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Original Article

Observation on the therapeutic effect of rolling the target muscle groups of lower limbs with foam rollers of different shore hardness on DOMS

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Abstract: Objective: This experiment aims to explore how foam rollers of different Shore hardness affect DOMS, providing insights for sports therapy. Methods: Forty participants from Shanghai Sanda University who have no habit of strength training, no lower limb injury, and meet the health standards were selected to conduct three experiments under the conditions of no intervention, using a 50 Shore hardness foam roller, and using a 60 Shore hardness foam roller, respectively. Data were recorded before and after modeling, as well as 24, 48, and 72 hours later. Results: There were no significant differences in various indicators among the three groups of subjects before and immediately after DOMS modeling ($P>0.05$). Following intervention, the 60 Shore hardness foam roller significantly reduced DOMS pain (NRS score) compared to the 50 Shore hardness roller, improved knee flexion range of motion, and increased standing long jump distance ($P<0.05$). Conclusions: The 60 Shore hardness foam roller is superior to the 50 Shore hardness foam roller in alleviating DOMS, improving joint range of motion, and enhancing athletic performance.

Keywords: DOMS, foam rolling, pain, range of motion, athletic performance, shore hardness

Introduction

Delayed-onset muscle soreness (DOMS) is a transient complaint that generally arises from high-force, lengthening muscle contractions or from novel forms of exercise [1]. Symptoms typically develop 6-12 hours post-exercise, peak at 24-72 hours, and subside over 5-7 days [2]. DOMS tends to be somewhat localized to specific areas, such as the muscle-tendon junctions, which may exhibit increased vulnerability to discomfort and damage [3]. Eccentric exercises, defined by active muscular elongation under tension, are notably efficient in triggering the protective mechanism of DOMS because they provoke a greater extent of muscle micro-damage [4].

The intensity of eccentric exercises may influence the severity of DOMS; specifically, high-intensity eccentric contractions lead to increased soreness and higher muscular function impairment [5]. Certain research, including Mavropalias, has observed that high-intensity eccentric work results in greater aggravation of DOMS symptoms than low-intensity work, even although the mechanical loads are similar [6, 7]. DOMS is linked to a decline in muscle function, encompassing strength loss, which may need up to 48 hours before recovery commences. Additional physiological activities that may be impaired during this period include anaerobic threshold and heart rate [8].

Treatment modalities for DOMS encompass pharmaceutical interventions, mostly NSAIDs [9], which may alleviate symptoms but also impede long-term muscle development [10]. Non-pharmacological treatments get significant interest; cold compresses represent a relatively novel therapeutic modality, while the lingering effects of phototherapy may become manifest due to its anti-inflammatory properties [11]. Other approaches, including traditional Chinese medicine such as acupuncture and massage, may offer potential advantages [12]; neverthe-

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less, their efficacy when utilized independently is constrained.

Foam rolling (FR) has gained significant popularity as a self-myofascial release technique for enhancing recovery of muscles, flexibility, and functionality [13]. Nonetheless, despite inconsistent findings about the augmentation of force production in explosive performance, the technique has been extensively utilized in post-exercise recovery owing to its capacity to alleviate muscle soreness while mitigating tension and enhancing neuromuscular function [14]. Findings on the impact of varying degrees of FR hardness on DOMS recovery is scarce. The research initiative will assess the effects of foam rolling on DOMS using several metrics to provide significant empirical evidence for its role in rehabilitation.

Methods

Subjects

A total of 40 healthy young subjects currently enrolled at Sanda University of Shanghai were recruited for this study. They were required to have no regular strength training habits in the past year, no history of lower limb sports injuries in the past year, normal sleep for the week prior to the experiment, no participation in intense physical activity for three days before the experiment, and no smoking or drinking for 24 hours before the experiment. All subjects were informed of the study precautions and participated voluntarily.

Study design

Drawing on previous DOMS inducing exercise protocols, participants would perform a series of eccentric exercise loads after completing a warm-up routine. Specifically, they would undertake walking squat jumps (15 reps per set) and in-place weighted (10 kg) half-squat jumps (30 reps per set), completing a total of 10 sets. A 2-minute rest interval was provided between each set of exercises, and an additional 2-minute rest was arranged between the squat jumps and the weighted half-squat jumps. The entire exercise session would last approximately 50 to 60 minutes. The success of the exercise model would be evaluated based on whether subjects experienced symptoms such as muscle soreness, stiffness, reduced muscle strength, and impaired muscle function within 24 hours after the modeling.

