



Foam Rolling Is More Effective Than Passive Stretching in Reducing Delayed-Onset Muscle Soreness in the Hamstring Muscles

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ABSTRACT

Delayed Onset Muscle Soreness (DOMS) can impair muscle function, limit physical performance, and delay recovery, highlighting the need for effective recovery strategies. This study aimed to compare the effectiveness of Passive Stretching (PS) and Foam Rolling (FR) in reducing DOMS of the hamstring muscles following resistance training. A randomized pretest-posttest design was employed with 14 participants who were equally assigned to two intervention groups: Passive Stretching (PS; n = 7) and Foam Rolling (FR; n = 7). Muscle soreness was assessed using the Faces Pain Scale (FPS) at 24, 48, and 72 hours following resistance training, before and after each intervention. Statistical analyses were conducted using SPSS version 25.0. Within-group changes were analyzed using paired-samples t-tests, while between-group differences in pain reduction were compared to determine the relative effectiveness of the interventions. Both interventions significantly reduced DOMS at all assessment points ($p < 0.05$). In the PS group, pain scores significantly decreased at 24 hours ($p = 0.002$), 48 hours ($p = 0.001$), and 72 hours ($p = 0.027$). Similarly, the FR group demonstrated significant reductions at 24 hours ($p < 0.001$), 48 hours ($p = 0.017$), and 72 hours ($p = 0.014$). Furthermore, the reduction in pain was significantly greater following FR than PS at 24 hours ($p = 0.015$), 48 hours ($p = 0.016$), and 72 hours ($p = 0.016$). These findings indicate that both Passive Stretching and Foam Rolling may reduce DOMS-related pain, with Foam Rolling demonstrating a greater reduction in pain scores across all assessment periods. However, the small sample size limits the generalizability of these findings. Further studies involving larger samples and more rigorous experimental designs are warranted to confirm these results.

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INTRODUCTION

Hamstring strain injuries are among the most common injuries in sports, accounting for approximately 12–26% of all sport injuries, 24% of injuries in football, 17% in track and field, and 22% in rugby union (Bramah et al., 2024). Hamstring injuries in women's basketball ranked sixth out of 13 female sports, while in men's sports, they were in the bottom third out of 12 sports (Nagai et al., 2021). They are especially prevalent in activities that involve quick movements, jumping, or sudden changes in direction (Chang et al., 2020).

One of the efforts in preventing hamstring injuries is through muscle strengthening, one of these approaches uses exercises involving eccentric movements, in which the muscle lengthens while contracting (Putri et al., 2023). This movement is often found in weight lifting or weight training activities (Triansyah & Haetami, 2020). Consistent weight training can increase muscle strength, prevent injury, improve muscle balance, and prevent atrophy, a decrease in muscle function (Ciolac & Rodrigues-da-Silva, 2016).

Weight training contributes to increased muscle strength, but eccentric movements in weight training are known to trigger delayed onset muscle soreness (DOMS) (Wilke & Behringer, 2021). DOMS is a condition characterized by muscle soreness that appears approximately 24 hours after exercise and peaks 48–72 hours afterward (Rahayu et al., 2020). Although DOMS is the body natural response, the pain can last up to 5–7 days, depending on the severity (Torre et al., 2021). These symptoms often interfere with the ability to move, reduce performance, affect motivation, and create a negative perception of exercise (Ali et al., 2021).

Various recovery methods have been developed to alleviate DOMS, one of which is passive stretching. Passive stretching is a technique in which the target muscle is stretched with assistance from external forces, such as another person, body weight, ropes, or gravity, allowing the muscle to reach a greater range of motion (ROM) without active contraction (Kusworo et al., 2018; Oktafianti et al., 2020). The use of external assistance makes the stretching process safer and more effective by enabling the muscles to adapt without excessive self-generated effort (Alipasali et al., 2019). Consequently, passive stretching has been widely used to improve flexibility and facilitate muscle recovery following exercise (Prihantoro & Ambardini, 2019; Suchomel et al., 2018).

Another recovery method that has gained considerable popularity in recent years is Foam Rolling (FR) (Nazarudin et al., 2021). Foam Rolling is a form of self-myofascial release in which individuals use their own body weight to apply pressure to soft tissues by rolling targeted muscle groups over a cylindrical foam roller (Ali et al., 2021). This technique has been widely adopted in sports and rehabilitation settings because it can reduce acute muscle soreness, relieve muscle tension, correct muscle imbalances, and improve neuromuscular performance and ROM (Fernández-Lázaro et al., 2023).

