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Acute Effect of Pre-stretching Foam Rolling on Hamstring Flexibility in University Students with Hamstring Muscle Shortness: A Randomized Controlled Clinical Trial

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ABSTRACT

Purpose: The current study aims to compare the acute effects of pre-stretching foam rolling with static stretching alone in university students with hamstring shortness.

Methods: The study included volunteers aged 18–25 years with hamstring shortness greater than 20° on the knee joint extension test. Using randomization, participants were assigned to either a static stretching-only group or pre-stretching foam rolling group**.** Foam rolling was performed in 2 sets of 3 minutes each, with a 20-second rest between sets. Hamstring flexibility was assessed before and 5 minutes after the interventions using the active knee extension (AKE), sit-and-reach, and Fingertips-to-Floor Distance (FFD) tests. Post-treatment between-group comparisons were performed using ANCOVA, with the baseline value included as a covariate.

Results: Of the 65 individuals evaluated, 54 participants with hamstring shortness were included (n = 27 control; n = 27 foam rolling). After adjustment for baseline values, no statistically significant between-group differences were observed in right or left AKE scores ($F(1, 51) = 0.73$, $p = 0.39$, $\eta p^2 = 0.01$), although the the effect size was small and favored the foam rolling group. Similarly no statistically significant between-group differences were found in the sit-and-reach test ($F(1, 51) = 0.624$, $p = 0.343$, $\eta p^2 = 0.01$), although the effect size was small and favored the control group.. No statistically significant between-group difference was observed in the FFD test ($F(1, 51) = 1.09$, $p = 0.43$, $\eta p^2 = 0.01$).

Conclusion: Pre-stretching foam rolling did not provide an additional benefit for hamstring flexibility, as assessed by the AKE, sit-and-reach, and FFD tests. These findings indicate that, in terms of acute effects, incorporating foam rolling prior to stretching does not confer a significant advantage over static stretching alone.

Keywords: Myofascial release therapy, Muscle stretching exercises, Hamstring muscles

ÖZET

Amaç: Bu çalışma, hamstring kısalığı olan üniversite öğrencilerinde, statik germe öncesi uygulanan foam roller'ın, tek başına statik germeye göre akut etkilerini karşılaştırmayı amaçlamaktadır.

Metod: Çalışmaya, diz eklemi ekstansiyon testinde 20°'den fazla hamstring kısalığı olan, 18-25 yaş arası gönüllüler dahil edilmiştir. Katılımcılar, randomizasyon yöntemiyle kontrol grubuna (sadece statik germe) veya foam roller grubuna (foam roller uygulamasını takiben statik germe) atanmıştır. Foam roller uygulaması setler arasında 20 saniyelik dinlenme verilerek, 3'er dakikalık 2 set halinde uygulanmıştır. Hamstring esnekliği; müdahalelerden önce ve 5 dakika sonra aktif diz ekstansiyonu (AKE), otur ve uzan ve parmak-zemin mesafe testi kullanılarak değerlendirilmiştir. Tedavi sonrası grup karşılaştırmaları, başlangıç değeri kovaryant olarak alınarak ANCOVA ile yapılmıştır

Bulgular: Değerlendirilen 65 bireyden, hamstring kısalığı olan 54 katılımcı çalışmaya dahil edilmiştir (n = 27 kontrol; n = 27 foam roller). Başlangıç değerlerine göre düzeltme yapıldıktan sonra, sağ veya sol AKE skorlarında gruplar arasında istatistiksel olarak anlamlı bir fark gözlenmedi ($F(1, 51) = 0.73$, $p = 0.39$, $\eta p^2 = 0.01$); ancak etki büyüklüğü küçük olup foam rolling grubu lehineydi. Benzer şekilde, otur ve uzan testinde gruplar arasında istatistiksel olarak anlamlı bir fark bulunmadı ($F(1, 51) = 0.624$, $p = 0.343$, $\eta p^2 = 0.01$); ancak etki büyüklüğü küçük olup kontrol grubu lehinedir. FFD testinde de gruplar arasında istatistiksel olarak anlamlı bir fark gözlenmedi ($F(1, 51) = 1.09$, $p = 0.43$, $\eta p^2 = 0.01$).

