ORIGINAL RESEARCH

EFFECT OF NEURODYNAMIC SLIDING ON HAMSTRING FLEXIBILITY, STATIC AND DYNAMIC BALANCE AMONG ATHLETES.

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ABSTRACT

Introduction: Injury to hamstrings caused due to muscle tightness are common among athletes. In the presence of neural mechanosensitivity, muscle tightness may result from protective muscle contraction. Changes in the length and stiffness of muscle tendon units affect proprioception, which in turn affects balance. Interventions using neurodynamic sliding are thought to reduce neural mechanosensitivity, which is beneficial for increasing the flexibility and, in turn, balance. Hence, the purpose of the study was to find out the immediate effect of neurodynamic sliding technique on hamstring flexibility and static and dynamic balance among athletes.

Methodology: Present study was conducted as Pre-test - Post-test experimental study. 40 male athletes (n=20 cricketers, n=20 football players) from Delhi-NCR sports academies, aging between 18-30yrs (mean=21.35±3.83) having unilateral hamstring tightness participated in the study. Subjects were randomly allocated to any of the 2 groups: Group 1 – Neurodynamic sliding or Group 2 - Moist heat pack. Straight leg raise (SLR) and active knee extension (AKE) tests were used to assess hamstring flexibility and stork stand test (SST) and modified star excursion balance test (mSEBT) were used to assess static and dynamic balance respectively, at baseline and post intervention.

Results: No significant differences were found at baseline for demographics and any of the outcome measures. Significance level was set at 95%. Paired t-test for within group analysis revealed a significant improvement (p =.000) for SLR, AKE, SST and mSEBT scores in both the groups. Independent t-test for between group comparisons revealed significant improvement for SLR (p=.003), AKE (p=.048.), SST (p=.046), mSEBT_AN (p=.013), mSEBT_PM (p=.005), mSEBT_PL (p=.011), mSEBT_NS_PM (p=.037) and mSEBT_CS (p=.047) whereas no significant improvement for was observed for mSEBT_NS_AN (p=.070) and mSEBT_NS_PL (p=.060).

Conclusion: This study concluded that neurodynamic sliding technique is effective in improving the hamstring flexibility and static and dynamic balance among athletes. Therefore, it is recommended that neurodynamic sliding should be added in the pre-participation warm-up to improve pre-competition flexibility and athletic performance, hence preventing injuries and improving performance.

Key words: Neurodynamic sliding, hamstrings, flexibility, straight leg raising, active knee extension, static balance, dynamic balance, modified star excursion balance test, athletes, cricketers, football players.

INTRODUCTION

Neurodynamic sliding technique is a method of producing a sliding movement of neural structures relative to their mechanical interfaces. Through joint motions, tension is applied to the targeted nerve structure proximally, while tension of the nerve is released distally, and then reversing the sequence (Shacklock M, 2005). Neurodynamic sliding technique involves alternation of combined movements of at least two joints where the length of the nerve bed at one joint is increased (increasing the nerve tension) while the length of the nerve bed at an adjacent joint is simultaneously shortened (relieving the nerve tension) (Coppieters MW et al, 2007).

By mobilising the nervous system or the structures that surround it, neural mobilization aims to restore equilibrium in and around the nervous system. Through manual techniques or gliding exercises, neural mobilization restores the dynamic balance between the relative movement of neural structures and surrounding mechanical interfaces, resulting in reduced intrinsic pressures on the neural structures promoting optimal physiological function (Basson A et al, 2017; Ellis RF et al, 2008). Hence, neurodynamic sliding techniques are beneficial as it intend to mobilize a nerve with increase in the nerve's longitudinal excursion while causing minimum strain on nerve (Coppieters MW et al, 2007).

The hamstring muscles play an important role in the performance of activities of daily living as well as recreational and athletic activities and are crucial in maintaining balance and posture in standing position. As the hamstrings have tendency to get shorten, this reduced hamstring flexibility results in decrease in trunk stability and balance leading to injury and pain (Banerjee SB et al, 2020; Babu VK et al, 2015; Park J et al, 2014), therefore it is important to assess the flexibility of the hamstrings before doing any physical activity. Tightness of hamstring is associated to affect static, dynamic balance of body and mobility (Anandhraj J et al, 2020).

