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A Comparative Study: Static Stretching Versus Eccentric Training on Popliteal Angle in Normal Healthy Indian Collegiate Males

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Abstract.
Objective: To investigate and compared the effect of Static stretching (SST) and Eccentric Training (ECC) on popliteal angle i.e. hamstrings flexibility in normal healthy Indian collegiate males.
Design: Experimental study with Pre-post design was used.
Participants: Twenty healthy Indian collegiate males with hamstring tightness were randomly divided into two equal groups. Group-A subjects were treated with SST whereas other group-B were treated by eccentric training with 3ft black Theraband. The treatment was given for 5 consecutive days and follow-up measurement on 8th day.
Main outcome measures: The outcome was measured in terms of popliteal angle/Active Knee Extension test.
Results: Statistical analysis indicated significant hamstring flexibility more in SST ($p<0.001$) than ECC ($p<0.029$) but improvement level decreased in the follow up measurement.
Conclusion: It can be concluded that the Static stretching and eccentric training program improves the Popliteal angle i.e. hamstring flexibility and it will enhance the athletic performance. Static stretching resulted in maximum improvement as compared to eccentric training/contraction on hamstring flexibility.

Key words: Static stretching, eccentric training, popliteal angle, Hamstring muscles.

1. Introduction

Sports coaches, performers and scientist are constantly in search of new means to enhance sports performance and gain a competitive edge. Flexibility is a physical fitness and is often evaluated from the joint range of motion (Herris ML, 1996; M. J. Alter, 1996). It is defined as “performance of smooth and extensive movement of body joints” (Herris et al, 1996; Takada et al, 1998). Reports on the significance of flexibility have focused on contribution of preventing injuries and improving sports performance (Yamamoto T et al, 1996; Witvrouw & Lysen, 2000; Sharon & Susan, 1993). For example, in hurdles an extensive joint range of motion i.e. flexibility is required in the hip joint (Yamamoto T et al, 1996).

Flexibility is considered an essential element of normal biomechanical functioning in sport (Hopper, Decan & Das et al, 2005; Huston et al, 1996). The literature reports a number of associated benefits of flexibility including improved athletic performance, reduced injury risk, prevention or reduction of post-exercise soreness and improved co-ordination (Pope, Herbert & Krwan, 2000).

Some studies have shown that decreased hamstring flexibility is a risk factor for development of patella tendinopathy and patellofemoral pain, hamstrings strain injury (Harvard, Ronald, 2007; Johagen &Nemeth, 1994; Russell & William, 2004; Witvrouw & Lysen, 2000).

Hamstring muscle injuries are one of the most common musculotendinous injuries in the lower extremity (Ekstrand & Gilquist, 1983). They occur primarily during high speed or high intensity exercises and have a high rate of recurrence (Murphy, Connolly & Beynnon, 2003; Russell & William, 2004). Worrel et al stated

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that a “lack of hamstring flexibility was the single most important characteristics of hamstring injuries in athletes (C. D. Weijer, Gorniak, 2003).

Static stretching is one of the safest and most commonly performed stretching methods used to measure muscle length (C. D. Weijer et al, 2003). This type of stretch is applied slowly and gradually at a relatively constant force to avoid eliciting a stretch reflex. The literature supports that a static stretch of 30 seconds at a frequency of 3 repeated stretches per single session is sufficient to increase muscle length (William D Bandy et al, 1996).

Eccentric contractions/training that allows the muscle to elongate naturally and in its relaxed state this elongation is achieved by having the subjects eccentrically contract the antagonist muscle to move the joint through the full available range in slow controlled manner to stretch the agonist muscle group (Russell & William, 2004). It is a better training strategy to improve the flexibility and also able to increase in strength and protect against muscle damage (Daniel, Janaina & Michael, 2007).

The aim of the study was to investigate and compared the effectiveness of Static Stretching (SST) and Eccentric Training (ECC) on popliteal angle i.e. hamstrings flexibility in normal healthy Indian collegiate males.

