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Neurodynamic sliding versus PNF stretching on hamstring flexibility in working women with prolong sitting job: A comparative study

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Abstract
Background: Muscular flexibility is an important aspect of normal human function. Limited flexibility has been shown to predispose a person to several musculoskeletal overuse injuries and significantly affect a person's level of function. Hamstring muscle is a two joint muscle. Hamstrings are the major knee flexors and also aid in hip extension. Physiologically full stretch occurs in this muscle only if the knee is fully extended and hip fully flexed.
Materials and Methods: 40 participants with hamstring tightness were allocated into two groups (20 participants in each group). The outcome measure used was AKE test. Subjects of group A were treated with Neurodynamic sliding technique, whereas the subjects of group B were treated with PNF hold relax stretching. For both experimental groups, the technique was performed three times a week for a total training period of four weeks.
Results: The results demonstrated significant improvement in hamstring flexibility for subjects of group A when compared with those of group B (P = 0.01) at the end of six weeks.
Conclusion: PNF (Hold-Relax) stretching technique is more effective than Neurodynamic sliding technique for improving hamstring flexibility.

Keywords: neurodynamic sliding, PNF stretching, Active knee extension test and hamstring flexibility

1. Introduction
Hamstring is one of the three posterior thigh muscles in between the hip and the knee and plays an important role in locomotion. Muscular flexibility is an important component of the physical fitness and held as an important attribute that enable the person to move smoothly and safely. Limited flexibility has been shown to predispose a person to several musculoskeletal overuse injuries and significantly affect a person's level of function [1].
According to Gajdosik *et al*., 2011, pelvic as well as thoracic angle and range of motion are affected by hamstring flexibility in forward bending. Hamstring tightness also influences the lumbar pelvic rhythm [2].
Hamstring tightness is also associated with the development of plantar fasciitis[3] as well as patellar tendinopathy and patellofemoral pain syndrome [4]. An association between hamstring tightness and mechanical low back pain is also found in studies showing a positive correlation between hamstring tightness and severity of low back pain [5]
Emerging evidences suggests that hamstring tightness contributes to musculoskeletal dysfunctions such as impaired postural balance, reduced range of motion of the knees and hips, increased risk of musculoskeletal and soft tissue injuries as patella tendinopathy, patellofemoral pain, hamstring strain injury, low back pain, herniated lumbar disc, decreased lumbar lordosis, decreased range of lumbar spine flexion and a higher risk of muscle injury thus causing an inefficiency in the workplace [6-9]. The numerous factors influencing the hamstring flexibility includes the age, gender, race, tissue temperature, strength training, stiffness, awkward posture and reduced warm up period during exercise [10].
Recent studies show that that people with prolonged hours of chair sitting are prone to develop hamstring tightness as during prolonged sitting hamstring muscle becomes inactive and is consequently held at shortened length [11].

Maintaining normal muscle length requires regular stretching to prevent muscle stiffness and benefit from the decreased risk of musculoskeletal injuries and enhance physical performance. Previous studies concerning muscle stiffness suggests that, at a given muscle length, cyclic stretching will reduce the force that is placed upon the muscle and associated connective tissue [12].

An academic study found that the most common and prevalent musculoskeletal injury in the world, is a hamstring strain which results mostly from hamstring stiffness [13]. A meta-analysis article showed evidence that a history of hamstring injury and being of older age were associated with increased risk of hamstring strains [14]. Women were approximately 3 times more likely to suffer hamstring strain than males with the majority of these being non-sporting scenarios [15].

Employed women are two to five times more likely than men to report musculoskeletal problems and their higher prevalence among the women reflects the accumulation of many factors related to office work load, domestic work load and biological difference [16]. Hence, the working females with sitting jobs of more than 8-10 hours may have preponderance for the development of hamstring tightness which makes them susceptible to various musculoskeletal problems such as low back pain and other musculoskeletal injuries [11, 15, 16, 17].

Numerous stretching techniques have been developed, reported and applied by physical therapists, coaches and athletic trainers. Four methods of stretching have been emerged: 1) Ballistic stretching, 2) Static stretching 3) PNF stretching [18] and 4) Neurodynamic sliding [19]. All four methods have been shown to increase ROM immediately after stretching.

However, recent studies have shown that the Proprioceptive Neuromuscular Facilitation (PNF) stretching techniques are emerging as effective techniques to counter the hamstring tightness [18]. PNF stretching utilizes inhibition techniques, and of these, contract relax, hold- relax and contract - relax antagonist-contract appear to be commonly used [19]. The PNF methods, particularly those involving reciprocal activation such as hold relax (HR), provide the greatest potential for muscle lengthening, under the assumption that greater motor pool inhibition reduces muscle contractibility and therefore allows more muscle compliance [20].

