Original Article

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Comparative Effectiveness of Active Release Technique versus Mulligan Bent Leg Raise Technique in Improving Hamstring Flexibility in Asymptomatic Healthy Subjects: A Randomised Controlled Trial

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Abstract:

Objective: Hamstring flexibility is essential for maintaining optimal musculoskeletal function and preventing injuries. Manual therapy techniques such as Active Release Technique (ART) and Mulligan Bent Leg Raise (MBLR) have been explored to enhance flexibility, yet their comparative effectiveness remains unclear. This study aimed to compare the effectiveness of ART, MBLR, and conventional hamstring stretching in improving hamstring flexibility among asymptomatic healthy subjects.

Material and Methods: Thirty-six asymptomatic healthy subjects were randomly assigned to three groups: Group 1 (n=12) received ART, Group 2 (n=12) received MBLR, and Group 3 (n=12) received conventional hamstring stretching. Interventions were administered six days in the 1st week. Hamstring flexibility was assessed using the Active Knee Extension (AKE) at three time points: baseline, at post 1 week, and at post 2 weeks. Data were analyzed using repeated measures ANOVA to evaluate the effects of time and group on AKE ROM, followed by Tukey-Kramer post-hoc tests for pairwise comparisons.

Results: Repeated measures ANOVA showed a significant main effect of time on AKE ROM ($F(2,66)=24.78$, p-value<0.001), with improvements from baseline to weeks 1 and 2 (p-value<0.001). No significant group effect ($F(2,33)=0.80$, p-value=0.458) or group × time interaction ($F(4,66)=1.01$, p-value=0.409) was found.

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Conclusion: All three interventions—ART, MBLR, and conventional stretching—produced statistically significant improvements in hamstring flexibility, with no significant differences between groups. However, the changes did not exceed the minimal clinically detectable threshold, limiting any conclusions about functional relevance. Future trials with larger samples may offer clearer insights into their comparative effectiveness.

Keywords: flexibility, healthy subjects, mulligan technique, range of motion, Tightness

Introduction

Flexibility is a key aspect of physical fitness, contributing to enhanced athletic performance, a lower risk of injuries, reduced post-exercise muscle soreness, and better coordination[1]. The hamstring is a two-joint muscle located at the back of the thigh and acts as an extensor of the hip and flexor of the knee[2]. It is a postural muscle that shows a great tendency to shorten even among young and healthy individuals[3]. Hamstring extensibility is a well-established element of physical fitness and is widely acknowledged as a significant indicator of overall health and quality of life. Studies showed that there is a 40.17% prevalence of hamstring muscle tightness among adults[4]. Restricted hamstring flexibility has been associated with an increased risk of low back pain, as well as diminished range of motion in the hip, knee, and lumbar spine flexion[5].

Flexibility exercises are designed to enhance tissue elasticity, enabling smooth and efficient movement. Various techniques are employed to stretch the tight connective tissue, including static[6] and dynamic stretching[7], Muscle Energy Technique (MET)[8], Myofascial Release Technique (MFR)[9], Active Release Technique (ART)[10], Proprioceptive Neuromuscular Facilitation (PNF)[11], and Mulligan's Bent Leg Raise (MBLR) technique[9,12] . Among these, both ART and MBLR have individually demonstrated effectiveness in improving hamstring flexibility. Active Release is a manual soft-tissue therapy designed to modify changes in tissue texture and tension[13], which helps break down the scar tissue and adhesions, enabling the muscle to fully lengthen and restore flexibility for optimal functional performance[14]. ART for the hamstring aims to relieve pain and tightness while assisting the hamstring to return to its natural, healthy state[15]. MBLR is a gentle, pain-free approach involving isometric stretching of the hamstrings in targeted directions, performed in progressively increasing angles of hip flexion[12].