After completing the exercise modeling, the 40 subjects would undergo no intervention measures. Data would be collected and recorded before the modeling, immediately after the modeling, and at 24, 48, and 72 hours post-modeling, based on the evaluation indicators. Following a washout period (7 days), subjects would repeat the experiment using a 50 Shore A foam roller, and data would be recorded. After another washout period (7 days), subjects would repeat the experiment using a 60 Shore A foam roller, with data recorded accordingly.

Outcome measurements

Evaluation would be conducted using the Numeric Rating Scale for pain, joint range of motion, and standing long jump distance as indicators.

Statistical analysis

In general measurement data, one-way analysis of variance (ANOVA) was used for intergroup comparisons. For clinical measurement data, repeated measures ANOVA was performed to evaluate the main and interaction effects of time and grouping across all time points before and after the intervention among the three groups. One-way ANOVA was used to compare the control group and the two experimental groups, with post-hoc pairwise comparisons conducted using the Least Significant Difference (LSD) method. Paired t-tests and two-time-point repeated measures ANOVA were applied for comparisons within each group at different time points. Measurement data were expressed as mean ± standard deviation ($\chi \pm s$). Fisher's exact test was used for categorical data. For data not meeting parametric test assumptions, or for categorical data in ordinal form, non-parametric rank-sum tests were employed. All analyses were performed using SPSS 23.0 statistical software, with a significance level of $\alpha=0.05$. *$P<0.05$ indicated statistically significant differences, and **$P<0.01$ indicated highly statistically significant differences.

Results

NRS

After modeling, the 50 Shore hardness foam roller intervention did not produce significant changes in NRS scores at 24, 48, and 72 hours,

Table 1. Comparison of NRS numerical rating scale results after two kinds of foam axis interventions

Group	NRS baseline	NRS After modeling	NRS Immediately after the intervention	NRS 24 h	NRS 48 h	NRS 72 h
Control	0.00±0.00	1.00±0.64	1.00±0.56	4.95±0.932^{c}	3.78±0.66^{c}	2.80±0.69^{c}
50 Shore	0.00±0.00	1.00±0.32	1.03±0.36	4.53±0.82^{c}	3.50±0.56^{c}	2.45±0.51^{c}
60 Shore	0.00±0.00	0.95±0.32	0.98±0.36	2.53±0.55^{a,b}	1.55±0.50^{a,b}	0.53±0.51^{a,b}
P	0.00	0.85	0.88	0.00	0.00	0.00

Note: The results of repeated measures analysis showed a significant time effect (*P*=0.00, F=909.889), a significant group effect (*P*=0.00, F=375.869), and a significant interaction between time and group (*P*=0.00, F=64.566). Post hoc comparisons with the control group indicated that "a" denotes a significant difference compared to the control group (*P*<0.05), "b" denotes a significant difference compared to the 50 foam roller group (*P*<0.05), and "c" denotes a significant difference compared to the 60 foam roller group (*P*<0.05).

