IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

"EFFECTIVENESS OF SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE ON HAMSTRING FLEXIBILITY AND AGILITY – AN EXPERIMENTAL STUDY

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Abstract:

Background & Purpose: Recent studies have introduced "Anatomy Trains" concept, the sub-occipital and hamstring musculature are included in the superficial back line. If any tensions arise in that myofascial chain, it will result in hamstring tightness and release of the tension may help to elongate the muscle. Suboccipital Muscle Inhibition Technique (SMI) is a new intervention targeting suboccipital muscles for improving hamstring flexibility. This technique may add new dimensions to traditional treatment. The objective of the study was to compare the immediate effect of suboccipital muscle inhibition technique with static stretching and static stretching alone on hamstring flexibility and agility in persons with hamstring tightness.

Methods: 116 subjects having hamstring tightness within the age group of 18-40 years were randomly divided into two groups (58 in each). Group A received sub occipital muscle inhibition technique and static stretching and Group B received static stretching. The subjects were evaluated for outcome measures with Active Knee Extension test, Back Saver Sit and Reach test and Finger to Floor test for hamstring tightness and ILLINOIS AGILITY TEST test for agility. All the parameters were measured before and immediately after the treatment intervention.

Results & Conclusion Results of present study demonstrated that there was significant increase in Hamstring flexibility and functional performance in both the groups ($p<0.05$) immediately post intervention. When the two groups were compared, Hamstring flexibility improved more significantly ($p<0.05$) in group A than group B while improvement in agility was not significantly different ($p>0.05$) between the groups. Thus, from the present study it can be concluded that SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE should be incorporated along with static stretching technique to improve hamstring muscle flexibility and agility in healthy young adults.

Keywords: Functional Performance, Hamstring Flexibility, RCT, Suboccipital Muscle Inhibition Technique

INRODUCTION

Mobility is ability of body structures or segments of the body to move or to be moved to allow the presence of range of motion (ROM) for functional task and activities. Mobility is related with joint integrity as well as flexibility in relation to functional ROM.[1] The extensibility of soft tissue that cross or surrounds joints-muscles, tendons, fascia, joint capsule, ligaments, nerves, blood vessels, skin which altogether comprises human body is termed as flexibility. Muscles have a very important role in maintaining mobility across the joints in the body. The properties of contractility, extensibility and flexibility of a muscle affect the range of motion of joints that are crossed by them.[2] Flexibility is the ability to move a single joint or series of joints smoothly and easily through an unrestricted, pain-free range of motion.[1] It is an important component of physical conditioning program along with muscle strength and endurance training. Flexibility allows tissue to accommodate more easily to stress, to dissipate shock impact and improve efficiency and effectiveness of movement that helps in minimizing or preventing injury.[3]

Flexibility of a muscle is related to the extensibility of musculotendinous units that cross a joint, based on their ability to relax or deform and yield to a stretch force.[4] To carry out everyday task, it required to have flexibility and compatibility of soft tissue that cross or surround joints such there is unrestricted, pain- free movements of the body. Various other factors like age, gender and warm up also contribute to flexibility.[1]

Reduced extensibility of the muscle causes muscle tightness. This reduced extensibility of muscles i.e., muscle tightness denotes adaptive shortening of the contractile and non-contractile elements of muscle.[1] Muscle length (tightness) in conjunction with joint integrity and the extensibility of periarticular soft tissues determine flexibility.[1] Muscle Tightness has also been used to denote a decrease in muscle length; usually limiting movement in the direction of theelongating muscle. [5]

Muscle tightness results due to inadequate or improper rehabilitation following sustained muscle injury or low levels of physical activity in individuals.[5] Muscles in the lower extremity which are most liable to tightness are Gastrocnemius, Soleus, Tibialis posterior, Rectus Femoris, Iliopsoas, Tensor fascia lata, Hamstrings and the short adductors.[6] Hamstring muscle has tendency to shorten even under normal circumstances. It may become very tight leading to muscle imbalance, which can give rise to number of problems and thus result in muscle injury.[3] The tightness of hamstring muscles is one of the main factors hindering performance in daily and sporting activities. Reduction in the flexibility of the hamstrings is reported to increase risk of damage to the musculoskeletal system and affect functional performance. Thus, flexibility of the hamstrings is important for general health and physical fitness.[7,8]

In a study conducted by **Akinpelu AO, Bakare U, Adegoke BOA (2005),** it was observed that hamstring tightness was present in all age groups which tended to increase till the age of 40-49 years. In the same study, results also proved that males recorded higher values of hamstring tightness compared to their female counterparts across the age groups.[5]

Bhagyashree K. Koli and Deepak B. Anap (2018), conducted a study among college students and concluded that prevalence of hamstring tightness is very high in college going students of age group 18-25 years.[9]

Tightness could also lead to some pathological conditions at the joint on which the muscle acts, especially in a muscle like the hamstrings which passes over two joints. Tight hamstrings increase the patella-femoral compressive force because of increased passive resistance during the swing phase of functional activities like ambulation and running.[5] Inadequate hamstring flexibility can cause low back pain, alter the lumbar pelvic rhythm, posterior pelvic tilting, reduce lumbar lordosis, decrease lumbar and thoracic flexion, may increase chances of lower extremity injuries, hamstring strains, patellofemoral pain and also affect the posture and gait.[3]

F. Garcia-pinillos, A. Ruiz-Ariza et al (2015) observed that Hamstring flexibility is a key factor for carrying out sprinting, jumping, agility tasks and kicking in young football players.[10]

Thus, to prevent all the above mentioned conditions, flexibility of the hamstrings is important for general health, physical fitness and functional performance.[7,10]

Functional performance includes various elements such as strength, endurance, power, speed, balance, reaction time, flexibility and agility. Strength is defined as maximum amount of force one can generate during a specific movement pattern, at a specified velocity of muscle contraction. Endurance is the ability to sustain performance and resist fatigue. Power is the rate of performing work. Speed is capacity of an individual to perform given activity as rapidly as possible. Balance is ability of an individual to maintain equilibrium while performing activity. Reaction time is ability of an individual to respond rapidly to a stimulus. Flexibility is ability of joint to move freely in its ROM. Improving joint flexibility helps to reduce injury risk, enhance muscle balance and function and boost performance.[11] Agility has been defined as the ability to maintain a controlled body position and rapidly change direction without a loss of balance, body control or speed.[12] Agility is one of the most commonly used parameters to assess functional performance in young healthy adults and athletes Agility has been used as a measure of functional performance, after intervention to improve muscle flexibility, in many studies.