Neurodynamics encompasses interactions between mechanics and physiology of the nervous system. Changes in neural mechanics or physiology may lead to pathodynamics. Altered posterior lower extremity neurodynamics could arguably influence resting muscle length and lead to changes in the perception of stretch or pain. Providing movement or stretching could lead to changes in the neurodynamics and modification of sensation and could help to explain the observed increase in flexibility. The mechanosensitivity of the neural structures in the posterior leg, thigh, buttock, and vertebral canal may play a part in determining the flexibility of the hamstring muscles. Protective muscle contraction of the hamstring muscles found in the presence of neural mechanosensitivity may account for hamstring tightness and thereby predispose the muscle to subsequent strain injury. Neurodynamic sliding interventions are thought to decrease neural mechanosensitivity and it is shown that the inclusion of these interventions in the management of hamstring flexibility could be beneficial [19].

Considering the importance of hamstring flexibility in general population, maintaining the flexibility of hamstring muscle is of utmost importance for health care professionals and to achieve this goal one needs to know the most effective and efficient technique to gain hamstring flexibility. Numerous investigations established PNF techniques are more effective than traditional stretching exercises for range of motion or flexibility enhancement [20].

Numerous studies have shown the individual effectiveness of Neurodynamic sliding and PNF in improving the flexibility of hamstring muscle but there are very few studies which shows the superiority of one technique with respect to the other in working women with prolong sitting job, hence the purpose of the study is to compare the effectiveness of Neurodynamic sliding versus PNF (Hold-Relax) technique in improving the hamstring flexibility in long sitting working women.

2. Materials and Methods

The study was conducted at Out Patient Department of Florence college of Physiotherapy. Ethical clearance was obtained from institutional ethical committee, Florence college of Physiotherapy, Bangalore as per ethical guidelines for biomedical research on Human subjects, 2000 ICMR, New Delhi. The study design was a pre-post experimental study. 40 participants with age ranging 25-35 years, only females with unilateral hamstring tightness [21] - as defined by limitation of 20 degree or more from full knee extension as determined by active knee extension test were included in the study. Subjects with history of neck trauma, history of fracture, disc hernia/protrusion, chronic low back pain, history of surgery were excluded from the study. Prior to participation, a written informed consent was taken from all subjects and subjects were informed about study protocol. Standard full circle goniometer, cross bar made of PVC pipe, straps, foam mattress, marker, paper, stop watch materials were used for the study. All the subjects were undergone a pre-treatment examination to assess hamstring tightness using the AKE test.

Subjects were assessed for hamstring tightness using the AKE test [22]. The subject was in supine position with hips in 90 degree flexed and knee flexed. PVC cross bar was used to maintain the proper position of hip and thigh. The testing was done on the right lower extremity and subsequently the left lower extremity and the pelvis were strapped down the table to stabilize the pelvis and control any accessory movements. Landmarks used to measure hip and knee range of motion is greater trochanter, lateral condyle of femur and the lateral malleolus which were marked by a skin permanent marker. The fulcrum of the goniometer was centred over the lateral condyle of the femur with the proximal arm secured along the femur using greater trochanter as a reference. The distal arm was aligned with the lower leg using the lateral malleolus as a reference. The hip and knee of the extremity being tested was placed into 90 degree flexion with the anterior aspect thigh in contact with the horizontal bar of the PVC frame at all times to maintain hip in 90 degrees of flexion. Then subject was asked to extend the right lower extremity as far as possible until a mild stretch sensation was felt. A full circle goniometer was used to measure the angle of knee flexion. Three repetitions were performed and an average of the three will be taken as the final reading for knee flexion range of motion (hamstring tightness).

Then the patients were randomly assigned into two groups of 20 each, using a simple random distribution into 2 intervention groups: group A- Neurodynamic sliding group (20 subjects) and group B- PNF- Hold- Relax stretching group (20 subjects).

In group A Subjects received sciatic Neurodynamic sliders performed in supine.

All the 20 subjects were in supine position with their cervical and thoracic spine was maintained in flexion. Sliders involve the application of movement/ stress to the nervous system proximally while releasing movement/ stress distally and then reversing the sequence. Concurrent hip and knee flexion were alternated dynamically with concurrent hip and knee extension. The therapist alternated the combination of movement depending on the tissue resistance level. This combination of movements was performed for 30 seconds, 6 times on their dominant leg for a total stretching time of 180 seconds. The treatment was given for 3 times per week for period of 6 weeks.

