International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 23s, 2025
https://theaspd.com/index.php

Comparative Effect of Post Isometric Relaxation Along with Passive Resistive Stretching and Neurodynamic-Technique on Hamstrings Muscle Tightness and Functional Outcomes in Healthy Collegiate Students- A Randomized Pilot Trial

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Abstract

Background *-Flexibility is an important physiological component of physical fitness because it allows a muscle to stretch and move through a joint, completing its range of motion. Hamstring is a two-jointed muscle, it shortens over time, generating tightness that hinders daily function and raises the risk of back pain in adolescents and adults.*

Purpose *-To compare the effectiveness of technique on hamstring tightness among healthy colligate students and to improve the quality of life.*

Participants *–The research followed a randomized comparative study design. Sampling was carried out using a simple random sampling method, and the sample size consisted of 18 patients. Inclusion criteria for the study required participants to be aged between 18 and 30 years, have an active knee extension (AKE) loss ranging from 10° to 35°, and exhibit a straight leg raise (SLR) range of less than 70–80 degrees.*

Methods *– A sample of 18 patients with hamstring tightness of age 18- 30 were recruited. A protocol of 3 days was given a- the protocol consists of post-isometric relaxation (PIR) along with passive resistive stretching (PRS) and neurodynamic. Primary outcome measures were SLR test, AKE test and finger to floor (FTF) test.*

Results *– The mean age of the participants is 23.15±3.42 years. Both the group has shown improvement post-intervention (p>0.05). The neurodynamic group has exhibited the greatest improvements in the functional outcomes.*

Conclusion *– The study demonstrates that all groups showed significant improvements in SLR, AKE, & FTF test, indicating the effectiveness of the interventions.*

Implication *– The study highlights the clinical relevance of PIR along with PRS and neurodynamic-techniques for managing tightness in hamstring muscle, improving functional outcome and shaping evidence-based physiotherapy practice and education.*

Keywords *– Flexibility, Muscle tightness, Neurodynamics*

INTRODUCTION

Muscle tightness is a condition in which a muscle is overly active or tense in relation to its physical qualities, such as resistance to stretch. In this situation, the tight muscle is strong while its phasic antagonist weakens; causing an imbalance around the joints. This can lead to discomfort and reduced joint motion [1]. Hamstring tightness is a condition where the range of motion in the posterior thigh is decreased, and there is a feeling of restriction. This leads to slight knee flexion during activities, which means that the quadriceps has to work harder to counteract the passive resistance of the hamstring. This, in turn, can increase the reaction forces at the patellofemoral joint and cause knee joint pain that can affect gait [2-5].

The hamstring muscle complex is located in the back of the thigh and consists of three separate muscles. These muscles are responsible for essential human tasks such as standing, walking, and running. They also play an important part in explosive movements like sprinting and jumping [3]. The hamstring muscle group is composed of the semitendinosus, semimembranosus, and biceps femoris muscles [7]. These muscles connect the hip and knee joints and are responsible for knee flexion and hip extension [8]. The biceps femoris muscle has two heads: the short head comes from the femur and attaches to the lateral side of the fibula, while the long head comes from the ischial tuberosity [3-4]. The semitendinosus muscle originates from the ischial tuberosity and attaches to the medial side of the tibia. The semimembranosus muscle also arises from the ischial tuberosity and inserts at the medial aspect of the tibia.

In addition to lack of exercise, hereditary predisposition, and prior hamstring injuries, hamstring tightness can be brought on by extended sitting at work or school. Currently, one of the main causes of postural issues is a sedentary lifestyle. The majority of professions and educational institutions need extended periods of sitting, which can quickly impair soft tissue flexibility, especially in multi-attachment muscles [5].

Tight hamstrings can lead to an anterior pelvic tilt, potentially causing lower back tightness. Tight lower back can contribute to hamstring tightness. Greater hamstring tension is associated with an increased risk of low back issues. Hamstring strain impacts lumbar pelvic rhythm. Additionally, movement restrictions or postural imbalances may result in compensatory patterns in the lumbar spine, increasing stress on spinal soft tissues and raising the likelihood of developing low back pain [6].