To improve hamstring flexibility several different interventions have been studied and practiced. These include soft tissue mobilization techniques, static, ballistic and proprioceptive neuromuscular facilitation stretching techniques, muscle energy technique, Mulligan bent leg raise techniques, eccentric training etc.[13]

Stretching is the most commonly performed intervention for treating muscle tightness and is believed to increase muscle extensibility, prevent injury and assist in rehabilitation following musculoskeletal injury.[14] Several studies have proved that flexibility of the hamstrings is usually improved by stretching. Stretching is a commonterm used to describe any technique to increase the elasticity of soft tissues which willlengthen structures that have become short and hypomobile over time.[1]

The commonly used stretching techniques are Static stretching, Ballistic stretching, Dynamic stretching, Various proprioceptive neuromuscular facilitation techniques. **Diulian M. Medeiros et al (2016),** conducted systematic review and meta-analysis on influence of static stretching on hamstring flexibility in healthy young adults in which they concluded that static stretching was successful in increasing hamstring flexibilityin healthy young adults.[15]

Recent studies have reported that flexibility of the hamstrings increased as a result of an intervention targeting the sub occipital muscles.[3,16,17,18,19] According to the concept of "Anatomy Trains", human body is connected through fascial linkages i.e. there are different lines according to the fascial connectivity. It includes superficial back line, deep back line, superficial front line, deep front line, lateral line and oblique line. The sub-occipital and hamstring musculature are included in the superficial back line. [20]

There are many techniques described to improve flexibility of hamstrings by working on sub occipital muscles which include inhibition, stretching, myofascial release and muscle energy techniques. Among the methods mentioned above, sub occipital muscle inhibition technique has been found to produce immediate effects on improving flexibility of hamstrings.[16,17,18,21,22] The sub occipital muscle inhibition (SMI) technique is a method of relaxing tension in the four muscles sub occipital muscles i.e.rectus capitis posterior major, rectus capitis posterior minor, obliqus capitis inferior, and obliqus capitis superior which are located between the occiput and axis.[18] Though, the effect of SMI technique has been studied in isolation, there is paucity of studies which have considered a combination of both Static Stretching and Sub occipital muscle inhibition technique together to improve hamstring flexibility and functional performance.

To our knowledge, there has been no study published which compares a combinationof both Static Stretching and Sub occipital muscle inhibition technique, and Static Stretching alone on Hamstring flexibility and agility in subjects with Hamstring tightness. Therefore, this study was aimed to determine the effectiveness of sub occipital muscleinhibition technique on hamstring flexibility and agility.

AIM

To study the effectiveness of sub occipital muscle inhibition technique onhamstring flexibility and agility.

OBJECTIVES

1. To study effect of static stretching on hamstring flexibility and agility.
2. To study effect of sub occipital muscle inhibition technique with static stretching on hamstring flexibility and agility.
3. To compare effect of static stretching alone and sub occipital muscle inhibition technique with static stretching on hamstring flexibility and functional performance agility.

HYPOTHESIS

Null hypothesis: There is no added effect of Sub occipital muscle inhibition technique along with static stretching on hamstring flexibility and agility.

Experimental hypothesis: There is added effect of Sub occipital muscle inhibition technique along with staticstretching on hamstring flexibility and functional performance agility.

METHODOLOGY

- **Study Design:** Pre-post experimental study
- **Study duration:** 6 months.
- **Sampling Technique:** Convenient Smapling
- **Sample Size:** 126 (63 in each group)

The sample size was estimated using G Power 3.9.1 version at 95% confidence interval and 80% power of study by mean difference method taking into consideration mean difference and standard deviation values from the pilot study

The sample size was calculated as 57 in each group so total sample size was calculated to be 57x2 = 114. Therefore, sample size is 114 (57 in each group). Assuming the non-response rate 10% of the sample size, number of non-responses is 6 in each group.
Corrected sample size was 126.

- **Inclusion Criteria:**

  - Subjects having hamstring muscle tightness. On Active knee extension test, knee flexion angle of 15 degrees and more.
  - Males or females of 18-35 years of age.
  - Subjects giving their consent to participate.

- **Exclusion Criteria:**

  - Subject having history of any musculoskeletal, neurological and cardio-respiratory pathologies.
  - Subject having history of any neck pathologies.
  - Subject having history of any vestibular disorders.
  - Subject participating in fitness program

PROCEDURE

- The individuals were included in the study after screening for inclusion and exclusion criteria.
- The purpose of the study and study procedure was explained to all participants.
- Written informed consent was obtained from individuals participating in the study.
- Data record sheet included the demographic details of participants was filledin case record form.
- Subjects were tested for hamstring tightness using Active knee extension test, Back saver sit and reach test and Finger to floor test.
- Subjects were tested for functional performance using Illinois agility test.
- Findings obtained were recorded in case record form.
- The following outcome measures were evaluated pre and post intervention:

OUTCOME MEASURES

1. Active Knee Extension Test (AKE) [23,24,25]
2. Back Saver Sit And Reach Test (BSSRT) [26,27]
3. Finger To Floor Test [28,29]
4. Illinois Agility Test[30,31,32]