Flexibility is defined as the ability of a joint to move freely through its entire range of motion (Peterson DD 2018) and reflects the ability of muscle tendon unit to elongate (Babu VK et al, 2015). Individuals must demonstrate appropriate range of motion as well as stability at the joints for optimal function. Balance is defined as the ability to maintain static and dynamic equilibrium (Peterson DD 2018). Flexibility, balance, strength, endurance, agility, and other qualities are essential for optimal athletic performance and injury avoidance in sporting activities. At professional sport level for athletic activities, where milliseconds can make the difference between winning and losing, even minor changes in flexibility, reaction time, movement time and balance can have a significant impact. Inadequate warm up, decreased flexibility, imbalance in muscle strength, neural tension, fatigue, and previous injury to hamstrings have been identified as risk factors for hamstring pathology resulting in poor athletic performance (Balci A 2020).

Since the muscle spindles are the primary proprioceptive sensory organs, therefore any change in the length and flexibility of muscle tendon units alters the proprioception which initiates the corresponding muscle responses, consequently affecting balance (Lim KI et al, 2014). Stimulation of joint mechanoreceptors results in increased proprioception input consequently improving the balance.

The hamstrings act as a mechanical interface surrounding the sciatic nerve. Nerve adhesions alters neurodynamics and cause abnormal mechanosensitivity of the sciatic nerve; resulting in protective muscle contraction of hamstring which influence hamstring flexibility. Neurodynamic sliding interventions decreases the neural mechanosensitivity and therefore are recommended in management of hamstring flexibility (Satkunskiene D et al, 2020; Anandhraj J et al, 2020; Jung JH et al, 2021; Ridder RD et al, 2020; López LL et al, 2019; Golhar et al 2017; Ahmed AR et al, 2016; Babu VK et al, 2015; Castellote- Caballero et al, 2014, Méndez-Sánchez R et al, 2010) and hence improving the balance (Mahajan R et al, 2022; Roy S et al, 2021; Park JM et al, 2014).

Passive straight leg raise test (SLR) and active knee extension (AKE) are common tests used by clinicians to assess hamstring flexibility. Both the tests are valid and reliable tool to determine the change in hamstrings muscle length [Passive SLR: high interobserver reliability= 0.94–0.96 (Babu VK et al, 2015; Castellote et al, 2014)]; [AKE: intratester reliability = 0.99 (Norris CM et al, 2005)].

Commonly available tests for measuring the lower limb balance among athletes include stork stand test (SST) and modified Star Excursion Balance Test (mSEBT). SST tests the static balance and is a valid and reliable tool [test-retest reliability (r = 0.87)] (Peterson et al, 2018) while mSEBT tests the dynamic balance and is a valid and reliable tool (Onofrei et al, 2019; Bulow A et al, 2019; Van Lieshout R et al, 2016).

Neural mobilization has been used in clinical practice for treatment of various musculoskeletal and neuromuscular pathologies by restoring normal mechanical and physiological responses of the nervous system to movement and posture. However, limited research has been done on the effects of neurodynamic sliding on athletic performance. Hence, the purpose of the study was to find out the effect of neurodynamic sliding on hamstring flexibility and static and dynamic balance among athletes.

MATERIALS AND METHODS

Design

Study design was pre-test & post-test experimental design. Sample design was non-probability sampling (convenient sampling). The study was in accordance with Declaration of Helsinki and approved by Independent Ethical Committee, Indian Fertility Society (Registration-ECR/222/Indt/DL/2015/RR-21) and registered on Clinical Trials Registry-India (CTRI) vide trial registration no. CTRI/2022/02/039977.