In group B the subjects were in supine position with their non dominant lower extremity strapped down the table. Pre-determined time intervals for stretching, contracting and relaxing were used to standardize the method utilizing a stop watch. For each stretch, the therapist stretched the hamstring muscle by passively flexing the hip with knee fully extended, allowing no hip rotation. The dominant leg was rested on the therapist right shoulder. The hamstring muscle was stretched until the subject first reports a mild stretch sensation; this position was held for 7 sec. Next, the subject then isometrically contracted the hamstring muscle for 3 sec by attempting to push his leg down towards the table against the resistance of the therapist. Following this, the subject was asked to relax for 5 sec. The therapist then passively stretched the muscle until a mild stretch sensation is reported. This stretch was held for 7sec. This sequence was repeated 5 times with each sequence separated from each by a 20 second interval. The treatment was given for 3 times per week for period of 6 weeks.

Data analysis was performed using SPSS software (version17). Alpha value was set at 0.05. Descriptive measures such as range mean and standard deviation was used to assess the hamstring flexibility in both the groups before and after the experiment. Unpaired t-test was used to find out significant difference among demographic variable such as age, duration and baseline variable such as ROM. Mann-whitney U test was used to find the significant difference among base line variable such as VAS. Chi-square test was performed to find out the gender difference among both groups. Paired t-test was used to find out significant difference within group for ROM/ Active knee extension test. Unpaired t-test was used to find out significant difference between groups for ROM (AKE). Wilcoxon's signed rank sum test was used to find out significant difference within group for VAS (pain). Mann-whitney U test was used to find out significant difference between groups for VAS (pain).

3. Results & Discussion

3.1 Results

Base line characteristics of 40 subjects for both groups are shown in Table 1.

Table 1: Baseline data for demographic variables

Variable	Group A	Group B	p- value
Age	30.50±3.28	30.45±2.26	0.101
Dominance- L/R	9/11	7/13	.5186

The Chi-square test was used for distribution of subjects according to dominance in both groups**.** There was no significant difference in the proportion of subjects with hamstring tightness in both the groups i.e. p>0.05. The difference in mean age of group A and group B was not significant difference. Thus the demographic variables were homogeneous in both the groups.

Table 2: Pre and post data within group

Groups	Pre		Post		p- value
	AKE	VAS	AKE	VAS	
Group A	129.75±4.14	7.3±0.98	140.95±4.44	2.95±0.99	0.00
Group B	129.35±3.78	7.5±0.94	146.25±4.3	2.15±0.87	0.00

The paired t- test and wilcoxon test was carried out and also, the pre and post test were compared for active knee extension ROM and VAS for pain and it showed significant improvement with p value < 0.05

Table 3: Pre and post data between groups

Variables	Group A	Group B	p- value
AKE	140.95±4.44	146.25±4.3	0.0002
VAS	2.95±0.99	2.15±0.87	0.015

The mean difference in AKE score in group A was 140.95 with SD of 4.44 and mean difference in AKE score in group B was 146.25 with SD of 4.3 which was statistically significant (p=0.0002).

For the group A the mean reduction in VAS score was 2.95 with SD of 0.99 and in group B mean reduction in VAS score was 2.15 with SD of 0.87 which was statistically significant (p=0.015)

3.2 Discussion

The aim of this study was to compare the effects of Neurodynamic sliding and PNF (hold-relax) stretching on hamstring flexibility in working women with prolonged sitting job.

The subjects were selected who fulfilled the predetermined inclusion and exclusion criteria with a age of 25-35. The subjects were divided into two groups 20 in each group. In group A there were 20 female subjects. Similarly, in group B there were 20 female subjects. In group A the mean age is 30.50 with SD of 3.28 and in group B the mean age is 30.45 with SD of 2.26

The total duration of the treatment was 3 days a week for 6 weeks.

In group B, the mean AKE have improved significantly. Possible explanation for the improved hamstring flexibility for the subject in group B could be because of viscoelastic nature of the muscle, and also Knott. M and Voss. D. (1968) proposed that the golgi tendon organ is a nerve receptor found in tendons. These receptors fires when tension increases in the tendon, this tension can be due to stretch or contracting muscle when the golgi tendon organ fires a signal is sent to the spinal cord causing the agonist muscle to relax [23].