INTERVENTION

Group A received static stretching and suboccipital muscle inhibition

- **Static Stretching**

  - Patient position: supine lying.
  - Therapist position: Besides patient.
  - The subject was in supine lying, the therapist supported the subject's lower leg with arm or supported the leg over the therapists shoulder. The contralateral extremity was stabilised along the anterior aspect of thigh with the knee in extension and the hip in neutral rotation. The ipsilateral limb was flexed from the hip passively and maintained at a position of tissue resistance. 3 repetitions with 30 seconds hold were given 3 times/week for 2 weeks.[1,15,23]

- **Suboccipital muscle inhibition technique**

  - Patient position: supine lying.
  - Therapist position: Sitting position at head end of the patient.
  - The subject was in supine lying with eyes closed. The therapist placed her hands belowthe subjects occiput and applied pressure to the area below the atlas which is the first cervical spine, in upward direction and towards the subjects nose, towards herself and in the direction of the subjects head. The sub occipital muscle inhibition technique was applied for 5 minutes. A single session of SMI was given 3 times per week for 2 weeks[16,17]

Group B received static stretching: Static stretching was given as per the guidelines mentioned for group A.

DATA ANALYSIS

- The data was entered using Microsoft Excel 2007, and it was analysed using SPSS version 15.
- Normality was assessed using the one-sample Kolmogorov-Smirnov test.
- Parametric tests were used whenever data passed the test of normality. Non-parametric tests were used whenever data did not pass the test of normality.
- Within the group analysis: Paired t test and Wilcoxon signed Ranks test were used for comparison of means within the group.
- Between the groups Analysis: Unpaired t test and Mann Whitney U test were used for comparison of mean difference between the groups.
- P value less than 0.05 was considered as statistically significant.

RESULTS

- Statistically significant difference (improvement) in Rt. and Lt AKE angles was observed in group A (SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING) post intervention.
- Statistically significant difference (improvement) in Rt. and Lt AKE angles was observed in group B (STASTIC STRETCHING) post intervention.
- On comparison between both groups for Rt. And Lt AKE angles, statistically significant difference was observed with mean value for SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING group being higher.
- Statistically significant improvement in Rt. And Lt BSSRT was observed in group A (SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATICSTRETCHING) post intervention.
- Statistically significant improvement in Rt. And Lt BSSRT, was observed in group B (STATIC STRETCHING) post intervention.

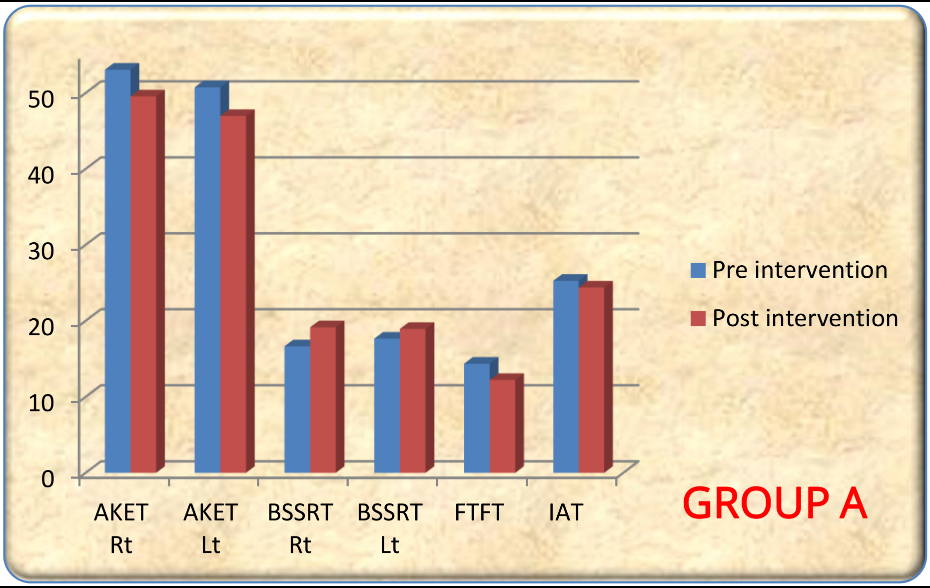
- On comparison between both groups for Rt. And Lt BSSRT statistically significant difference was observed with mean value for SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING group being higher.
- Statistically significant improvement in the FTFT was observed in group A (SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING)post intervention.
- Statistically significant improvement in the FTFT was observed in group B (STATIC STRETCHING) post intervention.
- On comparison between both groups for FTFT, statistically significant difference was observed with mean value for SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING group being higher.
- Statistically significant improvement in the IAT was observed in group A (SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING)post intervention.
- Statistically significant improvement in the IAT was observed in group B (STATIC STRETCHING) post intervention.
- On comparison between both groups for IAT, there was no statistically significant difference observed.

Table-1: Comparison of Demographics and pre outcome values between the groups.