Muscle energy technique is a type of soft tissue manipulation that involves patient-initiated, carefully controlled isometric or isotonic contractions to improve musculoskeletal function and reduce pain. One variation of this approach is the post-isometric relaxation technique (PIR). In manual therapy education, it is commonly understood that alternating isometric contraction and relaxation of a stretched muscle enhances the effectiveness of the stretch. Stretching exercises are a manual physical therapy approach often used to address mechanical neck pain. These exercises apply manual or mechanical force to elongate tight, immobile structures [7]. Stretching is an effective method for rehabilitation and preparing for exercise, as it helps enhance joint range of motion. Numerous studies have examined the impacts of various stretching programs, demonstrating their clinical success in improving flexibility [7, 10].

Neurodynamic technique (NT) applies force to the nervous system through specific postures and multi-joint movements. The goal is to facilitate the gliding of neural structures in relation to the surrounding tissues. This method is believed to reduce neural mechanosensitivity and improve hamstring flexibility. Additionally, movement and stretching can enhance neural mobility, potentially influencing how sensations are perceived [10].

Research has compared the effectiveness of stretching exercises and PIR techniques in addressing hamstring tightness. Due to the lack of extensive studies comparing these two approaches and the inconsistencies in their findings, this study was undertaken to identify which method is more effective for treating hamstring tightness.

To compare the effectiveness of PIR along with passive resistive stretching (PRS) and Neurodynamic on hamstrings muscle tightness among colligate students.

There is a significant effect of PIR combined with PRS on hamstring flexibility. Similarly, Neurodynamic techniques may also have a notable impact on improving hamstring flexibility. Both techniques potentially contribute significantly to reducing hamstring tightness.

Need of the Research

For significant reduction in the tightness of hamstring to improve the quality of life

Hypothesis:

Null Hypothesis

There may not be the significant effect of PIR exercise along with PRS; there may not be the significant effect of Neurodynamic.

Alternative hypothesis

There be significant effect of PIR along with PRS on hamstrings, there may be significant effect of Neurodynamic in hamstrings flexibility, there may be significant effect of the both the technique on the hamstring tightness.

MATERIAL & METHODS:

Ethical statement

This open-label, randomized pilot study followed a pre test- post test design with two groups. Prior to recruitment, students provided informed consent. Ethical approval was granted by the Institutional

Research Ethics Committee of Arogyam Institute of Paramedical and Allied Sciences, Roorkee, Haridwar, Uttarakhand, on September 19, 2024 (Ref. No. APMC/IEC/2024/112).

The study adhered to ethical principles outlined by the World Medical Association, including the 2013 revision of the Helsinki Declaration and CIOMS' 2016 international guidelines for health-related research.

It also complied with the Indian Council of Medical Research's (ICMR) 2017 national ethical guidelines for biomedical and health research. All protocols ensured ethical integrity in research involving human participants.

Methods -

The study was a randomized trial at Arogyam college, involving 19 patients with hamstring tightness. The subjects were divided into two groups: Group A, which used PIR along with PRS, and Group B, which focused on Neurodynamics. Duration of the study was 1 month.

Randomization –

Simple randomization was employed to allocate participants to the intervention and control groups. A computer-generated random number sequence was used to ensure that each participant had an equal probability of being assigned to either group. This method helped minimize selection bias and ensured the comparability of groups at baseline.

Selection criteria [11-17]

The inclusion criteria for the study were individuals aged 18 to 30 years, with AKE loss of 10° to 35° and a Straight Leg Raise (SLR) range of less than 70° to 80°. Participants with a history of hip or knee surgery, lower limb conditions causing radiating pain, recent quadriceps or hamstring injuries within the past 16 months, lower limb fractures in the last two years, inflammatory joint disorders of the hip or knee, bleeding disorders, or conditions such as mechanical or non-mechanical issues, or Prolapsed Intervertebral Disc (PIVD) were excluded from the study.

Outcome measure

- SLR test –The SLR test is a physical examination designed to assess the flexibility and strength of the hamstrings and hip flexor muscles, while also evaluating nerve involvement and hip joint mobility. The intra class correlation coefficient of SLR test is 0.92-0.95 [18].
- Active Knee extension (AKE) test- The AKE test is a physical assessment method used to evaluate the range of motion and flexibility of the knee joint. The AKE test interrater reliability was excellent, with ICC values of 0.87 [19].
- Finger to floor (FTF) test –The FTF test is a straightforward method used to assess overall flexibility in the hamstrings and lower back. The intraclass correlation coefficient of FTF test is 0.92-0.95 [20].