Participants

40 male athletes (n=20 cricketers, n=20 football players) were recruited from sports academy of Delhi-NCR, India. Inclusion criteria was age between 18-30 years, unilateral hamstring tightness measured by straight leg raise test (80 degree or less) (Chaitow L., 2006; Castellote et al, 2014) and ability to read english. Subjects were excluded if they were not willing to participate, if they

had hamstring injury within the past year, low back pain in the last 6 months, recent major trauma or fracture of the lumbar spine or lower limb in the last 6 months, leg length discrepancy or if there were signs of serious pathology such as malignancy, infection, inflammatory disorder, disc prolapse, stenosis, spondylolisthesis, spinal or lower limb deformity (Srithren NS et al,2020; Satkunskiene D et al, 2020; Babu VK et al, 2015; Castellote et al, 2014).

Equipment

Hydrocollator unit including hydrocollator pack, universal goniometer, couch, pillow, towel, stabilizing belt, stopwatch, measuring tape, stadiometer, weighing machine, micropore tape, pen, paper, and marker.

Procedure

A duly signed participant informed consent and descriptive data for demographics was obtained from subjects. This was followed by filling of Physical Activity Readiness Questionnaire (PAR-Q) and baseline measurement (SLR, AKE, SST and mSEBT). Subjects were randomly allocated to any of the 2 groups: Group 1 – Neurodynamic sliding (NDS + moist heat pack) and Group 2 – MHP (moist heat pack only), followed by measurement of SLR, AKE, SST and mSEBT post intervention.

Intervention

Group-1 NDS, received moist heat therapy for 15 min to the hamstring followed by neurodynamic sliding. For performing Neurodynamic sliding, subjects were positioned in supine lying with their neck and thoracic spine supported in a forward flexed position using a pillow. Concurrent hip and knee flexion with ankle dorsi-flexion were alternated dynamically with concurrent hip and knee extension with ankle plantar-flexion. This combination of movements was performed for 180 seconds (Ahmed AR et al, 2016; Castellote et al, 2014; Mendez R et al, 2010). Group-2 MHP, received moist heat therapy for 15 min to the hamstring.

Outcome measures

Straight leg raise (SLR): The subject was positioned in supine lying. Axis of the goniometer was placed over the mark on the greater trochanter of the femur. The stationary arm of the goniometer was placed parallel to the table and the moving arm was placed directing to lateral condyle of femur and towards the head of the fibula. The therapist performed the passive SLR (with the knee in full extension and the ankle in neutral position) to the point where subject first felt a stretch in the posterior thigh and the degree of elevation of the straight leg was noted (Babu VK et al, 2015; Castellote et al, 2014).

Active knee extension (AKE): The subject was positioned in supine lying with both lower extremities extended. The examiner flexed the ipsilateral hip and knee to 90^0. Then, maintaining this 90^0 hip angle, the ipsilateral knee was extended actively and the angle of knee extension was measured. Axis of the goniometer was placed over the mark on knee joint axis over the lateral joint line. The stationary arm of the goniometer was placed directing towards greater trochanter of the femur and the moving arm was placed directing towards the lateral malleolus (Balcı A et al, 2020; Norris CM et al, 2005).

Stork stand test (SST): In standing position, the subject removed their shoes, placed the hands on the hips, and positioned the non-supporting foot on the inside knee of the supporting leg. Subject then raised the heel of the supporting leg to balance on the ball of the foot. Time was started when the heel was raised from the floor and stopped when any of the following occurred: Hand(s) came off the hips, non-supporting foot lost the contact with the knee, and heel of the supporting foot touched the floor. Best of three attempts was the recorded as the final score (duration in seconds). (Castillo-Rodríguez A et al, 2020; Peterson et al, 2018; Makhlouf I et al, 2018; Hammami R, 2016).

Modified Star Excursion Balance Test (mSEBT): Prior measuring the mSEBT, limb length of the subject was measured. Then, a grid consisting of 3 lines was made on floor using a universal goniometer and adhesive micropore tape. The 2 posterior lines extended from the centre of the grid and were angled 135° from the anterior line with 90° between the two posterior lines. Then the subject stood on a single leg in the centre of a grid. For the anterior reach direction, subject stood with the most distal aspect of the great toe at the cross of the Y and for the posterior reach directions, subject stood with the most posterior part of the heel at the cross of the Y at the beginning of measures. While maintaining a single-leg stance and hands on the hips, the subject was instructed to reach with the free limb in AN, PM, and PL directions in relation to the single limb stance foot and return the reach foot to the starting position. The distance was measured (3 trials were taken) (Onofrei et al, 2019; Bulow A et al, 2019; Reghabi S et al, 2018; Van Lieshout R et al, 2016).

