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Original Article

A comparison of proprioceptive neuromuscular facilitation and slump stretch technique on hamstring flexibility

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ABSTRACT

Introduction: Hamstring muscles, being biarticular, are particularly susceptible to adaptive shortening, especially in individuals with prolonged sedentary behaviours such as extended sitting. This shortening reduces flexibility and restricts range of motion, which may contribute to functional limitations and increased injury risk.
Materials and Methods: A six-week randomized experimental study was conducted to compare the efficacy of the slump stretching technique versus proprioceptive neuromuscular facilitation (PNF) using the hold-relax method in improving hamstring flexibility. A total of 30 participants, selected based on predefined inclusion criteria from a reputed academic institution, were randomly assigned to two groups. Group A received slump stretching, while Group B received PNF hold-relax stretching. Hamstring flexibility was assessed pre- and post-intervention using the Modified Back Saver Sit and Reach (BSSR) test.
Results: Post-intervention analysis revealed a statistically significant improvement in hamstring flexibility in both groups. However, Group B (PNF hold-relax) demonstrated a significantly greater mean improvement compared to Group A (slump stretch), with a p-value < 0.001, indicating superior effectiveness.
Conclusions: The study findings suggest that the PNF hold-relax stretching technique is more effective than slump stretching in enhancing hamstring flexibility. Incorporating PNF techniques may be beneficial in clinical and athletic settings for improving muscle extensibility.

Introduction

Muscle flexibility is essential for efficient movement and the performance of daily functional activities. In modern sedentary lifestyles, prolonged periods of sitting contribute to a high prevalence of hamstring tightness, a condition increasingly observed across all age groups. An individual's routine physical activity largely influences flexibility levels[1]. Reduced hamstring flexibility is associated with restricted joint range of motion and may contribute to postural imbalances, creating a cycle of musculoskeletal dysfunction.

Limited muscle extensibility is recognized as a primary risk factor for strain injuries, particularly in the hamstrings[2]. Tight hamstring muscles elevate the risk of tearing, alter gait mechanics, and contribute to postural deviations[3]. To mitigate such risks, stretching routines targeting the hamstrings are commonly incorporated before physical activity, often following an aerobic warm-up[4,5]. According to Worrell's theoretical model, hamstring injuries result from an interaction of multiple intrinsic and extrinsic factors, including inadequate warm-up, reduced flexibility, muscular fatigue, and strength deficits[6]. A clinically tight hamstring is typically defined as the inability to achieve full knee extension (last 20–25 degrees) while the hip is maintained in 90 degrees of flexion[7].

Interventions aimed at improving flexibility include a range of techniques such as static, dynamic, ballistic stretching, myofascial

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release, and heat therapy. Among these, slump stretching—a technique performed in a neurodynamic slump position—and proprioceptive neuromuscular facilitation (PNF) stretching using the hold-relax method—have demonstrated clinical potential in enhancing hamstring extensibility[8,9]. Slump stretching is a gentle, pain-free approach that can be self-administered at home. Based on Kabat's principles, PNF stretching involves voluntary isometric contractions followed by passive elongation of the muscle group[10,11]. The hold-relax PNF technique combines neuromuscular inhibition and mechanical elongation, targeting increased flexibility and muscle compliance through controlled isometric contraction[12,13].

Despite their widespread clinical use, there remains limited comparative evidence regarding the effectiveness of slump stretching versus PNF hold-relax techniques in improving hamstring flexibility. Therefore, this study aims to evaluate and compare the efficacy of these two interventions in enhancing hamstring muscle flexibility.

Materials and methods

A randomized experimental study involved 30 participants recruited from a reputed college. Individuals aged between 17 and 26 with reduced hamstring flexibility were included, as determined by a positive Active Knee Extension Test (AKET)[14]. Exclusion criteria comprised a history of recent hamstring injury or fracture, chronic low back pain, neurological impairments, or signs of neural tension.