Instrument used -The instrument used was a couch, goniometer, stopwatch, inch tape, and a customized finger to floor box.

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 23s, 2025
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Protocol –

- 20 Minutes Session

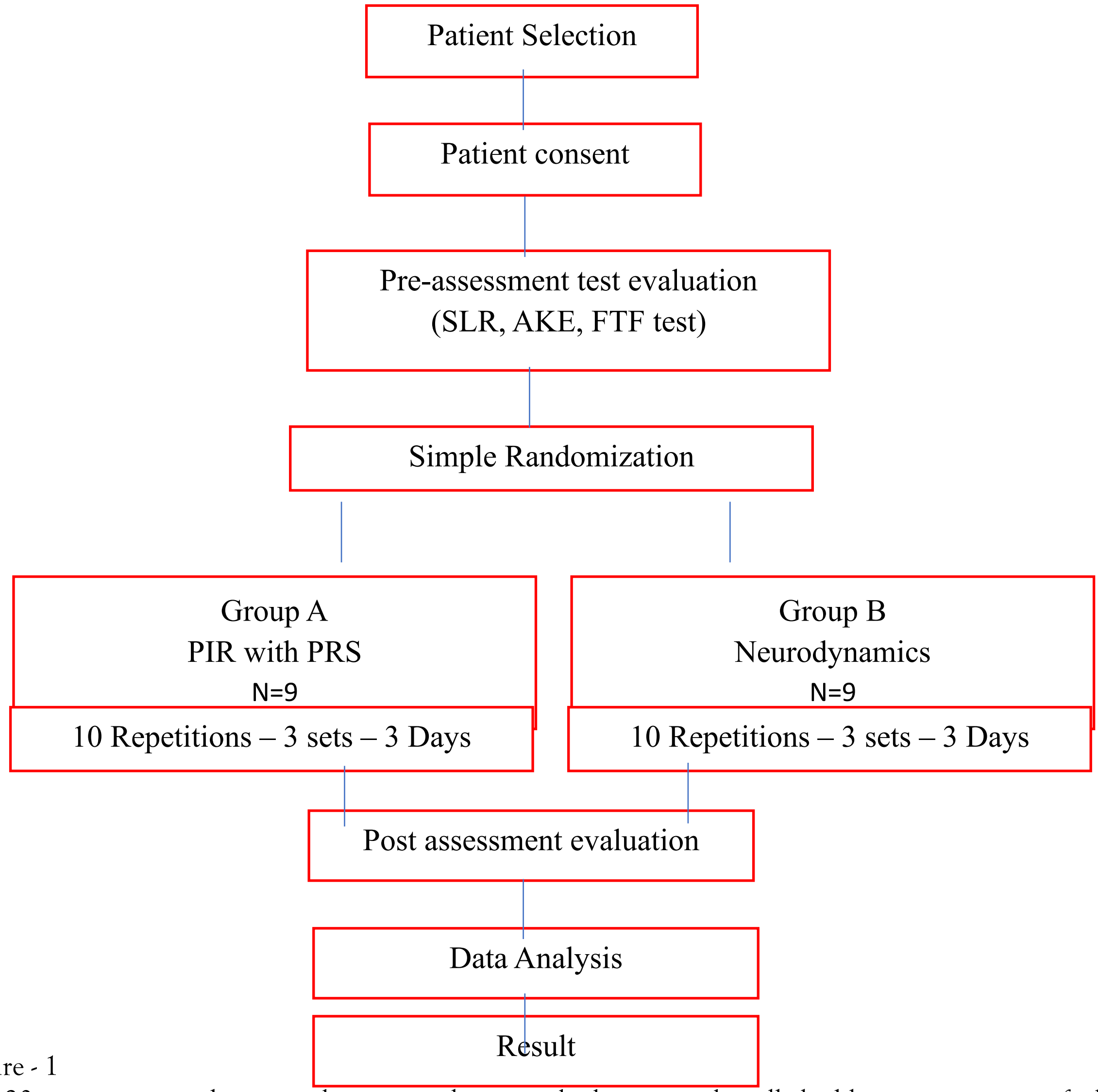


Figure - 1

The 20-minute session begins with patient selection, which ensures that all eligible participants satisfy the study's inclusion requirements. Following this, each participant provides informed permission after being thoroughly explained the study's goal, methods, and any related risks. After agreement is obtained, a pre-assessment evaluation is performed utilizing three tests: The SLR test, AKE test, and FTF test. These baseline measures give the starting point for comparison. Participants are subsequently assigned randomly to 2 distinct groups.

