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Title: Acute Effect of Massage, Static Stretching, and Foam Rolling on Hamstring Muscle Flexibility

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Abstract

Purpose: Optimized flexibility, a critical component of physical fitness, substantially influences sports performance and injury prevention. This study aimed to evaluate the immediate effects of static stretching (SS), massage, and foam rolling (FR) on hamstring muscle flexibility.

Method: This study was quasi-experimental with a pre-post-test design. The statistical population consisted of football players with hamstring tightness. Thirty participants, aged between 17 and 25 years, were selected as research samples considering the incorporation and exclusion criteria and entered the study with full consent and awareness. The subjects were divided into three groups: SS, massage, and FR. The Straight Leg Raise (SLR) test assessed hamstring flexibility. A one-way ANCOVA was conducted to compare the three groups, with a significance level of $p \leq 0.05$.

Results: The one-way ANCOVA revealed a significant difference in the immediate effects of three interventions [$F(2,27) = 5.274$, $p<0.05$]. The Bonferroni post hoc pairwise comparison revealed that the SS group showed significantly greater flexibility improvement than the FR group ($p=0.004$). Additionally, in contrast to the massage group, SS performed better ($p=0.04$). However, the Bonferroni post hoc test did not find a significant difference between the massage and FR groups ($p=0.289$).

Conclusion: Compared to massage and FR, SS seems to be a suitable option for increasing immediate flexibility in football players with hamstring tightness.

Keywords: Hamstring tightness, Foam rolling, Static stretching, Massage.

Highlights

- In people with short hamstrings, in terms of acute effect, static stretching is superior to massage in increasing hip flexion range of motion (ROM).
- In individuals with shortened hamstrings, in terms of acute effect, static stretching is better than foam rolling to increase hip flexion ROM.
- Massage and foam rolling have no acute effect on the hip’s ROM.

Plain Language Summary

This paper was done to assess the immediate effect of static stretching, massage, and foam rolling on the flexibility of football players' hamstring muscles. The study involved thirty football players aged 17 to 25 with tight hamstrings. These players were assigned to one of three groups: static stretching, massage, or foam rolling. The Straight Leg Raise (SLR) test assessed hamstring flexibility. The results showed that static stretching significantly improved hamstring flexibility compared to massage and foam rolling. In simple terms, if you're a football player with tight hamstrings, doing static stretches is likely the best way to acutely increase your flexibility compared to getting a massage or using a foam roller. In conclusion, for football players with tight hamstrings, static stretching is an effective method to enhance hip flexion ROM immediately. This finding is helpful for athletes and coaches looking to improve performance and prevent sports injuries through optimal flexibility and ROM.

Introduction:

Flexibility refers to the capacity to move a specific joint through its full ROM, which is influenced by the joint's structure, the condition of the ligaments and fascia, and the elasticity of the surrounding muscles (1). It is a key factor that significantly affects physical fitness and sports performance (2, 3). The type of joint, periarticular tissues, gender, and age all influence flexibility (2, 4). Abnormal stiffness in the muscles, which impairs the elastic properties of these tissues, makes it difficult to lengthen the muscles during physical activities when internal and external forces are applied. This restriction ultimately leads to a reduction in the ROM (5). Adequate flexibility and muscle stiffness can improve performance, reduce muscular pain, and lower the risk of sports injuries. In contrast, a lack of optimal flexibility results in restricted ROM and muscle imbalance, which not only negatively affects athletic performance but also increases the likelihood of injury (6, 7). Hamstring strains are among the most common sports injuries in football players, and due to the high risk of recurrence in affected individuals, scientific research into these injuries is essential (8). Studies have shown that insufficient strength or poor flexibility is usually the cause of most hamstring injuries (8, 9).

Stretching exercises can lead to long-term increases in joint range of motion (ROM) (10). There are various stretching exercises; however, static stretching (SS) and proprioceptive neuromuscular facilitation (PNF) are the most common strategies. Muscles and surrounding connective tissues are stretched to mild discomfort or stretch perception during SS (11). SS can be used to enhance flexibility and lower the risk of injuries, as it is incorporated into warm-up routines (12). In this context, previous studies have affirmed the effectiveness of these exercises in enhancing ROM (11, 13). Changes in flexibility after SS interventions are attributed to alterations in stiffness of the tendon-muscle unit (14, 15) and stretch tolerance (16). The impact of SS on these two mentioned factors is influenced by the duration of stretching (17,18). It has been reported that ROM increases immediately following SS(17, 18). However, some studies have shown that, for instance, in the hamstring muscles, the myotendinous unit is significantly affected after 180 seconds of SS (19, 20).