The study utilized a universal goniometer, hot packs, and a standard treatment table. Outcome measures included the Active Knee Extension Test (AKET)[14] and the Modified Back Saver Sit and Reach Test (BSSR test)[15], which were administered pre- and post-intervention to assess hamstring flexibility. The Active Knee Extension Test (AKET) and the Modified Back Saver Sit and Reach Test (BSSR) were selected due to their high reliability and validity in assessing hamstring flexibility. These variables directly relate to the study's aim of evaluating interventions that improve posterior thigh extensibility[4,14,16].

Participants were randomly assigned into two equal groups (n=15 each): Group A: Received the slump stretching technique, and Group B: Received the proprioceptive neuromuscular facilitation (PNF) hold-relax technique[17]. Both groups received their respective interventions five times per week for six weeks, after applying a hot pack for 10 minutes. Each stretching session was performed once daily, five days per week, for six weeks. All stretches were applied up to the point of mild discomfort (POD), avoiding pain.

Active knee extension test (AKET)

Participants were positioned supine with the hip flexed to 90°. A universal goniometer was aligned over the lateral epicondyle of the femur. Participants actively extended the knee until a firm resistance was perceived, and the extension angle was recorded.

Group A

Slump Stretch Technique—After a 10-minute moist heat session, participants were seated on a high table, with their thighs supported and feet not touching the floor. They adopted cervical and thoracolumbar flexion, with legs hanging freely and knees flexed. Participants actively extended the knee while maintaining ankle dorsiflexion until a stretch was felt in the posterior thigh. This position was held while counting backward from one to four. A total of 15 repetitions were performed per session.

Group B

PNF Hold-Relax Stretching Technique—After 10 minutes of heat being applied to the posterior thigh, the hamstring was passively stretched for 10 seconds. Participants were then instructed to perform an isometric contraction against the therapist's resistance for six seconds. This was followed by a 30-second passive stretch applied by the therapist. Five repetitions were completed per session.

Modified back saver sit and reach test (BSSR test)

Like the traditional sit and reach test, this test involved participants placing one leg on the reach box while keeping the other foot flat on the floor. With hands aligned and arms extended, participants were instructed to bend forward along the measurement scale as far as possible without jerking. The furthest reach was held for 1–2 seconds and measured to the nearest centimeter. Both pre- and post-intervention scores were recorded.

Data were analyzed using IBM SPSS version 24. Descriptive statistics were used to summarize participant characteristics and outcome measures. Paired t-tests were conducted to compare pre- and post-intervention scores within and between groups. A p-value of <0.05 was considered statistically significant.

Results

A total of 30 participants completed the study and were included in the analysis. All the Participants were sedentary college students with no regular exercise routine, identified through screening using the Active Knee Extension Test (AKET). This population was chosen to represent individuals at higher risk for hamstring tightness due to prolonged sitting.

Hamstring flexibility, assessed using the Modified Back Saver Sit and Reach (BSSR) test, improved significantly in both groups following the six-week intervention. Pre-test scores were comparable between Group A (Slump Stretch; 22.33 ± 1.75) and Group B (PNF Hold-Relax; 21.93 ± 1.79), with no statistically significant difference ($p = 0.542$).

Table 1 presents the descriptive statistics for the anthropometric and baseline physical performance variables of participants in both Group A and Group B. The mean age of participants in Group A was 20.4 ± 1.2 years, while Group B had a mean age of 20.1 ± 1.4 years, with no statistically significant difference between the groups ($p = 0.412$). Similarly, height and weight did not differ significantly between the groups, with Group A measuring 165.3 ± 6.8 cm and 61.7 ± 7.4 kg, and Group B measuring 166.1 ± 5.9 cm and 60.9 ± 6.6 kg, respectively ($p = 0.589$ for height; $p = 0.673$ for weight).

The Body Mass Index (BMI) was also comparable between the groups, with Group A showing 22.6 ± 2.1 kg/m^2 and Group B showing 22.1 ± 1.9 kg/m^2 ($p = 0.482$). In terms of baseline flexibility, as measured by the BSSR (Back-Saver Sit and Reach) score, Group A scored 22.5 ± 3.2 cm and Group B scored 22.9 ± 3.0 cm. Again, no statistically significant difference was observed ($p = 0.641$) (Table 1).