Sonuç: Germe öncesi foam rolling uygulaması, AKE, otur-uzan ve FFD testleri ile değerlendirilen hamstring esnekliği açısından ek bir fayda sağlamamıştır. Bu bulgular, akut etkiler açısından, germe öncesinde foam rolling uygulamasının yalnızca statik germe uygulamasına kıyasla anlamlı bir avantaj sağlamadığını göstermektedir.

Anahtar Kelimeler: Miyofasyal gevşetme tedavisi; Kas germe egzersizleri; Hamstring kasları

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The hamstring muscle group, due to its biarticular architecture and predominantly tonic postural function, demonstrates a heightened predisposition to adaptive shortening. This tendency results from the continuous exposure of the musculature to substantial tensile demands arising from both postural maintenance and dynamic lower-limb activities (1,2). A high prevalence of hamstring shortness (63%) has been observed among university students (3). The persistent shortening of the hamstrings can contribute to altered lumbopelvic rhythm and increased posterior pelvic tilt, both of which are strongly correlated with the development of chronic low back pain (4,5). Furthermore, in athletic contexts, restricted hamstring flexibility is a proven risk factor for acute muscle strains and decreased power output during high-velocity movements, such as sprinting and jumping (6,7). Consequently, maintaining optimal flexibility defined as the ability of the muscle-tendon unit to passively stretch through its full physiological range of motion (ROM) remains a focal point of physical therapy and sports conditioning.

Stretching exercises have long been the gold standard for increasing ROM (8). However, foam rolling has emerged as a popular adjunct to traditional methods (9,10). Foam rolling involves the application of pressure to soft tissues using a cylindrical foam device of varying densities. These rigid cylindrical devices are thought to stimulate Golgi tendon organs to reduce muscle tension and increase localized blood flow, potentially breaking down myofascial adhesions (11). Furthermore, the friction generated during foam rolling may alter the thixotropic properties of fascial tissue, theoretically "priming" the muscle for subsequent elongation (12).

Despite their popularity, the literature regarding foam rolling's efficacy remains inconsistent. Su et al. reported that participants experienced significantly greater acute improvements after foam rolling compared with stretching alone, whereas Kamandalius et al. found no additional immediate benefit from foam rolling (13,14). Similarly, the use of a bar roller massage, which operates on principles comparable to foam rolling, produced an acute enhancement in hamstring flexibility (15). However, Bharad et al., in a study involving 60 healthy individuals aged 18–30, no additional advantage was observed when foam rolling was combined with static stretching for managing hamstring shortness (16). Given these conflicting findings, further research is needed to clarify whether foam rolling provides additional benefits when used before stretching. Although dynamic stretching is generally recommended as part of warm-up routines before activities requiring maximal performance, static stretching remains one of the most widely used interventions for improving hamstring extensibility in clinical practice and rehabilitation. Because the primary objective of the present study was to investigate flexibility gains in individuals with hamstring shortness rather than athletic performance, static stretching was selected as the comparator intervention.

This study hypothesized that foam rolling before static stretching may enhance acute hamstring flexibility by reducing interfascial resistance and transiently modulating muscle tone, thereby facilitating subsequent stretching. Determining whether foam rolling provides additional benefits beyond static stretching alone may help clinicians optimize intervention selection and treatment time for individuals with hamstring shortness.

Therefore, this study aims to compare the acute effects of pre-stretching foam rolling versus static stretching alone in university students with hamstring shortness.

Material and Methods

Study Design and Selection Criteria

This prospective, single-blind randomized controlled trial was conducted at Hatay Mustafa Kemal University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, between May 26 and December 28, 2025. Ethical approval for this study was obtained from the Clinical Research Ethics Committee of Hatay Mustafa Kemal University Faculty of Medicine (date: 21.05.2025, decision no: 41). All participants provided written informed consent prior to enrollment. The research followed the Declaration of Helsinki guidelines. This study was not prospectively registered in a clinical trial registry. This randomized controlled trial is reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2010 Statement.