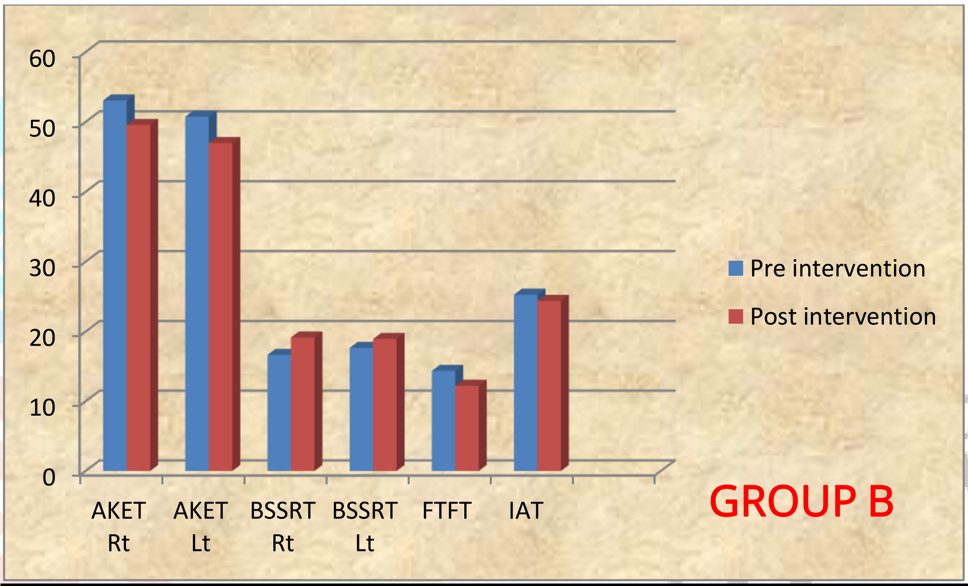
VARIABLE	**GROUP A**	**GROUP B**	**P value**
	Mean ± SD	**Mean ± SD**	
AGE	21.31±2.37	20.91±2.23	0.3856
BMI	23.2±4.4	23.74±4.4	0.593
AKET Rt	52.41±5.49	53.06 ±4.45	0.4883
AKET Lt	50.81 ±5.86	50.74±6.52	0.952
BSSRT Rt	16.29 ±6.7	16.65 ±6.5	0.7488
BSSRT Lt	16.79 ±7.7	17.66 ±6.2	0.6475
FTFT	16.77 ±8.0	14.36 ±7.47	0.0961
IAT	25.66 ±2.79	25.27 ±2.99	0.4669

Table-2: Comparison of pre and post intervention outcome values within the group.

VARIABLES	**GROUP A**		**P value**	**GROUP B**		**P value**
	Pre intervention (Mean ± SD)	**Post intervention (Mean ± SD)**		**Pre intervention (Mean ± SD)**	**Post intervention (Mean ± SD)**	
AKET Rt	52.41±5.49	43.84 ±5.9	< 0.0001	53.06 ±4.45	49.55±5.6	< 0.0001
AKET Lt	50.81 ±5.86	41.74 ±5.73	< 0.0001	50.74±6.52	46.97±6.39	< 0.0001
BSSRT Rt	16.29 ±6.7	20.28 ±7.4	< 0.0001	16.65 ±6.5	19.15 ±6.26	< 0.0001
BSSRT Lt	16.79 ±7.7	20.99 ±7.6	< 0.0001	17.66 ±6.2	18.94 ±6.3	< 0.0001
FTFT	16.77 ±8.0	12.29 ±8.3	< 0.0001	14.36 ±7.47	12.22 ±7.64	< 0.0001
IAT	25.66 ±2.79	24.39±2.81	< 0.0001	25.27 ±2.99	24.39 ±2.86	< 0.0001



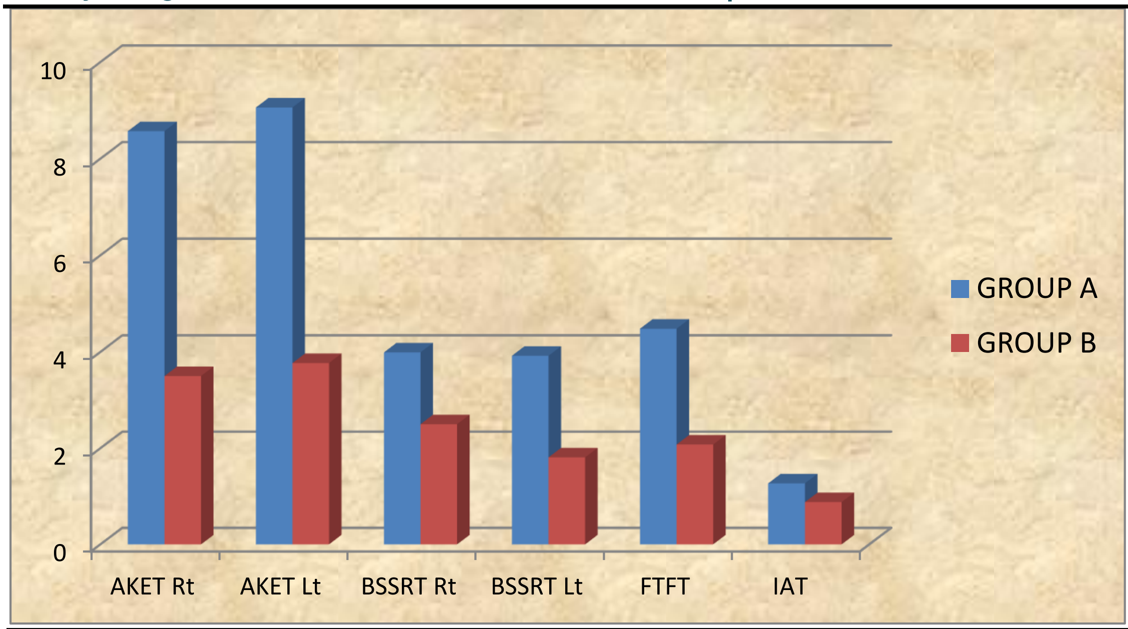
Graph – 1 Comparison of pre and post intervention outcome values of group A.



Graph-2: Comparison of pre and post intervention outcome values of group B.

Table-3: Comparison of pre-post difference of outcome values between groups.