STATISTICAL ANALYSIS

All statistical analysis was performed using SPSS software, Version 21.0. Descriptive statistics was used to describe the mean ± SD for all variables. Paired t-test was used for within group analysis and independent t-test was used for between group analysis. Level of significance was set at 95%.

RESULTS

Descriptive data of demographics is shown in Table 1. There were no significant differences in the mean age and BMI between the groups. No baseline differences were found in any of the outcome measures (SLR, AKE, SST and mSEBT) (Graph 1).

Means and standard deviation for the pre-test and post-test scores of SLR, AKE, SST and mSEBT (distance in anterior direction, postero-medial direction and postero-lateral direction; normalized scores in anterior direction, postero-medial direction and postero-lateral direction; and composite scores) are shown in table 2 for group 1 and table 3 for group 2. Paired t-test for the pre and post-test comparisons within groups revealed significant improvement (p=.000) for SLR, AKE, SST and mSEBT scores.

Independent t-test for between group comparisons revealed significant improvement for SLR (p=.003), AKE (p=.048.), SST (p=.046), mSEBT_AN (p=.013), mSEBT_PM (p=.005), mSEBT_PL (p=.011), mSEBT_NS_PM (p=.037) and mSEBT_CS (p=.047) whereas no significant improvement for was observed for mSEBT_NS_AN (p=.070) and mSEBT_NS_PL (p=.060). Comparison of pre-test and post-test scores of SLR, AKE, SST and mSEBT reach distance is shown in Graph 2,3,4 and 5 respectively.

Table 1: Descriptive data of demographics for group 1 & 2:

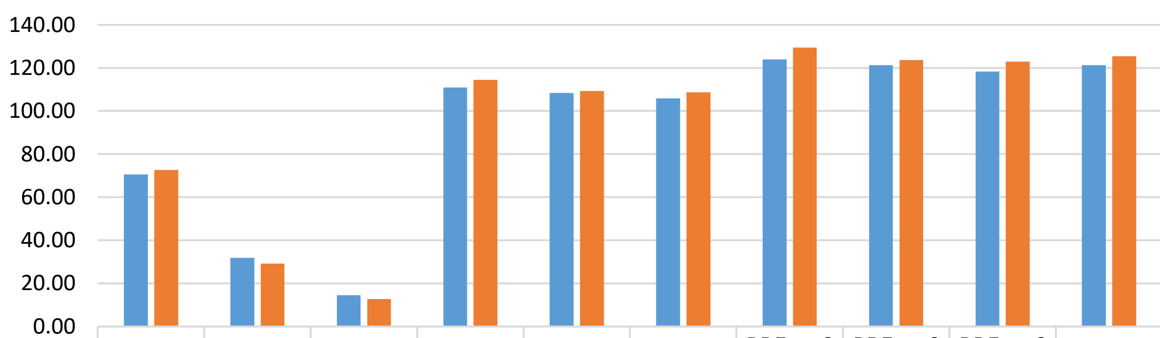
	Group	**Mean ± SD**	**N**	**Sig.**
AGE (yrs)	1	20.05 ± 2.48	20	.06
	2	22.65 ± 4.52	20	
BMI (kg/m^2)	1	21.08 ± 2.10	20	.347
	2	21.69 ± 1.94	20	

Table 2: Within group comparison of group 1 (NDS):

	Mean ± SD		Sig.
	Pre-test	Post-test	
SLR	70.60 ± 6.34	84.50 ± 5.37	.000
AKE	31.85 ± 4.57	22.40 ± 4.74	.000
SST	14.5 ± 8.57	17.75 ± 8.05	.000
mSEBT_AN	110.90 ± 8.95	124.25 ± 8.28	.000
mSEBT_PM	108.40 ± 10.21	120.05 ± 9.59	.000
mSEBT_PL	105.85 ± 9.42	118.65 ± 9.24	.000
mSEBT_NS_AN	124.00 ± 11.98	138.90 ±11.55	.000
mSEBT_NS_PM	121.27 ±13.81	134.29 ± 13.55	.000
mSEBT_NS_PL	118.36 ± 12.29	132.66 ± 12.39	.000
mSEBT_CS	121.21 ± 12.36	135.28 ± 12.18	.000

