pharmaceutical Sciences and Research University, New Delhi, India

[7]Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[8]Senior Physiotherapist, brain, spine & Joint Clinic, Kharar, Punja, India

[9]HOD & Senior Physiotherapist, Gajraj Medical College, , GWALIOR, MP

[10]Principal, BIMR College Of Professional Studies, Gwalior, MP

***Corresponding Author:**

Prachi Doshi

Email ID: dr.prachidoshi2412@gmail.com

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ABSTRACT

Background: Non-specific lower back pain (NSLBP) is a major contributor to global disability and impairs functional independence. Characterized by pain without any recognizable specific pathology, NSLBP accounts for up to 90% of lower back pain cases and is a leading cause of disability, absenteeism, and reduced quality of life. One biomechanical contributor is hamstring muscle tightness, which influences lumbopelvic posture and increases mechanical stress on the lower spine. Static hamstring stretching has long been implemented as a traditional physiotherapy intervention aimed at improving flexibility and reducing discomfort in the lower back, addressing local musculoskeletal issues but often neglecting broader kinetic and neuromuscular systems essential for recovery. Emerging evidence highlights the role of kinetic chain dysfunction in NSLBP, pointing to the need for dynamic interventions. The kinetic chain activation (KCA) technique offers a dynamic alternative by promoting coordinated muscle recruitment across multiple body segments —particularly the lower limb, pelvis, and trunk—to restore neuromuscular control, postural alignment, and functional movement.

Objective: This study compares the effectiveness of static hamstring stretching and kinetic chain activation techniques in reducing pain and improving functional ability in individuals diagnosed with NSLBP. The primary objective was to evaluate which of the two interventions provides superior therapeutic outcomes, with implications for neuromuscular retraining strategies in rehabilitative care.

Methods: A randomized clinical trial was conducted with 60 participants (aged 25–50 years) clinically diagnosed with NSLBP. Subjects were randomly assigned to either Group A (static hamstring stretching) or Group B (kinetic chain activation technique), with 30 participants in each group. Group A received a protocol of passive static stretching targeting the hamstring muscles, performed thrice a week for four weeks. Group B underwent a structured kinetic chain activation regimen emphasizing lower limb muscle activation. Both groups received three sessions per week over four weeks. Pain intensity, functional disability and hamstrings muscle flexibility were assessed pre- and post-intervention using the Visual Analog Scale (VAS), the Oswestry Disability Index (ODI) and Popliteal Angle respectively. Data were statistically analyzed using paired and unpaired t-tests, with a significance level set at $p < 0.05$.

Results: Both intervention groups demonstrated significant within-group improvements in pain and functional ability after the four-week protocol ($p < 0.05$). However, between-group comparisons revealed that Group B (kinetic chain activation) exhibited significantly greater reductions in VAS scores and ODI scores compared to Group A (static stretching). This suggests kinetic chain exercises more effectively alleviate pain and support functional recovery by targeting underlying neuromuscular imbalances in NSLBP.

Conclusion: While static hamstring stretching remains beneficial in NSLBP management, kinetic chain activation techniques yield superior results in pain reduction and functional improvement. These results support the integration of dynamic, multi-joint activation strategies in physiotherapy for NSLBP. Beyond musculoskeletal care, the findings hold translational relevance for stroke rehabilitation, where restoring intersegmental coordination and neuromuscular control is critical. Applying kinetic chain principles to neurorehabilitation may enhance outcomes in stroke and related conditions. Future research with larger samples and longer follow-up is needed to validate these findings.

Trial Registration: This study was not registered in a clinical trial registry.

Keywords: *Hamstring Tightness, Kinetic Chain Activation, Static Stretching, Non-Specific Low Back Pain, Flexibility, Functional Ability, Oswestry Disability Index, Visual Analogue Scale.*

1. INTRODUCTION

Non-specific lower back pain (NSLBP) is defined as pain not attributable to a recognizable, known specific pathology such as infection, tumor, or fracture. It remains one of the most common and costly musculoskeletal conditions globally, affecting both occupational and recreational activities.[1–3]

Students and working professionals, are increasingly affected due to prolonged sitting, poor posture, and sedentary lifestyles.[4] The hamstring muscle group, when shortened or tight, can influence pelvic positioning and spinal alignment, contributing to lower back discomfort.[5]

Physiotherapeutic interventions have included modalities like static stretching, manual therapy, and more recently, kinetic chain-based techniques.[6] Static hamstring stretching is frequently employed to reduce musculoskeletal tension and improve range of motion.[7] Alternatively, kinetic chain activation (KCA) techniques aim to enhance muscle recruitment and neuromuscular control across interdependent muscle groups, offering a holistic rehabilitation approach.[8–9]

Despite the widespread use of both methods, limited literature compares their relative effectiveness in treating NSLBP. This study aims to evaluate and compare the efficacy of static hamstring stretching and kinetic chain activation technique in reducing pain and improving function in individuals with NSLBP.

2. MATERIALS & METHODS

Ethical Approval- This study was reviewed and full ethical approval was given by **Institutional Ethics Committee of Pacific Medical University, Udaipur (Approval no: PMU/PCMH/IEC/2024/279)**

Consent to Participate

All participants were fully informed about the nature, objectives, procedures, and potential risks and benefits of the study prior to enrollment. Written informed consent was obtained from each participant before enrollment. Participants were assured that their participation was voluntary and that they had the right to withdraw from the study at any time without any consequences to their ongoing care or academic standing. Confidentiality and anonymity of all personal and clinical data were strictly maintained throughout the study.

Study Design

This randomized control trial is reported in accordance with the CONSORT 2010 guidelines. The CONSORT checklist and participation flow diagram are provided as supplementary material.

This study was a **prospective, parallel-group, randomized clinical trial** designed to compare the effectiveness of two physiotherapeutic interventions—static hamstring stretching and kinetic chain activation technique—in the management of individuals with non-specific lower back pain (NSLBP). The study design allows for a detailed comparison of pre- and post-intervention outcomes between the groups, providing insights into the specific contributions of Kinetic Chain Activation Technique. The study was conducted at the outpatient physiotherapy department of Pacific Medical College, Udaipur, from September 2024- March 2025.

The study involved two intervention groups with equal allocation:

- **Group A** received static hamstring stretching.
- **Group B** received kinetic chain activation technique.

The study was designed to evaluate and compare outcomes based on pain intensity, functional disability and popliteal angle after a structured intervention period of 4 weeks.

Participants

- A total of **60** participants aged **25-50 years** with a clinical diagnosis of NSLBP were recruited based on predefined inclusion and exclusion criteria. Participants were randomly allocated into two intervention groups: Group A (Static Hamstring Stretching) and Group B (Kinetic Chain Activation Technique), with equal numbers in each group.

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

A **sample size of 60 participants (30 participants in each group)** was determined based on a pilot study and review of previous literature, which indicated a medium effect size for similar interventions on pain and functional disability in NSLBP. All participants completed the study protocol, and data from all 60 subjects were included in the final analysis.

Interventions

- **Group A – Static Hamstring Stretching:** Participants in this group underwent a structured static stretching protocol targeting the hamstring muscles. Each stretch was held for 2 minutes, repeated **3 times per leg**, with **1 minute** rest between repetitions (Figure 1). The intervention was administered **3 times per week (alternate days)** for **4 weeks**.

Figure 1. Static Hamstring Stretch position is illustrated.

- **Group B – Kinetic Chain Activation Technique:** Participants in this group received kinetic chain activation-based exercises designed to enhance muscle activation across the lower limb and trunk. The protocol included gentle fascial stimulation by tapping the posterior chain area for 7–8 seconds (Figure 2) followed by 15 repetitions of active prone knee flexion (Figure 3)**.** The intervention was administered **3 times per week (alternate days)** for **4 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.

- Isometric hamstring contractions
- Static gluteal contractions
- Transverse abdominalis activation exercise
- Seated resisted knee flexion using opposite limb

Outcome Measures

- Outcome measures were assessed at **baseline (pre-intervention)** and after the **4 weeks (12 sessions)** intervention period:
- **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, paired and unpaired **t-tests** were used to assess within-group and between-group differences, respectively. A *p*-value of <0.05 was considered statistically significant. Descriptive statistics (mean, standard deviation) were also calculated for demographic and outcome variables.

For each group average of pre and post-treatment scores of VAS, ODI and Popliteal Angle is calculated with SD, S.E., and t-test. Data is also calculated individually in both groups for comparison of VAS, ODI and Popliteal Angle with in different age groups and for different duration of treatment.

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%**

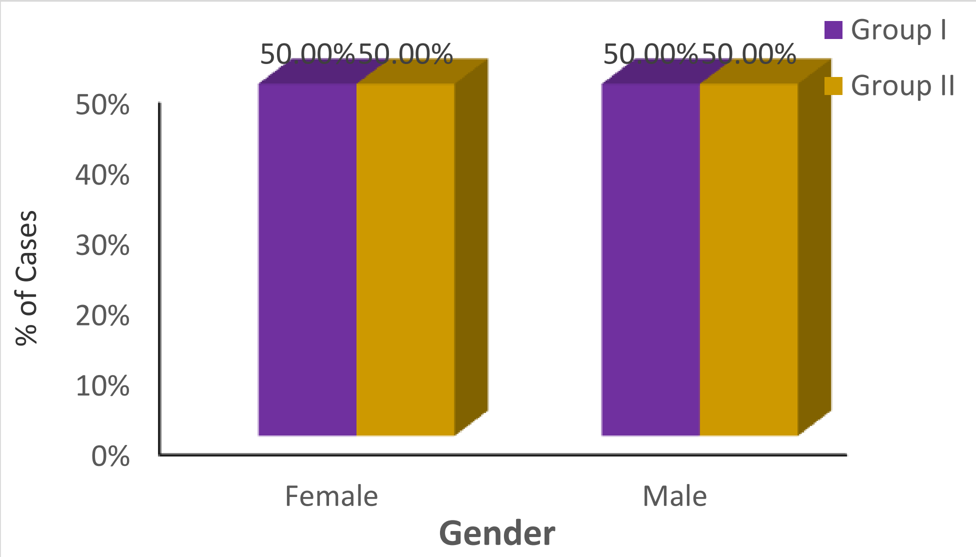


Table 2: Age wise Distribution

	Group A		**Group B**	
Age group (yrs)	**No.**	**%**	**No.**	**%**
21-30	8	26.67%	10	33.33%
31-40	12	40.00%	10	33.33%
41-50	10	33.33%	10	33.33%
Total	**30**	**100.00%**	**30**	**100.00%**