VARIABLE	GROUP A Pre-post diff Mean ± SD	GROUP B Pre-post diff Mean ± SD	P value
AKET Rt	-8.57±5.44	-3.50±5.13	< 0.0001
AKET Lt	-9.06 ±4.98	-3.77±3.5	< 0.0001
BSSRT Rt	3.99±2.58	2.50±1.86	< 0.0001
BSSRT Lt	3.92 ±2.75	1.81±1.73	< 0.0001
FTFT	-4.48 ±1.6	-2.077 ±3.81	< 0.0001
IAT	-1.27 ±11.73	-0.88±0.83	0.1008



Graph-3 Comparison of pre-post difference of outcome values between groups.

DISCUSSION

The present study was undertaken to investigate the effect of sub occipital muscle inhibition technique and static stretching on hamstring flexibility and agility in young healthy adults. Age, gender and BMI were similarly distributed between the two groups. Group A (SUB OCCIPITAL MUSCLE INHIBITION TECHNIQUE and STATIC STRETCHING) consisted of 51 females and 12 males with mean age of 21.31 $\pm$ 2.37 years and mean BMI of 23.2 $\pm$ 4.4 Kg/cm^2. Group B (STATIC STRETCHING) consisted of 49 females and 14 males with mean age of 20.91$\pm$ 2.23 years and mean BMI of 23.74 $\pm$ 4.4 Kg/cm^2.

In a study conducted by **William D Bandy and Jean M Irion et al. (1994),** they have explained that 30 seconds of static stretch is as effective as 60 seconds of static stretchin improving flexibility of the hamstring muscles. In addition, there was no difference between stretching one or three times/ day using either 30 or 60 seconds duration ofstretching.[33]

The acute effect of different time periods of passive static stretching on hamstring flexibility was study conducted by **Cini A, De Vasconcelos GS et al (2017),** They inferred that 30 seconds of stretching was sufficient for increasing hamstring flexibilityof young women.[34]

Statistically significant improvement in Hamstring flexibility was noted in subjects treated with STATIC STRETCHING in Group B. (Table no. 7, 8, 11, 12, 14; Graph no. 4c,4d, 5c, 5d, 6b).

The mechanism of static stretch for improving flexibility could be change in the viscoelastic properties of the muscle. **Kubo Keitaro, Hiroaki Kanehisa et al (2001),** in their study explained that static stretching decreases muscle stiffness by decreasing the viscosity of tendon and increasing its elasticity. An immediate increase in muscle length after static stretching occurs due to this viscous behaviour.[35] Another proposed theory suggested that when muscle is stretched and elongated, stretch force is transmitted to muscle fibres via connective tissue (endomysium and perimysium) i.e., molecular interactions link the non-contractile elements to the contractile unit of muscle, the Sarcomeres. When initial lengthening occurs in the series elastic component (connective tissue), tension rises sharply. After a point, there is mechanical disruption of cross bridges as the filaments slide apart (influenced by neural and biomechanical changes), leading to abrupt lengthening of the sarcomeres referred to as sarcomere give. After releasing stretched force sarcomeres returns to resting length. Tendency of muscle to return to its resting length after short-term stretch is called elasticity. When a stretch is applied for an extended period of time, the tissue elongates, resulting in permanent deformation. It is related to the viscosityof the tissue and is time-dependent.[1]

Golgi tendon organ is stimulated when small bundle of muscle fibers is “tensed” by contracting or stretching the muscle i.e. the tendon detects muscle tension. Increased tension in muscle stimulates its Golgi tendon organs, signals are transmitted to the spinal cord to cause reflex that is inhibitory in response. This prevents the development of too much tension in the muscle. When tension on the muscle followed by tendon becomes extreme, the inhibitory effect from the tendon organ increases which leads to a sudden reaction in the spinal cord that causes instantaneous relaxation of the entire muscle. This effect is called the lengthening reaction. [36]

However, most static stretching intervention studies report an increase in ROM due to an increase in stretch tolerance (ability to withstand more stretching force), not extensibility (increased muscle length). **Phil Page (2012),** suggested static stretching often results in increases in joint ROM. According to him, increase in ROM may not be caused by increased length (decreased tension) of the muscle; but rather due to an increased tolerance to stretching.[37] **Diulian M. Medeiros et al (2017),** conducted systematic review and meta-analysis on influence of static stretching on hamstring flexibility in healthy young adults in which they observed that static stretching was effective in increasing hamstring flexibility in healthy young adults.[15] In study conducted by **Ruhi Pereira, Annamma Varghese (2017),** they concluded that Hamstring flexibility was increased immediately after static stretching intervention in basketball players.[38] **Yuichi Nishikawa, Junya Aizawa et al (2015),** compared immediate effect of passive and active stretching on hamstrings flexibility and they concluded that passive stretching was more effective than active stretching at achieving an immediate increase in hamstring flexibility.[7] **D. Scott Davis, Paul E. et al (20005),** studied effectiveness of 3 stretching techniques on hamstring flexibility and they concluded that static stretching increased hamstring length in young healthy subjects more than active self-stretching and PNF- stretching.[39]

Statistically significant improvement in hamstring flexibility was noted in subjects in Group A. A possible explanation for improvement in flexibility of hamstring muscle is the additional effect of suboccipital muscle inhibition technique over static stretching.The possible explanation of suboccipital muscle inhibition technique for improving flexibility could be Myofascial chain connection and dural mechanism. [3,18,19,20,21,40] Superficial back line is a cardinal line primarily mediating posture and movement in sagittal plan. It connects the entire posterior surface of the body from bottom of the foot to the top of the head. There are two superficial back lines one on the right and one on the left. It is to support the body in full upright extension, to prevent the tendency to curl over into flexion. The sub-occipitals and hamstring musculature are included in the superficial back line.[20] If any tensions arise in that myofascial chain, it will result in hamstring tightness.[21] As, suboccipital muscle and hamstring muscles are included in superficial back line, addressing any of the structures in superficial back line may cause positive effect of entire line itself.[3] **Schleip,** observed that if the tension of the suboccipital muscle decreases, the length of the hamstring muscles increases.[18] Release of suboccipital muscle fascia allows tension reduction in the knee flexors (hamstring muscles).[18]