Studies have substantiated the standalone effectiveness of these techniques. Studies comparing these techniques and their effects on hamstring flexibility are limited. Existing research primarily examines their immediate effects and often lacks a control group[10,16], making it challenging to isolate and assess the specific efficacy of each technique. Moreover, there is a dearth of evidence on the follow-up effects of interventions when treatment is discontinued. Hence, the current study is designed to overcome the limitations in the existing literature. The present study aimed to compare the efficacy of these two techniques to determine which is more effective in improving hamstring flexibility with a one-week intervention and follow-up at the end of the 2nd week. The findings of this study can contribute to understanding whether ART and MBLR have a role beyond traditional hamstring stretches in enhancing hamstring flexibility among asymptomatic healthy individuals.

Material and Methods

Approval for the study was given by the Research Review Committee and the Ethics Committee of the Indian Spinal Injury Centre (ISIC/RP/2023/001), New Delhi, India. All subjects provided written informed consent before the commencement of data collection. The screening protocol used the standardized Active Knee Extension (AKE) Test,

which is a well-known and validated assessment tool for measuring hamstring flexibility and range of motion[17,18]. In total, 36 healthy, asymptomatic subjects who fulfilled the inclusion and exclusion criteria were recruited from the Indian Spinal Injury Centre (ISIC), New Delhi. The sample size of 36 subjects was divided into three groups of 12 each, and it was calculated to achieve 80% power at a 0.05 significance level to detect a moderate effect size (Cohen's)[10]. The Sampling was purposive. This study had a comparative design.

The subjects were both males and females, aged between 18 and 25 years[19], with tight hamstrings (defined as the inability to achieve greater than 160° of knee extension, while the hip is maintained at 90° flexion)[12,20] on the dominant leg (leg used for kicking a ball). Subjects with any history of neurological or orthopedic disorders affecting the spine or lower extremities[9,11,17], deformity of the spine or lower limb[9,21], swelling in the area of the hamstring muscle[1], or history of trauma at the hip, knee, ankle, or back, which can affect hamstrings, were excluded[5,10].

After screening, subjects were randomly assigned into three groups by Research Randomizer software (https://www.randomizer.org/): Group 1 received ART, Group 2 underwent MBLR, and Group 3 received conventional hamstring stretching (Figure 1). The intervention in all three groups was administered over one week, six days consecutively, with a single rest day on the seventh day. No intervention was given in the 2nd week. The interventions were administered by a qualified physiotherapist with substantial experience in delivering both the ART and MBLR techniques. Outcome assessment was conducted by a separate, experienced physiotherapist who was blinded to group allocation to minimize assessment bias.

Intervention

Group 1- active release technique (ART)

ART was applied with subjects in the supine position, with the tested leg positioned at 90° hip flexion, while the contralateral leg was stabilized using a belt. The therapist, standing at the subject's side, palpated the tender point on the hamstring muscle and applied gentle tension. The subject was then instructed to actively extend the lower leg from a flexed knee position to full extension until a mild stretching sensation was felt[13,16], which was held for 30 seconds (Figure 2). This technique was repeated 3 times.

Group 2- Mulligan's bent leg raise technique (MBLR)

Subject's position for this technique was supine with the lower limb passively flexed at the hip and knee to 90°. The therapist, standing at the subject's side, placed the subject's flexed knee over the therapist's shoulder. The subject was instructed to apply sub-maximal force to the therapist's shoulder by pushing against the therapist for five seconds, followed by a five-second relaxation period. The therapist then passively increased hip flexion toward the subject's same-side shoulder, ensuring pain-free movement. A longitudinal traction force along the long axis of the femur was also added with this technique[10,12,21]. This sequence was repeated for ten seconds, then the leg was lowered (Figure 3). The sequence was performed five times, followed by a one-minute rest period. This cycle was repeated three times[9].

Group 3- conventional hamstring stretching

Subjects were positioned in a supine posture with the hip and knee flexed to 90°. The opposite leg was stabilized using a belt. The therapist, standing beside the subject, passively extended the knee until a mild stretch was reported (Figure 4). The stretch was held for 30 seconds, and the leg was then slowly lowered back to the plinth. This procedure was repeated three times, with a 15-second rest interval between each stretch[6,22].