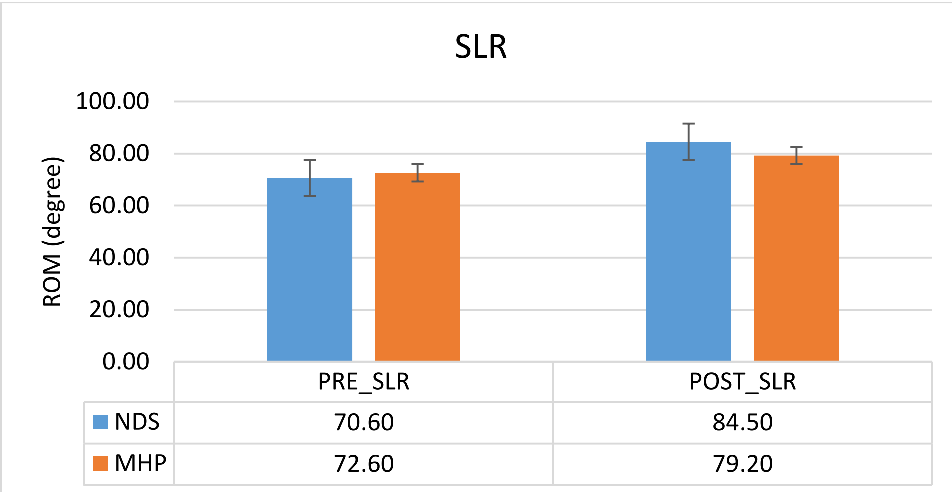
Table 3: Within group comparison of group 2 (MHP):

	Mean ± SD		Sig.
	Pre-test	Post-test	
SLR	72.60 ± 5.97	79.20 ± 5.34	.000
AKE	29.20 ± 5.24	25.50 ± 4.87	.000
SST	12.7 ± 6.17	13.15 ± 5.89	.000
mSEBT_AN	114.40 ± 9.88	116.40 ± 10.62	.000
mSEBT_PM	109.25 ± 9.07	111.05 ± 9.43	.000
mSEBT_PL	108.60 ± 9.90	110.30 ± 10.43	.000
mSEBT_NS_AN	129.47 ± 11.98	131.73 ± 11.55	.000
mSEBT_NS_PM	123.64 ± 13.81	125.69 ± 13.55	.000
mSEBT_NS_PL	122.96 ± 12.29	124.88 ± 12.39	.000
mSEBT_CS	125.36 ± 12.36	127.43 ± 12.18	.000