Self-myofascial release (SMR) has recently become a common technique in both sports and clinical environments. This self-administered approach involves applying compressive forces to soft tissues. It simulates the impacts of manual techniques and is intended to address soft tissue dysfunctions (21, 22). A foam roller is a widely utilized SMR tool in sports and physiotherapy practices (23). Two of the benefits of SMR using a foam roller are that it does not negatively affect muscle strength (24) or vertical jump performance (25). Additionally, foam rolling (FR) can improve maximal running speed (26), reduce muscle soreness (27), and enhance neuromuscular efficiency (28). Several studies have primarily investigated the effects of FR on ROM, pain, and the mechanical characteristics of the lower limbs (29). While some investigations have demonstrated that FR can enhance ROM, the underlying mechanisms of this enhancement remain insufficiently understood (25). The effectiveness of SMR is attributed to the direct application of pressure to soft tissues, which may result in fascia warming, the breakdown of fibrous adhesions, and the restoration of the elastic properties of soft tissues (30).

Massage is described as the purposeful manipulation of soft tissues using fingers, hands, forearms, elbows, knees, or feet, with or without the application of lubricants, coverings, heat, cold, handheld tools, or other external devices, for therapeutic or enhancement purposes (31). Swedish massage applied to the hamstrings appears to enhance hamstring flexibility in female athletes, with the effect remaining even after a 5-day cessation of the massage (32). In a previous study, Crossman et al. (1984) investigated the impact of massage on hamstring flexibility in women, and their results showed that this intervention significantly enhanced the hamstring's excursion (33). Since then, several studies have investigated the effect of massage on flexibility, but the results remain inconclusive. Some studies have indicated that massage can enhance flexibility (34-36), while other studies have reported contradictory findings (38,39). In this regard, Hopper et al. (2005) found that soft tissue mobilization can increase hamstring flexibility (37).

There is limited experimental evidence supporting SMR, with the existing literature primarily reporting chronic rather than acute effects of myofascial release on muscle function. Several methods are employed to enhance muscle flexibility, and numerous studies have been conducted in this area. This research compares the effects of SS, massage, and FR on hamstring flexibility in football players with hamstring tightness.

Methods:

The paper was a semi-experimental study that included pre-test and post-test design. The study's statistical population included male football players aged 17-25 with hamstring tightness. The sample consisted of 30 individuals from the population who were purposefully selected and randomly allocated to 3 research groups. The incorporation criteria for the current research were being a football player, being a boy in the age range of 17-25 years, and having hamstring tightness. Participants with a history of hamstring muscle injury, lower limb injury in the past year, back pain (38). Participation in exercise programs and corrective exercises affecting the test result were excluded.

Before starting the test process, all stages were fully explained to the participants; they were instructed to fill out and sign the consent form and personal information questionnaire if they fully agreed to partake in the study. The researcher used the massage technique and flexibility measurement, but SS and FR were used independently after teaching the subjects these techniques. The test was conducted in three separate sessions (day 1: massage, day 2: SS, and day 3: FR). In the test session, the participant's height, weight, and hamstring muscle flexibility were initially measured and recorded. After the interventions, hamstring muscle flexibility was measured again and recorded on a specific form. The classic massage technique, which includes stroking and circular movements with the palm (effleurage) from the distal to proximal part, similar to kneading dough towards the front, applying pressure with the hand, lifting and shaking from proximal to distal, was applied to the back of the thigh. These steps were repeated five times in order. The entire massage process lasted for 8 minutes.

For the SS, the participant was supine with their trunk upright and the non-tested leg resting flat on the ground. The tested leg was gradually lifted off the ground while maintaining a straight knee. The participant maintained this position for 30 seconds, completing four repetitions of 30 seconds each (39).

To perform FR, the subject was instructed to position the foam roller near the origin of the hamstring muscle and sit on it. Then, they moved it towards the knee, with the knees straight and the ankle relaxed. Next, the participant was instructed to bear their weight with extended arms while the palms were on the floor and lift the torso upward to create more pressure between the foam roller and the hamstring muscles (Three 1-minute repetitions, with a 30-second rest interval) (38).In this study, DTR foam rollers with a circumference of 10 centimeters and a thickness of 3 centimeters were used (39). DTR foam rollers have semi-flexible and asymmetrical nodes on their body, which increase pressure on the tissues.