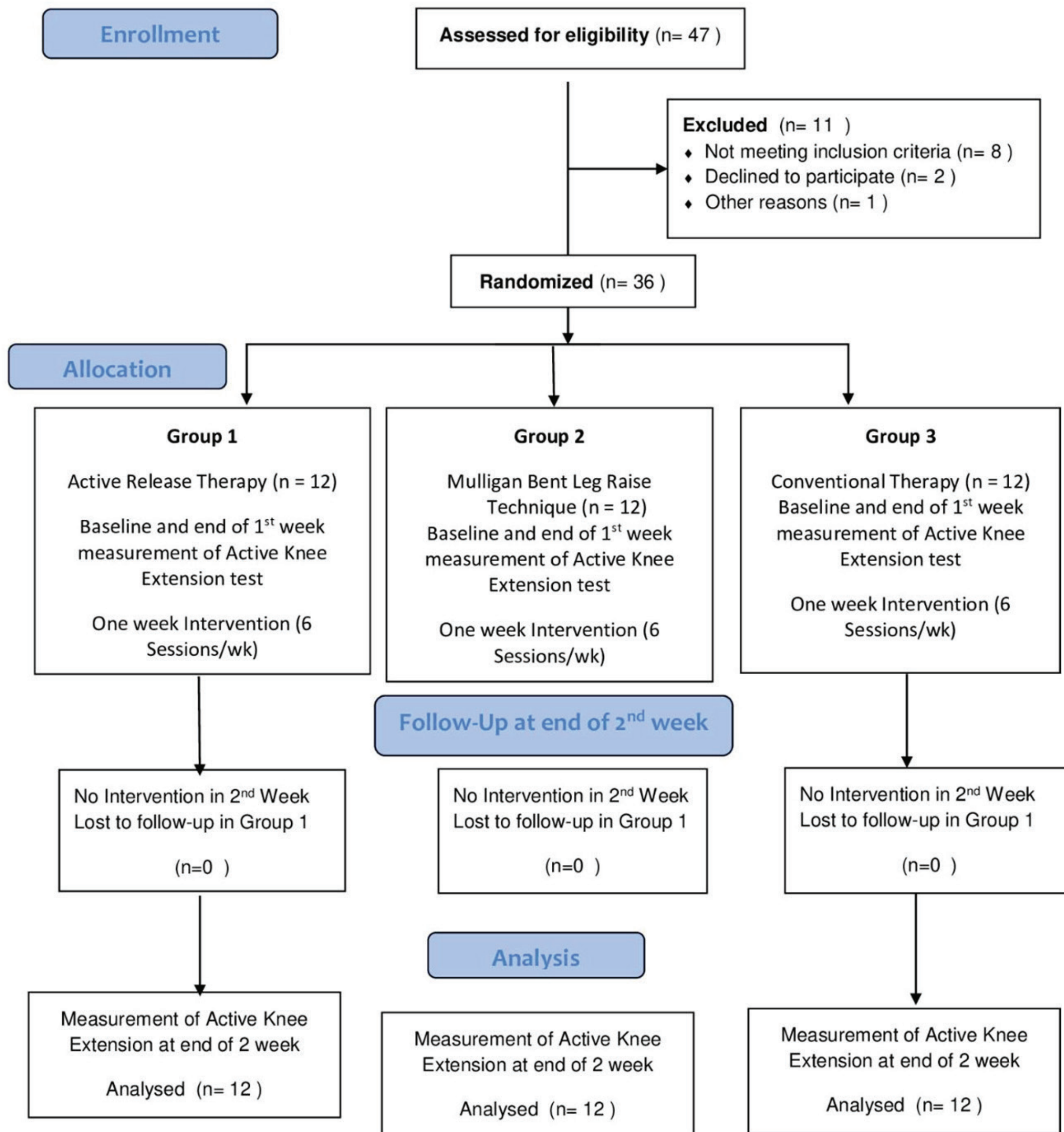

Figure 1 Consort flow diagram

Outcome measure

Active knee extension (AKE)