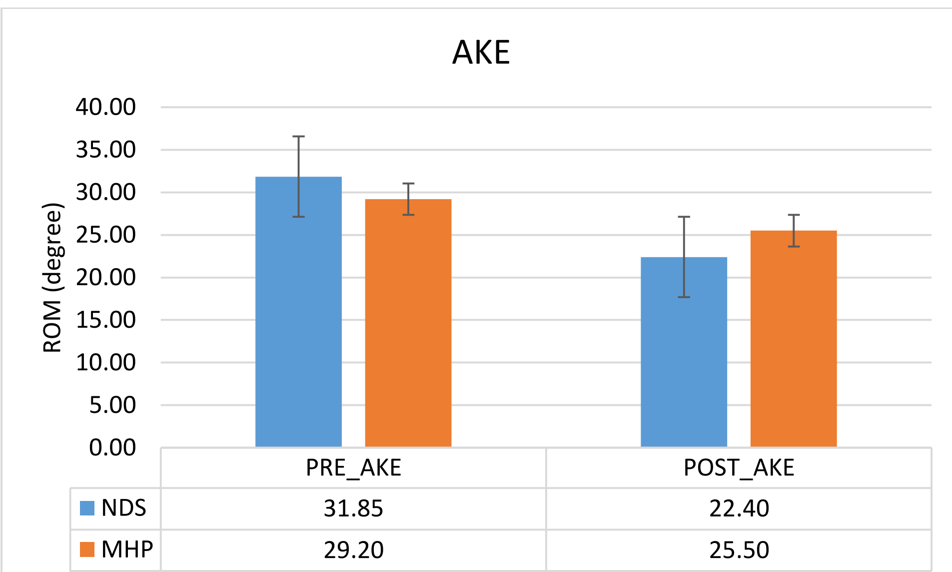


	PRE_SLR	PRE_AKE	PRE_SST	PRE_mSEBT_AN	PRE_mSEBT_PM	PRE_mSEBT_PL	PRE_mSEBT_NS_AN	PRE_mSEBT_NS_PM	PRE_mSEBT_NS_PL	PRE_mSEBT_CS
NDS	70.60	31.85	14.5	110.90	108.40	105.85	124.00	121.27	118.36	121.21
MHP	72.60	29.20	12.70	114.40	109.25	108.60	129.47	123.64	122.96	125.36

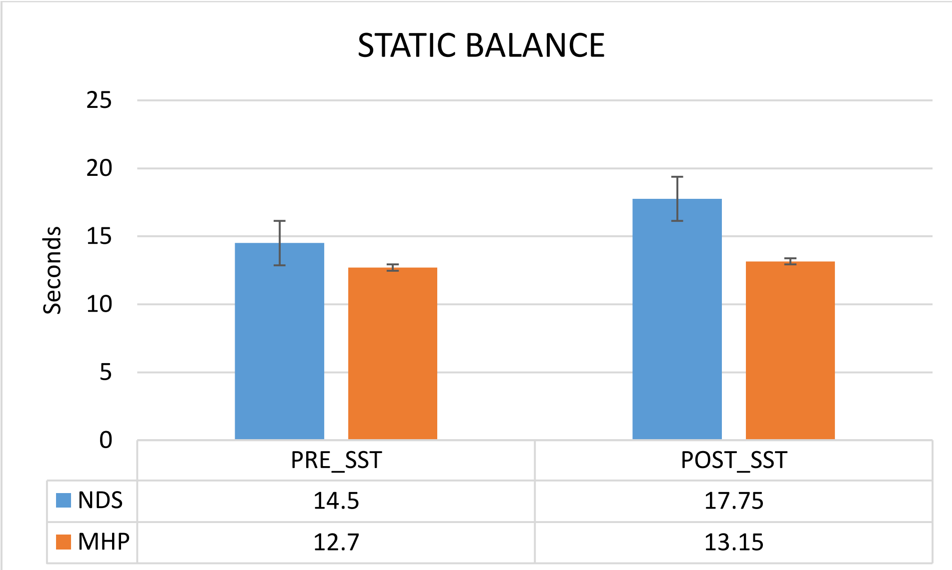
Graph 1: Baseline comparison of all outcome measures for group 1(NDS) and 2 (MHP).