Previous studies have demonstrated the effectiveness of both Passive Stretching and Foam Rolling in alleviating DOMS symptoms. Stretching durations of 30, 60, and 120 seconds have been shown to reduce muscle stiffness and ROM (Palmer et al., 2019). Likewise, Passive Stretching has been reported to reduce pain associated with DOMS in the tibialis muscle (Rehman et al., 2021). Similarly, Foam Rolling has been shown to reduce muscle soreness following eccentric exercise, with a 90-second intervention effectively decreasing quadriceps muscle pain (Nakamura et al., 2021). In addition, the use of Foam Rolling resulted in faster recovery compared to the passive recovery group (Naderi et al., 2020). Previous research has found that sport massage and Foam Rolling were able to reduce muscle soreness by 20–40% (Nazarudin et al., 2021). In addition, Passive Stretching was also found to be effective in

reducing muscle pain and improving hamstring flexibility after exercise (Priantara et al., 2023).

Despite these promising findings, the existing evidence remains limited because most studies evaluated Passive Stretching and Foam Rolling separately or compared each intervention with other recovery methods, such as passive recovery or sport massage. Direct comparisons between Passive Stretching and Foam Rolling are still scarce, particularly for hamstring DOMS induced by resistance exercise. Consequently, it remains unclear which intervention provides superior recovery outcomes for this muscle group. Therefore, the present study aimed to compare the effectiveness of Passive Stretching and Foam Rolling in reducing hamstring DOMS following resistance training and identify more effective recovery strategy for post-exercise muscle soreness.

METHODS

Study Design

This study used a randomized pretest-posttest design involving two groups, namely the Passive Stretching group and the Foam Rolling group. This study compared the pretest and posttest values between the two groups and determined their effect on delayed onset muscle soreness (DOMS).

Resistance Training Protocol

The resistance training programme provided was specific to eccentric movements in the hamstring muscles. There were four variations of movement, including cable hamstring raise, lying leg curl, Romanian deadlift, and lunge (Arya, 2025). The exercises were performed by all subjects on the first day using a load of 60–70% of 1RM, with 12 repetitions per set for 4 sets and a 2-minute rest period between variations. These movements aimed to induce delayed-onset muscle soreness (DOMS).

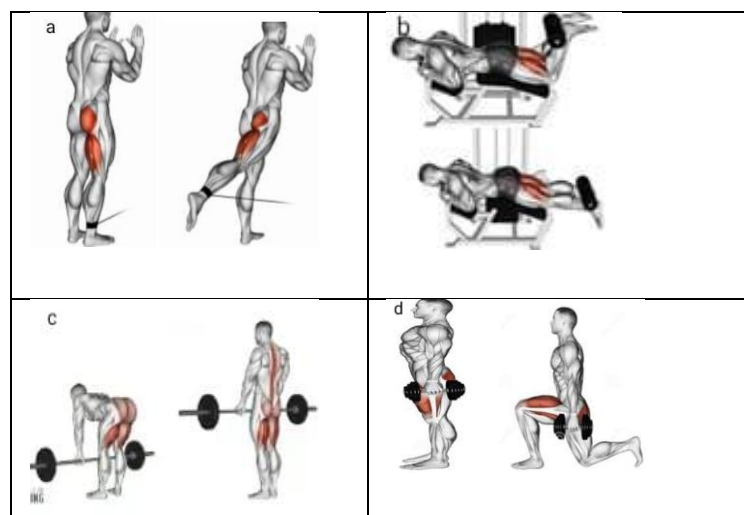


Figure 1. Variations of Movement

(a) cable hamstring raise, (b) lying leg curl, (c) Romanian deadlift, (d) lunge

Intervention

The intervention after weight training used Passive Stretching and Foam Rolling. In the Passive Stretching group, the muscles were stretched slowly to the maximum limit without any resistance from the subjects, with the help of others. While in the Foam Rolling group,

the subjects applied pressure using body weight by rolling back and forth on the foam rolling tool on the hamstring muscles.

The interventions were performed at 24, 48, and 72 hours after resistance training. Each movement was performed for 30 seconds for three repetitions on each leg (right and left), with one set performed per session. The total duration of each treatment session was 12 minutes. There were four movements in Passive Stretching, including calf stretch, hamstrings stretch, knee to chest, and hip abduction (snow angel). As for Foam Rolling, it included the posterior hip, hamstring, iliotibial band, and adductors (Roberts & Wilson, 1999; Stull, 2023).