2. Methods

2.1. Participants

20 Indian collegiate males, aged 18-25 years, having tightness in hamstrings muscles (inability to achieve greater than 160° of knee extension with hip at 90° of flexion) (David, Jeniffer & Shane, 2004), were included in the study. Those subjects have acute or chronic low back pain, hamstring injury, inhibition to actively extend the knee fully in sitting position, visual acute swelling in the region of hamstring muscles and subject already involved in any exercise program of lower extremity were omitted from the study. The written informed consent was obtained from all the subjects. The study was approved by Institutional Medical Ethics Committee of Jamia Hamdard University, Delhi, *INDIA.*

2.2. Testing Procedure

The study was experimental with different subject design. The subjects were randomly assigned into two equal groups- A (Static stretching) & group-B (Eccentric training). Subject was assessed for hamstring tightness by measuring popliteal angle/AKE. The testing was taken over 5 days period with each subjects in both group A and B receiving one treatment session in a day for consecutive 5 days and follow up measurement on 8th day. The study was conducted at Hamdard University, N.D., India. The subjects were tested approximately at the same time of each day.

2.3. Outcome Variable

Popliteal angle/ Active knee extension test

Pre-post and follow up measurement data on Popliteal angle were collected from both groups. Subjects were assessed for hamstring tightness using the Active Knee Extension test (Popliteal angle). The subject was in supine position with hips flexed 90° and knee flexed. A cross bar was used to maintain the proper position of hip and thigh. The testing was done on the right lower extremity and subsequently the left lower extremity and the pelvis were strapped down to the table for stabilization and control on accessory movements. Landmarks used to measure hip and knee range of motion were greater trochanter, lateral condyle of femur and the lateral malleolus which were marked by a skin permanent marker. The fulcrum of the goniometer was centered over the lateral condyle of the femur with the proximal arm secured along the femur using greater trochanter as a reference. The distal arm was aligned with the lower leg using the lateral malleolus as a reference. The hip and knee of the extremity being tested were placed into 90° flexion with the anterior aspect of thigh in contact with the horizontal cross bar frame at all times to maintain hip in 90° flexion. The subject was then asked to extend the right lower extremity as far as possible until a mild stretch sensation was felt .A full circle goniometer was then used to measure the angle of knee flexion. Three repetitions were performed and an average of the three was taken as the final reading for Popliteal Angle (Russell & William, 2004).

2.4. Protocol

Static stretching

After pre-treatment range of motion measurement of Group-A subjects were asked by the investigator to endure as much stretching force a possible without pain when the knee was passively and gradually extended in the Active Knee Extension test position. Readjustment of the stretching force was made after 15 seconds of stretching when the subject's perception of maximum stretch tolerance was decrease considerably *(Fig.1)*. This readjustment was performed to maintain the maximum stretching force during most of the static stretch period, which lasted for 30 seconds. This sequence was repeated 3 times per lower extremity with 10 seconds rest intervals between each stretch (C. D. Weijer, Gorniak, 2003).

Fig.1: Application of Static Stretching

Eccentric training

The eccentric training group performed full range of motion eccentric training for the hamstring muscles. The subject lay supine with the leg fully extended. A- 3ft (0.91-m) long piece of black Theraband was wrapped around the heel and the subject held the ends of the Theraband in each hand. The subject was instructed to keep the opposite knee locked in full extension and the hip in neutral internal and external rotation throughout the entire activity. The subject was then instructed to bring the test hip into full hip flexion by pulling on the Theraband attached with the foot and both arms, making sure that knee remained locked in full extension at all times. Full hip flexion was defined as the position of hip flexion at which a gentle stretch was felt by the subject. As the subject pulled the hip into full flexion with the arms, he was instructed to simultaneously resist the hip flexion by eccentrically contracting the hamstring muscle during the entire range of hip flexion. The subject was instructed to provide activity of the hamstring muscles, so that the entire hip flexion took approximately 5 seconds to complete. Once achieved, this flexed hip position was held for 5 seconds and then the extremity was lowered to the ground (hip extension) by the subject's arms. (Fig.2)

This procedure was repeated 6 times with no rest between repetitions, thereby providing a total 30 seconds of stretching at the end range (Russell & William, 2004).