The dura attaches to the circumference of the foramen magnum and the posterior aspect of the vertebral bodies of C1 and C2. There are also secondary attachments by fibrous slips to the posterior longitudinal ligament (PLL), especially in the lower lumbar spine. At the second sacral tubercle, the subdural space ends and the dura extends as the filum terminale to end at the coccyx. Laterally, the dura engulfs the existing spinal nerve roots at the level of the intevertebral foramen. There are three areas of the spine where the dura is tethered to the bony canal, and these are called tension sites. The sites are located at C6, T6, and L4. The sites limit the dural movement between sites so that the dura does not float freely through the vertebral canal. This tethering provides stability to spinal cord. One of the functions of dural tissue is to adapt to changing lengths of the vertebral canal during movement.[19]

Hack et al (1995), provides evidence for a direct linkage between a cervical extensor muscle i.e. suboccipital muscle (rectus capitus posterior minor) and the dura mater.[40] The sub-occipital muscles attach from Spinous Process and Transvers Process of C2 to the TP of C1 and the superior nuchal line of the occipital bone.[2] Obstruction to movement of the dura along its attachment sites, can potentially affect the range of movement available to the lower limb. Release applied to the suboccipital muscles initiates inhibitory reflexes relaxing the agonists, causing a relaxation of the suboccipital muscles.[19] Release of sub-occipital muscles is believed to cause an increased length of dura, therefore increasing the ROM available to the lower limb. **Erika Quintana Aparicio et al (2009),** studied the immediate effect of the suboccipitalmuscle inhibition technique in the subject with short hamstring syndrome and concluded that SMI technique modifies hamstring muscle length.[18]

In the study conducted by **Sung-Hak CHO et al (2015),** to compare immediate effect of SMI and self-myofascial release technique in suboccipital region on short hamstring, they concluded that SMI and self-myofascial release technique immediately increased hamstring muscle flexibility. However, Sub occipital muscle inhibition was better for improving hamstring muscle flexibility due to relaxation of superficial back line as a result of relaxing the suboccipital muscles.[16] **Pramod K. Jagtap, Shubhangi D. (2015),** studied the effect of sub occipital muscle inhibition technique immediately post intervention and at the end of 5th session on hamstring tightness patients, they concluded that Sub occipital muscle inhibition waseffective in improving the flexibility of hamstring muscles by using Active knee extension and Finger to floor distance test.[17] **Nilam Dave, Tushar Palekar and Soumik Basu (2017),** compared individual and combined effect of Sub occipital muscle inhibition and Doming of diaphragm technique for hamstring tightness, and they concluded that individual as well as combination of sub occipital Muscle Inhibition technique and Doming of Diaphragm technique helped in immediate improvement of hamstring flexibility in subject with hamstring tightness.[22] **Razouvohu and Saravana Hari Ganesh (2017),** compared effect of Neurodynamic sliding versus sub occipital Muscle Inhibition technique on hamstring flexibility in asymptomatic subjects with hamstring syndrome and concluded that both techniqueswere effective in immediate improvement of hamstring flexibility.[21]

Statistically significant improvement in agility was noted in both the groups. **Alexandra Avloniti et al (2015),** suggested that Static Stretching of short duration (<30sec) may actually improve acute speed performance.[41] Since speed is a component of agility[13] which improves with static stretching, it can be hypothesized that with static stretching there can be an improvement in agility performance.**John-Paul Favero, Adrian W. Midgley et al (2009),** stated that baseline flexibility may have implications for the efficacy of stretching and subsequent dynamic athletic performance. They suggested that static stretching may have a tendency to enhance sprint performance in individuals with low baseline levels of flexibility in lower limb muscles.[42] **Abbas Asadi (2016),** studied relationship between jumping ability, agility and sprint performance of elite young basketball players and suggested that sprint, agility and jumping ability share common physiological and biomechanical determinants.[43] Since static stretching improves sprint performance in individuals with low baseline levels of flexibility in lower limb muscles, it may also improve the agility performance. The inclusion criteria for this study was hamstring muscle tightness, with knee flexionangle of 15 degrees and more on Active knee extension test i.e. their baselinehamstring flexibility was reduced. As, agility and sprint performance are interlinked, it can be hypothesized that improvement in flexibility may lead to an improvement in agility performance with static stretching. This may be one of the reasons for improved performance on agility test.

Starling law states that, within physiological limits, the force of muscle contraction is directly proportional to the initial length of the muscle fibers.[44] As flexibility (length) of hamstring muscle improved following stretching intervention, it could have led to increased force production resulting in improved agility performance. Another explanation for the improvement in agility could be a "practice effect". The agility test was conducted once pre intervention and post intervention, within a period of 20 mins. Hence, the improvement in agility time could have been due to the pre- intervention agility assessment which acted as a practice trial for the post interventionagility assessment.

In contrast with the results of current research, many studies have recorded deteriorative effect of static stretching on agility performance, **Evan Peck, Greg Chomko et al (2014),** reviewed the effects of stretching on performance. They concluded that, dynamic stretching generally can be recommended in the period immediately prior to activity for most athletes while static stretching and PNF stretching probably are reserved best for the period after activity, if used. If static stretching or PNF are used prior to activity, they probably should be followed by an intervening sufficient period, dynamic stretching session, or general warm-up prior to the activity to dissipate any potential negative effects on performance.[45]

There is paucity of literature related to effect of suboccipital muscle inhibition technique on agility. However, the improvement in hamstring muscle flexibility (length) post intervention could have contributed to improved force production leading to improvement in agility performance.[44] There was no significant difference in Functional performance between the groups The possible explanation is the significantly better improvement of hamstring flexibility (length) for group A due to the combined effect of both techniques. This could have led to better force production in the muscle (According to Starling's law) resulting in better agility performance in group A. However, the improvement did not reach significant values.