Passive Stretching



Foam Rolling



Figure 2. Intervention: Passive Stretching and Foam Rolling

(a) calf stretch, (b) hamstrings stretch, (c) knee to chest, (d) hip abduction (snow angel), (e) posterior hip, (f) hamstring, (g) iliotibial band, (h) adductors

Faces Pain Scale (FPS)

Subjects were measured for pain levels using the Faces Pain Scale (FPS), a pain measurement based on facial expressions, with a pain scale of 0 = no pain, 1-2 = mild pain, 3-4 = moderate pain, 5-6 = severe pain, 7-8 = severe pain, and 9-10 = very severe pain (Pinzon, 2016; Rejeki, 2020). Pain measurements were taken at 24, 48, and 72 hours before and after the intervention in both groups.

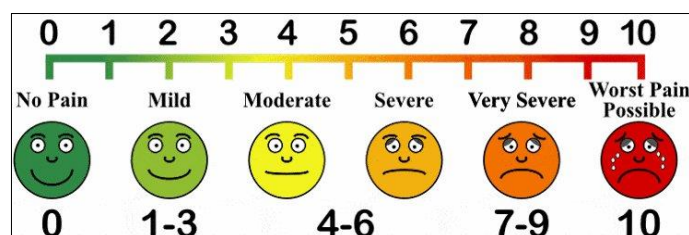


Figure 3. Faces Pain Scale (FPS)

Ethics

This study obtained ethical approval from the Health Research Ethics Commission, Faculty of Medicine, Semarang State University, Indonesia, with approval number 3/KEPK/FK/KLE/2025. Written informed consent was obtained from the parents of all participants prior to their participation in the study. In addition, all participants provided assent after receiving an explanation of the study procedures.

Participants

Participants of this study were male basketball extracurricular students at SMA Negeri 1 Kutowinangun, aged 15–17 years. A total of 20 participants were initially recruited. Six participants were subsequently excluded based on the exclusion criteria, with three having ankle injuries and three regularly engaging in gym-based exercise. The final sample consisted of 14 participants who were randomly assigned to two treatment groups, namely Passive Stretching (PS, $n = 7$) and Foam Rolling (FR, $n = 7$).

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 25. All variables were tested for normality using the Kolmogorov–Smirnov test. Independent sample t-test was performed to determine the differences in training parameters between the two groups.

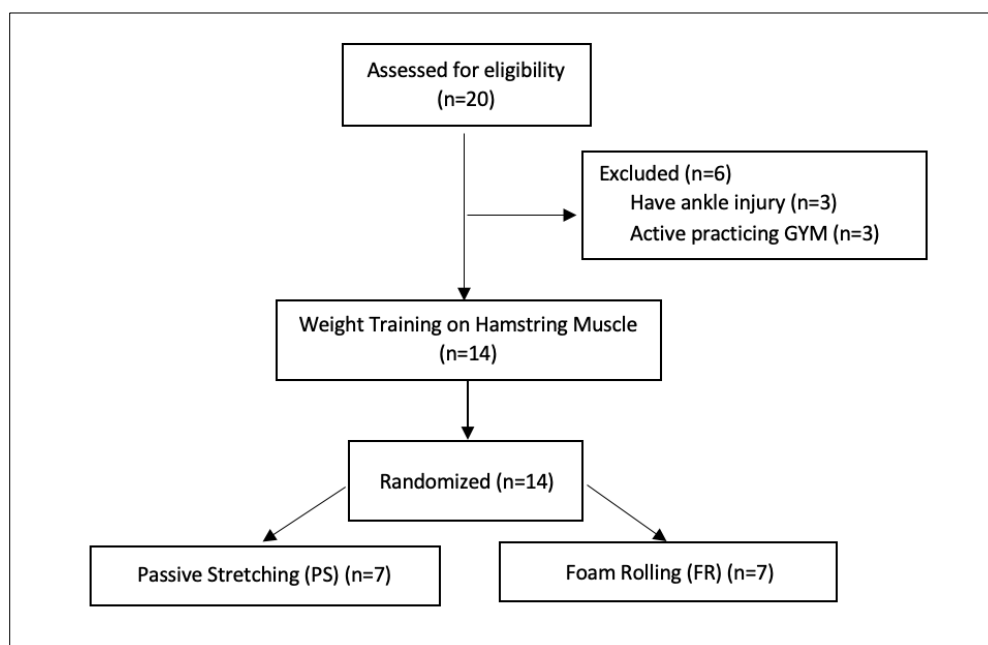


Figure 4. The Consort Flowchart

RESULTS

The results showed that both recovery methods, Passive Stretching and Foam Rolling, were effective in reducing delayed onset muscle soreness (DOMS) in hamstring muscles after eccentric exercise. However, the Foam Rolling method showed more significant results compared to Passive Stretching in reducing DOMS at all measurement times (24, 48, and 72 hours).