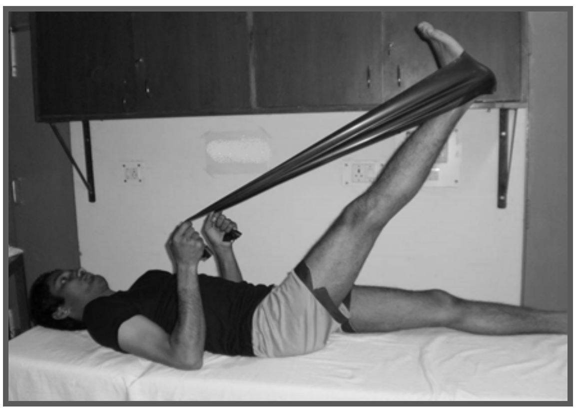


Fig. 2: Application of Eccentric training.

2.5. Statistical analysis

The data were statistically analyzed using the -SPSS

(Statistical Package for Social Science)/15.0. (Copyright © SPSS Inc.) . Statistical test used in the present study were independent-t-test and repeated-Measure ANOVA test

3. Results

The mean physical parameters of the subjects are as shown in Table-1. There was no significant difference in the baseline popliteal angle values of the subjects when compared across the groups as shown in table-2. There was however a significant difference in the post 5 days ranges of motion across the both groups, as shown in table 2. On the post intervention and carryover/follow-up mean values showed significant difference (p<.05).

Table 1: Participant group Characteristics, Values represent mean (± standard deviation).

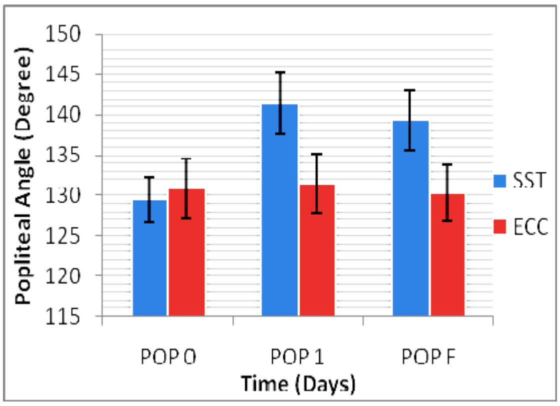
Group	Age (Years) X ±S.D.	Height (Cm.) X ±S.D.	Weight (Kgs.) X ±S.D.
A	**22.4 ± 1**	**159.9 ± 4.5**	**60.7 ± 10.1**
B	**22.0 ± 0.6**	**164.4 ± 4.5**	**63.5 ± 10.5**

Between Group Analysis *(Graph-1)*

The comparison of pre-post and follow-up result of outcome (Popliteal angle) shows that the both experimental group was significant (p<0.01). Group-A and B shows significant difference at post intervention with p value is 0.001 (lesser than 0.05). Follow-Up: Group-A and B shows significant difference with p value is .001 (lesser than .05).

Table 2: The baseline and post-follow up Popliteal Angle ranges of the subjects (N=20).

Group	Baseline X ±S.D.	Post-Intervention X ±S.D.	Follow-Up X ±S.D.
A	**129.5 ±2.8**	**141.4 ± 3.8**	**139.3 ± 3.7**
B	**130.8 ± 3.7**	**131.5 ± 3.6**	**130.3 ± 3.5**
P	**0.397 NS**	**.001***	**.001****



***Graph.1*: Between-group comparison on POP angle. (Pre-Post to Followup)

POP. 0: Pre test value of Popliteal Angle (Active Knee Extension).