LIMITATIONS AND SUGGESTIONS

- SMI can be compared with other different types of stretching techniques like dynamic stretching, PNF stretching techniques etc to evaluate and treat othermuscles in the body.
- Long term effect of SMI technique on hamstring flexibility and Agility performance can be assessed.
- Future studies should consider different populations. For e.g., athletes.

CONCLUSION

The present study conclude that sub occipital muscle inhibition technique should be incorporated along with static stretching technique to improve hamstring muscle flexibility and agility in healthy young adults.

REFERENCES

1. Carolyn Kisner, Lynn A. Colby. Chapter 4, Stretching for Impaired Mobility. In: Therapeutic Exercise Foundations and Techniques. Sixth Edition. F.A. Davis Company; 2012.p. 72-118.
2. Sembulingam, K and Sembulingam, P. Essentials of medical physiology. 5th edition. Jaypee; 2010, 167.
3. Sonal Balani, Chitra Kataria. Comparing Effectiveness of Suboccipital Muscle Energy Technique Alone, Passive Hamstring stretching Technique Alone and Combination of both for Improving Hamstring Muscle Flexibility in Healthy Collegiate Subjects. International Journal of Health Sciences & Research Vol.5;Issue: 8; August 2015.
4. Wang SS, Whitney SL, Burdett RG et al Lower extremity muscular flexibility in long distance runners. J Orthop Sports Phys Ther. 1993; 17(2): 102107.
5. Akinpelu AO, Bakare U, Adegoke BOA. Influence of age on hamstring tightness in apparently healthy Nigerians. Journal of the Nigeria society of physiotherapy(2005) vol. 15 no.2.
6. Hellsing A. Tightness of Hamstring- and Psoas Major Muscles. Upsala Journal of Medical Sciences. 1988; 93(3):267-276.
7. Yuichi Nishikawa, PT, Juny Aizawa, PT, Naohiko Kanemura, PT. Immediate effect of passive and active stretching on hamstrings flexibility: a single-blinded randomized control trial. J. Phys. Ther. Sci. Vol. 27, No. 10, 2015.
8. Chaurasia B, Garg K. B.D. Chaurasia's Human anatomy. 6th edition. CBS Publishers & Distributors; 2004 (2): 84.
9. Bhagyashree K. Koli, Deepak B. Anap. Prevalence and severity of hamstring tightness among college student: a cross sectional study. International Journal of Clinical and Biomedical Research. 2018;4(2):65-68.
10. F. Garcia-pinillos, a. Ruiz-ariza, R. Moreno del castillo, P. Á. Latorre-roman. Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. Journal of Sports Sciences, 2015 Vol. 33, No. 12, 1293–1297.
11. Nicholas Ratamess. Chapter 1, Introduction to strength training and conditioning. ACSM's Foundation of strength training and conditioning. Lippincott Williams and Wilkins;2011,3-21.
12. Michele A. Raya, PhD, PT, Robert S. Gailey, PhD, Pt. Comparison of three agility tests with male servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. The Journal of Rehabilitation Research and Development, Volume 50, Number 7, 2013.
13. Pavol Horicka, Jan Hianik,Jjaromir Simonek. The relationship between speed factors and agility in sport games. Journal of human sport & exercise. Vol. 9, ISSUE 1,2014.
14. De Weijer V, Gorniak G, Shamus E. The Effect of Static Stretch and Warm-up Exercise on Hamstring Length Over the Course of 24 Hours. Journal of Orthopaedic & Sports Physical Therapy. 2003;33(12):727-733.
15. Diulian M. Medeiros Diulian M. Medeiros Diulian M. Medeiros PT, Anelize Cini PT, Graciele Sbruzzi PT, ScD & Cláudia S.Influence of static stretching on hamstring flexibility in healthy young adults: Systematic review and meta- analysis. Physiotherapy theory and practice 2016, VOL. 32, NO. 6, 438–445.
16. Sung-Hak Cho, Soo-Han Kim, Du-Jin Park. The comparison of the immediate effects of Application of the sub occipital muscle inhibition and self-myofascial release techniques in the sub occipital region on short hamstring. J. Phys. Ther.Sci. Vol. 27, No. 1, 2015
17. Pramod K. Jagtap, Shubhangi D. Mandale. THE effect of sub occipital muscle inhibition technique on hamstring tightness patients.Journal of Evolution of Med and Dent Sci/ eissn- 2278-4802, pissn- 2278-4748/ Vol. 4/ Issue 33/ Apr 23, 2015.
18. Erika Quintana Aparicio, DO,a Luis Borrallo Quirante, PT,Immediate effects of the sub occipital muscle inhibition technique in subjects with short hamstring syndrome. Journal of Manipulative and Physiological Therapeutics Volume 32,Number 4.
19. Henry peter pollard. A study of two stretching techniques for improving hip flexion range of motion. Journal of Manipulative and Physiological Therapeutics · October 1997.