All variables (age, height, and weight) are presented as mean $\pm$ standard error (SE). Table 1 shows that there is no significant difference between groups in the age, weight, and BMI variables ($p > 0.05$), while in the height variable, there is a significant difference ($p < 0.05$).

Table 1. Comparison Between Groups

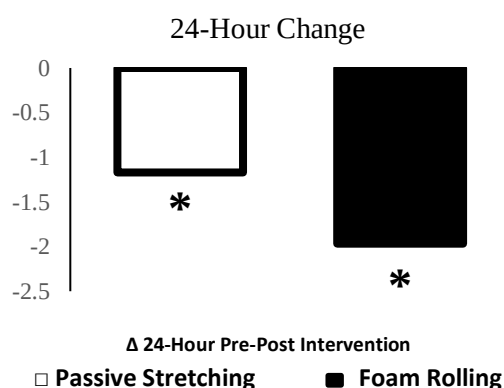
Variable	Passive Stretching	Foam Rolling	p-Value
	(n = 7)	(n = 7)	
	Mean ± SE	Mean ± SE	
Age (years)	16.43 ± 0.30	16.00 ± 0.31	0.304
Weight (kg)	50.00 ± 3.46	61.07 ± 3.82	0.053
Height (cm)	160.86 ± 1.22	168.14 ± 1.65	0.004
BMI (kg.m ⁻²)	19.34 ± 1.32	21.57 ± 1.04	0.209

Data in Table 2 were analysed using paired t-test for Passive Stretching (24 hours, 48 hours, 72 hours), and paired t-test (24 Hours) and Wilcoxon Signed-rank test (48 hours, 72 hours) for Foam Rolling. P (pre-post difference between groups) was analysed using an independent t-test (24 hours) and a Mann-Whitney U test (48 hours, 72 hours). An asterisk (*) indicates statistical significance ($p < 0.05$).

Table 2. Pre-Post Mean Data

Intervention	N	Time (Hours)	Pre-test	Post-test	P (pre vs post)	P (Difference pre-post between groups)
			Mean ± SE	Mean ± SE		
Passive Stretching	7	After 24	4.16 ± 0.31	2.99 ± 0.16	0.002*	0.015*
Foam Rolling	7		4.23 ± 0.50	2.26 ± 0.41	0.000*	
Passive Stretching	7	After 48	2.73 ± 0.27	1.99 ± 0.26	0.001*	0.016*
Foam Rolling	7		2.53 ± 0.55	1.17 ± 0.37	0.017*	
Passive Stretching	7	After 72	1.37 ± 0.31	0.84 ± 0.23	0.027*	0.016*
Foam Rolling	7		1.29 ± 0.29	0.16 ± 0.14	0.014*	

The difference in 24-hour in Passive Stretching and Foam Rolling treatment used the sig value ($p < 0.05$). Based on Figure 5, there was a decrease in muscle pain in both interventions, but the Foam Rolling group obtained higher decrease than Passive Stretching group.

**Figure 5.** Changes in Muscle Pain 24 Hours After Intervention

The difference in 48-hour in Passive Stretching and Foam Rolling treatment used sig value ($p < 0.05$). Based on Figure 6, there was a decrease in muscle pain in both interventions, but the Foam Rolling group experienced greater decrease than Passive Stretching group.

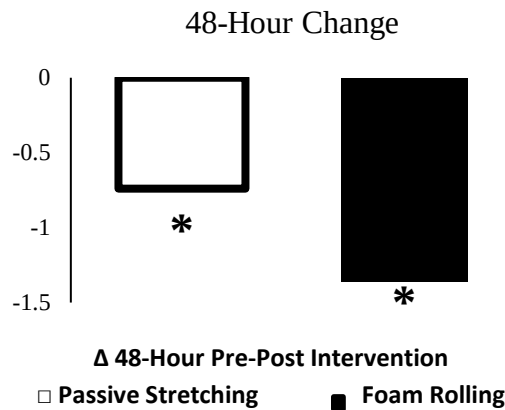


Figure 6. Changes in Muscle Pain 48 Hours After Intervention

The 72-hour difference in Passive Stretching and Foam Rolling treatment used sig value ($p < 0.05$). Based on Figure 7, there was a decrease in muscle pain in both interventions. The decrease was higher in the Foam Rolling group than in the Passive Stretching group.