The study recruited university students aged 18–25 years with hamstring shortness of greater than 20° on the active knee extension test. This cutoff was selected based on previous studies that have identified an AKE deficit of more than 20° as indicative of clinically relevant hamstring shortness in healthy young adults (17). Participants were excluded if they had a history of lower extremity surgery, musculoskeletal disorders affecting the lower extremity, ligament or tendon injuries, orthopedic conditions such as patellar fractures, pain, or inflammation, neurological or systemic disorders, or congenital shortening of the lower extremities.

Study Protocol

Participants were randomly allocated to either the control group or the foam-rolling group using a computer-based randomization program (www.random.org). An independent individual prepared numbered index cards, sealed them in opaque envelopes, and delivered them to the treating physiotherapist. All post-intervention assessments were performed by the same blinded physiotherapist, with acute effects measured within five minutes after the intervention. Participants were instructed not to disclose their treatment allocation to the assessor throughout the study. Owing to the nature of the interventions, neither the participants nor the treating investigator could be blinded.

Outcome Measures

Demographic characteristics (age, body mass index, and gender), lower extremity length and joint laxity were collected. Outcome assessments were performed before and after the intervention. The Active Knee Extension (AKE) test was used to determine eligibility because it is a valid and reliable measure of hamstring extensibility with minimal influence from lumbopelvic mobility and other posterior chain structures. The sit-and-reach and Fingertips-to-Floor Distance (FFD) tests were also included to assess overall posterior chain flexibility, reflecting the combined mobility of the hamstrings, lumbopelvic region, and associated soft tissues. Lower extremity length was measured as the distance between the anterior superior iliac spine and the medial malleolus using a tape measure while the participant was in the supine position. The intra-observer correlation coefficient was 0.95 (CI = 0.85) (18). Joint hypermobility was assessed using the Beighton score, a nine-point scale based on five maneuvers comprising four passive bilateral movements and one active unilateral movement (19). The intrarater reliability of the Beighton score has been reported to range from substantial to almost perfect (ICC: 0.71–0.82) (20).

The AKE test was performed to assess hamstring extensibility (21). While lying in the supine position, the patient held their hip at a 90° angle and straightened their leg as far as possible. A manual goniometer was used to precisely measure the final angle of the knee. Measurement was performed twice, and the mean of the two repetitions was recorded for analysis. The interrater reliability, assessed using intraclass correlation coefficients ($ICC_{2,1}$), was 0.87 for the dominant knee and 0.81 for the nondominant knee (22). For the AKE test in healthy or asymptomatic adults, research suggests that a Minimal Detectable Change at the 95% confidence level (MDC_{95}) of ≥12° is required to exceed measurement error (23).

The sit-and-reach test was used to assess overall posterior chain flexibility, including the flexibility of the hamstrings and lower back muscles (24). Participants sat with legs extended and feet against the box, kept their knees straight, placed the right hand over the left, and slowly reached forward as far as possible with both hands, without bending the knees. The fingertip-to-box distance during maximal trunk flexion was measured in centimeters, and the average of two trials was used for analysis. The FFD test was used to evaluate global posterior chain mobility during trunk flexion. Participants performed maximal lumbar flexion with knees fully extended, and the distance from the tip of the middle finger to the floor was measured using a tape measure. The test demonstrated excellent intra- and interobserver reliability (ICC = 0.99) (25).

Interventions

Participants in the foam rolling group performed foam rolling for two 3-minute sets separated by a 20-second rest interval before static hamstring stretching. Each static hamstring stretch consisted of a 30-second hold followed by a 15-second rest interval and was repeated five times. Participants in the control group performed only the static hamstring stretching protocol.

Control Group

They were positioned on a treatment table while a practitioner carried out passive stretching techniques. With the participant's hip flexed and knee extended, the leg was gently moved to the point of discomfort, but not pain. The opposite leg and hip were stabilized on the treatment table using a restraint strap. Each static hamstring stretch was held for 30 seconds, followed by a 15-second rest interval, and repeated five times. This protocol was based on evidence that cumulative static stretching durations of ≥90 seconds improve flexibility regardless of repetition number (26). Therefore, five 30-second stretches with 15-second rest intervals were used to provide a standardized, clinically applicable stimulus and adequate cumulative stretching duration.