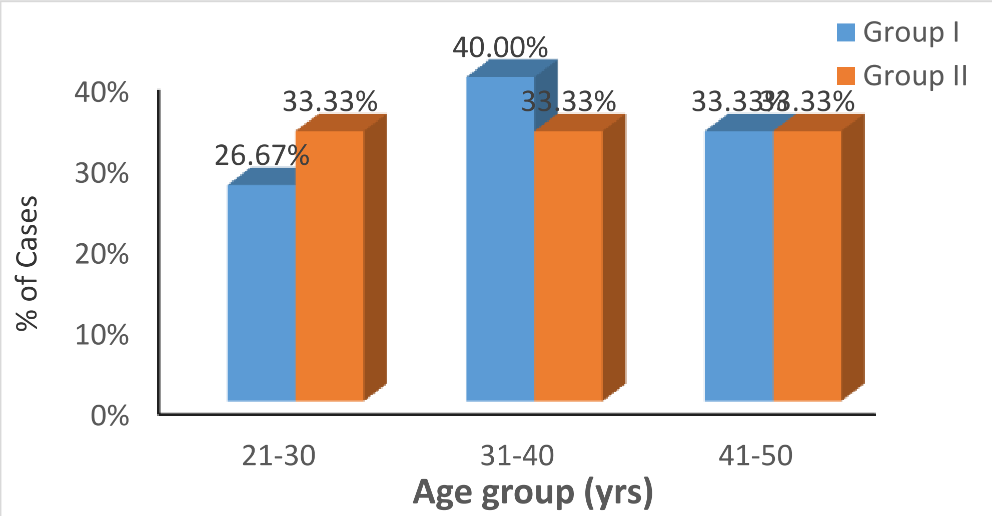
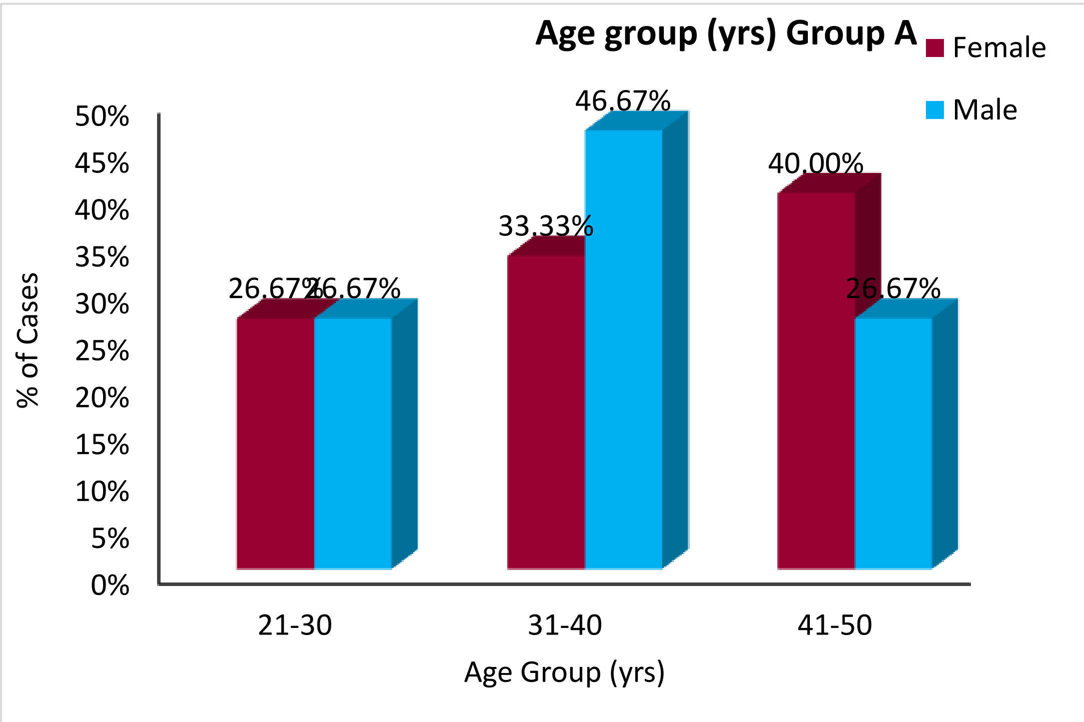


Table 3: Age and Gender wise Distribution

Age group (yrs)	Group A				Group B			
	Female		Male		Female		Male	
	No.	%	No.	%	No.	%	No.	%
21-30	4	26.67%	4	26.67%	4	26.67%	6	40.00%
31-40	5	33.33%	7	46.67%	6	40.00%	4	26.67%
41-50	6	40.00%	4	26.67%	5	33.33%	5	33.33%
Total	**15**	**100%**	**15**	**100%**	**15**	**100%**	**15**	**100%**



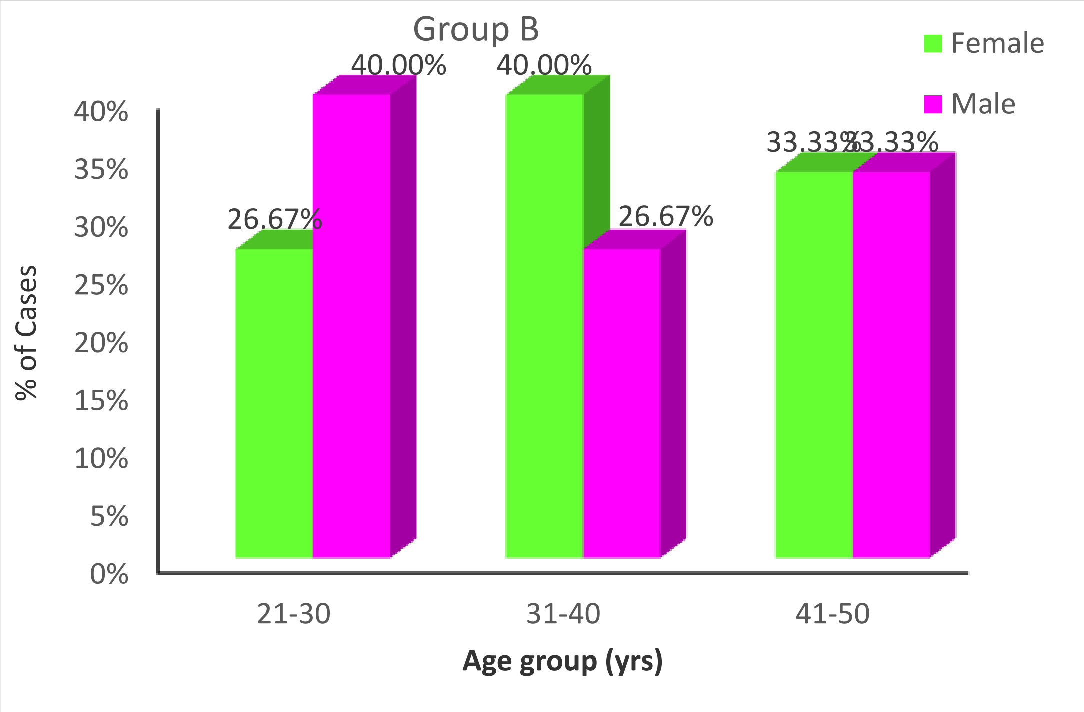


Table 4: Gender wise Pre Op VAS Score in Both Groups

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**		

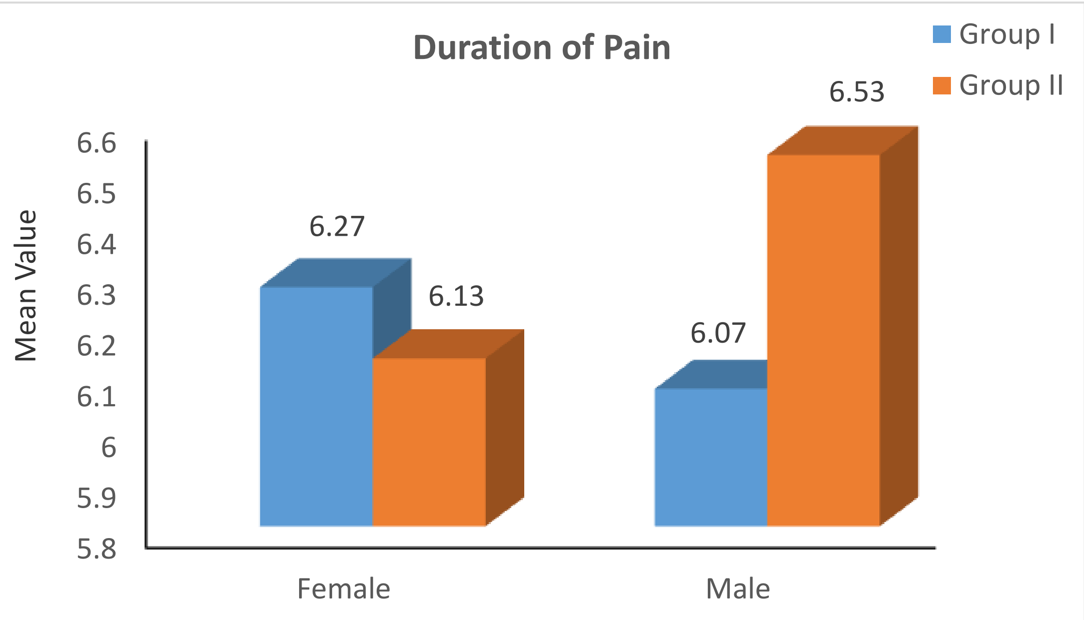


Table 5: Gender wise Post Op VAS Score in Both Groups

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**		

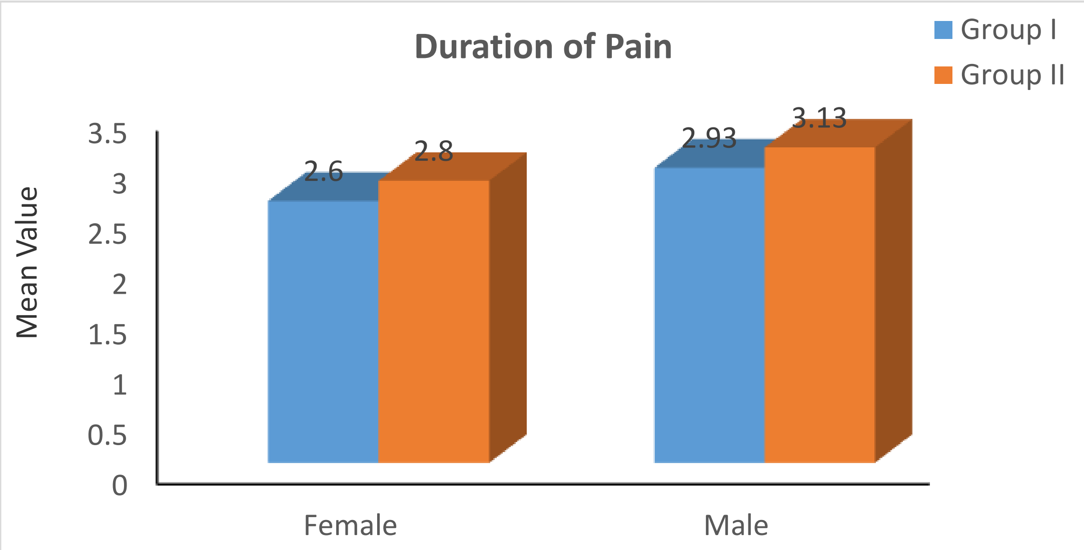


Table 6: Age group and VAS Distribution in Group A Patients

VAS	Pre Op		Post Op		
Age group (yrs)	**Mean**	**SD**	**Mean**	**SD**	**P value**
21-30	6.13	0.99	2.38	0.92	<0.001
31-40	6.17	1.03	3.33	1.15	<0.001
41-50	6.20	1.23	2.40	1.07	<0.001
ANOVA P value	>0.05		>0.05		

