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The influence of dynamic stretch of quadriceps, hamstrings and its combined stretch effect on knee joint position sense (JPS) in healthy adults

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Abstract
Background: Proprioceptive deficits can both predispose an individual to a greater risk for injury; impair sport performance. Stretching is commonly used as a technique for injury prevention in the clinical setting.
Objective: To study the effect of combined dynamic hamstring and quadriceps stretching on knee joint position sense.
Method: 15 healthy individuals randomly allocated in to three groups. Each group underwent dynamic quadriceps stretch, hamstring stretch and combined quadriceps & hamstring stretch. Shadow goniometer (SG) was the instrument used to measure Absolute angular error at 70º
Results: The analysis of pre and post stretch Absolute angular error within group reveals that it was statistically significant within combined group (p<.012), hamstring (p<.005) than quadriceps group (p>.378). However comparison between group revealed that, the analysis of variance between three group after intervention i.e. combined (2.47±1.60), Hamstring (1.93±1.44) and Quadriceps (4.80±3.30) was found to be statistically significant with (p <.003).
Conclusion: It is concluded that dynamic stretching of hamstrings or combined stretch (quadriceps and hamstring) has significant effect on improving knee JPS compared to quadriceps alone in healthy adults when measurements were taken in knee flexion movement.

Keywords: Proprioception, Joint position sense (JPS), Target angle (TA), Perceived Angle (PA), Absolute Angle of Error (AAE)

1. Introduction

Proprioceptive acuity is an essential component of injury prevention and rehabilitation, but it is often ignored with devastating consequences, because Proprioceptive deficits may be responsible for many acute ankle and knee injuries [1].The ability to sense joint position, however, is only one of the perceptual attributes of the Proprioceptive system, which also includes the ability to sense movement (amplitude and angular velocity) and to perceive force and weight [2]. It is now generally accepted that the greatest contribution to position sense is from muscular receptors [3]. The joint receptors are only activated at the extremes of the joint range and during movement a property that makes them poor candidates to signal joint position. Skin mechanoreceptors contribute little to Proprioceptive acuity, at least in the larger joints of the lower extremity. But any reduction in muscle afferents could be more detrimental for Proprioceptive acuity because signals from muscle spindles appear to be critical to our ability to sense joint position and movement [2]. This role of muscular receptors indicates that modifying the functional state of the muscle can affect the precision of position sense [3]. Impaired proprioception is cited as a major factor predisposing to degenerative joint disease and ongoing instability in the ACL deficient knee [4]. however subtle Proprioceptive deficits can both predispose an individual to a greater risk for injury and impair sport performance [1].

Stretching is commonly used as a technique for injury prevention in the clinical setting.[5] it has been suggested that stretching augments the sensibility of mechanoreceptors of the muscle spindle and improves the subsequent physical activity. The muscular receptors have has an important role in the elaboration of limb position sense, it seems that stretching may improve sensory and motor capabilities of perception of JPS. It has been reported that the accuracy of JPS will improve as the muscle stretched and that this increase in accuracy might be responsible for the increase in motor capabilities after stretching. Such an increase may be due to a better proprioceptive feedback, but may also act indirectly by leading to a better sensory imaginary [3]. Accordingly stretching may diminish the amount of error observed when measuring the JPS [6].

The different methods of stretching are ballistic stretching, static stretching, and variations of proprioceptive neuromuscular facilitation (PNF) techniques and dynamic stretching. Ballistic (bouncing) stretching is a rapid, jerky movement in which a body part is put into motion and momentum carries the body part through the range of motion until the muscles are stretched to their physiological limit. Static stretching is performed by placing muscles at their greatest possible length and holding that position for a period of time [7]. Static stretching is slow and prolonged stretch is applied to avoid the reflex contraction from the muscle spindle and Golgi tendon organ. In this stretch the muscle is elongated gently and maintained for long period of time (30 sec) [8]. J Voss *et al* have defined proprioceptive neuromuscular facilitation as a method of promoting or hastening the response of a neuromuscular mechanism through stimulation of the proprioceptors. Frequently, PNF techniques involve

isometric contractions of a lengthened muscle, followed by further lengthening, either actively or passively [7]. However dynamic stretching is moving the limb from its neutral position to end range, where the muscles are at their greatest length and then moving the limb back to its original position. This dynamic action is carried out in a smooth, controlled manner and is repeated for a specific period of time [9].