POP. 1: Post test value of Popliteal Angle (Active Knee Extension).

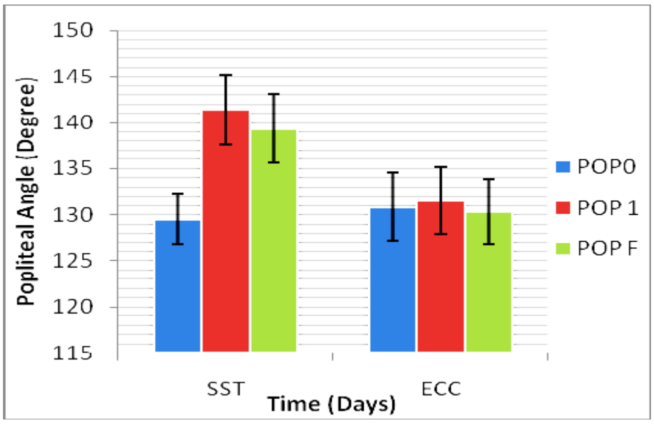
POP. F: Follow up value of Popliteal Angle (Active Knee Extension).

SST: The group that received Static Stretching.

ECC: The group that received Eccentric Training intervention.

Within-group analysis (Graph.2)

In both groups range of Popliteal angle (Degree) shows that the mean range of motion during post test is higher than that during pretest (p<0.001). In group-A: follow up values is lesser than post test value (p< 0.020) but higher than pretest value after application of Static stretching. In group-B: follow up values is lesser than post test value (p<0.008) but less than pretest value after application of Eccentric training (p<0.733).



Graph.2: Within group comparison on POP angle.

Table 3: Within group comparison of group-A (SST).

Variable	Pre-test X ±S.D.	Post-test X ±S.D.	Follow-Up X ±S.D.	ANOVA F	ANOVA P	Pair wise Comparison (p) Pre/Post	Pre/FU	Post/FU
Popliteal Angle (Degree)	129.5 ±2.8	141.4 ± 3.8	139.3 ± 3.7	16722.3	.001***	.001***	.001***	.020*

Table 4: Within group comparison of group-B (ECC).

Variable	Pre-test X ±S.D.	Post-test X ±S.D.	Follow-Up X ±S.D.	ANOVA F	ANOVA P	Pair wise Comparison (p) Pre/Post	Pre/FU	Post/FU
Popliteal Angle (Degree)	130.8 ± 3.7	131.5 ± 3.6	130.3 ± 3.5	13156.4	.001***	0.02*	.733NS	.008**

NS: non significant, * significant p< 0.05, ** significant p<0.01, *** significant p<0.001.

Group-A: Static Stretching, Group-B: Eccentric training, S.D. – Standard Deviation, FU-Follow-Up.

4. Discussion

The review of existing literature regarding the role of different techniques in improving flexibility reveals a confusing picture so as to which technique out of Eccentric training/contraction and SST is best for the purpose. Therefore the current study was undertaken to investigate and compared the effectiveness between Static stretching (SST) and Eccentric Training (ECC) on popliteal angle i.e. hamstrings flexibility in Indian collegiate males and to determine which is better in the long run. For the purpose of this; a pre–post test, follow up (experimental study) was carried out. Hamstring was the muscles of choice since it is the muscle that is most prone to injuries during sporting activities, and if the flexibility of hamstrings is adequate the incidence of hamstrings strains can be decreased and performance can be enhanced as well. Also there are well documented, reliable and valid methods of testing flexibility of hamstring muscles, such as the Popliteal angle/ Active Knee Extension test.

A comparison of the pre-test and the post test values of the Popliteal angle for the groups show that there is a significant improvement in both groups. Thus it may be said that these techniques are effective individually in improving flexibility of hamstrings.