Post-intervention, both groups demonstrated significant increases in BSSR scores. Group A improved from 22.33 ± 1.75 to 28.60 ± 1.54 ($p < 0.001$), while Group B improved from 21.93 ± 1.79 to 34.00 ± 2.50 ($p < 0.001$). When comparing post-test scores between the two groups, Group B exhibited a significantly greater increase than Group A ($t = 7.09$; $p < 0.001$), indicating that the PNF Hold-Relax technique was more effective

Table 1
Descriptive statistics of anthropometric and physical performance variables (pre-test).

Variable	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Age (years)	20.4 ± 1.2	20.1 ± 1.4	0.412
Height (cm)	165.3 ± 6.8	166.1 ± 5.9	0.589
Weight (kg)	61.7 ± 7.4	60.9 ± 6.6	0.673
Body Mass Index (kg/m^2)	22.6 ± 2.1	22.1 ± 1.9	0.482
BSSR Score (cm) – Pre-test	22.5 ± 3.2	22.9 ± 3.0	0.641

in enhancing hamstring flexibility than the Slump Stretch (Table 2).

Within-group comparisons of Back-Saver Sit and Reach (BSSR) test scores between the pre-test and post-test phases for both groups. In Group A, the mean BSSR score increased significantly from 22.33 ± 1.75 cm in the pre-test to 28.60 ± 1.54 cm in the post-test. This improvement was statistically significant, with a t-value of -15.40 and a p-value of 0.02 ($p < 0.05$), indicating a meaningful gain in flexibility following the intervention. Similarly, Group B demonstrated a significant enhancement in BSSR performance, with scores rising from 21.93 ± 1.79 cm to 34.00 ± 2.50 cm. The corresponding t-value was -24.39 with a p-value of 0.017, which is also statistically significant (Table 3).

Discussion

The present study investigated and compared the effects of the Proprioceptive Neuromuscular Facilitation (PNF) Hold-Relax technique and Slump Stretching on hamstring muscle flexibility. The findings demonstrated that although both interventions resulted in statistically significant improvements in hamstring flexibility, the PNF Hold-Relax technique produced superior outcomes, as evidenced by greater mean post-test scores in the Back Saver Sit and Reach (BSSR) test.

Between-group analysis revealed no statistically significant difference in baseline (pre-test) BSSR scores ($p > 0.05$), indicating comparability of groups before intervention. However, post-test comparison demonstrated a statistically significant difference ($p < 0.001$), favouring the PNF Hold-Relax group (Mean = 34.00 ± 2.50) over the Slump Stretch group (Mean = 28.60 ± 1.54). Within-group comparisons also showed significant improvements from pre- to post-test in both groups ($p < 0.001$), indicating that both stretching techniques effectively enhanced hamstring flexibility.

The greater efficacy of the PNF Hold-Relax technique may be attributed to its neurophysiological basis. It operates via autogenic and reciprocal inhibition mechanisms, which facilitate muscle relaxation following an isometric contraction and enhance subsequent elongation of the muscle fiber during passive stretching[17]. Sherrington first elucidated these mechanisms, which were later applied to rehabilitation protocols by Moore et al., supporting the theoretical rationale for the effectiveness of PNF techniques[18].

In contrast, Slump Stretching is widely utilized in clinical and athletic populations, but there is comparatively limited empirical evidence supporting its isolated efficacy in improving hamstring extensibility[19,20]. Although the current study observed statistically significant gains within the Slump Stretch group, the magnitude of improvement was notably lower than that observed in the PNF group. This finding aligns with prior studies, such as those by Pratiksha et al., who reported modest improvements with neural stretching techniques[2].

Unlike the Slump Stretch, which can be self-administered, the PNF Hold-Relax technique requires therapist assistance to provide resistance during the isometric phase[17]. This may limit its feasibility in home-based programs, highlighting the need for supervised clinical implementation.