A reliable method for the estimation of JPS is the measurement of the reproduction of a specific target position, the difference between target position and the estimate position being used [6].

A number of techniques for clinically examining proprioceptive acuity are described in the literature, including threshold detection of passive movement, the absolute method and joint position sense (JPS). An individual's JPS primarily determines his or her ability to perceive a target joint angle or limb position and then, after the limb has been returned to its starting position, to reproduce the predetermined angle. The conscious ability to position a limb is a highly specialized proprioceptive function and is a vitally important clinical outcome measure, involving both the control of movement and stability. The JPS tests are routinely administered by clinicians to assess any proprioceptive deficits in the knee joint after anterior cruciate ligament injury, stretching, fatigue, pain, patellar taping, and cooling. The primary reason JPS is assessed by clinicians is to identify any reduction that may predispose an individual to proprioception-related injury [1].

Farahnaz Ghaffarinejad, Shohreh Taghizadeh, Farshid Mohammad studied the effect of static stretch of muscles surrounding the knee on the knee joint position sense. In this study JPS was estimated by the ability to reproduce the two target positions (20^0 and 45^0 of flexion) in the dominant knee and the absolute angular error (AAE) are defined as the absolute difference between the target angle and the subject perceived angle of knee flexion. Knee JPS is assessed by the subject's ability to reproduce passive positioning of the leg that is the target angle and perceived angle, using an electro goniometer at the lateral aspect of knee joint. The study concluded that accuracy of the knee JPS in 45^0 of flexion is increased subsequent to static stretch regimen of quadriceps, hamstrings and adductors in healthy subjects [3].

The study by Kieran O Sullivan, Elaine Murray, and David Sains Burry on The effect of warm up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects suggest that static stretch has little or no impact on injury prevention it has also become clear that static stretching may negatively affect immediate physical performance. Because of this dynamic stretching has been suggested as an alternative to static stretching post warm up, as evidence suggest that dynamic stretching positively impact on immediate physical performance [9].

Streepey *et al* conducted a study on Effects of Quadriceps and Hamstrings Proprioceptive Neuromuscular Facilitation Stretching on Knee Movement Sensation. Their study on 18 healthy subjects, aged 18 to 30 years, on their dominant knee concluded that PNF stretching of the hamstrings and quadriceps might acutely diminish sensitivity to knee movement. For coaches and trainers, these findings are consistent with previous reports of loss in muscle force and power immediately after stretching, suggesting that stretching just before competition may diminish performance [11].

Ballistic stretches force the limb into an extended range of motion when the muscle has not relaxed enough to enter it. It involves fast "bouncing" movements where a double bounce is performed at the end range of movement. Ballistic stretching should only be used by athletes who know their own limitations and with supervision by their trainer. Ballistic stretching has been found to be hazardous towards the body. It can injure vital muscles and nerves with the sharp jerking movements. It is even possible for tissue to be ripped off the bone [12].

Though the study on static stretch on Knee joint position sense in healthy subject by R Larsen *et al*, [6] Farahnaz *et al* [3] shows an improvement in joint position sense, the negative impact after static, PNF and ballistic stretch were already proven. They are decrease in performance, strength, movement sense, the need of therapist assistance to do the stretching. So the above mentioned stretches cannot be given before sports events. Dynamic stretching is preferred as warm up program before the sport activities. Since there are no available literatures on effect of dynamic stretch on joint position sense, there is a need to find out the effect of dynamic stretch on the joint position sense. This study on knee joint positions sense will help to know whether dynamic stretching is safe to apply before sports activities thereby minimises sports injuries. The objective of the study is to find out effect of dynamic stretch of hamstrings, quadriceps & combined stretching on knee joint position sense.