20. Myers TW: Anatomy trains. Edinburgh: Churchill Livingstone, 2005, pg. 75-96.
21. Razouohu and Saravana Hari Ganesh. Comparative study of the effect of Neurodynamic sliding vs Suboccipital Muscle Inhibition on hamstring flexibility ISSN 1753-0431 International Journal of Clinical Skills (2017) 11(4), 113-119.
22. Dr. Nilam dave, tushar J. Palekar and Dr. Soumik Basu. individual and combined effect of suboccipital muscle Inhibition technique and doming of diaphragm Technique for hamstring tightness. Int j pharm bio sci 2017 apr ; 8(2): (b) 980-988.
23. Gajdosik R, Lusin G. Hamstring muscle tightness. Reliability of an active knee- extension test. Phys Ther. 1983 Jul; 63(7): 1085-90.
24. Tiago Neto, Lia Jacobsohn, Ana Isabel Carita, and Raul Oliveira. Reliability of the active knee extension test and the straight leg raise test in subjects with flexibility deficits. Journal of sport rehabilitation · October 2014.
25. Hamid M, Ali M, Yusof A. Inter-rater and Intra-rater Reliability of the Active Knee Extension (AKE) Test among Healthy Adults. Journal of Physical Therapy Science. 2013; 25(8): 957-961.
26. G Baltaci, N Un, V Tunay, A Besler, S Gerçeker. Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. Br J Sports Med 2003;37:59-61.
27. Patricia Patterson, Denise L. Wiksten, Lori Ray, Cheryl Flanders & Dawn Sanphy. The Validity and Reliability of the Back Saver Sit-andReach Test in Middle School Girls and Boys. American Alliance for Health, Physical Education,Recreation and Dance Vol. 67, No.4, pp. 448-451.
28. Knapik H, Szuszkiewicz A, Mateja SzD et al. Flexibility measured by Fingertips- to-Floor test among groups practicing yoga, Brazilian jujitsu, tricking and tai chi in comparison to non-active group. Kalina RM (ed.) Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA2015. September 2015. Pg. no.: 135–138.
29. Caroline Perret, Serge Poiraudeau, Jacques Fermanian, Marie Martine Lefevre Colau, Marie Anne Mayoux Benhamou, Michel Revel. Validity, Reliability, and Responsiveness of the Fingertip-to-Floor Test. Arch Phys Med Rehabil Vol 82, November 2001 pg. no. 1566-1570.
30. Michele A. Raya, PhD, PT, Robert S. Gailey, PhD, Pt. Comparison of three agility tests with male servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. The Journal of Rehabilitation Research and Development, Volume 50, Number 7, 2013, Page no. 951–960.
31. Younes Hachana, Helmi haabe Ne, Mohamed A. Nabli. Test-retest reliability, criterion-related validity, and minimal detectable change of the illinois agility test in male team. Journal of strength and conditioning research 27(10)/2752–2759.
32. Mohammadtaghi Amiri-Khorasani, Mansour Sahebozamani, Kourosh G. Tabrizi, and Ashril B. Yusof. Acute effect of different stretching methods on illinois agility test in soccer players. Journal of Strength and Conditioning Research. 24(10)/2698–2704
33. William D Bandy, Jean M Irion. The Effect of Time and Frequency of Static Stretching on Flexibility of the Hamstring Muscles. Physical Therapy, September. 1994; 74(9): 845-850
34. Cini A, de Vasconcelos G, Lima C. Acute effect of different time periods of passive static stretching on the hamstring flexibility. Journal of Back andMusculoskeletal Rehabilitation. 2017; 30(2): 241-246.
35. Keitaro Kubo, Hiroaki Kanehisa, Yasuo Kawakami, and Tetsuo Fukunaga. Influence of static stretching on viscoelastic properties of human tendonstructures in vivo. J Appl Physiol 90: 520–527, 2001.
36. C. Guyton, J. E. Hall. Chapter 54, Motor Functions of the Spinal Cord; the cord Reflexes. In: Textbook of Medical Physiology. Eleventh Edition. Elsevier Saunders. Philadelphia, Pennsylvania; 2006.p. 679.
37. Phil Page. Clinical Commentary Current Concepts in Muscle Stretching for Exercise and Rehabilitation. The International Journal of Sports Physical Therapy. February 2012; 7(1): 109-119.
38. Ruhi Pereira and Annamma Varghese. Comparative study of the immediate effects of eccentric training, dynamic stretching and static stretching on hamstring flexibility and vertical jump performance in basketball players. International Journal of Recent Scientific Research Vol. 8, Issue, 12, pp. 22777-22790, December, 2017.
39. D. Scott Davis, Paul E. Ashby, Kristi l. Mccale,jerry A. Mcquain, and Iaime M. Wine. The effectiveness of 3stretching techniques on hamstring flexibility using consistent stretching parameters. Journal of Strength and Conditioning Research, 2005, 19(1), 27–32.
40. Hack G, Koritzer R, Robinson WE, Hallgren R, Greenman R. Anatomic relation between rectus capitis posterior minor muscle and the dura mater. Spine 1994;19:2421-4.
41. Alexandra Avloniti, Athanasios Chatzinikolaou, Ioannis G. Fatouros, Maria Protopapa, Ioannis Athanailidis, Christina Avloniti, Diamanda Leontsini, George Mavropalias, and Athanasios Z. Jamurtas. The effects of static stretching on speed and agility: One or multiple repetition protocols? European

Journal of Sport Science, DOI: 10.1080/17461391.2015.1028467.

42. John-Paul Favero A, Adrian W. Midgley B & David J. Bentley. Effects of an Acute Bout of Static Stretching on 40 m Sprint Performance: Influence of Baseline Flexibility. Research in Sports Medicine, 17:50–60, 2009.
43. Abbas Asadi. Relationship Between Jumping Ability, Agility and Sprint Performance of Elite Young Basketball Players: A Field-Test Approach. Revista Brasileira de Cineantropometria e Desempenho Humano. 18(2) March 2016; pg. no. 1-13.
44. C.Guyton, J. E. Hall. Chapter 16, Characterstics of skeletal Muscle Contraction. In: Textbook of Medical Physiology. Second South Asia Edition. Elsevier Saunders. Philadelphia, Pennsylvania; 2016.p. 99-100.
45. Evan Peck, Greg Chomko, Dan V. Gaz, and Ann M. Farrell. The Effects of Stretching on Performance. Current Sports Medicine Reports. Pg. no 179-185.