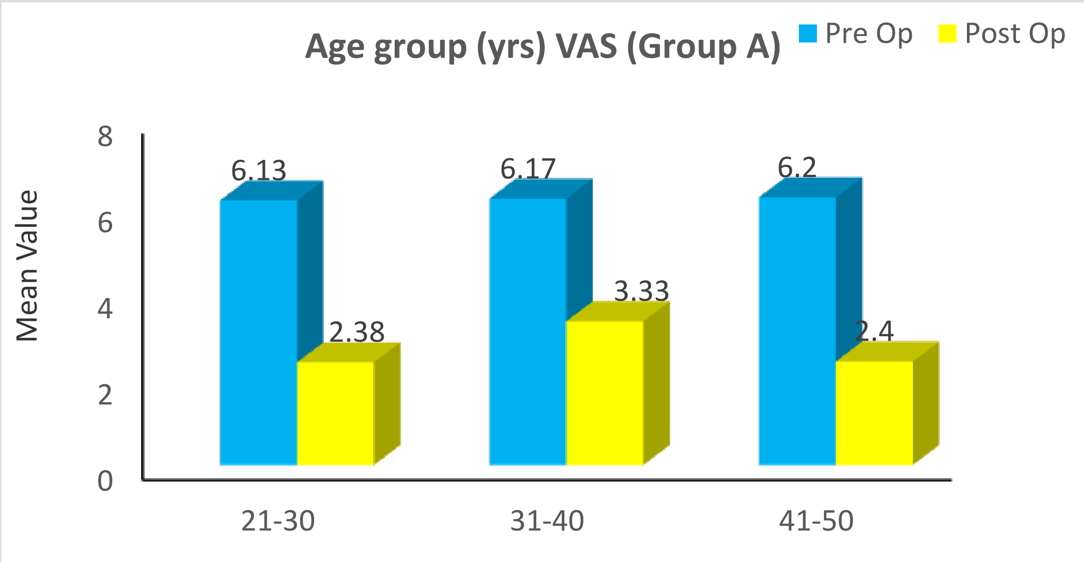


Table 7: Age group and VAS Distribution in Group B Patients

VAS	Pre Op		Post Op		
Age group (yrs)	**Mean**	**SD**	**Mean**	**SD**	**P value**
21-30	6.00	1.05	2.80	1.32	<0.001
31-40	6.40	0.97	3.30	1.42	<0.001
41-50	6.60	1.58	2.80	1.81	<0.001
ANOVA P value	>0.05		>0.05		