2. Materials & Methods

Random samples of 15 students were taken from Padmashree Institute of physiotherapy, Bangalore. The study design was Cross over experimental design. Males subjects with age (21–26 yrs), height (160–190cms), and weight (50- 80), full range of motion in the knee, muscle power minimum of 4/5 on manual muscle testing were included in the study. Subjects were excluded if they have known knee joint pathology, history of trauma to the lower extremity, rheumatologic, orthopedic or neuromuscular disorders, restricted knee joint range of motion, subjects with sensory, visual or auditory defect. Ethical clearance was taken from the institution. Informed and written consent from each concerned patient was taken.

15 subjects were randomly allocated to three groups; Group A (5 members), Group B (5 members) and Group C (5 members) using chit method. The envelope containing the chit had a description about the stretches to be made. Each group underwent specific stretching randomly and the observer was blinded. A 24 hour gap was given between the experiments of each group to wash out the effects of stretch of the previous session. Each group (A, B and C) underwent respective stretches randomly - dynamic quadriceps stretch, hamstring stretch and combined quadriceps and hamstring stretch.

Hamstrings stretch was performed in standing on the leg to be stretched and slowly bent forward from hip joint keeping the spine as straight as possible, as if the opposite side hand would be going to touch the feet or floor. After reaching the maximum possible forward bent which was allowed by the hamstring stretch discomfort the subject returned back to the starting position. This stretch was repeated three times without any rest periods in between. Quadriceps stretch was performed in standing. The dominant leg was bent from knee and heel was held as close as to the buttock with one hand. The hip

joint was taken backwards (extension) till the stretch discomfort from quadriceps allowed and then returned back to the starting position (hip neutral with knee bent and held with hand).This stretch was repeated three times without rest period. In the combined stretch, the hamstring stretch was followed by quadriceps stretch without any rest periods. The stretching procedures are same as described above.

The pre and post intervention scores were made through direct observation and were documented. Participants were barefoot and dressed in half pants during all tests, so that the knee movements were not restricted. The test position was prone lying on the experiment couch. A towel of 3cm thickness was kept under the thigh of test leg for the free movement of patella during knee flexion. In this position subjects were instructed to bent the knee to the full extend and bring back the leg to resting position of 15˚ of flexion so that the skin and underlying soft tissues were aligned and ready for further movements. This resting position (15˚ knee flexion) was maintained with a towel roll under the ankle. In the test position as described above, the subjects were instructed to bent from testing knee (right knee flexion) to the Target Angle(TA) of 70^0 and hold there for 5 seconds, then returned back to the resting position (15^0 of flexion). A period of five seconds gap was kept, and then the subject would take the leg to the target position (70˚ knee flexion) without any instructions. The subjects would say 'YES' on perceiving they reached the target position of 70˚ and held for 5 seconds. This is the Perceived Angle (PA). The difference between TA and PA is the Absolute Angular Error (AAE) were observed and documented. Target angle and perceived angle was measured using shadow goniometer. Because of the unavailability and high cost of electro-goniometer, we developed this instrument. A pilot study was done to check its reliability and validity which was published later. The study concluded that shadow goniometer was reliable and valid in measuring knee range of motion.[13]

Data analysis was performed using SPSS software (version17) for windows. Alpha value was set as 0.05. Descriptive statistics was used to find out mean, standard deviation, name for baseline and demographic variables. Paired t-test was used to compare pre and post measurements of knee range of motion to measure absolute angular error (AAE) with in group. ANOVA test was used to compare the absolute angle error between three groups. Post hoc analysis was done for multiple comparisons with Tukey HSD test. Microsoft word, excel were used to generate table, graph etc.