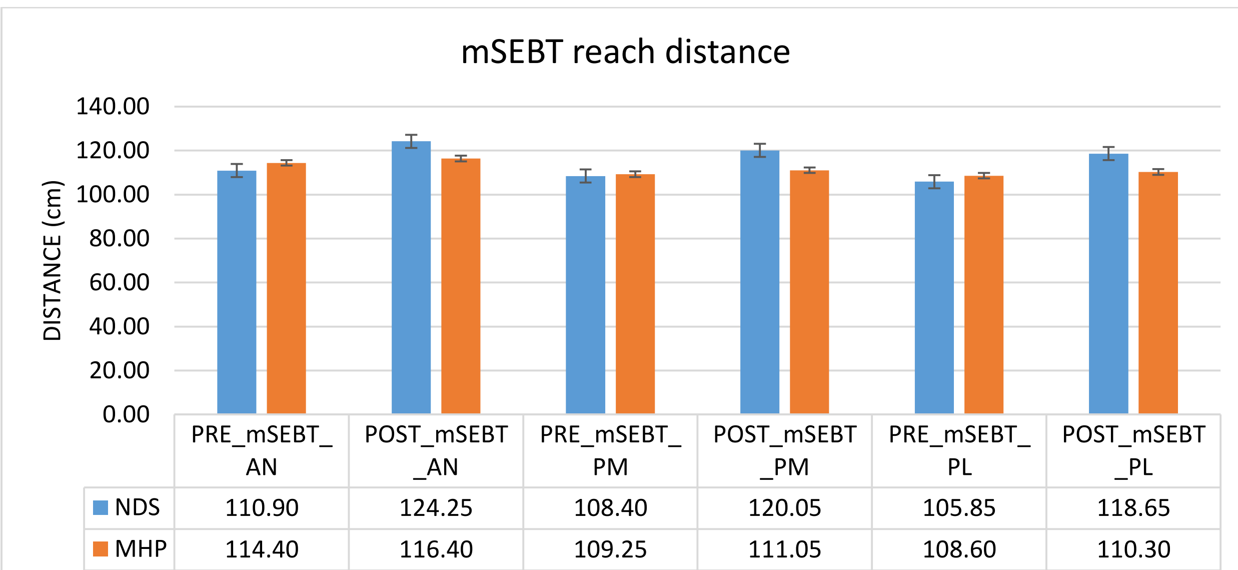
Graph 2: Comparison of pre and post SLR for measuring hamstring flexibility between groups.



Graph 3: Comparison of pre and post AKE for measuring hamstring flexibility between groups.



Graph 4: Comparison of pre and post SST for measuring static balance between groups.



Graph 5: Comparison of pre and post mSEBT for measuring dynamic balance between groups.

DISCUSSION

In the present study, we investigated the immediate effects of the application of neurodynamic sliding on hamstring flexibility and static and dynamic balance of the lower limb among athletes. We observed that NDS significantly ($p<0.05$) improved the hamstring flexibility as measured by SLR and AKE, as well as static balance as evaluated using the stork stand test. In addition, dynamic balance measured using the mSEBT revealed significant improvement in anterior, postero-medial and postero-lateral direction ($p<0.05$). The mSEBT normalized scores for postero-medial direction and composite score significantly improved ($p<0.05$) in the NDS group compared to the control group whereas no significant improvement was observed in mSEBT normalized scores for anterior and postero-lateral direction (p>0.05).

Various stretching techniques (Borges MO et al,2018; Medeiros DM et al,2016) and neurodynamic exercises (López LL et al,2019) have been shown to significantly increase the range of motion, according to a large body of research. Improved flexibility can significantly affect both daily activities and athletic performance. Implications of stretching and neurodynamics on other components of health, such as balance, are less well understood. There is a dearth of research on the efficiency of neurodynamic intervention in enhancing balance, and the results of this study can be added to the growing body of knowledge concerning the potential role of neural tissue mechanosenstivity in improving balance.

Neurodynamic sliding technique has been proven to be effective in increasing the flexibility of hamstrings (Satkunskiene D et al, 2020; Anandhraj J et al, 2020; Jung JH et al, 2021; Ridder RD et al, 2020; López LL et al, 2019; Golhar et al 2017; Ahmed AR et al, 2016; Babu VK et al, 2015; Castellote- Caballero et al, 2014, Méndez-Sánchez R et al, 2010) and enhancing balance among athletes (Mahajan R et al, 2022), elderly population (Roy S et al, 2021) and healthy adults (Park JM et al, 2014).

The underlying mechanism that accounts for increase in hamstring flexibility after application of neurodynamic sliding technique is attributed to the regain in the mobility and elasticity of nervous system by improving axoplasmic flow and restoring nerve tissue homeostasis (Jung JH et al, 2021; Castellote- Caballero et al, 2014). Neurodynamic sliding leads to decreased mechanosensitivity of the neural tissue that results in changes in neurodynamics and the perception of stretch, pain, muscle activation, optimization of muscle function and improvement in balance (Mahajan R et al, 2022; Roy S et al, 2021; Park JM et al, 2014). NDS affects the extraneural interface and provide linear excursion of the sciatic nerve which may prevent the adhesions between neural and surrounding tissue, limiting the neural tissue excursions, thus leading to a decrease in neural mechanosensitivity and an increase in neural tissue viscoelasticity, resulting in increase in hamstring mobility (Basson A et al, 2017; Ellis RF et al, 2008; Coppieters MW et al, 2008). The longitudinal excursion and strain related to a specific joint movement are significantly influenced by the location or concurrent movement of an adjacent joint. When movements that increase and decrease the length of the nerve bed are performed concurrently at adjacent joints, nerve gliding occurs with a nearly negligible increase in nerve strain (Coppieters MW et al, 2008).