The subject was positioned supine, with both the hip and knee of the tested limb flexed to 90°, ensuring standardized alignment for the assessment, while the therapist stood beside the limb being tested. A crossbar was used to maintain proper alignment of the hip and thigh, and the pelvis was secured to the table with a strap for stabilization. The assessment was conducted on the lower extremity, using anatomical landmarks—greater trochanter, lateral femoral condyle, and lateral malleolus—which were marked with a skin-safe marker. Throughout the

assessment, the front aspect of the thigh remained in touch with the horizontal crossbar to ensure the hip remained in 90° flexion. The subject was then asked to actively extend the leg until a mild stretch was felt. A full-circle goniometer was used to measure the knee extension angle (Figure 5). This procedure was repeated three times, and the mean of the three measurements was recorded as the final knee extension angle. The inter- and intra-rater reliability for AKE measurement was 0.99[17,23].

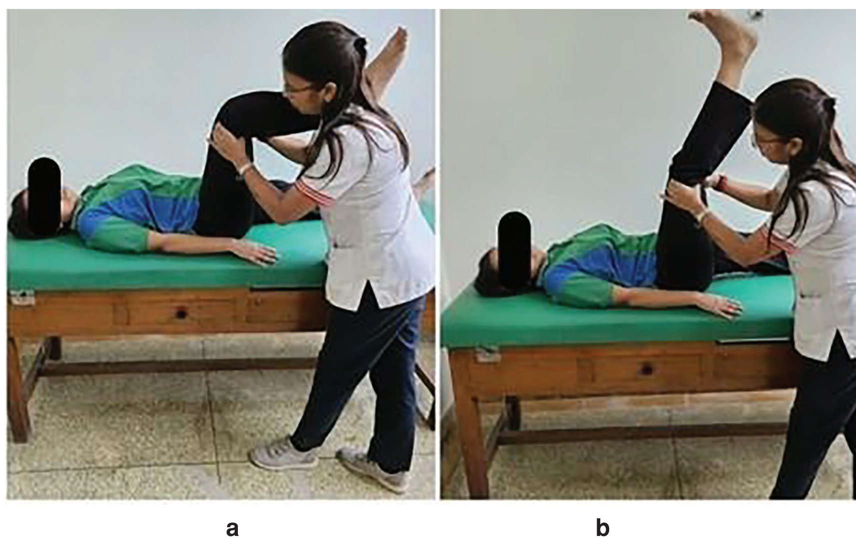

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Figure 2 Active release technique (a) start position (b) end position

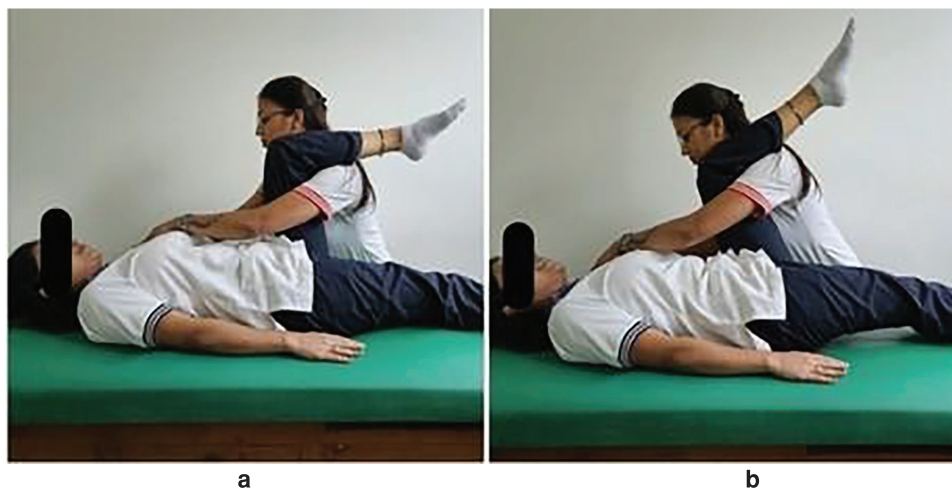

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Figure 3 Mulligan's bent leg raise technique (a) start position (b) end position

Baseline data were collected prior to the commencement of the study. All groups received a supervised intervention with six repetitions per week. Post-intervention data were gathered at the end of the first week, and follow-up data were obtained at the conclusion of the second week to assess short-term retention effects.