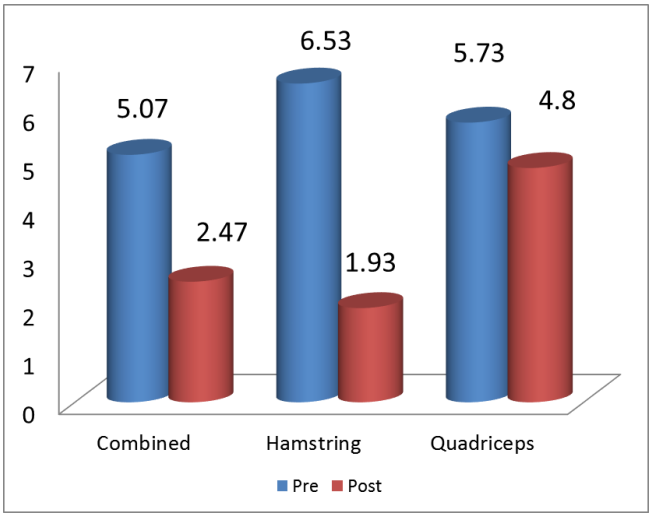
3. Results & Discussion

3.1 Results

In this study the participants were healthy male adults with age group between 20 and 23 years with mean age of 20.93. The mean height of the group was 168.97cm and weight was 61.07 Kg. The analysis of pre and post stretch AAE within group reveals the following data (Table 1; data are mean ± SD). In the combined group the pre-stretch mean AAE is 5.07 has reduced to 2.47 which was statistically significant (p value<.012).In the hamstring group the pre-stretch mean AAE is 6.53 has reduced to post stretch value of 1.93 which was statistically significant(p value <.005). In the quadriceps group the pre-stretch mean AAE is 5.73 has reduced to post stretch value of 4.80 which was not statistically significant (p value >.378). The analysis of variance between three group was found to be statistically significant with p value of <.003. A post hoc analysis was done for multiple comparisons with Tukey HSD test was performed and showed that Combined v/s Hamstring (P>.798), Combined v/s Quadriceps (p<.020) & Hamstring v/s Quadriceps (<.004). In summary hamstring stretch is better than combined stretch and combined stretch is better than quadriceps in improving knee joint position sense.

Table 1: Pre post stretch AAE differences within groups

SI no:	Group	Pre	Post	p value
1	Combined	5.07±3.31	2.47±1.60	<0.012
2	Hamstring	6.53±5.57	1.93±1.44	<0.005
3	Quadriceps	5.73±5.06	4.80±3.30	>0.378



Graph 1: comparison within groups

3.2 Discussion

The objective of the current study was to investigate the effect of dynamic stretching of hamstrings, quadriceps and their combined stretch on knee joint position sense. As it was a first study on dynamic stretching and its influence on proprioception, the study was done on healthy individuals with uniform baseline characteristics. This study was a cross over design where each individual acted as their own control, so further statistical analysis of baseline data was not required. Here the TA 70^0 degree of knee flexion is a mid-flexed position of the knee, where the Proprioceptive input is mainly from muscles rather than from capsules and ligaments. Farahnaz in his study on knee joint position sense comments early ranges of knee flexion afferent inputs from the ACL is most likely to be detected, but in intermediate ranges, muscle receptors are primarily responsible for knee JPS and stretching may affect these receptors [3].

The analysis revealed that the post stretch AAE was reduced in all three groups, but significant only in two. The improvement in joint position sense post stretch could be due to the following changes in the muscles as revealed in the various studies. The dynamic stretching would have increased the sensitivity of the muscle spindles. A study done by Proske *et al* concluded that muscle spindle have thixotropic property; stretching may improve Proprioceptive input of muscular receptors [20]. J.E Gregory concluded that the mean sensitivity of the both primary and secondary spindle endings increased slightly, after a series of eccentric contractions [21]. Edith Ribot

in his study says proprioceptive feedback associated with performance of even quite simple movements is always generated by the whole set of muscles subjected to mechanical deformation during a particular movement [22].