Improvement seen in static stretching (SST) group was expected with considering the previous research studies that provide consistent evidence regarding the effectiveness of SST to improve flexibility. C. D. Weijer et al (2003) reported that the positive effect of SST on hamstring muscle length immediately after 15 minutes and over the course of 24 hours. But according to one study done by Russell T. et al, 2004; eccentric exercises/contraction through full range of motion is a continual movement lasting only 5 seconds and the muscle spindle doesn't appear to have time to adapt. The mechanism behind the increased flexibility with eccentric hamstring activity through the full range of motion is unclear. Skeletal muscle has a large adaptation potential induced by eccentric contraction and morphological changes are related to addition of sarcomeres in series (Daniel N., 2007). On repeated contraction (eccentric) leads to disruption and membrane damage, this lead to uncontrolled Ca+ movements and the development of localized contracture (J.E.Gregory,2002) this could be an reason in improvement of hamstring flexibility/ Popliteal angle. However, Keitaro Kubo et al, 2000; suggested that stretching decreased the Viscosity of tendon structures but increased the elasticity i.e. the stiffness of the muscle. Static stretching resulted in an increased flexibility due to changes in viscoelastic properties. They related the resultant increase in muscle length to viscoelastic behavior i.e. this type of stretching may adjust the positional sensitivity of the Golgi tendon organs by affecting the series elastic component of the muscle. (C. De Weijer et al, 2003). At the time of follow-up the values of Popliteal angle was higher than the pre-test values but showed a decrease from the post-test values. Thus an analysis of the muscle flexibility after 72 hours maintenance of flexibility. The deterioration from the post-test values at the time of follow-up can be attributed to the fact that there was no maintenance program that was being followed during that period, and the subjects were not undergoing any active or passive stretching regime during those 72 hours.

5. Conclusion

It can be concluded that the Static stretching and eccentric training program improves the Popliteal angle i.e. hamstring flexibility and it will enhance the athletic performance. Static stretching resulted in maximum improvement as compared to eccentric training/contraction on hamstring flexibility.

Practical Application

It guides to coaches, trainer, sports-physiotherapist as well as athlete to prefer static stretching over eccentric training when both can be performed and where gain in flexibility/ range of motion is the objective/goal of treatment.

Conflict of Interest

None

Ethical Approval

Ethical approval was granted by Jamia Hamdard University Research Board Committee.

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6. References

[1] C. D. Weijer, C Gorniak.. The effect of static stretch and warm up exercise on hamstring length over the course of 24 hours. *Journal of Orthopedic Sports Physical Therapy*. 2003, **33**(12): 727-732.

[2] Daniela NF, Janaina LL, Michelle FS, Aikelton FS, Macro TA. Analysis of the influence of static stretching and eccentric training on flexibility of hamstring muscles. *XXV ISBS Symposium*. 2007, pp.454-7.

[3] David O. D., Jennifer L., Shane S., Dennis E. Shortwave diathermy and prolonged stretching increase hamstring flexibility more than prolonged stretching alone. *J Orthop Sports Phys Ther.* 2004, **34**: 13-20.

[4] Ekstrand J , Gilquist. Frequency of muscle tightness and injury in soccer players. *American Journal Sorts Medicine.* 1983, **4**: 124-128.

[5] Emika Kato, Toshiaki Oda, Kentaro Chino, Toshiyuki Kurihara. Musculotendinous factors influencing difference in ankle joint flexibility between women and men. *International Journal of Sport and Health Science.* 2005, **3**: 218-25.

[6] Gregory JE, Brockett CL, Morgan DL, Whitland NP, Proske U. Effect of eccentric muscle contraction on golgi tendon organ responses to passive and active tension in the cat. *Journal of Physiology.* 2002, **538(**18): 209.

[7] Harris ML. Flexibility. *Physical Therapy.* 1996, **49**: 591-601.

[8] Harvard V, Roald B. The evaluation of eccentric training as treatment for patellar tendinopathy (jumper's knee): a critical review of exercise programmes. *British J Sports Med*. 2007, **41(**23): 217

[9] Hopper D, Decan S, Das S, Jain A, Riddell D, Hall T. Dynamic soft tissue mobilization increases hamstring flexibility in healthy male subjects. *British J Sports Med.* 2005, **39(**8): 594.