Figure 4 Conventional stretching

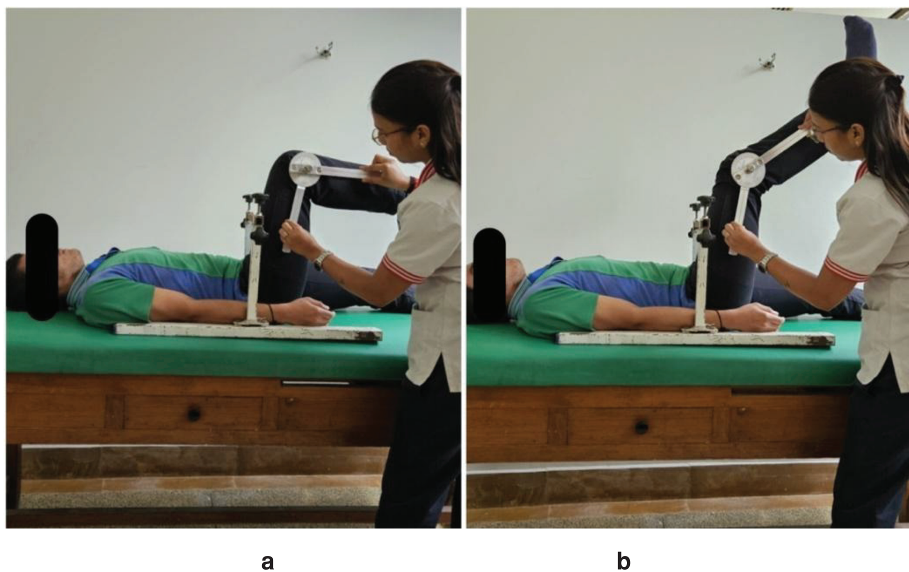

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Figure 5 Active knee extension test (a) start position (b) end position

Data analysis

Statistical analyses were performed using the NCSS package version 12.0 (NCSS, Kaysville, UT, USA). The normality of the data was verified using the Shapiro-Wilk test, and the data were found to be normally distributed. Repeated Measures ANOVA was employed to compare the average AKE ROM (Degrees) across the three groups and three time points, followed by Tukey-Kramer post-hoc tests for pairwise comparisons. A significance level of p-value<0.05 was set for all statistical comparisons. Data from all 36 subjects who completed the study were included in the analysis. The Active Knee Extension (AKE) was used as the primary outcome measure.

Results

In total, 36 asymptomatic healthy subjects were included (10 males and 26 females). The demographic characteristics of subjects are given in Table 1, and the descriptive values of AKE are given in Table 2.

Repeated measures ANOVA results revealed that (Table 3):

The main effect of time on AKE ROM was statistically significant (F=24.78, p-value<0.001), indicating appreciable changes across assessment periods.

The main effect of the group was not statistically significant (F=0.80, p-value<0.46), suggesting that there were no significant differences in AKE ROM among the 3 groups at the group level.

The group × time interaction was not statistically significant (F=1.01, p-value<0.41), denoting that the pattern of change over time was similar across all groups.

Post-hoc Tukey-Kramer tests confirmed significant improvements from baseline to both post 1 week and post 2 weeks but did not indicate significant differences between the groups at comparable time points.

Table 1 Demographic characteristics of group 1 (ART), group 2 (MBLR), and group 3 (Conventional)

Demographic characteristics	Group 1 (n=12)	Group 2 (n=12)	Group 3 (n=12)
Male	2 (16.7%)	2 (16.7%)	6 (50%)
Female	10 (83.3%)	10 (83.3%)	6 (50%)
Age (years)	20.75±0.96	23.08±1.83	23.17±1.52
Weight (kg)	57.07±9.32	60.87±2.81	61.73±13.08
Height (cm)	161.53±7.35	164.33±8.59	164.27±7.58
BMI (kg/m^2)	21.78±2.56	22.48±2.81	22.66±3.06