The Passive Straight Leg Raise (PSLR) test and the Sit-and-Reach (SR) test are commonly employed in both clinical and research settings to assess hamstring flexibility (40). In this study, the PSLR test was utilized. The Shapiro-Wilk test was conducted to evaluate the normality of the data distribution, and one-way ANCOVA was used to compare the immediate effects of the interventions. Following this, the Bonferroni post-hoc test was conducted for pairwise comparisons. A significance level of 95% and an alpha level of 0.05 or lower were considered in the analysis.

Results:

In this study, 30 participants participated in every research stage. Regarding demographic factors such as body mass index (BMI), weight, height, and age, the participants were homogeneous, with no significant differences noted. The normality of the data distribution was assessed using the Shapiro-Wilk test. A significance level greater than 0.05 indicates a normal distribution of the data (Table 1).

Table 1. Participants' Demographic Characteristics

Group / Variable	Static Stretching	Massage	Foam Rolling	Significance
	Standard deviation ± mean	**Standard deviation ± mean**	**Standard deviation ± mean**	
age (years)	۱۹/۳۰±۱/۶۳	۱۹/۰۰±۱/۸۲	۱۹/۴۰±۱/۵۰	۰/۸۵
height (cm)	۱۷۷/۸۰±۷/۰۲	۱۸۰/۵۰±۵/۰۶	۱۷۷/۳۰±۵/۰۳	۰/۴۲
weight (kg)	۶۹/۶۰±۷/۸۴	۷۱/۴۰±۹/۲۱	۶۷/۴۰±۵/۰۱	۰/۵۰
BMI	۲۲/۰۲±۲/۱۵	۲۱/۸۷±۲/۲۹	۲۱/۴۶±۱/۶۸	۰/۸۲

Another assumption of the ANCOVA test is the homogeneity of variances. Levene's test was conducted to assess the homogeneity of variances.

Considering the results of Shapiro-Wilk and Levene's tests, we used a one-way analysis of covariance (ANCOVA) to compare flexibility among the three groups (SS, massage, FR). The output of the ANCOVA analysis showed that (Table 2), after controlling for pretest effects (covariate), there is a significant difference in hamstring muscle flexibility among the three groups.

Table 2: Results of Analysis of Covariance (ANCOVA)

Variable	sum of squares	Degree of freedom	mean square	F ratio	P-value	Effect size
Pre-test	441.975	1	441.975	171.449	.00۱	**.868**
Group	174.648	2	87.324	33.874	.00۱*	**.723**
Error	67.025	26	2.578			
Sum	148830.000	30				

*significant difference

The results of the ANCOVA indicated significant differences among the groups. Therefore, we employed the Bonferroni post-hoc to detect which specific pairs of groups showed significant differences. Since we had three groups, the significance level, set at 0.05, was divided by the number of groups, resulting in a significance level of 0.017 for each comparison. The results revealed significant differences between the SS and massage groups and between the SS and FR groups. However, no significant difference was found between the massage and FR groups (Table 3).

Table 3: Results of the Bonferroni post-hoc test

Group	Group	mean difference	Standard error of the mean (SEM)	P-value
Static stretching	Massage	4.014	-.718	**0.001**
	Foam rolling	5.770	0.719	**0.001**
Massage	Foam rolling	1.756	0.719	**0.065**

Discussion:

This study aimed to compare the effectiveness of three stretching interventions—SS, FR, and massage—on hamstring flexibility in football players with hamstring tightness. The results showed that all three interventions positively impacted hamstring flexibility, as measured by the PSLR test. However, SS led to a significant improvement in hip ROM in football players with hamstring tightness. These findings align with the studies conducted by Siebert et al. (2022), Skarabot et al. (2015), Couture et al. (2015), and Evans (2014) (41-44). Siebert et al. (2022) compared the effects of dynamic stretching (DS), FR, and SS on hip joint ROM. Their study suggested that SS and DS are effective methods for increasing actual ROM, whereas the benefits of FR seem more related to pain threshold adjustments rather than a direct improvement in ROM (43). Skarabot et al. (2015) investigated the effects of FR and SS on ankle ROM in adolescent athletes. Participants in the mentioned study were randomly assigned to three groups: FR, SS, and a combination of both. The results revealed that SS increased ROM by 6.2%, while the combination of FR and SS led to a 9.1% increase in ROM. However, FR alone had no significant effect on ROM, which aligns with the current study's findings (44). Couture et al. (2015) compared the impacts of long-term (4 × 30 seconds) and short-term (2 × 10 seconds) myofascial release interventions on knee ROM in healthy individuals. The findings of that study indicated that neither of the myofascial release protocols led to a significant improvement in knee ROM (41). Evans (2014) also demonstrated that SMR does not affect flexibility or hamstring strength during movements. This researcher recommended avoiding reliance on SMR to increase flexibility during warm-up, as its effectiveness contradicts previous findings, suggesting the need for further research in this area (42).