Foam Rolling Group

Foam rolling was performed using a high-density EVA foam roller (Livepro LP8231; 33 × 14 cm) with a rigid core and textured surface. Participants rolled the posterior thigh from the popliteal fossa to the ischial tuberosity without hip rotation, maintaining moderate pressure corresponding to 5–6/10 on the Numeric Pain Rating Scale. The protocol consisted of two 3-minute sets for each leg, separated by a 20-second rest interval (Figure 1).

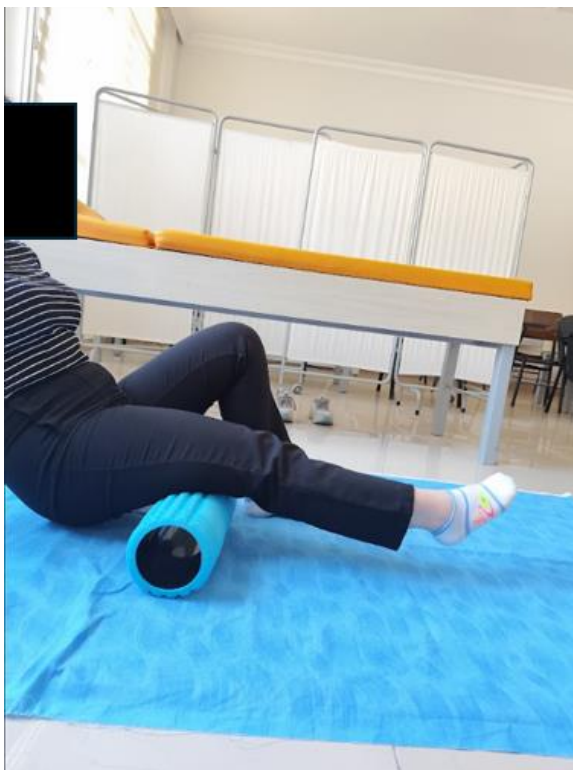


Figure 1. Application of foam rolling

Statistical Analysis

Statistical analysis of the collected data was conducted using SPSS (version 20.0, SPSS Inc., Chicago, Illinois, USA). Normality and homogeneity of variance were assessed using the Shapiro–Wilk test and variance tests, respectively. Baseline variables were compared using independent samples *t*-tests and the chi-square test for categorical variables. Between-group differences in post-intervention outcomes were examined using analysis of covariance (ANCOVA), with the corresponding baseline measurement entered as the covariate. Group was included as the fixed factor, and the post-intervention measurement was specified as the dependent variable. Where multiple pairwise comparisons were performed, the Bonferroni adjustment was applied to control for the family-wise error rate. ANCOVA results are reported as F statistics, p values, partial eta squared (ηp^2), and covariate-adjusted estimated marginal means with 95% confidence intervals. Partial eta squared was interpreted as small ($\eta^2 p = 0.01$), medium (0.06), and large (≥0.14). Statistical significance was set at $p<0.05$.

Sample Size

An a priori sample size calculation was performed using the effect size reported by Lee et al. (27) for knee extension ROM (Cohen's d = 1.14). For the present ANCOVA design, this corresponded to an estimated effect size of Cohen's f = 0.57. Assuming $\alpha = 0.05$ and 95% statistical power ($1 - \beta = 0.95$), the required total sample size was 43 participants for two groups. To allow for potential dropouts and ensure adequate statistical power, 54 participants (27 per group) were recruited.

Results

A total of 65 participants were evaluated for the study. Hamstring shortness was identified in 54 participants, all of whom were included in the analysis (Figure 2). Twenty-seven participants were assigned to the control group and received only static hamstring stretching (mean age ± SD: 22.22 ± 1.12 years; 17 female; 27 right-side dominant participants). The remaining 27 participants performed foam rolling prior to static hamstring stretching (mean age ± SD: 22.37 ± 1.69 years; 20 female; 27 right-side dominant participants). The groups were similar with respect to demographic characteristics, hypermobility, and lower-extremity length (Table 1). However, significant between-group differences were observed at baseline in the sit-and-reach and FFD tests.