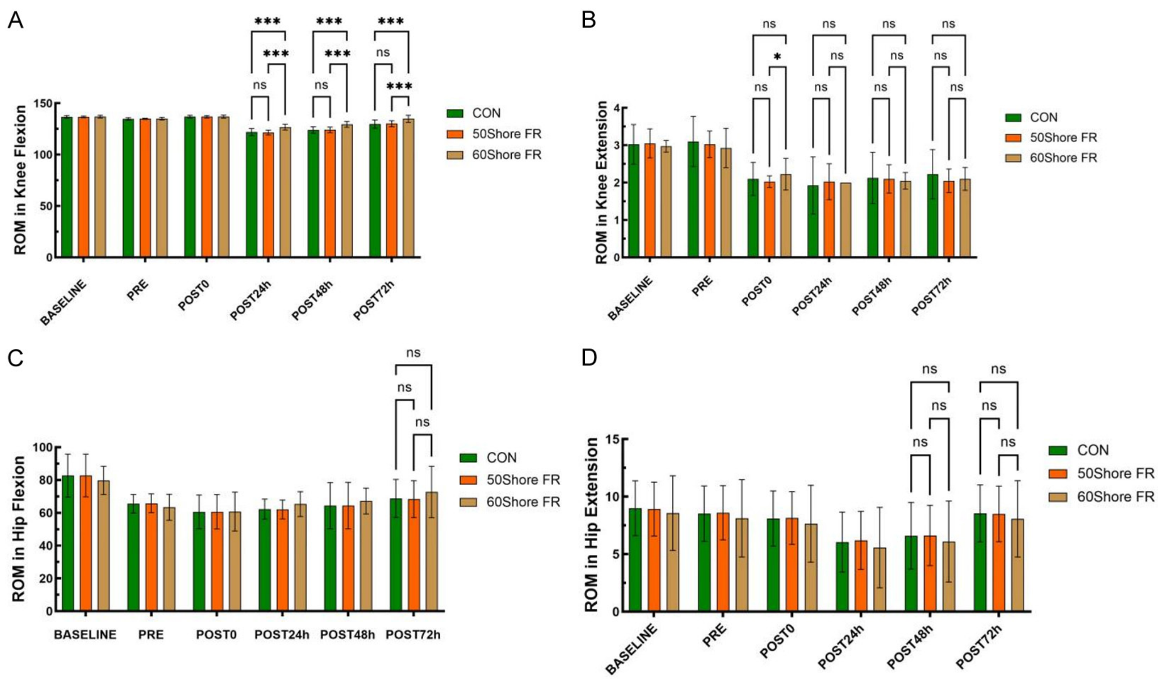

Figure 1. ROM in Knee Flexion (A) (P<0.05), ROM in Knee Extension (B), ROM in Hip Flexion (C), ROM in Hip Extension (D).

indicating no reduction in pain intensity. In contrast, the 60 Shore hardness foam roller intervention significantly reduced the NRS scores at 24 h, 48 h, and 72 h (*P*<0.05), and the scores were significantly lower than those of the 50 Shore hardness foam roller group at all time points, suggesting its greater effectiveness in alleviating pain. Notably, the 60 Shore hardness foam roller reduced pain from moderate to mild within 24 h of intervention, while the 50 Shore hardness foam roller did not achieve this effect. See **Table 1**.

ROM

Regarding the effects of the two different foam rollers on knee flexion range of motion (ROM), the results showed that modeling did not alter the baseline knee flexion ROM, confirming the validity of the modeling. The key finding was that after the 60 Shore hardness foam roller intervention, knee flexion ROM significantly improved at 24 h, 48 h, and 72 h, not only showing significant differences compared to the control group (P<0.05) but also outperforming the 50 Shore hardness foam roller group. See **Figure 1A**.

The effects of foam rollers with different Shore hardness levels on knee extension are shown in **Figure 1B**. No significant changes in knee extension were observed before and after DOMS modeling, indicating the successful establishment of the DOMS model. Additionally,

Table 2. Comparison of standing long jump distance results after intervention with two types of foam rollers

Group	SLJ baseline	SLJ After modeling	SLJ Immediately after the intervention	SLJ 24 h	SLJ 48 h	SLJ 72 h
Control	168.18±23.45	158.85±18.53	160.90±20.57	145.68±27.87[c]	148.83±18.11[c]	151.48±24.77[c]
50 Shore	168.28±23.13	158.43±18.35	160.95±20.43	149.43±26.13[c]	152.73±15.31[c]	156.35±23.37[c]
60 Shore	169.85±15.76	162.63±26.34	162.98±20.60	160.25±26.97[a]	167.43±32.51[a,b]	170.90±23.30[a,b]
P	0.92	0.63	0.88	0.05	0.00	0.00

Note: The results of repeated measures analysis showed a significant time effect (*P*=0.00, F=7.470), a significant group effect (*P*=0.00, F=13.188), and a significant interaction between time and group (*P*=0.00, F=1.747). Post hoc comparisons with the control group indicated that "a" denotes a significant difference compared to the control group (*P*<0.05), "b" denotes a significant difference compared to the 50 foam roller group (*P*<0.05), and "c" denotes a significant difference compared to the 60 foam roller group (*P*<0.05).

at 24, 48, and 72 hours post-DOMS, interventions with foam rollers of varying Shore hardness did not result in significant changes in knee extension distance.