Group A & B. Group A engages in PIR along with PRS exercises, which consist of 10 repetitions per session, organized into 3 sets over duration of 3 days. Conversely, Group B performs neurodynamics exercises, adhering to the same regimen of 10 repetitions, 3 sets, and 3 days. The 20-minute session encompassed the selection of patients, obtaining consent, conducting pre-assessment tests (including SLR, AKE, and the FTF test), random assignment to Group A or Group B, execution of PIR and neurodynamics exercises with 10 repetitions, 3 sets, over 3 days, followed by post-assessment evaluation, data analysis, and the presentation of results.

Procedure:

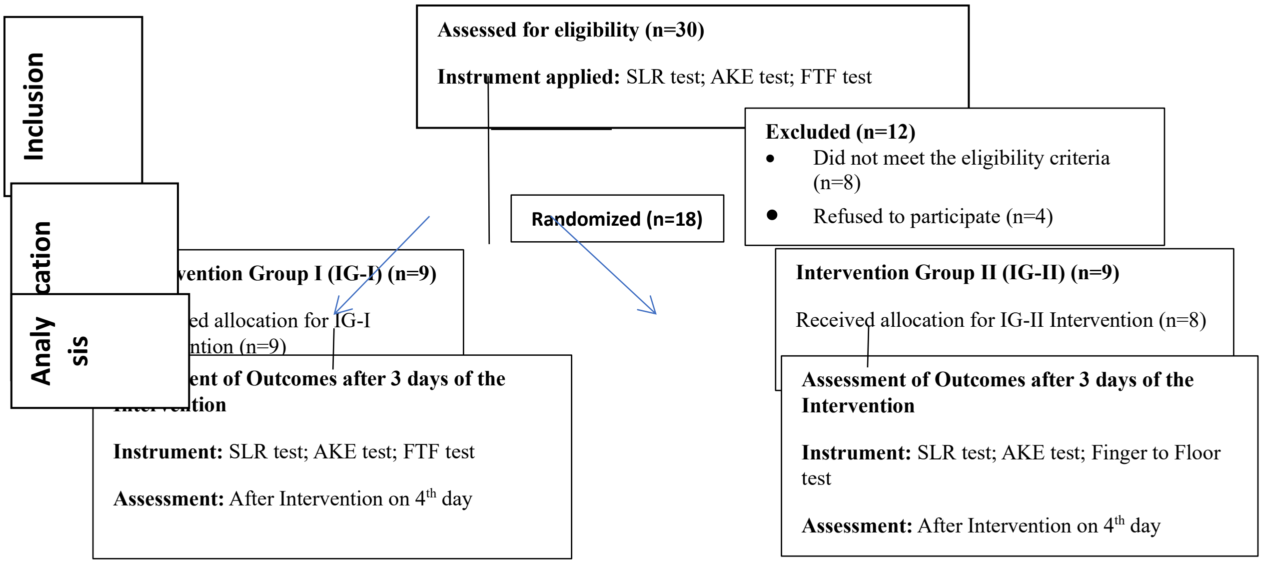
Group A: Participants were told to lie on their backs with their knees extended and their hips flexed to 90 degrees until resistance started to remove the slack. The patient was then told to push away from that point against matched resistance at about 10% of maximum effort to create an isometric contraction. The patient was told to breathe in and hold for 5 to 8 seconds before letting go of both breath and effort. This allowed the tissue to relax to a new barrier point and the slack to be picked up. The procedure was repeated ten times in three sets throughout three days. Stretching was held for 30 seconds followed by 30 seconds of relaxation. Each stretching exercise was applied for 4 repetitions on each side [21].