Following adjustment for baseline values, the estimated marginal means for the foam rolling group were 35.82° (95% CI: 33.24–38.40) for the right AKE test and 33.18° (95% CI: 30.11–36.26) for the left AKE test. The corresponding adjusted means for the control group were 37.38° (95% CI: 34.80–39.95) and 35.55° (95% CI: 32.47–38.62), respectively. The ANCOVA revealed no statistically significant between-group differences in AKE test scores, $F(1, 51) = 0.73$, $p = 0.39$, $\eta p^2 = 0.01$. The adjusted between-group differences were 1.56° for the right side and 2.37° for the left side, favoring the foam rolling group (Table 2).

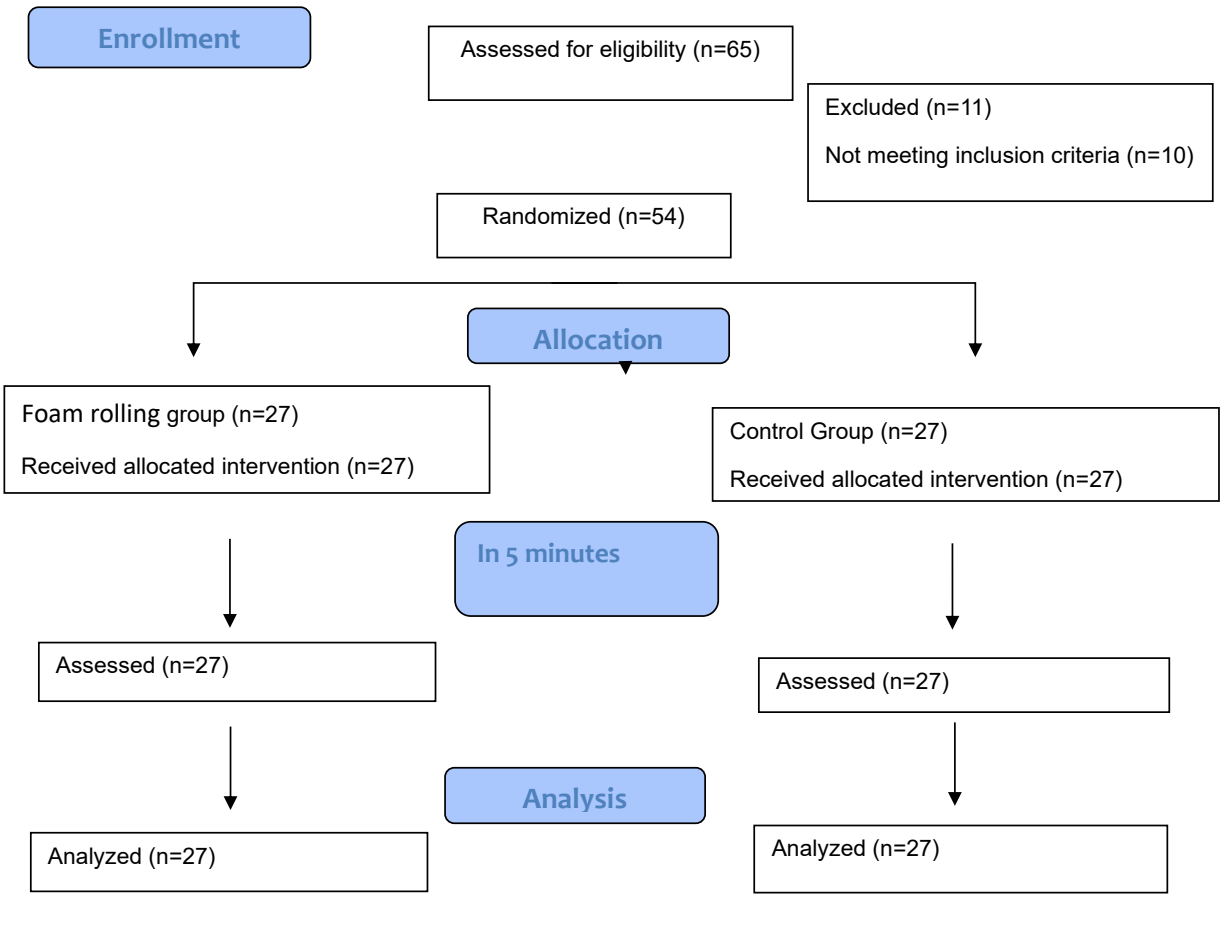


Figure 1. Consort flow diagram of the study

Table 1. Comparison of demographic characteristics between groups

Variables		Control group (n=27) Mean ± SD/n	Foam rolling group (n=27) Mean ± SD/n	p
Age		22.22±1.12	22.37±1.69	0.70[a]
BMI		22.83±3.78	22.32±3.34	0.60[a]
Lower extremity length	right	86.66±6.61	86.25±5.59	0.80[a]
	left	86.40±6.94	86.55±5.71	0.93[a]
Beighton score		2.07±1.73	2.44±2.08	0.48[a]
Measured limb, n (right/ left)		27/27	27/27	1.00[b]
Gender (Female/Male)		17/10	20/7	0.55[b]
Active knee extension	Right	39.81±6.86	40.46 ±9.81	0.77[a]
	Left	39.18±7.11	37.75±8.02	0.49[a]
Finger to ground distance		2.03±10.36	-5.29±9.21	**0.008[a]**
Sit-and-reach test		0.51±10.20	-7.50±9.94	**0.005[a]**

BMI: *Body Mass Index, SD= Standard Deviation; n=number of participants P[a]= independent t test; P[b] = chi-square test*

Table 2. Comparison of knee extension test between groups

Measure Outcomes	Knee Side	Baseline (n=27) Mean ± SD		Post intervention (n=27) Mean ± SD		Adjusted Mean ± SE (95% CI)		Between group difference baseline to after treatment (FRG-CG) [95% CI]	ANCOVA		
		CG	FRG	CG	FRG	CG	FRG		F	np^2	p
Active knee extension	Right	39.81±6.86	40.46 ±9.81	37.18±8.20	36.01±8.38	37.38±1.28 (34.80-39.95)	35.82±1.28 (33.24-38.40)	-1.55[-5.20-2.08]	0.73	0.01	0.39