The SS technique is recognized as an efficient approach for increasing muscle flexibility and ROM in the sports world. This method improves the extensibility of muscles and connective tissue, as it induces neural and muscular adaptations that can enhance the ROM. From a neurocognitive perspective, this method can also help increase an individual's tolerance to stretching by reducing the excitability of motor neurons and stretch reflex sensitivity, subsequently leading to an increase in the ROM (45). Additionally, SS reduces the sensitivity of muscle spindles and increases their adaptation to stretching. This method can minimize the signals of primary and secondary afferent receptors embedding in muscle spindles. Also, by exerting forces on tendons, autogenic inhibition reflexes and muscle relaxation are mediated by Ib nerve fibers. This combination of neurophysiological effects can enable muscles to elongate further and increase their flexibility (46).

Another reason for the superior effect of SS on hip flexion ROM compared to FR can be attributed to the nature of the applied forces. SS primarily applies longitudinal forces to tendon and muscle tissue, substantially increasing the ROM. However, FR primarily induces transverse forces on muscle tissue, indicating that the reported improvement in the ROM in previous studies may be due to a change in pain threshold rather than actual tissue adaptation (47).

The results of the current study do not align with the results of Reiner et al. (2022), Killen et al. (2019), and Nai-Jen et al. (2016) (39, 48, 49). Reiner et al. (2022) conducted a study comparing the effects of SS and vibration FR on hip ROM. The results indicated that vibration FR led to a larger improvement in hip flexion ROM than SS exercises (49). Killen et al. (2019) also demonstrated that all interventions (FR, SS, and DS) were effective in improving hamstring and quadriceps muscle flexibility, with FR significantly more efficient at enhancing flexibility compared to SS and DS (48). Nai-Jen et al. (2016) also found similar results (39). Another potential reason for the lack of change in the hip ROM due to SMR in the current study may be inadequate pressure applied to the tissue of interest during SMR. Several participants in Evans et al.'s (2014) study reported feeling minimal or no pressure during the SMR protocol. Suboptimal positioning during rolling causes more body weight to be applied to the hands rather than the roller and the tissue of interest. Subsequent studies could improve the effectiveness of SMR by using yoga blocks under the hands and applying more pressure on the thighs. It is noteworthy that, unlike previous studies whose participants had a normal hip joint ROM, the samples in the current study had hamstring tightness.

The current study's findings indicated that 8 minutes of massage had no significant effect on hip ROM. Similarly, Barlow et al. (2004) discovered that one massage on the posterior thigh muscles had a significant effect on SLR performance (50). Wiktorsson-Moeller et al. found that (51) massage, whether performed alone or with a warm-up, did not significantly increase hip ROM. It has been stated that massage does not alter the mechanical characteristics of myotendinous units and does not lead to an increase in ankle ROM (52).

The limitations of the current study include a small sample size and limited familiarity with the participants' SMR. This study investigated the immediate effects of SS, massage, and FR on hip flexion ROM in football players with hamstring tightness. Future research should explore the long-term impact and sustainability of these methods in athletes with hamstring tightness.

Conclusion

This study compared hamstring muscle flexibility among SS, massage, and FR groups. The results of the ANCOVA revealed that, after adjusting for pretest effects as a covariate, hamstring flexibility was substantially different among the three groups. Overall, the findings suggest that SS is a more effective option to increase flexibility immediately in football players with short hamstrings than massage and FR. These findings can be beneficial for athletes and coaches in selecting the optimal method for enhancing flexibility and preventing physical injuries.

Ethical Considerations

Compliance with ethical guidelines

The Islamic Azad University of Research Sciences' ethics committee approved this study (Code:IR.IAU.SRB.REC.1400.005).

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Contribution of authors

Study design and data collection: Hashem Piri, Bahar Darvish; Writing: Elahe Shadi, Mohammad Rahimi
Final approval: All authors

Conflict of interest:

The authors declare no conflict of interest.

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60cm


30cm
60cm

Foam roll protocol
Massage protocol
static stretching