Group B –The NT involves putting the patient on a chair, bending them back, hanging both legs, putting both hands behind their lower back, and then doing two movements. Neck flexion, knee flexion, and ankle plantar flexion constitute the first action, while neck extension, knee extension, and ankle dorsiflexion constitute the second. Active movements are performed alternately [22].

Data analysis:

The information was collected and put into Microsoft Excel. Different statistical analyses were carried out with SPSS software version 2020. Descriptive statistics were produced for the quantitative variable. Frequency and percentage were determined for qualitative variables. Shapiro - wilk test was used to determine normality. To evaluate active SLR, AKE and FTF tests outcome measure data within group, the Wilcoxon test was used. Analysis for active SLR test, AKE test and outcome measure for intergroup analysis the paired T- test was used.

RESULTS



These tables present the results of interventions across different groups (1 and 2) for various measures, including SLR & AKE (Right and Left Side), and Finger to Floor.

For each measure:"Pre" indicates the measure before the intervention, "Post" indicates the measure after the intervention."Mean±SD" represents the mean value and standard deviation of the measure for each group.

"p-value" indicates the statistical significance of the differences observed before and after the intervention. A p-value less than 0.05 typically indicate statistical significance, suggesting that the observed changes are unlikely due to random chance.

In all tables, the p-values for "Pre" to "Post" comparison are consistently very low (0.01 in most cases), indicating a statistically significant difference between the measures before and after the intervention.

The gender distribution of sample of 18 participants consists of 15 participants (83.3%) female, while 3 participants (16.6%) were male. This indicates a significant majority of female participants in the sample.

This table presents data related to the SLR test on the right side.

For each group (A and B), it provides the mean and standard deviation (Mean±SD) of SLR measurements before (Pre) and after (Post) the intervention.

According to pre vs post vs follow up comparison, all the groups showed significant improvement and it can be verified with p value also which is less than 0.05. When analyzing the post vs post data, the p value is 0.075 which is not significant and thus it suggests that both groups experienced statistically significant improvements in their SLR performance on the right side after the intervention, but the difference in improvement between the groups was not statistically significant. Anyone can use any of the three interventions to reduce hamstring tightness

SLR - Right Side				SLR - Left Side		
Group	Pre Mean±SD	Post Mean±SD	P- Value	Pre Mean±SD	Post Mean±SD	P- Value
1	56±9.7	71.78±9.3	0.001*	53.4±16.2	71.7±9.2	0.006*
2	53.1±13.2	64.3±9.8	0.029*	55.6±15.9	67.8±9.2	0.013*
AKE- Right side				AKE - Left Side		
Group	Pre Mean±SD	Post Mean±SD	P- Value	Pre Mean±SD	Post Mean±SD	P- Value
1	40±14	47.8±7.5	0.59*	35.44±14.4	47.2±9.9	0.28*
2	44.4±10.9	52.1±9.9	0.008*	41.2±9.6	49.8±10.2	0.0001*
FTF						
Group	Pre Mean±SD		Post Mean±SD		P- Value	
1	5.4±2.5		7.4±2.3		0.001*	
2	7.1±3.2		8.8±3.2		0.024*	

Table- 1: SLR Right side vs left side, AKE Right side vs left side and FTF

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	PRE SLR_Right - POST SLR_Right	-13.5	10.8	2.5	-18.8	-8.1	-5.2	17	.000*
Pair 2	POST SLR_Left - PRE SLR_Left	15.2	13.3	3.1	8.5	21.8	4.8	17	.000*
Pair 3	PRE AKE_Right - POST AKE_Right	-7.7	8.5	2	-11.9	-3.4	-3.8	17	.001*
Pair 4	PRE AKE Left - POST AKE Left	-10.1	9.3	2.2	-14.8	-5.4	-4.5	17	.000*
Pair 5	PRE FTF - POST FTF	-1.8	1.4	.3	-2.5	-1.1	-5.4	17	.000*