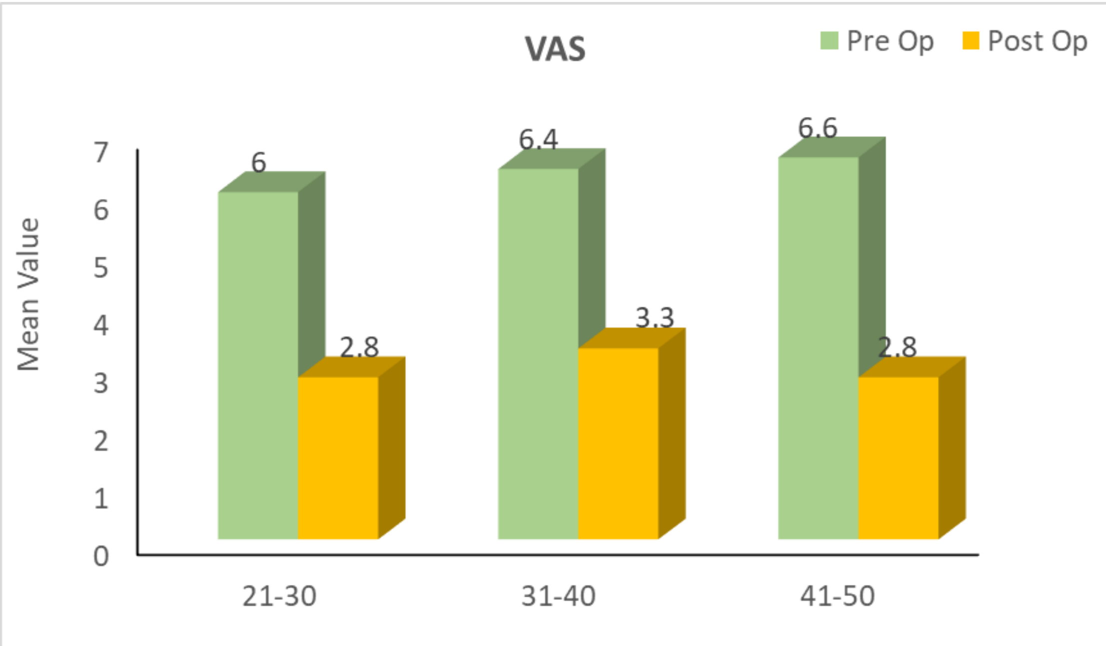


Table 8: VAS in Both Groups

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		

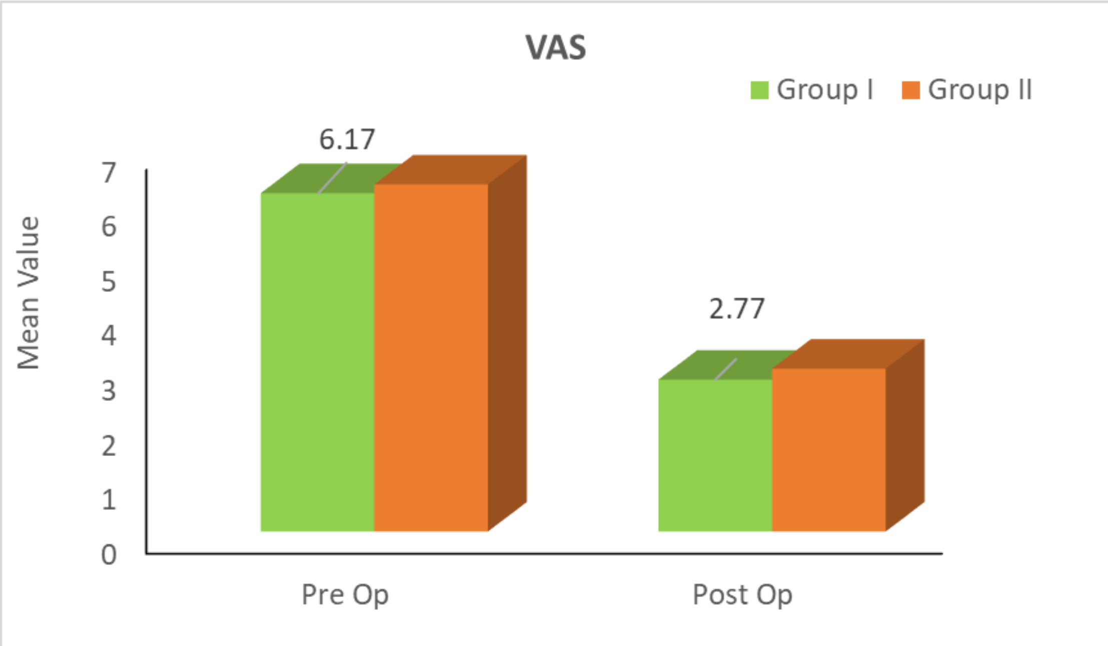


Table 9: ODI Score in Group A

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

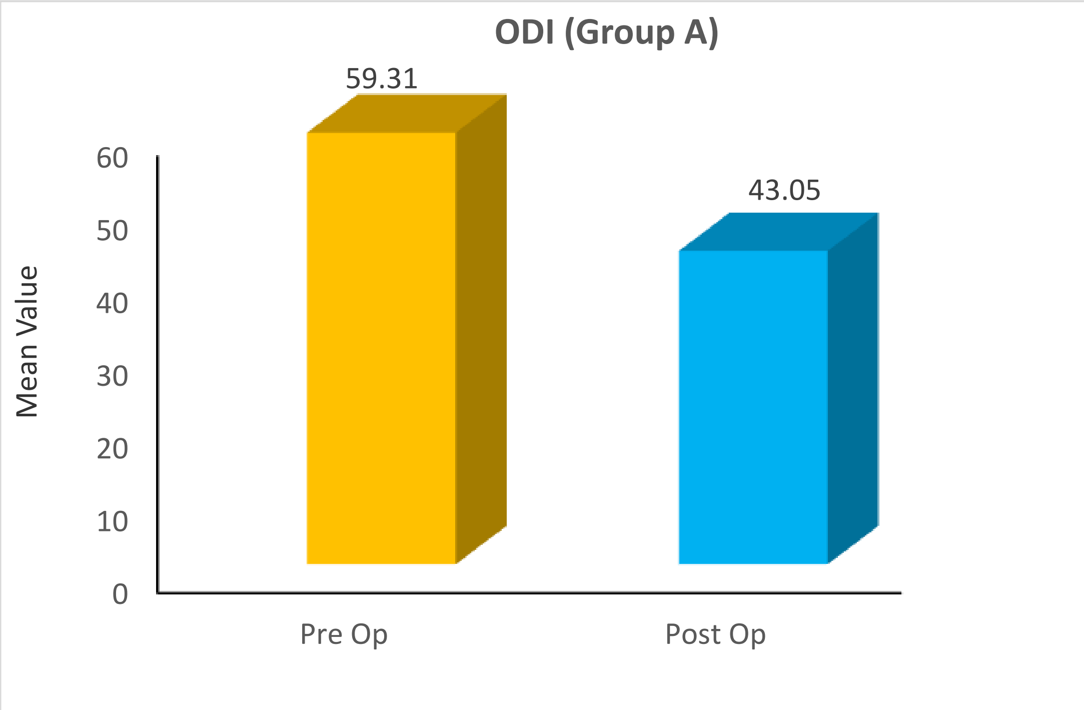


Table 10: ODI Score in Group B

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

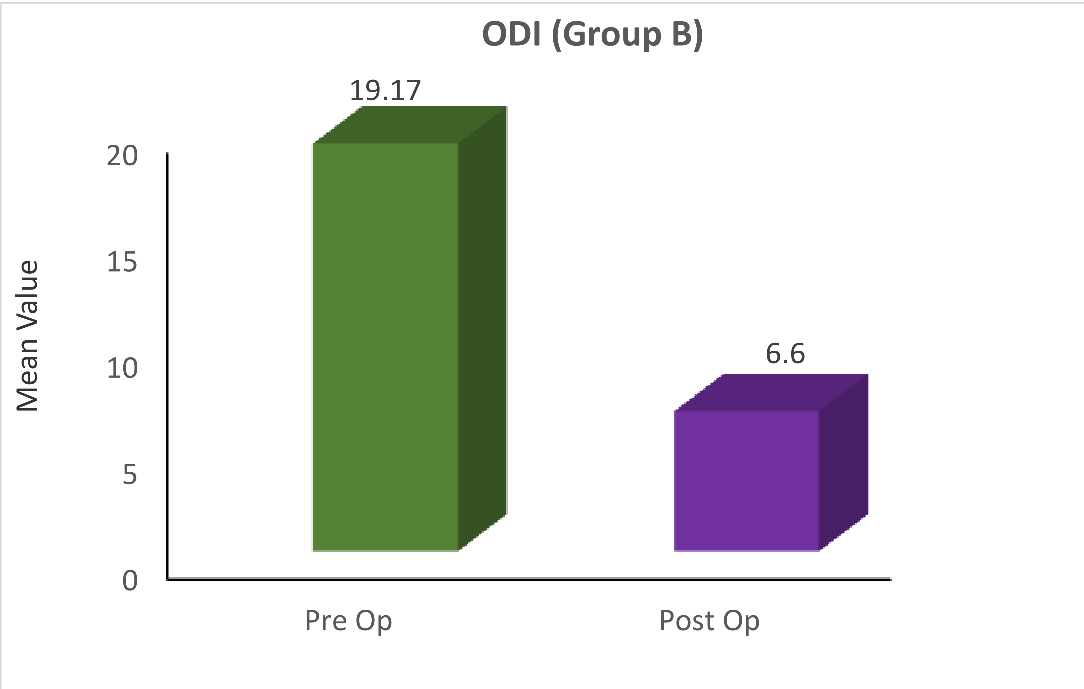


Table 11: Age group and ODI Score Distribution in Group A Patients

ODI Score	Pre Op		Post Op		
Age group (yrs)	**Mean**	**SD**	**Mean**	**SD**	**P value**
21-30	18.25	6.54	5.38	3.02	<0.001
31-40	22.58	6.08	10.33	5.47	<0.001
41-50	21.20	4.92	5.60	5.54	<0.001
ANOVA P value	<0.05		<0.05		

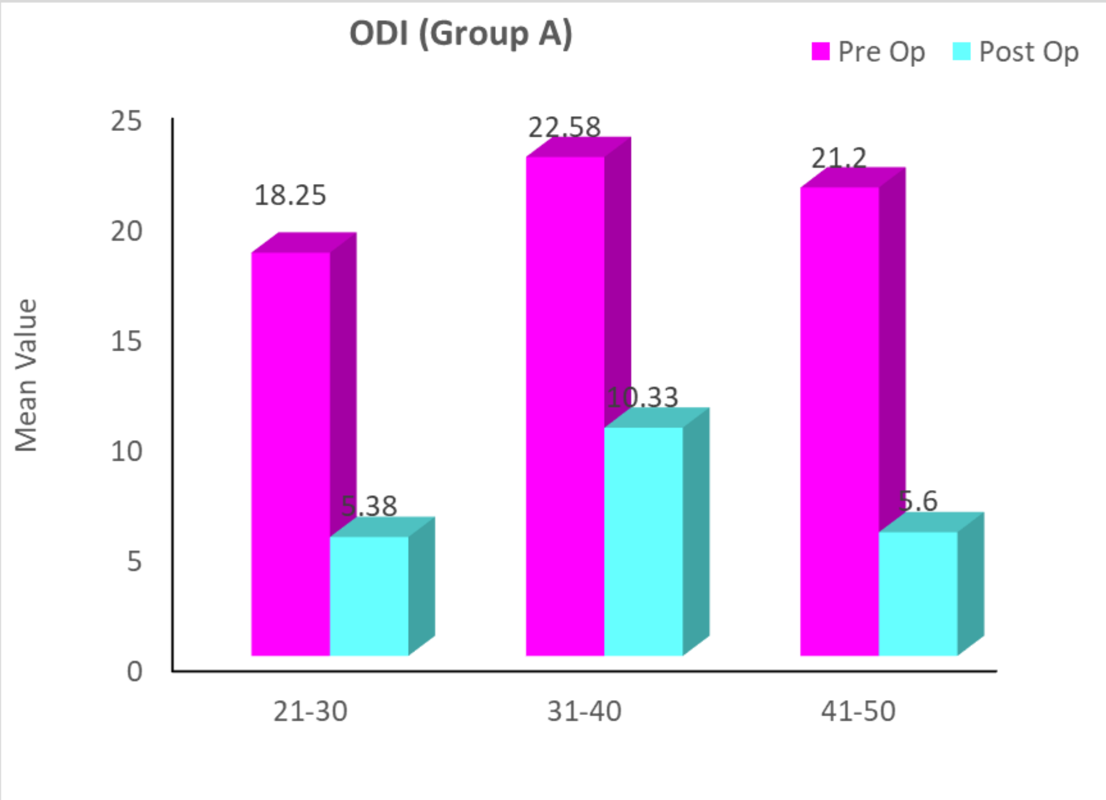


Table 12: Gender and ODI Score Distribution in Group A Patients

ODI Score	Pre Op		Post Op		
Gender	**Mean**	**SD**	**Mean**	**SD**	**P value**
Female	21.60	5.69	6.20	5.63	<0.01
Male	20.33	6.26	8.67	4.98	<0.01
P value	>0.05		>0.05		

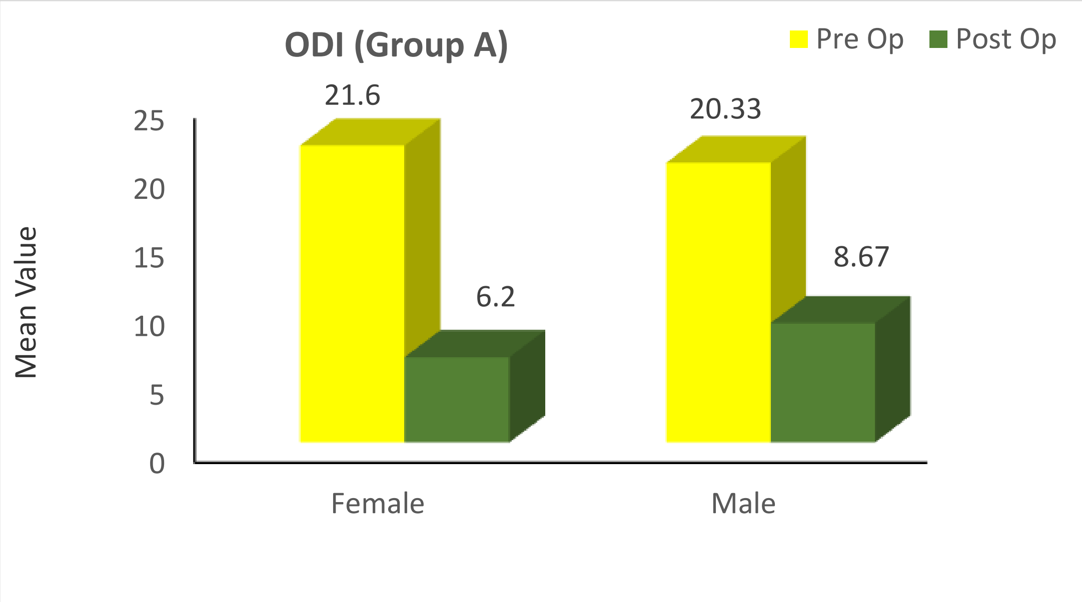


Table 13: Age group and ODI Score Distribution in Group B Patients

ODI Score	Pre Op		Post Op		
Age group (yrs)	**Mean**	**SD**	**Mean**	**SD**	**P value**
21-30	16.80	5.83	6.00	2.83	<0.001
31-40	20.70	4.90	7.70	6.07	<0.001
41-50	20.00	8.87	6.10	3.73	<0.001
ANOVA P value	<0.05		<0.05		

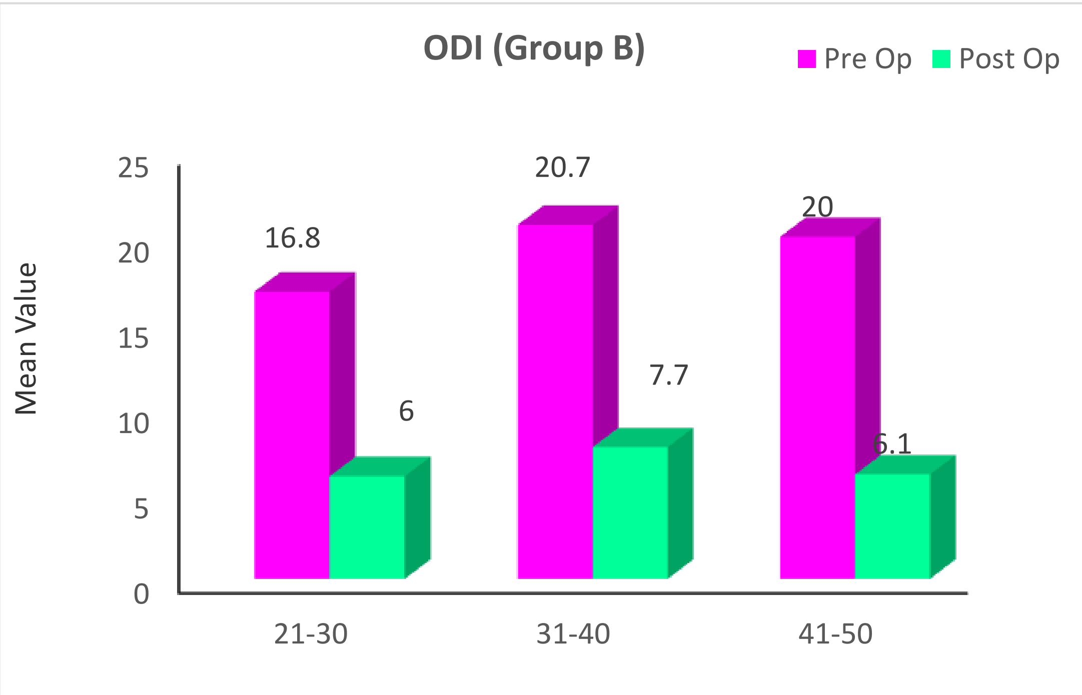


Table 14: Gender and ODI Score Distribution in Group B Patients

ODI Score	Pre Op		Post Op		
Gender	**Mean**	**SD**	**Mean**	**SD**	**P value**
Female	18.27	7.92	6.33	4.75	<0.001
Male	20.07	5.43	6.87	4.05	<0.001
P value	<0.05		<0.05		