[10] Huston M. *Sports injuries recognition and management, 2nd edition.* Oxford: oxford University Press, 1996.

[11] Jonhagen S,Nemeth G. Hamstring injuries in sprinter. The role of concentric and eccentric hamstring muscle strength and flexibility. *The American Journal of Sports Medicine*. 1994, **22**(2): 262-266.

[12] Keitaro Kubo et al. Influence of static stretching on viscoelastic properties of human tendon structures in vivo. *Journal of applied Physiology*. 2001, **90**: 520-527.

[13] Michael JA. Science of flexibility: *Modern view of flexibility and stretching. 3rd eds.*

[14] Murphy DF, Connolly DAJ, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. *Br J Sports Med.*. 2003, **37**: 13-29.

[15] N Gleeson, R Eston ,V Marginson. Effect of prior eccentric training on concentric exercise induced muscle damage. *British Journal of Sports Medicine.* 2003, **37**: 119-125.

[16] Pope R, Herbert R, Kirwan J. A randomized trial of pre-exercise stretching for prevention of lower limb injury. *Med Sci Sports Exercise*. 2000, **32**: 271-7.

[17] Richard L, Gajodsik, Melonie A, Rieck, and Debra K, Sulivan. Comparison of four clinical tests for assessing hamstring muscle length. *Journal of Orthopedic Sports Physical Therapy*. 1993, **18**(5): 614-618.

[18] Richard L. Gajdosik. Effect of static stretching on the maximal length and resistance to passive stretch of short hamstring muscles. *Journal of Orthopedic Sports Physical Therapy.* 1991, **14**(6): 250-255.

[19] Ross A Clark. Hamstring injuries: Risk assessment and injury prevention. *Ann Acad Med Singapore.* 2008, **37**(6): 341.

[20] Russell T N, William DB. Eccentric training and static stretching improve hamstring flexibility of high school males. *Journal of Athletic Training.* 2004, **39**(3): 254-8.

[21] Sharon S, Susan L, Ray G, Janine E. Lower extremity muscular flexibility in long distance runners. *J Orthop Sports Phys Ther*. 1993, **17**(2): 102-7.

[22] Takada, J. (Ed.). *Sports and health theory for students.* Kanagawa: Kogaku-Shuppan, 1990.

[23] Teddy W Worrell, Troy L. Smith, Jason Winegardner. Effect of hamstring stretching on hamstring muscle performance. *Journal of Orthopedic Sports Physical Therapy*. 1994, **3**: 1154-159.

[24] Weijer C.D, Gorniak PT. The effect of static stretch and warm-up exercise on hamstring length over the course of 24 hours. *J Orthop Sports Phys Ther.* 2003, **33**(12): 727-33.

[25] Wiliam D Bandy, Michelle Briggler. *The effect of time and frequency of static stretching on flexibility of the hamstring muscles. Physical Therapy.* 1997, **77**(10): 1090-1096

[26] William D Bandy, Jean M Irion, Michelle Briggler. Effect of time on static stretch and dynamic range of motion on the flexibility of hamstring muscle. *Journal of Orthopedic Sports Physical Therapy*. 1998, **27**(4): 295-300.

[27] Witvrouw E, Lysens R, Bellemans J. Intrinsic risk factors for the development of anterior knee pain in an athletic population: a two years prospective study. *Am J Sports Med.* 2000, **28**: 480-9.

[28] Worrell T.W. and Perrin D.H. Hamstring muscle injury: the influence of strength, flexibility, warm up and fatigue, *J Orthop Sports Phys Thera.* 1992, **16**:12-18.

[29] Yamamoto, T. Significance of flexibility for prevention of injuries and enhancement of sport performance. *Training Journal*. 1996: 84-87