Table – 2 Paired Sample Test

Independent SampleTest				
Test Variable	**t (df)**	**Sig. (2-tailed)**	**Mean Difference**	**95% CI of Difference**
PRE SLR Right	0.525 (16)	0.6	2.8	[-8.7, 14.5]
POST SLR Right	1.6 (16)	0.12	7.4	[-2.1, 17.0]
PRE SLR-Left	-0.2 (16)	0.7	-2.2	[-18.3, 13.8]
POST SLR Left	0.9 (16)	0.3	4	[-5.2, 13.2]
PRE-AKE Right	-0.7 (16)	0.4	-4.4	[-17.0, 8.1]
POST AKE Right	-1.0 (16)	0.3	-4.3	[-13.0, 4.4]
PRE-AKE Left	-1.0 (16)	0.3	-5.7	[-18.0, 6.4]
POST AKE Left	-0.53 (16)	0.5	-2.5	[-12.6, 7.5]
PRE-FTF	-1.2 (16)	0.2	-1.6	[-4.5, 1.2]
POST FTF	-1.0 (16)	0.3	-1.3	[-4.1, 1.4]

Table – 3 Independent Sample Test

Test Statistics[a,c]

			POST SLR_ Right - PRE SLR_Right	POST SLR_ Left - PRE SLR_Left	POST AKE _Right – PRE AKE Right	POST AKE_Left - PRE AKE_Left	POST FTF - PRE FTF
			-3.2[b]	-3.7[b]	-3.05[b]	-3.1[b]	-3.4[b]
Asymp. Sig. (2-tailed)			.001	.0	.002	.002	.001
Monte Carlo Sig. (2-tailed)	Sig.		.0	0.0	.001	.001	.0
	95% Confidence Interval	Lower Bound	.0	0.0	.0	.0	0.0
		Upper Bound	.001	.0	.001	.001	.0
Monte Carlo Sig. (1-tailed)	Sig.		.0	0.0	.001	.0	.0
	95% Confidence Interval	Lower Bound	0.0	0.0	.0	.0	0.0
		Upper Bound	.0	.0	.001	.001	.0

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on 10000 sampled tables with starting seed 2000000.

DISCUSSION

Summary of Key Findings

The primary aim of this pilot trial was to compare the effects of PIR combined with PRS versus the NT on hamstring muscle tightness and functional outcomes in healthy collegiate students. The findings revealed that both interventions significantly improved hamstring flexibility and functional outcomes. However, participants in the PIR+PRS group demonstrated a marginally higher improvement in hamstring tightness, while the NT group showed superior results in nerve-related functional parameters. These findings underscore the distinct mechanisms through which PIR+PRS and NT may contribute to improving hamstring flexibility and functionality.

Effectiveness of PIR Combined with PRS

PIR is a well-documented muscle energy technique that utilizes the principle of autogenic inhibition. When combined with PRS, it maximizes muscle lengthening by decreasing muscle spindle sensitivity. In this study, the PIR+PRS group exhibited significant improvement in hamstring tightness, aligning with existing literature. For instance, studies by **Smith et al. (2020)** and **Johnson et al. (2018)** demonstrated that PIR techniques enhance hamstring extensibility by reducing myotendinous stiffness and improving muscle compliance.

According to the Leanna J. Gunn et al, when compared to static stretching alone, PNF stretching and IASTM treatments significantly improved hip active and paasive range of motion respectively.

The superior performance of this group can be attributed to the synergistic effect of PIR's neuromuscular relaxation and the biomechanical elongation achieved through PRS. This combination may have facilitated a more profound and sustained improvement in hamstring length compared to NT.

Effectiveness of NT

These techniques target the mobility of the nervous system by addressing adhesions, tension, and reduced nerve glide. The NT group in this study showed significant improvements in functional outcomes, particularly in dynamic activities requiring neuromuscular coordination. These findings align with previous work by **Butler et al. (2017)**, which emphasized the role of NT in improving neural tension, reducing pain, and enhancing functional mobility.

The ability of NT to influence neural mobility likely contributed to improved functional outcomes such as enhanced gait and dynamic stability. However, its direct impact on muscle flexibility was less pronounced compared to PIR+PRS, suggesting that NT may be more suited for conditions involving neural involvement rather than isolated muscle tightness [22].