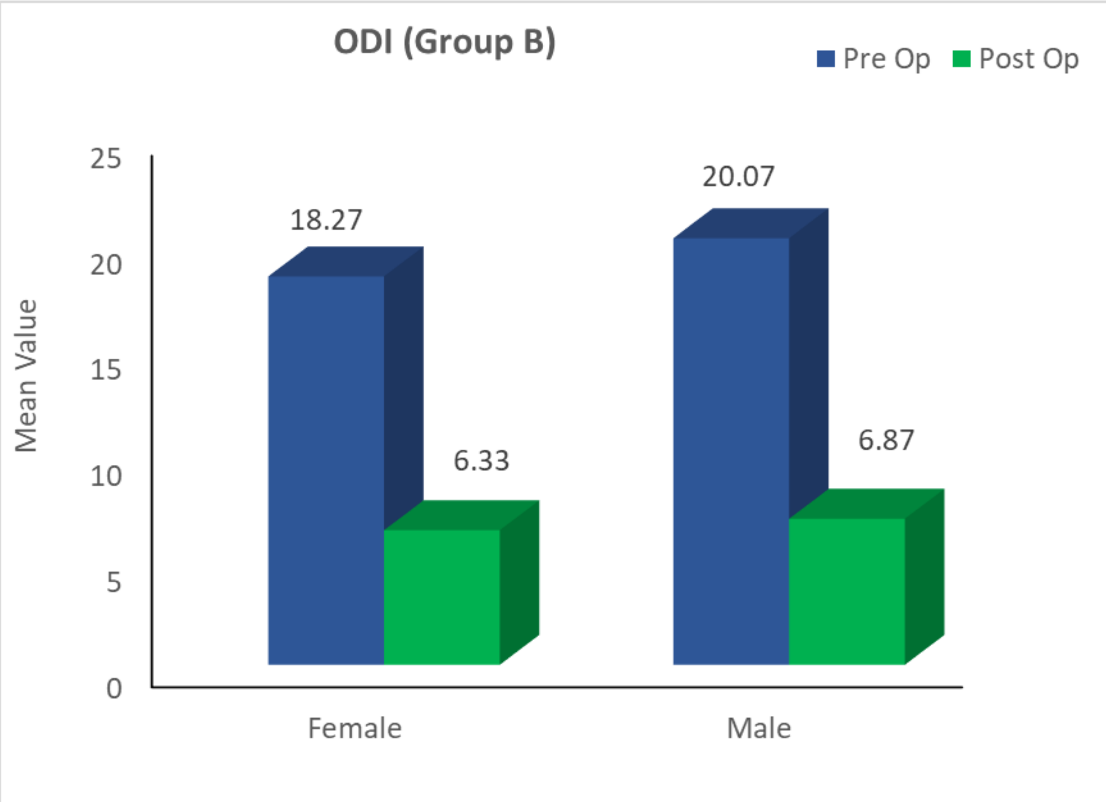


Table 15: Pre and Postop Popliteal Angle Distribution in Group A Patients

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		

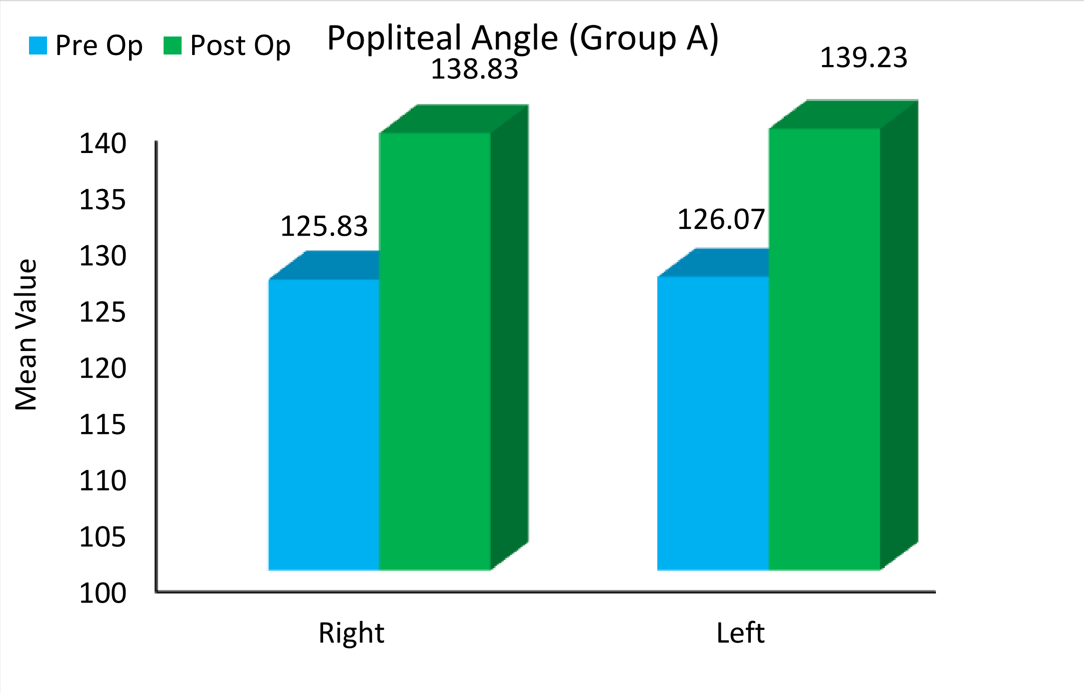


Table 16: Pre and Postop Popliteal Angle Distribution in Group B Patients

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		

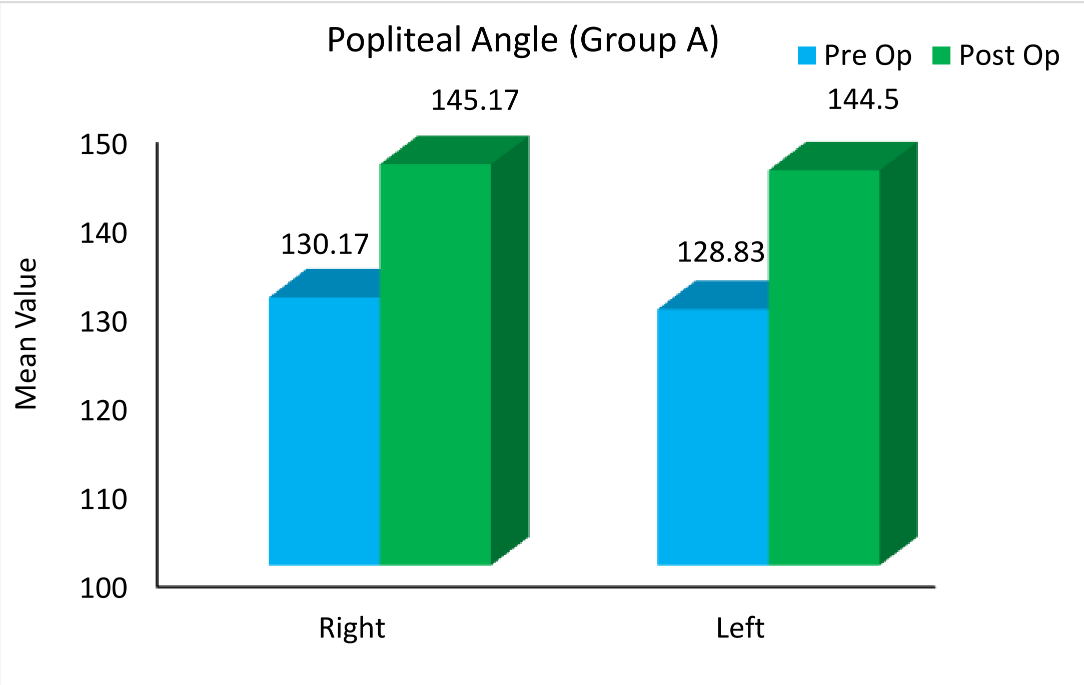


Table 17: Gender and Pre and Postop Popliteal Angle Distribution in Group A Patients

	Popliteal Angle	Pre Op		Post Op		
Gender	**Side**	**Mean**	**SD**	**Mean**	**SD**	**P value**
Female	Right	126.33	13.82	137.67	16.02	<0.05
	Left	127.33	12.37	138.13	15.82	<0.05
Male	Right	125.33	13.43	140.00	10.69	<0.05
	Left	140.00	10.69	124.80	13.96	<0.05