ART=active release technique, MBLR=Mulligan bent leg raise technique
*Age, Height, and Weight - (mean±S.D) is mentioned

Table 2 Descriptive active knee extension values for group 1 (ART), group 2 (MBLR), and group 3 (Conventional)

Average AKE ROM (Degrees)	Group 1 (mean±S.D.)	Group 2 (mean±S.D.)	Group 3 (mean±S.D.)
Baseline	138.67±6.86	138.58±7.97	141.25±7.78
Post 1 week	141.66±6.65	144.41±6.69	145.417±8.25
Post 2 week	141.00±8.112	143.25±7.12	145.583±7.26

Table 3 Repeated measures ANOVA results of AKE across groups and time

Factor	Degree of freedom (DF)	F-Value	p-value
Group	2	0.80	0.458[NS]
Time	2	24.78	<0.001*
Group xTime	4	1.01	0.409[NS]

*significant p-value<0.05, [NS] Not Significant

Discussion

The result of the present study depicted no significant difference between the ART and MBLR techniques over the Conventional Hamstring Stretching post 6 days of intervention sessions. The possible reason could be due to the shorter duration and dosage of intervention, and moreover, we did not combine the conventional treatment in the intervention groups, as we wanted to see the individual effects of the ART and MBLR techniques over the conventional hamstring stretch.

These results are in correlation with Boora et al.[24], who compared massage and static stretching on subjects with hamstring tightness and found no significant improvement post 1 week of intervention. On the contrary, Kage et al.[16] compared the immediate effectiveness of ART and MBLR in subjects with hamstring tightness using AKET and concluded that a single session of ART is better than the MBLR technique for increasing hamstring flexibility and ROM.

The results indicated no significant difference between ART and MBLR compared to conventional hamstring stretching at one and two weeks post-intervention. However, within-group analysis revealed that all three groups showed significant improvements in AKE measurements at both one and two weeks compared to baseline. These findings suggest that each stretching technique was individually effective in enhancing hamstring flexibility among asymptomatic healthy subjects with hamstring tightness.

Notably, the change in AKET angle in the study was less than 5 degrees, which is below the minimal clinically detectable change (MDC) for this test. Literature indicates the MDC for the AKE test is approximately 8-12 degrees, meaning changes smaller than this may represent a measurement error rather than true functional improvement[25]. Factors explaining this limited change include the short duration and dosage of intervention, the healthy asymptomatic population with mild tightness, and the similar effectiveness of all three techniques studied. Future studies should consider longer interventions, larger clinical populations, and combined or intensified treatments to achieve clinically meaningful improvements.

In general, insufficient regular stretching of the hamstring muscles increases the likelihood of muscle tightness, which may contribute to reduced flexibility and a higher risk of musculoskeletal injuries. Fascia tightens as a biomechanical protective response to trauma, losing its elasticity and becoming restricted. Over time, this restriction can impair muscle biomechanics, disrupt structural alignment, and reduce strength, endurance, and motor coordination. As a result, individuals may experience pain and diminished functional capacity[9]. This emphasizes the importance of incorporating stretching techniques like the MBLR and ART, which help release scar tissue adhesions,

promote full muscle lengthening, and restore flexibility for functional activities. Static stretching is hypothesized to increase flexibility due to changes in viscoelastic properties. It has also been suggested that increases in muscle length are related to viscoelastic behavior[26]. This type of stretching may influence the positional sensitivity of the Golgi tendon organs by affecting the muscle's series elastic component[27].

The significant improvement in Active Knee Extension (AKE) observed in Group 1 (ART) can be credited to the modification of tissue structures through the breakdown of restrictive cross-fiber adhesions and the restoration of normal soft tissue function. ART involves the application of pressure, tension, and movement to encourage the proper interaction between muscle and tissue layers. Additionally, ART is based on the Law of Repetitive Motion, which addresses the underlying causes of dysfunction by alleviating the persistent pressure and tension associated with adhesions or scar tissue formation. By eliminating these restrictions, ART not only enhances muscle function but also helps prevent recurrence of the issue[10]. This finding is supported by a study conducted by Kage et al.[16], which also reported significant improvements in Popliteal Angle and Sit and Reach Test scores in the same population as our study.