The effects of foam roller interventions with different Shore hardness levels on hip flexion following DOMS are shown in **Figure 1C**. There were no significant changes in hip flexion before or immediately after modeling, confirming the success of the model. At 24 hours post-DOMS, the 50 Shore hardness foam roller intervention did not lead to significant changes in hip flexion compared to the control group. However, the 60 Shore hardness foam roller intervention significantly increased hip flexion (P<0.05). At 48 and 72 hours post-DOMS, neither the 50 nor 60 Shore hardness foam roller interventions produced significant changes in hip flexion.

The effects of foam roller interventions with different Shore hardness levels on hip extension are shown in **Figure 1D**. There were no significant changes in hip extension before or after DOMS modeling, confirming the success of the model. Following the establishment of the model, no significant changes in hip extension were observed. At 24, 48, and 72 hours post-DOMS, neither the 50 Shore nor the 60 Shore hardness foam roller interventions resulted in significant changes in hip extension. Additionally, hip extension distance gradually decreased within the first 24 hours post-DOMS and then gradually increased between 48 and 72 hours.

Standing long jump distance

Comparing the changes in standing long jump distance between interventions using foam rollers of different Shore hardness revealed no significant change in standing long jump distance before and after modeling, indicating the successful modeling of the experiment. After modeling, the standing long jump distances at 24 h, 48 h, and 72 h were significantly higher with the 60 Shore hardness foam roller intervention compared to both the control group and the 50 Shore hardness foam roller group (*P*<0.05). See **Table 2**.

Discussion

This study investigated the impact of foam rollers with varying hardness levels (50 Shore and 60 Shore) on mitigating delayed-onset muscle soreness (DOMS) along with improving range of motion (ROM). The findings indicated that while both foam rollers alleviated DOMS, the 60 Shore roller was significantly more effective. It decreased DOMS scores by 48.89%, 58.99%, and 81.07% at 24, 48, and 72 hours, respectively, surpassing the 50 Shore threshold. Additionally, the 60 Shore roller markedly enhanced knee and hip flexion range of motion, however it resulted in a reduction of hip extension range of motion.

Foam rolling may mitigate DOMS by enhancing blood circulation, reducing lactic acid buildup [15], and facilitating self-myofascial release, which improves fascial hydration and flexibility [16]. The increased compression power of the 60 Shore roller may explain its enhanced efficacy in alleviating pain and enhancing flexibility. Enhanced muscle coordination and reduced stiffness by foam rolling may also augment lower limb explosiveness [17], as seen by improved performance in standing long jumps following the use of the 60 Shore roller.

The immune-mediated hypothesis of DOMS, encompassing inflammation and muscle fiber injury [18], may elucidate the results seen in this investigation. Nonetheless, constraints encompass a limited sample size and inadequate investigation into foam rollers with varying Shore hardness levels. Subsequent research ought to investigate the ideal length of foam rolling and its impact on athletes and those with functional limitations. Investigating foam roller hardness will improve its use in sports recuperation and rehabilitation.

Conclusion

This study investigated how foam rollers with 50 Shore and 60 Shore hardness decreased DOMS and increased range of motion (ROM). Whereas both foam rollers reduced DOMS, the 60 Shore roller was more effective. It reduced DOMS scores by 48.89%, 58.99%, and 81.07% at 24, 48, and 72 hours compared to the 50 Shore roller. The 60 Shore roller additionally lowered hip extension range of motion despite improved knee and hip flexion.

Foam rolling may alleviate delayed-onset muscle pain by increasing blood flow [19], reducing lactic acid accumulation [20], and promoting self-myofascial release to hydrate and stretch fascia. The 60 Shore roller's enhanced compression force may help to relieve discomfort and promote flexibility. Foam rolling may enhance muscle coordination and stiffness, boosting lower limb explosive power. Individuals perform better in standing long jumps after utilizing the 60 Shore roller.

The results of this research may be explained by the immune-mediated concept of DOMS, a condition that involves muscle fiber inflammation and destruction. The sample size was small, and foam rollers with different Shore hardnesses were not well-studied. The study has some drawbacks. Future research might investigate foam rolling's effects on athletes and individuals with functional limitations and when to do it. Increased foam roller hardness study would help sports recovery and rehabilitation.

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Disclosure of conflict of interest

None.

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