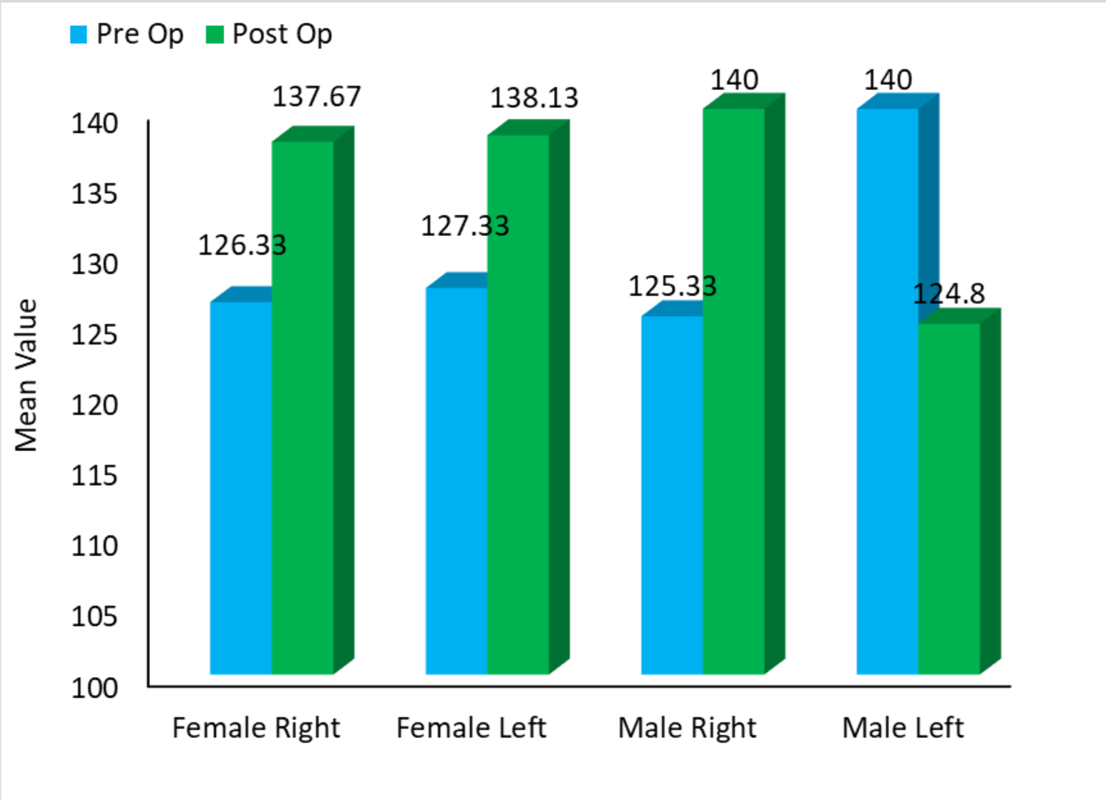


Table 18: Gender and Pre and Postop Popliteal Angle Distribution in Group B Patients

	Popliteal Angle	Pre Op		Post Op		
Gender	**Side**	**Mean**	**SD**	**Mean**	**SD**	**P value**
Female	Right	132.67	15.22	145.67	16.57	<0.05
	Left	130.00	14.39	145.33	16.53	<0.05
Male	Right	127.67	13.87	144.67	12.17	<0.05
	Left	127.67	12.94	143.67	12.02	<0.05

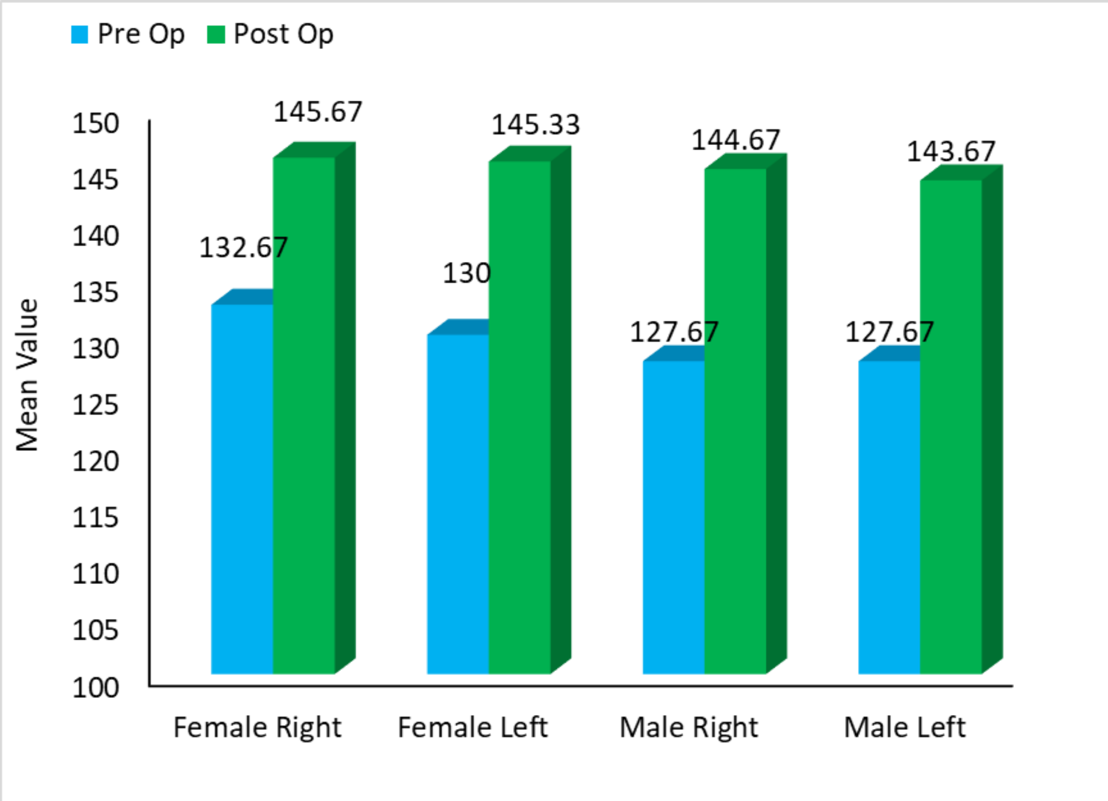


Table 19: Age group with Pre and Postop Popliteal Angle Distribution in Group A

Popliteal Angle		Pre Op		Post Op		
Side	**Age Group**	**Mean**	**SD**	**Mean**	**SD**	**P value**
Right	21-30	128.75	17.06	140.00	17.93	0.219
	31-40	121.25	11.31	134.17	10.62	0.009
	41-50	129.00	12.20	143.50	11.80	0.015
Left	21-30	127.13	16.87	140.00	18.52	0.122
	31-40	122.92	9.64	135.00	10.87	0.017
	41-50	129.00	13.70	143.70	11.75	0.019

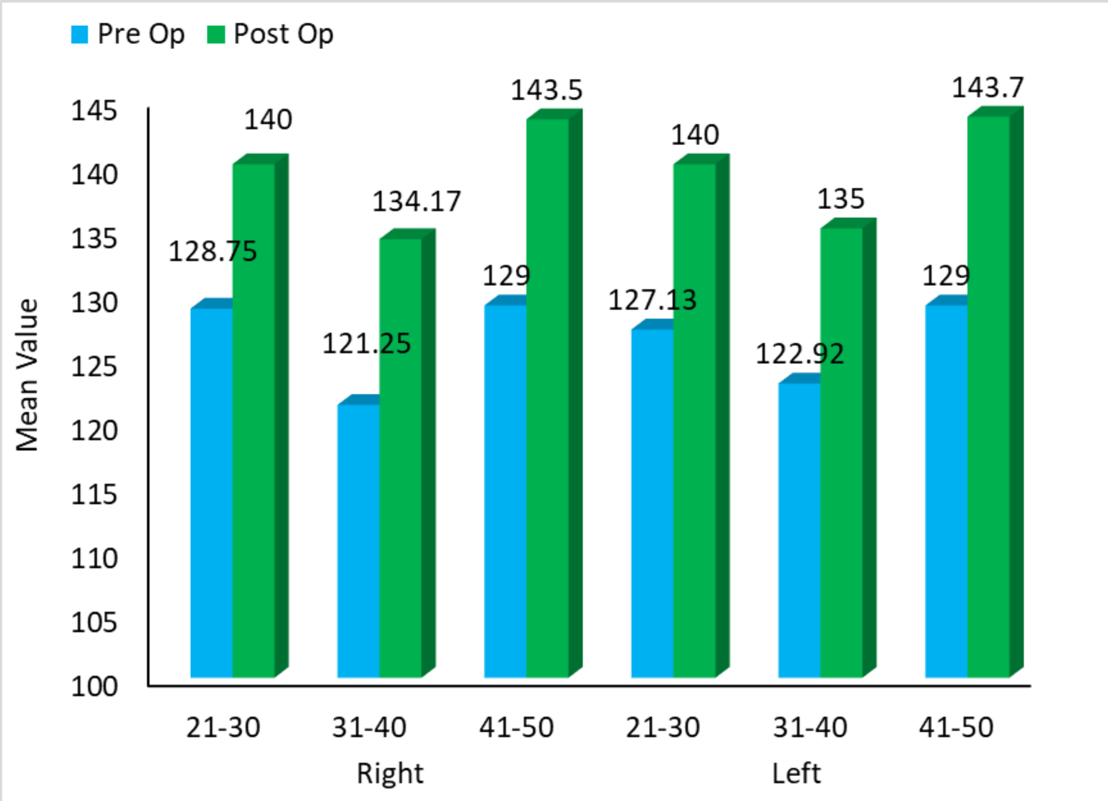


Table 20: Age group with Pre and Postop Popliteal Angle Distribution in Group B

Popliteal Angle		Pre Op		Post Op		
Side	**Age Group**	**Mean**	**SD**	**Mean**	**SD**	**P value**
Right	21-30	131.50	10.29	142.00	10.33	0.061
	31-40	128.00	12.52	145.50	16.74	0.008
	41-50	131.00	20.25	148.00	15.85	0.051
Left	21-30	127.50	10.34	140.00	12.02	0.023
	31-40	125.50	9.85	145.50	15.89	0.003
	41-50	133.50	18.57	148.00	14.76	0.069

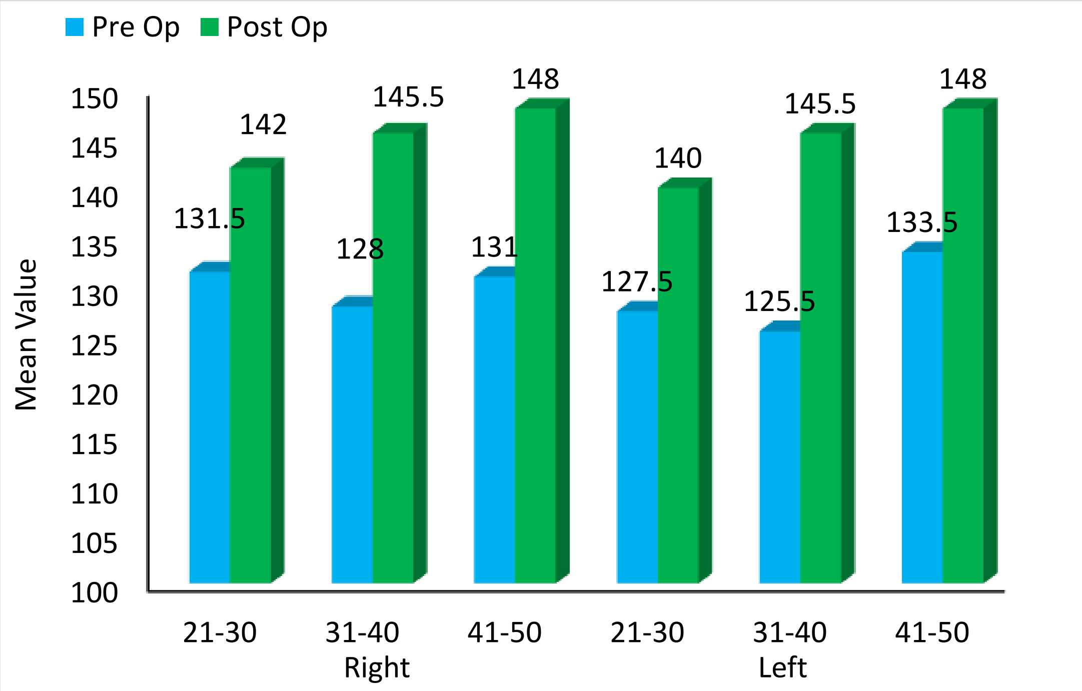


Table 21: Age group and ODI Score Distribution Among Groups

ODI Score	Age group (yrs)	Group A			Group B			ANOVA P value
		21-30	31-40	41-50	21-30	31-40	41-50	
Pre Op	**Mean**	18.25	22.58	21.2	16.8	20.7	20	>0.05 (NS)
	SD	6.54	6.08	4.92	5.83	4.9	8.87	
Post Op	**Mean**	5.38	10.33	5.6	6	7.7	6.1	>0.05 (NS)
	SD	3.02	5.47	5.54	2.83	6.07	3.73	

