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Redefining Rehabilitation in Non-Specific Low Back Pain: A Shift from Isolated Stretching to Kinetic Chain Integration

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ABSTRACT

Background: The increasing prevalence of non-specific lower back pain (NSLBP) presents a major clinical challenge, particularly in sedentary and younger populations. Traditional physiotherapy has long relied on static hamstring stretching to address musculoskeletal limitations. However, emerging strategies like Kinetic Chain Activation (KCA) are reorienting rehabilitation approaches toward neuromuscular re-education and intersegmental control. This article introduces the theoretical and clinical framework of a recent comparative study examining static stretching versus KCA in NSLBP. It outlines the limitations of isolated muscle-lengthening techniques and underscores the growing clinical relevance of dynamic, whole-body interventions. As sedentary behaviors continue to affect spinal health, evidence-based innovations like KCA offer promising advancements in long-term functional recovery.
Objective: To introduce and conceptualize the clinical rationale behind integrating kinetic chain activation techniques into the rehabilitation of non-specific lower back pain (NSLBP), by contrasting them with conventional static hamstring stretching methods; and to advocate for a paradigm shift toward neuromuscular coordination and functional movement retraining in modern physiotherapy practice.
Methods: A randomized clinical trial was conducted with 60 participants (aged 25–50 years) 30 male and 30 female, 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 analysed using paired and unpaired t-tests, with a significance level set at $p < 0.05$.
Results: Both intervention groups showed statistically significant improvements in pain intensity (VAS), functional disability (ODI), and hamstring flexibility (popliteal angle) after four weeks of treatment ($p < 0.001$). While there was no significant difference between

groups in post-treatment VAS and ODI scores (*p > 0.05*), the Kinetic Chain Activation group demonstrated slightly greater improvements in hamstring flexibility compared to the Static Stretching group. No significant gender-based differences were observed in outcomes.
Conclusion: Both static hamstring stretching and kinetic chain activation techniques are effective in reducing pain and disability in individuals with non-specific lower back pain. However, kinetic chain activation offers slightly superior improvements in hamstring flexibility, making it a more functionally sustainable approach in rehabilitation in individuals with mechanical LBP due to sedentary lifestyles without a history of trauma or structural pathology. It is simple to perform, does not require complex tools, and encourages proprioceptive re-education through muscle activity.
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.

INTRODUCTION

Non-specific lower back pain (NSLBP) is defined as pain not attributable to a specific underlying pathology such as infection, fracture, or malignancy, yet it remains one of the most disabling and costly musculoskeletal conditions globally (1,2). Most patients with NSLBP demonstrate no overt radiological or structural abnormalities, yet they experience persistent functional limitations. This highlights the importance of muscular and neuromechanical factors in its etiology.

Several physiotherapy schools of thought have historically guided clinical practice for mechanical lower back pain (MLBP), including:

1. **McKenzie Method (MDT):** Repeated movement testing and directional preference-based exercises to centralize symptoms (3).
2. **Maitland Concept:** Graded spinal mobilizations based on detailed clinical assessment (4).
3. **Kaltenborn-Evjenth OMT:** Joint gliding, traction, and biomechanical correction (5).
4. **Muscle Energy Techniques (MET):** Patient-assisted muscle contractions to restore mobility (6).
5. **Myofascial Release (MFR):** Sustained fascial tension release for soft tissue dysfunction (7).
6. **Core Stabilization:** Retraining deep spinal stabilizers (e.g., transverse abdominis, multifidus) to restore lumbar motor control (8).

Muscles often implicated in LBP include:

- **Erector Spinae:** Often strained or tight due to postural overload
- **Multifidus:** Atrophied or inhibited in chronic LBP
- **Psoas Major:** Tightness leads to anterior pelvic tilt and excessive lumbar lordosis
- **Hamstrings:** Frequently shortened, compromising pelvic alignment and lumbar mobility (9)

Among these, **hamstrings** play a critical role due to their anatomical and functional connection with the pelvis. Hamstring tightness limits pelvic movement, leading to postural imbalances and lumbar strain (10,11).

Traditionally, static stretching has been utilized to improve flexibility and reduce posterior chain tension (12). Static stretching has been shown to acutely increase hamstring extensibility and reduce muscle stiffness (13,14). However, it often addresses only the mechanical aspect of the muscle without considering its neuromuscular function, which is critical for movement efficiency and spinal stability (15).

MAJOR BIOMECHANICAL ISSUE: LENGTH-TENSION DISSOCIATION

A key concern in mechanical LBP is length–tension dissociation—where a muscle may appear tight but lacks functional strength and neuromuscular control (16). The hamstrings are particularly vulnerable due to:

1. Their eccentric loading role in movement control
2. Their tubular (long, dense) architecture
3. Their established clinical relevance in LBP due to postural compensations and impaired coordination

Conventional static stretching, while increasing muscle length, may reduce contractile power by 30–50% temporarily, especially in acutely guarded muscles (17,18). Hence, static stretching of already compromised hamstrings in sedentary individuals may be counterproductive.