Balance is the process of achieving and maintaining continuous postural stability, and it is comprised of interactions between reflective posture and voluntary movement (Bloem BR et al, 2000; Shiratori T et al, 2000). Most of the daily activities require balance, and both static and dynamic balance impairments relate to falls and injuries.

The underlying mechanism that accounts for improvement in static and dynamic balance in NDS group is due to enhanced proprioceptive input by stimulation of joint mechanoreceptors. The intrafusal muscle fibres, golgi tendon organs, and other proprioceptors plays role in maintaining balance and proprioception. The ability to perceive (afferent proprioception) and respond (efferent muscle activation) to changes in the immediate surroundings is altered by acute changes in muscle tendon unit length, stiffness, force output, and muscle activation, as a result, balance is affected (Nashner L. M., 1976; Lim KI et al, 2014). Stimulation of joint mechanoreceptors increases proprioception input, which leads to an increase in balance. (Lim KI et al, 2014; Filipa A et al, 2010). Furthermore, the gains in static and dynamic balance is considered to be the consequence of the enhancement of muscle performance and activation of muscle. Also, the lengthening of the hamstring muscle may have contributed to the increase in reach distance, which is indicated by increase in the dynamic balance.

Heat is believed to alter the viscoelastic properties of collagenous tissues. Reduced stiffness, greater viscous mechanical behaviour, improved neuromuscular control, retention of oxidative metabolism, and other positive temperature effects in the control group are potential mechanisms contributing to improved outcomes following MHP application. (Oranchuk DJ et al,2019; Bleakley CM et al,2013).

Limitations of the study

First, it is difficult to generalize the findings due to the small sample size. Second, determining the long-term effects of neurodynamic sliding on balance is somewhat difficult because the immediate effects were observed in present study. Determining the long term effects would have helped to find the maintenance of the improved outcome measures.

Future scope of the study

Future scope includes determining the long-term effects of neurodynamic sliding on hamstring flexibility and static and dynamic balance using a larger sample size of athletes. Further studies are needed to find the effects of NDS in conditions with secondary hamstring tightness.

CONCLUSION

NDS is effective in improving the hamstring flexibility and static and dynamic balance among athletes. Therefore, it is recommended that neurodynamic sliding should be added in the pre-participation warm-up to improve pre-competition flexibility and balance, hence preventing injuries and improving athletic performance. To understand the technique's effectiveness for its long-term effects and its application in various sporting contexts, more research in this area is necessary.

CONFLICTS OF INTERESTS

There is no potential conflicts of interest in the development and publication of this article.

LIST OF ABBREVIATIONS

AKE: Active knee extension
AN: Anterior
BMI: Body mass index
CS: Composite score
Kg: kilogram
m^2: Meter square
MHP: Moist heat pack
mSEBT: Modified star excursion balance test
mSEBT_AN: mSEBT distance in anterior direction
mSEBT_CS: mSEBT composite score
mSEBT_NS_AN: mSEBT normalized score in anterior direction
mSEBT_NS_PL: mSEBT normalized score in postero-lateral direction
mSEBT_NS_PM: mSEBT test normalized score in postero-medial direction
mSEBT_PL: mSEBT distance in postero-lateral direction
mSEBT_PM: mSEBT distance in postero-medial direction

MTU: Muscle tendon unit
NDS: Neurodynamic sliding
NS: Normalized score
PAR-Q: Physical Activity Readiness Questionnaire
PL: Postero-lateral
PM: Postero-medial
ROM: Range of motion
SD: Standard deviation
SLR: Straight leg raise
SST: Stork stand test

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