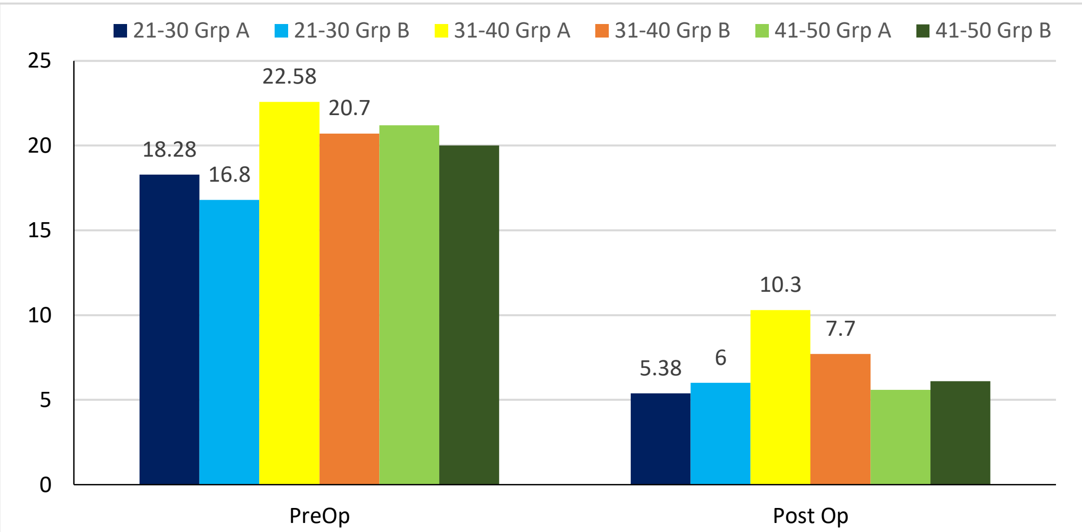


Table 22: Gender and ODI Score Distribution in Groups

		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		

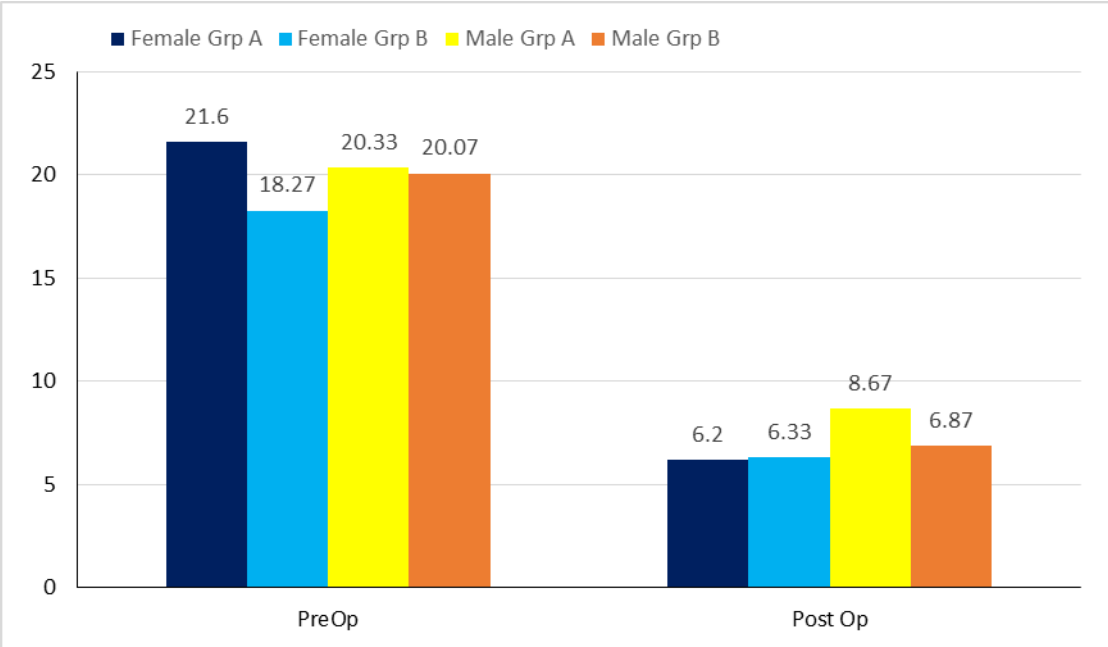
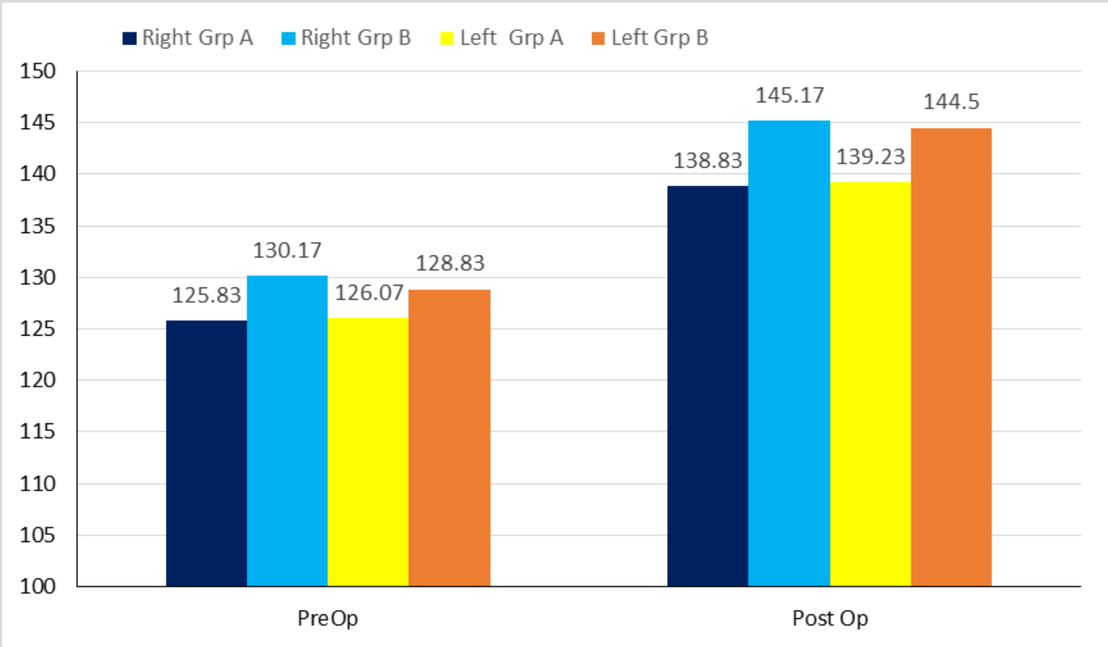


Table 23: Pre and Postop ODI Score with Popliteal Angle Among Groups

		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

This comparative study was undertaken to evaluate and compare the effectiveness of static hamstring stretching and the kinetic chain activation technique (K-CAT) on functional ability, pain intensity, and hamstring flexibility in individuals diagnosed with non-specific lower back pain (NSLBP). A total of 60 subjects aged between 20 and 50 years were randomly divided into two equal groups—Group A (Static Hamstring Stretching) and Group B (Kinetic Chain Activation). The study period consisted of 12 treatment sessions over 4 weeks. Three outcome measures were employed for assessment: Visual Analogue Scale (VAS) to assess pain intensity, Oswestry Disability Index (ODI) to assess functional disability, and the Popliteal Angle Test to assess hamstring muscle flexibility.

Pain intensity, as measured by the VAS, showed statistically significant improvement in both groups post-treatment (Table 8). The mean VAS score for Group A decreased from 6.17 ± 1.05 before treatment to 2.77 ± 1.14 after treatment. Similarly, in Group B, the mean VAS score reduced from 6.33 ± 1.21 to 2.97 ± 1.50. Although both groups showed significant within-group improvement ($p < 0.001$), the intergroup difference in post-treatment VAS scores was not statistically significant ($p > 0.05$), indicating that both static stretching and kinetic chain activation are effective in alleviating pain, with no clear superiority in terms of pain reduction.

Subgroup analysis based on gender revealed that female participants in both groups experienced slightly more reduction in pain compared to males (Tables 4 and 5). In Group A, the mean VAS for females dropped from 6.27 to 2.60, while males reduced from 6.07 to 2.93. In Group B, female VAS dropped from 6.13 to 2.80, and males from 6.53 to 3.13. However, the gender-based differences were not statistically significant, suggesting that both males and females benefited equally from the interventions.

When analyzing age-wise distribution, all age groups (21–30, 31–40, and 41–50 years) responded positively to treatment (Table 6). For instance, in Group A, subjects aged 21–30 showed a reduction from 6.13 ± 0.99 to 2.38 ± 0.92, while those aged 41–50 showed a reduction from 6.20 ± 1.23 to 2.40 ± 1.07. Group B followed a similar trend. These findings suggest that the interventions were effective across different age ranges, although younger participants tended to show slightly faster improvements, possibly due to greater tissue compliance and neuromuscular adaptability.