This clinical insight shifts attention to Kinetic Chain Activation (KCA) techniques, which preserve muscle strength while enhancing neuromuscular recruitment and myofascial continuity. KCA addresses muscle inhibition by activating proprioceptive feedback loops and optimizing intersegmental movement control (19,20).

EVOLVING CONCEPT: KINETIC CHAIN ACTIVATION

KCA is a more integrative and dynamic therapeutic method that operates on the principle of interdependence among body segments. It involves facilitating muscle activation across the posterior chain, particularly emphasizing fascial continuity, core engagement, and coordinated motor patterns (21,22). Unlike static stretching, which passively elongates muscle fibers, KCA actively re-trains neuromuscular pathways, improves proprioceptive awareness, and enhances postural correction (23).

The kinetic chain model asserts that dysfunction in one segment (e.g., hamstrings or ankle dorsiflexors) can lead to compensatory changes elsewhere, such as the lumbar spine (24). KCA attempts to reverse these compensations by restoring natural sequencing and neuromuscular coordination—an approach particularly suited for functional rehabilitation of NSLBP.

WHY NOW: SEDENTARY POPULATIONS AND CLINICAL RELEVANCE

Today's adults, students, and professionals with prolonged sitting and screen use often present with poor core control and posterior chain inhibition (25). In such populations, muscles like the hamstrings and glutes undergo guarding rather than true shortening, and their inability to contract effectively stems from neural inhibition, not stiffness (26).

KCA addresses this gap through:

1. Gentle tapping to stimulate mechanoreceptors and activate underused sensory pathways
2. Voluntary contraction through the full range, engaging both muscle and fascia
3. Gradual improvement in motor unit recruitment and movement fluidity

This sequence allows for correction of length–tension imbalance and promotes sustainable gains in both mobility and motor control (27).

In contrast to static stretching—which the nervous system often interprets as passive—KCA utilizes the language of the muscle: contraction. This makes it a more neurologically meaningful intervention for individuals with postural dysfunction or functional muscle disuse.

This context led to the design of a randomized clinical trial comparing static hamstring stretching with kinetic chain activation techniques in individuals with NSLBP. The goal was to evaluate which intervention more effectively improves pain, flexibility, and function—paving the way for more targeted, functional rehabilitation.

A SHIFT IN REHABILITATION PRIORITIES

Modern rehabilitation is increasingly shifting from muscle-specific protocols to systemic, movement-based strategies (28). While static stretching continues to be effective in improving muscle length and reducing tightness (12), it lacks the neuromuscular retraining component necessary for long-term functional recovery (29).

KCA fills this gap by integrating:

- Muscle activation
- Myofascial release
- Core control
- Movement pattern reorganization

It does so without overloading joints or causing fatigue, making it especially relevant in early or sub-acute rehab phases (30). Activating the kinetic chain influences lumbar-pelvic rhythm, core stabilization, and lower limb control, thereby reducing recurrence rates of NSLBP and improving functional independence (31).

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

Informed consent was obtained from all participants. Data confidentiality and withdrawal rights were respected.

Study Design

A randomized clinical trial reported in accordance with CONSORT 2010. Conducted at outpatient physiotherapy department of Pacific Medical College, Udaipur (Sept 2024 – Mar 2025). The study design allows for a detailed comparison of pre- and post-intervention outcomes between the groups. 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.

RESULT

Table 1: 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 2: 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 3: 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		

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.

Visual Analogue Scale (VAS) – Pain Intensity-

The VAS scores, which assess pain intensity on a 0–10 scale, demonstrated significant improvement within both intervention groups over the 4-week treatment period. In Group A (Static Hamstring Stretching), the mean pre-treatment VAS score was 6.17 ± 1.05, which reduced to 2.77 ± 1.14 post-treatment. In Group B (Kinetic Chain Activation), the pre-treatment mean score was 6.33 ± 1.21, which declined to 2.97 ± 1.50 after the intervention. (Table 1).

Within-group comparisons showed a statistically significant reduction in pain for both groups ($p < 0.001$), consistent with existing evidence supporting the use of both static stretching and neuromuscular activation techniques in managing NSLBP [1,2]. However, no statistically significant difference was observed between the two groups in post-treatment scores ($p > 0.05$), indicating that both interventions were effective in pain reduction, with comparable efficacy.

Oswestry Disability Index (ODI) – Functional Disability

ODI scores, representing functional disability, also showed notable improvements. In Group A, females improved from a mean pre-treatment score of 21.60 ± 5.69 to 6.20 ± 5.63, while males improved from 20.33 ± 6.26 to 8.67 ± 4.98. In Group B, female participants showed a reduction from 18.27 ± 7.92 to 6.33 ± 4.75, and males from 20.07 ± 5.43 to 6.87 ± 4.05. (Table 2 and 3).

Although both genders in both groups showed marked improvements, no statistically significant gender differences were observed in pre- or post-intervention ODI scores ($p > 0.05$ for both females and males across groups). This aligns with prior studies indicating that both static and functional exercise approaches can equally reduce disability in male and female NSLBP populations.