The significant improvement in AKET observed in Group 2 (MBLR) may be due to the opening of the facet joints and intervertebral foramina of the lumbar spine, as the pelvis moves into a posterior tilt at end range. This movement facilitates the stretching and release of the thoracolumbar fascia, thereby enhancing hamstring flexibility. These findings are in sync with Bandawe et al.[9], who also reported significant improvements in hamstring flexibility, as measured by the Sit and Reach Test, following one week of treatment and upon follow-up at the second week.

The significant improvement in AKET observed in Group 3 (Conventional Hamstring Stretch) might have been due to the inhibition of alpha motor neuron activity through activation of the Golgi Tendon Organ (GTO), which decreases muscle tension and promotes relaxation of the hamstring muscle[9,26]. Wasim et al. hypothesized that the mechanical response of muscle to stretching is due to changes in its viscoelastic properties. They proposed that passive static stretching activates the Golgi Tendon Organ (GTO), which inhibits muscle tension and allows the sarcomeres to lengthen. Their study determined that static stretching was more successful in improving the popliteal angle and hamstring flexibility in healthy Indian collegiate males[1].

Therefore, it can be concluded that each of these techniques is effective on its own in enhancing hamstring flexibility.

Clinical implication

There was no statistically significant difference observed among the three intervention groups, which validates that the effectiveness of each intervention is independently significant and should be implemented in clinical settings for evidence-based practice. Asymptomatic patients experiencing hamstring tightness can be treated with any of the interventions to reduce hamstring tightness.

This study has several limitations. First, the sample size was restricted due to time constraints inherent to the study timeline; future trials with larger cohorts are recommended to enhance the generalizability of findings. Second, Groups 1 and 2 included a disproportionately higher number of female subjects, and gender matching was not performed. This may limit the applicability of the results, as sex-based physiological and psychosocial differences could influence responsiveness to the interventions. Third, the short duration of both the intervention and follow-up restricted the ability to evaluate long-term outcomes or sustained benefits. A longer follow-up period would offer more robust insights into the durability of treatment

effects. Lastly, the inclusion criteria were limited to healthy individuals, which constrains the direct applicability of the findings to clinical populations with underlying conditions.

Conclusion

All three interventions—Active Release Technique, Mulligan's Bent Leg Raise, and Conventional Hamstring Stretch—were found to be individually effective in enhancing hamstring flexibility post 1 and 2 weeks of intervention. However, between-group significant differences in Active Knee Extension were not observed.

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Conflict of interest

The authors declare that there are no potential conflicts of interest related to the development and publication of this article.