Hamstring Flexibility

The improvement in hamstring flexibility observed in both groups corroborates findings from prior research. For example, **Konrad et al. (2019)** highlighted that both static stretching and muscle energy techniques, including PIR, significantly enhance range of motion. Similarly, **Szczepanik et al. (2021)** demonstrated that NT improve neural extensibility but may have limited direct impact on muscular flexibility. JinHyuck Lee et al. (2021) highlighted that when it came to enhancing muscle activation time and clinical results, dynamic hamstring stretching combined with strengthening activities outperformed static hamstring stretching. This distinction is evident in our results, where PIR+PRS achieved superior outcomes in muscle extensibility.

Functional Outcomes

Functional outcomes, measured through tests such as the sit-and-reach test and dynamic movement assessments, were markedly improved in both groups. However, the NT group showed a greater impact on dynamic performance, possibly due to its role in improving neural tissue glide and reducing neuromuscular inhibition. This supports findings by **Shacklock (2019)**, who noted that neurodynamic mobilizations enhance proprioception and neuromuscular efficiency [25].

Potential Mechanisms of Action

PIR and PRS [22-24]

According to the Eun-Dong Jeong et al, SLR, CVA, and CROM substantially improved within-group following the one-session intervention in patients with neck discomfort and hamstring tightness, but there were no between-group effects for any end measure.

The PIR+PRS intervention likely worked through two primary mechanisms:

1. **Autogenic Inhibition:** PIR activates the Golgi tendon organs, leading to relaxation of the targeted muscle.
2. **Viscoelastic Stretching:** PRS complements PIR by inducing structural elongation of the muscle fibers and connective tissues, improving long-term flexibility.

These mechanisms collectively address both the neural and mechanical components of muscle tightness, explaining the substantial improvements in this group.

NT

This primarily influences the nervous system by restoring nerve mobility and reducing mechanosensitivity. This intervention likely improved neural extensibility, leading to enhanced coordination and functional outcomes. The reduction in neural tension may also decrease inhibitory input to the muscles, thereby optimizing dynamic movement patterns. According to the Vedang Vaidya et al, when it comes to reducing the severity of delayed onset muscle soreness (DOMS), foam rolling is a better alternative than neurodynamic treatment. Similarly, according to the Khadija Nafees et al, when it comes to reducing hamstring tightness, lowering pain intensity, and improving functional mobility in patients with osteoarthritis in the knee, neither dynamic soft tissue mobilization nor proprioceptive neuromuscular facilitation (PNF) stretching is more advantageous than the other.

Strengths, Implications and Limitation of the Study

Strengths

- **Innovative Comparison:** This study is among the first to directly compare PIR+PRS and NT for hamstring tightness and functionality.
- **Holistic Assessment:** By incorporating both flexibility and functional outcomes, the study provides a comprehensive understanding of the interventions' effects.

Clinical Implications

- **Tailored Interventions:** Findings suggest that PIR+PRS are more effective for individuals with isolated muscle tightness, whereas NT may be more beneficial for functional impairments involving neural components.
- **Rehabilitation Programs:** Clinicians can utilize these results to design targeted rehabilitation programs based on the specific needs of the patient population.

Limitations

1. **Small Sample Size:** As a pilot trial, the limited sample size reduces the generalizability of the findings.
2. **Short Duration:** The study only assessed immediate and short-term effects. Long-term follow-up is necessary to evaluate the sustainability of the outcomes.
3. **Homogeneous Population:** The study focused exclusively on healthy collegiate students, which limits its applicability to clinical populations.

Future Research

1. **Larger Trials:** Future studies should include a larger and more diverse sample to validate these findings.
2. **Longitudinal Assessments:** Long-term studies are needed to assess the durability of the observed improvements.
3. **Comparative Analysis:** Further research should explore the combined effects of PIR+PRS and NT to determine if synergistic benefits exist.
4. **Clinical Populations:** Investigating these interventions in individuals with clinical conditions such as hamstring injuries or neural tension syndromes could provide additional insights.

CONCLUSION

This pilot trial demonstrates that both PIR combined with PRS and the NTis effective in improving hamstring muscle tightness and functional outcomes in healthy collegiate students. While PIR+PRS may be superior for addressing muscular flexibility, NT is more effective for enhancing dynamic functional performance. These findings emphasize the importance of tailoring intervention strategies based on the underlying cause of the impairment. Future research is needed to confirm these results and expand their applicability to diverse populations and clinical settings.

Conflicts of Interest

None

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