Hamstring Flexibility – Popliteal Angle Measurements

Hamstring flexibility was assessed using the popliteal angle, measured on both right and left sides, pre- and post-intervention. In Group A, the right-side angle improved from 125.83 ± 13.40 to 138.83 ± 13.43, and the left side from 126.07 ± 13.02 to 139.23 ± 13.60. In Group B, the right popliteal angle increased from 130.17 ± 14.53 to 145.17 ± 14.29, while the left side improved from 128.83 ± 13.50 to 144.50 ± 14.22. (Table 3).

Although the data shows clinically meaningful improvement in hamstring flexibility post-intervention for both groups, the intergroup comparisons were not statistically significant ($p > 0.05$). However, Group B showed slightly greater gains, supporting literature suggesting that dynamic and activation-based techniques may improve both flexibility and neuromuscular control more effectively than passive stretching alone.

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

DISCUSSION

The findings of this study support the growing clinical emphasis on functional rehabilitation in individuals with non-specific lower back pain (NSLBP). Both static hamstring stretching and kinetic chain activation techniques demonstrated statistically significant improvements in pain (VAS), functional disability (ODI), and hamstring flexibility (popliteal angle) over a 4-week intervention period. These results validate earlier research indicating the effectiveness of both static stretching and neuromuscular activation in managing NSLBP symptoms [1,2].

Although both groups achieved comparable pain and disability reductions, Group B (Kinetic Chain Activation) showed slightly greater improvements in hamstring flexibility, suggesting a potential advantage of dynamic, activation-based techniques in restoring full functional range. This aligns with the theoretical framework that emphasizes the role of neuromuscular coordination, proprioception, and intersegmental control in movement rehabilitation [3,4].

The concept of length-tension dissociation in chronically guarded muscles such as the hamstrings has been central to this study. Static stretching, while improving muscle extensibility, may lead to temporary reductions in strength and motor recruitment, especially in muscles with reduced neural input [5]. In contrast, kinetic chain activation engages the muscle through controlled, functional range contractions combined with fascial stimulation. This may lead to improved proprioceptive awareness, enhanced motor unit recruitment, and restoration of the length-tension relationship without compromising power or function.

Interestingly, gender-specific analysis revealed no significant differences in outcomes between males and females in either group. This finding supports prior evidence suggesting that both men and women benefit equally from stretching and activation-based physiotherapy interventions when properly tailored to their neuromuscular profile [6].

The improvements in hamstring flexibility observed in both groups, although statistically non-significant between them, highlight the fact that flexibility gains alone should not be the only outcome in NSLBP treatment. Functional capacity, neuromuscular efficiency, and symptom recurrence rates must also be considered in long-term care planning.

Overall, this study reinforces the evolving shift in physiotherapy from passive, segmental interventions to active, systemic approaches. Kinetic chain activation provides a feasible, low-tech, and clinically meaningful intervention that can be easily integrated into routine rehabilitation for patients with NSLBP, particularly those with sedentary lifestyles and postural dysfunction.

CONCLUSION

In young individuals with sedentary lifestyle, hamstrings are compromised due to sustained poor posture for extended hours, hamstrings undergo guarding. So old school techniques stretch this compromised muscle, but recent advances suggest that stretching reduces the muscles power by 40-50%

K-CAT improves- the tissues that has been compromised due to long standing poor posture of sedentary lifestyle undergo gentle tapping which causes its sensory awakening and then with gentle pressure it is made to contract through its entire range hence it recruits more motor units with each repetition and achieving full range from extension of knee to full flexion. Hence increases awareness and we thus correct the length tension relationship.

KCAT is more sustainable than static stretching as muscles understand the language of contraction as it is a contractile tissue and we make it contract through its full range in this. Stretching is not a muscle language.

Hence KCAT -

1. Is more functionally sustainable and neurologically integrated approach in individuals with mechanical LBP due to sedentary lifestyle without structural pathology.
2. It allows muscle recruitment through the full range, preserves contractile function, and corrects the length-tension dissociation commonly seen in mechanical lower back pain.
3. Technique is easy to do.
4. Given its simplicity, adaptability, and clinical efficacy, kinetic chain activation represents a promising direction for future rehabilitation protocols**.**
5. It requires a long cross-sectional study which is proposed for the benefit of the society to replicate the data in large population.

Both static hamstring stretching and kinetic chain activation techniques are effective in reducing pain and disability in individuals with non-specific lower back pain. However, kinetic chain activation offers slightly superior improvements in hamstring flexibility, making it a more functionally sustainable approach in rehabilitation.

SUMMARY

- A randomized clinical trial was conducted on 60 NSLBP patients comparing static hamstring stretching and kinetic chain activation techniques.
- Both groups showed significant improvements in VAS, ODI, and popliteal angle post-intervention ($p < 0.001$).
- The kinetic chain activation group demonstrated greater improvements in flexibility, although not statistically significant between groups.
- No gender-based differences were noted in treatment outcomes.
- Kinetic chain activation is effective, easy to implement, and may be more sustainable for postural correction and neuromuscular re-education in mechanical LBP due to sedentary habits.

Declaration by Authors

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