	Left	39.18±7.11	37.75±8.02	36.00±8.40	32.74±9.91	35.55±1.53 (32.47-38.62)	33.18±1.53 (30.11-36.26)	-2.36 [-6.72-1.99]	1.18	0.02	0.28

CG= Control Group, FRG= Foam rolling group, SD= Standard Deviation, SE= Standard Error, post= within in 5 minutes after intervention.

Following adjustment for baseline values, the estimated marginal means for the foam rolling group were −0.01 cm (95% CI: −1.16 to 1.13) for the sit-and-reach test and 1.55 cm (95% CI: 0.69 to 2.41) for the FFD test. The corresponding adjusted means for the control group were 0.64 cm (95% CI: −0.50 to 1.79) for the sit-and-reach test and 1.65 cm (95% CI: 0.79 to 2.51) for the FFD test. The ANCOVA revealed no statistically significant between-group difference in the sit-and-reach test, $F(1, 51) = 0.624$, $p = 0.343$, $\eta p^2 = 0.01$, or in the FFD test, $F(1, 51) = 1.09$, $p = 0.43$, $\eta p^2 = 0.01$ (Table 2). The adjusted between-group differences from baseline to post-treatment were 0.66 cm for the sit-and-reach test and 0.09 cm for the FFD test, favoring the control group (Table 3).

Table 3. Comparison of sit-and-reach test and finger-to-ground distance between groups

Measure Outcomes	Baseline Mean ± SD CG (n=27)		Post intervention Mean ± SD FRG (n=27)		Adjusted Mean ± SE (95% CI)		Between group difference baseline to after treatment (FRG-CG) (95% CI)	ANCOVA		
	Pre	Post	Pre	Post	CG	FRG		F	np^2	p
Fingertips-to-Floor Distance	2.03±10.36	5.09±10.15	-5.29±9.21	-1.88±8.67	1.65±0.42 (0.79-2.51)	1.55±0.42 (0.69-2.41)	-0,09 [-1.35-1.15]	0.025	<0.001	0.87
Sit-and-reach test	0.51±10.20	4.40±10.65	-7.50±9.94	-3.77±9.01	0.64±0.57 (-0.50-1.79)	-0.01±0.57 (-1.16-1.13)	-0.66 [-2.34-1.02]	0.624	0.012	0.43

CG= Control Group, FRG= Foam rolling group, SD= Standard Deviation, SE= Stndard Error, post= within in 5 minutes after intervention. For the FFD and sit-and-reach tests, positive values indicate reaching beyond the standardized reference line, whereas negative values indicate that the participant did not reach the reference line. Therefore, higher values indicate better performance.