Among the dynamic stretches post hamstring stretch led to least AAE or in other words improved knee joint JPS better than other two stretches. The possible reasons for this finding could be the active hamstring contraction during PA positioning would have increased the firing rate. This is in accordance with the review of U Proske where the author says that the position sense improves dramatically when subjects are allowed to place the limb themselves [23]. Here the additional cues from sense of effort and from gravity are likely to play an important role. Uwe Proske in his commentary on 'The distribution and abundance of muscle spindles' concluded that large muscles comprising many fascicles will therefore have more spindles than smaller muscles [24]. Also the hamstring length and bulk are more than the quadriceps.

The combined stretching effect on knee JPS was significant but less accurate than hamstring stretch group. This could be due to; in combined stretch the hamstring stretch was done first and followed by quadriceps stretch without any rest period in between, the possible appearance of fatigue was there. Sylvie Fortier in his study concluded that the nature of repetitive muscle contractions inducing fatigue should be taken in to consideration to minimize loss in movement accuracy [25]. The induced relaxation of hamstrings during quadriceps stretch would have affected accuracy of JPS; A.K Wise says in his study the proprioceptive threshold were much higher following conditioning to introduce slack in the muscle [26].

The quadriceps stretch showed improvement in proprioception (JPS) of knee joint but was not statistically significant. The AAE reduced from pre to post stretch values of 5.73 to 4.80 but did not become statistically significant. This finding could be due to the active positioning to PA was slow movement (knee flexion rate $<4^0$/sec), thus antagonist (quadriceps) eccentric contractions and stretch of their spindles would be less leading to less accuracy. This is in accordance with the study done by Edith Ribot where author concluded that the spindle discharge may mainly depend on changes in muscle length occurring at higher movement velocities [22]. In this study the dynamic stretching protocol of quadriceps is not as effective as hamstring stretch; this is very clear from the subject positions. The less number of subjects could be the other possible factor which could influence the study.

The comparison between groups showed statistically significant difference to the post mean AAE i.e. combined stretch (2.47), Hamstring stretch (1.93) and Quadriceps stretch (4.80) revealing post dynamic stretch the knee JPS improves. This is in accordance with the findings of Farahnaz *et al* in his study on knee JPS concluded that the accuracy of knee JPS in 45˚ of flexion is improved subsequent to a static stretch regimen of hamstrings, quadriceps and adductors in healthy subjects [3]. Larsen *et al* and Proske U *et al* suggest that stretching augments the sensitivity of the intrafusal fibers of the muscle spindles and improves performance of subsequent physical activity or exercise. Accordingly stretching may diminish the amount of error observed when measuring JPS [6] [14]. The post hoc analysis for multiple comparisons with Tukey HSD test revealed hamstring stretch is better than combined stretch and combined stretch is better than quadriceps in improving knee joint position sense. This could be due to above mentioned mechanisms.

The participants were not informed to stay away from other activities; some of the participants were involved in sports, games and other routine exercise which could have influenced their proprioception. This could be a limitation. Also the dynamic quadriceps stretching protocol was not effective as hamstring stretch. The stretch was carried out partly with assistance of the hand held at ankle in this stretching. There could be possibility of not reaching the maximum available stretch. Whereas dynamic hamstring stretching was done actively without any assistance till the subjects feels maximum stretch. Further studies can be done to find out the optimal duration of effectiveness of stretching as the present study was about the immediate effect. The same study can be replicated on subjects with OA knee, ligament injury etc. The same study can be replicated on other joints of the body.

4. Conclusion

This study revealed the influence of dynamic stretch on knee joint position sense that the dynamic stretching of hamstrings or combined stretch (quadriceps and hamstring) has significant effect on improving knee JPS compared to quadriceps alone in healthy adults when measurements were taken in knee flexion movement. Hamstring stretch is better than combined stretch and combined stretch is better than quadriceps in improving knee joint position sense. Thus dynamic stretch can be safely used in warm up programs before sport activities.