The outcomes of this study are consistent with existing literature that supports the use of PNF-based interventions for improving range of motion and muscular flexibility[7,9].

The significant increase observed in the PNF Hold-Relax group confirms the effectiveness of this approach in promoting extensibility in shortened muscle groups. The findings of this study demonstrate that targeted stretching techniques significantly improve hamstring flexibility, supporting previous research on the effectiveness of interventions aimed at mitigating muscle tightness. Furthermore, the role of hamstring function extends beyond flexibility; Praharsitha et al. (2019) emphasized the importance of medial and lateral hamstring strengthening in managing knee osteoarthritis, suggesting that balanced muscle control around the knee joint contributes to overall joint stability and pain reduction[21].

Kamalakannan et al. (2020) found a significant correlation between hamstring tightness and the prevalence of low back pain in college students, highlighting the clinical importance of early intervention[22]. In addition, anthropometric variations have been shown to influence hamstring muscle characteristics, as described by Murthy et al., who reported that parameters such as thigh length and girth may impact graft suitability in anterior cruciate ligament reconstruction[23]. These findings underscore the relevance of individualized assessment and intervention strategies for hamstring management, which are essential for injury prevention and functional restoration.

A limitation of this study is the presence of hot pack in both the groups. Comparing the effect of stretching alone would have helped isolate the specific contribution of stretching interventions to the observed improvements in flexibility.

In summary, the results of this investigation support the alternative hypothesis that the PNF Hold-Relax technique yields significantly greater improvements in hamstring flexibility compared to Slump Stretching. These findings highlight the clinical utility of PNF stretching techniques in flexibility training and rehabilitation programs targeting the posterior thigh musculature.

Table 2
Comparison of BSSR test values between group a (slump stretch) and group B (PNF hold-relax technique).

Test	Group A (Mean ± SD)	Group B (Mean ± SD)	t-value	df	p-value
Pre-Test	22.33 ± 1.75	21.93 ± 1.79	-0.617	28	0.542 (NS)
Post-Test	28.60 ± 1.54	34.00 ± 2.50	7.09	28	0.037*

Table 3
Within-group comparison of BSSR test scores pre- and post-test.

Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t-value	p-value
Group A	22.33 ± 1.75	28.60 ± 1.54	-15.40	0.02*
Group B	21.93 ± 1.79	34.00 ± 2.50	-24.39	0.017*

*$p < 0.05$ (Significant)

Conclusion

The findings of this study indicate that both the Slump Stretch and the Proprioceptive Neuromuscular Facilitation (PNF) Hold-Relax stretching techniques effectively improve hamstring flexibility. However, the PNF Hold-Relax technique significantly improved hamstring extensibility, as evidenced by higher post-intervention Back Saver Sit and Reach (BSSR) scores.

Given its superior efficacy, the PNF Hold-Relax technique may be recommended as a more effective intervention for enhancing hamstring flexibility, particularly in clinical and athletic populations where increased muscle extensibility is essential. Future studies with larger sample sizes and long-term follow-up are warranted to validate these findings further and assess the sustainability of improvements achieved through these stretching methods.

Author contributions

Conceptualization, P.G. and S.V.; methodology, P.G and S.S.S.; software, P.A.; validation, Z.N. and S.A.; formal analysis, S.V.; investigation, P.G.; resources, S.S.S.; data curation, B.A.; writing—original draft preparation, P.G., S.V., and S.S.S.; writing—review and editing, R. A.M., F.A, and P.G.; supervision, S.V.; project administration, S.S.S.; funding acquisition, S.M.F. All authors have read and agreed to the published version of the manuscript.

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Institutional review board statement

The study was conducted by the Declaration of Helsinki and approved by the Institutional Scientific Review Board (ISRB) of Saveetha College of Physiotherapy (Reference No: IV A—038/PHYSIO/IRB/2017-2018).

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of interest

The authors declare no conflicts of interest.

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