During PNF stretching (hold-relax) autogenic inhibition of the target muscle takes place. For example Moore and colleagues (1991) approved the theoretical basis of PNF stretching and proposed that the relax portion of hold-relax Manoeuvre should be applied quickly after the hold position. Therefore the results of this study can be correlated with the popular belief that PNF stretching techniques lead to relaxation/inhibition of the stretched muscle via the two physiological mechanisms proposed by Sherrington (1940) namely reciprocal inhibition and autogenic inhibition [24].

In group B, the mean VAS score have showed significant improvement. This is in accordance to the study by Cristina Bretischwerdt and colleagues found that stretching of the hamstring muscles, either unilateral or bilateral, exerts an immediate hypoalgesic effect, i.e., an increase in pressure pain threshold levels. The mechanism behind this is that muscle stretching also activates descending inhibitory pathways [25].

In group A the mean AKE have improved significantly. This is in accordance to "Sensory theory" proposed by Weppler and Magnusson suggested that muscle flexibility and its response to sudden stretch have more to do with perceptions of stretch and pain than the biomechanical effects of muscle tissue itself.[26] This proposal was supported in a study by Aparicio and colleagues which demonstrated that a suboccipital muscle inhibition technique altered hamstring flexibility when compared to a placebo intervention. The fact that such a distant technique (suboccipital region) could have an immediate effect on the flexibility in the hamstrings may tend support to the "Sensory theory" limiting flexibility of the posterior thigh structures. It seems reasonable to attribute the observed increase in hamstring tissue flexibility following the suboccipital muscle inhibition technique to changes in the subject's perception of stretch or pain [27].

The mean VAS score showed the significant improvement in group A which could be explained due to involvement of central and peripheral modulatory mechanisms, such as activation of muscle and joint mechanoreceptors that involve centrally mediated pathways, like the periaqueductal grey in the midbrain, or non-opioid serotonergic and noradrenergic descending inhibitory pathways [28].

When compared to both the groups, group B showed significant improvement in increasing flexibility then group A. In group A the post mean AKE score was 140.95 with SD of 4.44 and mean difference in AKE score in group B was 146.25 with SD of 4.3 which was statistically significant (p=0.0002)which was statistically significant. Increased hamstring flexibility in group B may be due to several factors. The most prominent are the viscoelastic, thixotropic, and neural properties of the musculotendinous unit. Musculotendinous units function in a viscoelastic manner, and, therefore, have the properties of creep and stress relaxation.

Creep is characterized by the lengthening of muscle tissue due to an applied fixed load.[29] Stress relaxation is characterized by the decrease in force over time necessary to hold a tissue at a particular length. The musculotendinous unit deforms or lengthens as it is being stretched and goes through elastic and then plastic deformation before completely rupturing [30].

Studies of similar PNF stretching techniques suggested that autogenic inhibition of the stretched muscle provides increased ROM.[31] Autogenic inhibition was defined by Knott and Voss as the inhibition of the homonymous muscle alpha motor neurons by the stimulation of the Golgi tendon organ. This inhibitory effect is thought to diminish muscle activity and, therefore, allow for relaxation so that the muscle can be stretched. Motor pool excitability has been measured by the Hoffman reflex during soleus muscle static stretching, contract-relax stretching, and contract-relax–agonist contract stretching techniques. Motor pool excitability significantly diminished after the contract-relax and contract-relax–antagonist-contract methods of PNF stretching over static stretching of the soleus. This inhibitory effect has been suggested to increase muscle compliance, allowing for increased length during a stretch without stimulation of the stretch reflex [32].

When comparing the mean VAS scores, group B was more effective in reducing the VAS score then group A. This could be due to the fact that Meena V, Shanthi .C *et al*l (2016) proposed that Hold – relax improves motor activity that affects vascular function. The muscle activation increases the release of vasoactive substances resulting in vascular dilatation. Resultant vascular dilatation causes the pain producing substance P to wash out and helps in reduction of pain.[33] In group A the post mean VAS score was 2.95 with SD of 0.99 and in Group B it was 2.15 with SD of 0.87, which was statistically significant. Hence the study concludes that group A (PNF hold-relax stretching) is effective in increasing the flexibility of hamstring and is even effective in reducing the VAS in working women with prolong sitting job.

Future research should look at longer term results and assess the effect of combining PNF stretching techniques with other interventions. Further study can be done with different sporting population for better outcome.

4. Conclusion

Study concludes that PNF stretching is more effective than Neurodynamic sliding in increasing hamstring flexibility in working women with prolong sitting job. Hence, the alternate hypothesis is accepted and null hypothesis is rejected. Both the techniques are almost equal in their clinical effectiveness for improving hamstring flexibility and that either of the techniques may be used in clinical practice for improving hamstring flexibility.

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