5. References

1. Joseph Costello T, Alan Donnelly E. editors. Cryotherapy and Joint Position Sense in Healthy Participants: A Systematic Review. Journal of Athletic Training. 2010; 45(3):306-316.
2. François Tremblay, Lorein Estephan, Martine Legendre, Ste´phanie Sulpher. Influence of Local Cooling on Proprioceptive Acuity in the Quadriceps Muscle. Journal of Athletic Training. 2001; 36(2):119-123.
3. Farahnaz Ghaffarinejad, Shoreh Taghizadeh, Farshid Mohamed. Effect of static stretching of muscles surrounding the knee on knee joint position sense. Br J sports med, 2007; 41:684-687.
4. Carter ND, Jenkinson TR, Wilson D, Jones DW, Torode AS. Joint position sense and rehabilitation in the anterior cruciate ligament deficient knee. Br J Sports Med. 1997; 31:209-212.
5. Sarah Marek M, Joel Cramer T, Louise Fincher A, Laurie Massey L, Suzanne Dangelmaier M, Sushmita Purkayastha *et al*. Acute Effects of Static and Proprioceptive Neuromuscular Facilitation Stretching on Muscle Strength and Power Output. Journal of Athletic Training. 2005; 40(2):94-103.
6. Larsen R, Lund H, Christensen Danneskiold R, Bliddal H. Effect of static stretching of quadriceps and hamstring muscle on knee joint position sense. Br J Sports Med. 2005; 39:43-46.
7. Bandy WD, Irion JM, Briggler M. The effect of time and frequency of static stretching on flexibility of the hamstring muscles. Phys Ther. 1997; 77(10):1090-1096.

8. Laxmi narayanan S. Textbook of therapeutic exercise. 1st Edition. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd, 2005, 159.
9. O'Sullivan K, Murray E, Sainsbury D. The effect of warm-up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects. BMC Musculoskeletal Disorders. 2009; 10(1).
10. Mary Paul Clapper, Steven Wolf L. Comparison of the Reliability of the Orthoranger and the Standard Goniometer for Assessing Active Lower Extremity Range of Motion. Phys ther. 1988; 68(2):214-218.
11. Streepey Jefferson W, Mock Marla J, Riskowski Jody L2 *et al*. Effects of Quadriceps and Hamstrings Proprioceptive Neuromuscular Facilitation Stretching on Knee Movement Sensation. J Strength Cond Res. 2010; 24(4):1037-1042.
12. Ballistic stretching. [Online]. Available from: URL: http:// *www.wikipedia.com.*
13. Pradeep Subin Solomen T. Pravin Aaron Reliability and validity of shadow goniometer for measuring range of motion in knee joint, 2015; 1(6):57-60.
14. Proske U, Morgan DL, Gregory JE. Thixotropy in skeletal muscle and in muscle spindles: a review. Prog. Neurobiol. 1993; 41:705-721.
15. Gregory JE, Morgan DL, Proske U. Responses of muscle spindles following a series of eccentric contractions. Exp Brain Res, 2004; 157:234-240.
16. Ribot-Ciscar E, Roll J. Ago-antagonist muscle spindle inputs contribute together to joint movement coding in man. Brain Research. 1998; 791(1-2):167-176.
17. Proske U, Wise AK, Gregory JE. The role of muscle receptors in the detection of movements. Progress in Neurobiology, 2000; 60:85-96.
18. Proske U. The distribution and abundance of muscle spindles. Brain Research Bulletin. 2008; 75(5):502-503.
19. Sylvie Fortier, Fabien Basset, Francois Billaut, David Behm, Normand Teasdale. Which type of repetitive muscle contractions induces a greater acute impairment of position sense? Journal of Electromyography and Kinesiology. 2010; 20:298-304.
20. Wise A, Gregory J, Proske U. The responses of muscle spindles to small, slow movements in passive muscle and during fusimotor activity. Brain Research. 1999; 821(1):87-94.