Regarding functional disability, both groups showed significant improvements in ODI scores (Tables 9 and 10). Group A's mean ODI decreased from 20.97 ± 5.92 to 7.43 ± 5.37, and Group B's from 19.17 ± 6.74 to 6.60 ± 4.34. The improvements within both groups were statistically significant ($p < 0.001$), showing that targeting the hamstrings is effective in reducing disability associated with NSLBP. However, similar to the VAS findings, the between-group comparison post-treatment showed no significant difference, though Group B (K-CAT) exhibited a slightly higher reduction, suggesting better overall functional recovery.

Further, gender-wise ODI scores followed a similar trend to VAS (*Tables 12* and *14*). Female participants in Group A had a greater functional improvement (ODI reduced from 21.60 to 6.20) compared to males (20.33 to 8.67). In Group B, females improved from 18.27 to 6.33 and males from 20.07 to 6.87. Again, while improvements were notable in both genders, the difference was not statistically significant.

Age-wise ODI analysis indicated that younger individuals (21–30 years) had more pronounced functional recovery (Tables 11 and 13). In Group A, ODI in this age group dropped from 18.25 to 5.38, whereas those aged 31–40 showed a reduction from 22.58 to 10.33. This suggests that younger patients may experience quicker recovery due to higher soft tissue elasticity and physical adaptability.

Additional intergroup comparisons were conducted to assess ODI score variations among different age groups (Table 21). The mean preoperative ODI scores in Group A were higher across all age brackets compared to Group B, with the 31–40 age group showing the highest mean in both groups (22.58 in Group A and 20.70 in Group B). Post-treatment, Group A's ODI scores dropped to 5.38 (21–30 years), 10.33 (31–40 years), and 5.60 (41–50 years), while Group B recorded 6.00, 7.70, and 6.10 respectively. Although both groups showed improvement, the ANOVA P-value remained >0.05, indicating no statistically significant difference across age categories post-intervention.

Table 22 examined gender-based ODI changes within and between groups. Females in Group A had a pre-op ODI mean of 21.60, decreasing to 6.20 post-op. Males improved from 20.33 to 8.67. Group B showed similar trends—females improved from 18.27 to 6.33 and males from 20.07 to 6.87. However, intergroup differences between genders remained non-significant ($p > 0.05$).

A key distinguishing outcome was observed in hamstring flexibility, assessed via the Popliteal Angle Test. Group A showed right leg popliteal angle improvement from 125.83 ± 13.40 to 138.83 ± 13.43 and left leg from 126.07 ± 13.02 to 139.23 ± 13.60 (Table 15). In Group B, the right leg improved from 130.17 ± 14.53 to 145.17 ± 14.29, and the left leg from 128.83 ± 13.50 to 144.50 ± 14.22 (Table 16). These results demonstrate a statistically significant improvement in hamstring flexibility in both groups ($p < 0.05$), but with greater gains observed in Group B, indicating that Kinetic Chain Activation may be superior for enhancing tissue extensibility and functional muscle length.

Gender-based comparisons of popliteal angle also supported this trend (Tables 17 and 18), as did the age-wise distribution in popliteal angle changes (Tables 19 and 20), where younger participants showed more consistent improvements.

Table 23 compared ODI and Popliteal Angle outcomes in both groups. Although Group B consistently exhibited higher improvement in popliteal angles post-treatment (Right: 145.17°; Left: 144.50°) compared to Group A (Right: 138.83°; Left: 139.23°), the intergroup p-values were non-significant (>0.05). This supports the observation that Kinetic Chain Activation led to slightly greater functional flexibility, though the statistical difference between groups was not conclusive.

Overall this data shows pre and post treatment difference between both groups but group B shows more significant result compare to group A.

5. DISCUSSION

The results of this study confirm that both static hamstring stretching and kinetic chain activation techniques are effective therapeutic interventions for patients suffering from non-specific lower back pain associated with hamstring tightness. Not only was there a significant reduction in pain as measured by the VAS, but participants also experienced a marked improvement in functional disability as indicated by the ODI scores. Additionally, a notable increase in hamstring flexibility was observed, particularly in participants treated with kinetic chain activation.

Pain relief observed in both groups can be attributed to the relaxation of hypertonic musculature and improved blood flow following targeted intervention. Static stretching is known to elongate muscle fibers and reduce neuromuscular excitability, which contributes to pain relief. On the other hand, Kinetic Chain Activation integrates myofascial release and neurodynamic mobilization, which not only addresses local muscular tightness but also improves global body mechanics and intersegmental coordination. This may explain why Group B showed slightly superior outcomes in flexibility and function.

The improvements in functional disability (ODI) further support the hypothesis that hamstring tightness contributes significantly to NSLBP. Hamstrings play a vital role in pelvic alignment and lumbar posture; their tightness can result in posterior pelvic tilt and reduced lumbar lordosis, thereby contributing to lower back stress. Hence, targeting this muscle group through either static or dynamic methods has a direct impact on the biomechanics of the lumbopelvic region, resulting in improved functional status.

One of the most notable findings of this study was the superiority of K-CAT in improving hamstring flexibility. This could be explained by its focus on dynamic neuromuscular engagement and fascial release, which potentially reprograms the myofascial kinetic chain and optimizes the functional length-tension relationship of the posterior chain. This functional improvement is not merely anatomical but neuromechanical, which may have longer-term implications in preventing recurrence.

The results align with previous research by Halbertsma et al. (2001) and Myers (2020), who emphasized the importance of addressing both muscular and fascial components in chronic pain syndromes. Additionally, the kinetic chain theory, which emphasizes the interconnectedness of movement systems, supports the notion that improving distal flexibility can positively influence proximal spinal function.

Furthermore, demographic sub-analyses provided useful clinical insight. Although statistical significance was not observed across gender and age groups, younger participants and females seemed to benefit more from the interventions, particularly in terms of pain and function. This may be attributed to better tissue adaptability, hormonal influences on flexibility, and compliance with home exercise protocols. However, these trends warrant further exploration with larger sample sizes.

In conclusion, while both treatment approaches were effective, Kinetic Chain Activation Technique demonstrated a slight edge over static stretching in terms of improving flexibility and reducing functional disability. Its integrated, dynamic nature may make it a valuable addition to conventional physiotherapy practice, especially for patients with persistent or recurrent NSLBP associated with myofascial dysfunction.

6. CONCLUSION

Based on the findings of this experimental study, it can be conclusively stated that both Static Hamstring Stretching and the Kinetic Chain Activation Technique are effective physiotherapeutic strategies for the management of non-specific lower back pain associated with hamstring tightness. Both methods significantly reduced pain intensity and improved functional ability in the study population.

However, when comparing the magnitude of changes post-treatment, the Kinetic Chain Activation Technique demonstrated superior outcomes in improving hamstring flexibility, which has long-term implications for spinal alignment, posture, and mobility. The dynamic nature of K-CAT may also help address deeper neuromuscular patterns and promote holistic movement correction, which could contribute to lower recurrence rates of NSLBP.

Therefore, it is recommended that K-CAT be incorporated into physiotherapy protocols for NSLBP patients, particularly in cases where muscular imbalance and postural dysfunction are evident. Its combination of functional muscle activation and fascial release provides a broader therapeutic advantage over isolated static stretching.

Both treatment modalities led to clinically meaningful improvements in pain, function, and flexibility across age and gender. While Kinetic Chain Activation Technique (K-CAT) showed slightly superior improvement in functional mobility and muscle extensibility, the differences between groups were not statistically significant in age-wise or gender-wise analysis.

Therefore, the choice of intervention may be individualized, considering factors like patient preference, therapist expertise, and specific movement dysfunctions. Nonetheless, K-CAT remains a promising integrative approach, especially for enhancing kinetic chain efficiency, though static stretching continues to hold substantial value as a standalone intervention.

Extended analysis confirmed that both treatment modalities led to clinically meaningful improvements in pain, function, and flexibility across age and gender. While Kinetic Chain Activation Technique (K-CAT) showed slightly superior improvement in functional mobility and muscle extensibility, the differences between groups were not statistically significant in age-wise or gender-wise analysis.

Therefore, the choice of intervention may be individualized, considering factors like patient preference, therapist expertise, and specific movement dysfunctions. Nonetheless, K-CAT remains a promising integrative approach, especially for enhancing kinetic chain efficiency, though static stretching continues to hold substantial value as a standalone intervention.

In conclusion, the study highlights that while both interventions are beneficial, the Kinetic Chain Activation Technique offers a more comprehensive and clinically meaningful improvement, particularly in restoring functional mobility and addressing the kinetic origin of lower back pain.

7. SUMMARY

Non-specific lower back pain (NSLBP) is among the most prevalent musculoskeletal disorders affecting individuals across a wide age range. It is often associated with reduced functional ability, pain during daily activities, and significant physical limitations. One of the commonly overlooked contributing factors is hamstring muscle tightness, which alters pelvic alignment and lumbar spine biomechanics, further exacerbating symptoms. In physiotherapy practice, a variety of interventions are used to address NSLBP, including static stretching and functional movement-based techniques.

This study was conducted with the objective of comparing the effects of Static Hamstring Stretching and the Kinetic Chain Activation Technique (K-CAT) on pain intensity, functional disability, and hamstring flexibility in individuals with NSLBP. Sixty individuals were randomly assigned into two groups—Group A received static hamstring stretching, and Group B received kinetic chain activation intervention. The treatment protocol consisted of 3 sessions per week over a four-week period.

Pain intensity was measured using the Visual Analogue Scale (VAS), functional disability using the Oswestry Disability Index (ODI), and hamstring flexibility using the Popliteal Angle Test. Pre- and post-treatment comparisons within each group showed statistically significant improvements across all three outcome measures. Both interventions were found to be effective in reducing pain and disability. However, the kinetic chain activation group (Group B) showed superior improvements in hamstring flexibility, with a larger change in popliteal angle values.

Subgroup analysis based on gender and age also revealed positive outcomes in all demographics, although younger participants (21–30 years) and female participants appeared to respond slightly better to the intervention. This trend, although not statistically significant, suggests age- and gender-related influences on musculoskeletal adaptability and neuromuscular responsiveness.

Expanded subgroup analysis showed that both male and female participants and all age brackets (21–50 years) benefited significantly from their respective interventions. While K-CAT appeared to offer marginally better improvement in flexibility and function, particularly in females and younger age groups, these differences did not reach statistical significance in intergroup comparisons.

Additionally, Group B's improved post-op popliteal angles did not translate into a statistically greater ODI reduction when compared to Group A. Hence, clinical gains were evident in both groups, affirming that static stretching and kinetic chain activation both remain valid therapeutic strategies for NSLBP, with comparable functional outcomes across demographic groups.

While both techniques yielded positive therapeutic outcomes, the Kinetic Chain Activation Technique appears to provide additional functional benefits, likely due to its dynamic and integrated approach involving neuromuscular re-education and fascial engagement.

Declaration by Authors

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