Discussion

The findings of this study indicate that the pre-stretching foam rolling group showed no additional improvements in the AKE, sit-and-reach, or FFD tests compared with the control group, which performed stretching alone.

Hamstring shortness can elevate patellofemoral joint reaction forces and lead to knee pain, postural deviations, and an increased risk of strain injuries (28). The literature presents conflicting findings regarding the acute effects of foam rolling on reducing hamstring shortness. Su, et al (13) reported that foam rolling led to significantly larger improvements compared with both static and dynamic stretching. However, Kamandulis et al. demonstrated that there was no difference in the benefits of foam rolling compared with static stretching in terms of straight leg raise (14). The present study found no significant difference in AKE, suggesting that, among young university students, incorporating pre-stretching foam rolling may not provide additional benefits when the primary objective is to achieve an acute reduction in hamstring tightness.

Proponents of sequential stretching suggest that foam rolling reduces tissue viscosity (the thixotropic effect) and modulates the Golgi Tendon Organ, theoretically making the muscle more receptive to elongation (29). However,

regarding the acute effects of pre-stretching foam rolling, the present study demonstrated no significant improvement in sit-and-reach and FFD test scores. Similarly, Folli et al., including twenty-nine young athletes, found that there was no difference between roller massage and static stretching after a single session, based on flexibility measured by the sit-and-reach test (30). There were no studies to evaluate the effect of foam rolling on hamstring flexibility by using FFD test. As noted by Behm and Wilke (29), the mechanical deformation of the fascia via foam rolling might be too transient to significantly alter the viscoelastic properties of the muscle-tendon unit when followed immediately by another lengthening modality.

Several limitations of the present study warrant consideration. First, the investigation focused solely on the acute effects of the interventions; therefore, the results may not reflect long-term adaptations. Second, the study population was limited to healthy university students, which may restrict the generalizability of the findings to older adults or those with severe clinical pathologies. Third, the study was not prospectively registered, although the protocol, eligibility criteria, outcome measures, and statistical analysis plan were predefined before recruitment. Fourth, the foam rolling group received an approximately 6-minute longer intervention than the control group, which may have acted as a confounder despite no significant between-group differences. Fifth, although the assessor was blinded, post-intervention measurements were obtained within 5 minutes using a manual goniometer, so assessor-dependent measurement error or detection bias cannot be excluded. Sixth, foam rolling was performed over participants' self-selected athletic clothing, which was not standardized and may have influenced friction, tissue compression, and the mechanical stimulus. Finally, the absence of a foam-rolling-only control group makes it difficult to definitively isolate the individual contribution of self-myofascial release to the observed outcomes. Future studies should use longitudinal designs with more diverse populations, including symptomatic and older adults, and should be prospectively registered to improve the generalizability and transparency of findings. In addition, future randomized controlled trials should employ time-matched, multi-arm intervention protocols and more objective measurement methods (e.g., digital inclinometers or motion analysis systems) to better isolate treatment effects and reduce potential bias. Standardizing clothing and/or ensuring that foam rolling is performed directly on the skin may further minimize this source of variability.

Conclusion

The present study demonstrated that incorporating foam rolling prior to stretching did not result in additional improvements in hamstring flexibility compared with stretching alone, as assessed by the AKE, sit-and-reach, and FFD tests. These findings suggest that, in young university students, pre-stretching foam rolling may not provide additional short-term benefits for improving flexibility beyond those achieved through stretching alone.

Declarations

Funding

No external funding was obtained for this study.

Conflict of interest

The authors declares no competing interests.

Ethics approval

Ethical approval for this study was obtained from the Clinical Research Ethics Committee of Hatay Mustafa Kemal University Faculty of Medicine (date: 21.05.2025, decision no: 41)

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