References

1. Waseem M, Nuhmani S, Ram CS, Ahmad F. A comparative study: Static stretching versus eccentric training on popliteal angle in normal healthy Indian collegiate males. Int J Sports Sci Eng 2009;3:180-6.
2. Worrell TW, Perrin DH. Hamstring muscle injury: the influence of strength, flexibility, warm-up, and fatigue. J Orthop Sports Phys Ther 1992;16:12-8.
3. Webright WG, Randolph BJ, Perrin DH. Comparison of nonballistic active knee extension in neural slump position and static stretch techniques on hamstring flexibility. J Orthop Sports Phys Ther 1997;26:7-13.
4. Koli BK, Anap DB. Prevalence and severity of hamstring tightness among college student: a cross sectional study. Int J Clin Biomed Res 2018:65-8.
5. Czaprowski D, Leszczewska J, Kolwicz A, Pawłowska P, Kędra A, Janusz P, et al. The comparison of the effects of three physiotherapy techniques on hamstring flexibility in children: a prospective, randomized, single-blind study. PLOS one 2013;8:e72026.
6. Medeiros DM, Cini A, Sbruzzi G, Lima CS. Influence of static stretching on hamstring flexibility in healthy young adults: systematic review and meta-analysis. Physiother Theory Pract 2016;32:438-45.
7. Iwata M, Yamamoto A, Matsuo S, Hatano G, Miyazaki M, Fukaya T, et al. Dynamic stretching has sustained effects on range of motion and passive stiffness of the hamstring muscles. J Sports Sci Med 2019;18:13.
8. Lad D, Patel P. Comparison of muscle energy technique and various stretching methods in assessing hamstring muscle flexibility in healthy individuals: a narrative review. Bharati Vidyapeeth Med J 2025;5:15-20.
9. Tai MZ, Bandawde M, Palekar T, Gondkar D. To compare effectiveness of mulligan bent leg raise versus myofacial release in physiotherapy students with hamstring tightness. Indian J Pharm Biol Res 2017;5:42-7.
10. Ul Abideen Z, Zahoor A, Amjad S, Akram R, Liaqat A, Ijaz Aet al. Effects of Active release technique versus mulligan bent leg raise on hamstring tightness in healthy individuals; a quasi-experimental study,the healer. J Physiother Rehabil Sci 2024;4:948-57.
11. Yadav H, Lehri A, Scholar P. Effect of proprioceptive neuromuscular facilitation on flexibility in males with hamstring tightness. Int J Health Sci Res 2019;9:191-5.
12. Shinde SV, Kanase SB. Effect of mulligan bent leg raise versus neural mobilization on hamstring tightness in college students. IOSR J Dent Med Sci 2017;16:59-63.
13. Abelson B, Abelson K. Release your pain: resolving repetitive strain injuries with active release techniques. North Atlantic Books; 2005.
14. Kothawale S, Rao K. Effectiveness of positional release technique versus active release technique on hamstrings tightness. Int J Physiother Res 2018;6:2619-2.

15. George JW, Tunstall AC, Tepe RE, Skaggs CD. The effects of active release technique on hamstring flexibility: a pilot study. J Manipulative Physiol Ther 2006;29:224-7.
16. Kage V, Ratnam R. Immediate effect of active release technique versus mulligan bent leg raise in subjects with hamstring tightness: a randomized clinical trial. Int J Physiother Res 2014;2:301-4.
17. Hamid MS, Ali MR, Yusof A. Interrater and intrarater reliability of the active knee extension (AKE) test among healthy adults. J Phys Ther Sci 2013;25:957-61.
18. Kane Y, Bernasconi J. Analysis of a modified active knee extension test. J Orthop Spots Phys Ther 1992;15:141-6.
19. Wahid SA. Age Influence on knee joint flexors. Al-Kindy Coll Med J 2012;8:6-11.
20. Oh JS, Kang MH. The Effectiveness of hamstring stretching with proprioceptive neuromuscular facilitation versus jack-knife stretching for individuals with hamstring tightness. J Musculoskelet Sci Technol 2021;5:14-20.
21. Chawla R, Raghani P, Shinde M, Chaudhari S. Immediate effect of suboccipital muscle inhibition technique versus mulligan bent leg raise technique on hamstring tightness in younger individuals: a comparative study. Int J Creat Res Thoughts 2021;9:f76-84.
22. Nagmode S, Borkar P. Effect of active release technique and static stretching on hamstring tightness in normal healthy individuals. Int J Sci Res 2020;4:92–9.
23. Kim MH, Kim YW, Jung DH, Yi CH. Reliability of measured popliteal angle by traditional and stabilized active-knee-extension test. Phys Ther Korea 2009;16:1-7.
24. Boora M, Sharma S. Study on effectiveness of static stretching and massage on hamstring flexibility in normal adults. IOSR J Sports Phys Educ 2016;3:01-5.
25. Olivencia O, Godinez GM, Dages J, Duda C, Kaplan K, Kolber MJ. The reliability and minimal detectable change of the ely and active knee extension tests. Int J Sports Phys Ther 2020;15:776.
26. Medeiros DM, Cini A, Sbruzzi G, Lima CS. Influence of static stretching on hamstring flexibility in healthy young adults: systematic review and meta-analysis. Physiother Theory Pract 2016;32:438-45.
27. Kubo K, Kanehisa H, Kawakami Y, Fukunaga T. Influence of static stretching on viscoelastic properties of human tendon structures in vivo. J Appl Physiol 2001;90:520-7.