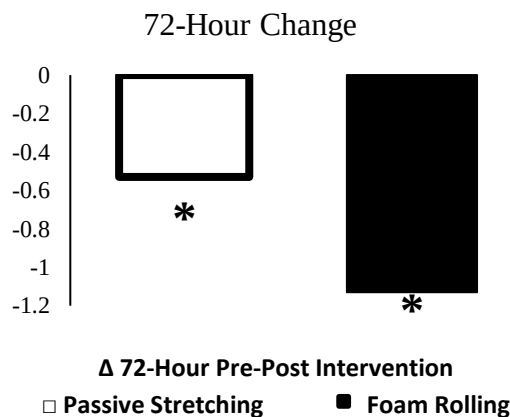


Figure 7. Changes in Muscle Pain 72 Hours After Intervention

DISCUSSION

This study compared two recovery methods after eccentric exercise, namely Passive Stretching and Foam Rolling, to reduce delayed onset muscle soreness (DOMS) in the hamstring muscle. This study aimed to examine if there was a difference in effectiveness between Passive Stretching and Foam Rolling groups. Both treatments were given within 24 hours, 48 hours, and 72 hours after eccentric exercise. The results of this study found that there was a significant decrease in both interventions.

Passive Stretching

The Passive Stretching intervention significantly reduced muscle pain at all measurement time points, pain score decreased from 4.16 ± 0.31 to 2.99 ± 0.16 at 24 hours, from $2.73 \pm$

0.27 to 1.99 ± 0.26 at 48 hours, and from 1.37 ± 0.31 to 0.84 ± 0.23 at 72 hours. These findings suggest that Passive Stretching may be beneficial in alleviating pain associated with delayed onset muscle soreness (DOMS). According to Kusworo et al. (2018), Passive Stretching is a technique of stretching the limbs with external assistance or assistance from others. This method is very useful for increasing flexibility and reducing tension in the muscles. Research conducted by Palmer et al. (2019) showed that stretching with a duration between 30-60 seconds is effective for reducing stiffness without reducing muscle performance. Prianthara et al. (2023) also found that Passive Stretching can reduce pain hamstring muscles in tailors with short hamstring syndrome. Also according to Rehman et al. (2021) Passive Static Stretching was effective in reducing DOMS in the tibialis anterior muscle. Their protocol consisted of four repetitions of 20-second static stretching performed on three consecutive days, with a 20-second rest interval between repetitions, resulting in a total stretching duration of 80 seconds per day. These findings support the effectiveness of Passive Static Stretching as a strategy for reducing DOMS.

Foam Rolling

The Foam Rolling treatment also showed a significant decrease in DOMS at the measurement time, with the average pain value decreasing from 4.23 ± 0.50 to 2.26 ± 0.41 at 24 hours, from 2.53 ± 0.55 to 1.17 ± 0.37 at 48 hours, and from 1.29 ± 0.29 to 0.16 ± 0.14 at 72 hours. Foam Rolling can help in correcting muscle imbalances, relieving muscle discomfort, and reducing muscle tension. In addition, this technique also improves neuromuscular performance and range of motion (ROM) (Nakamura et al., 2021; Nazarudin et al., 2021). Foam Rolling is a muscle massage tool that is used by rolling the body on it independently. The pressure exerted by body weight directly on soft tissue makes this tool a recommended method for reducing DOMS during recovery. Another advantage is that this tool is practical and can be used anywhere and anytime without the help of other people (Fernández-Lázaro et al., 2023).

In the present study, both Passive Stretching and Foam Rolling significantly reduced DOMS-related pain. However, Foam Rolling resulted in significantly greater reductions than Passive Stretching at 24, 48, and 72 hours after resistance training. This greater effect may be related to the mechanical and sensory stimulation produced by Foam Rolling. Unlike Passive Stretching, which primarily induces muscle elongation, Foam Rolling applies direct compressive and shear forces to the muscle and surrounding fascial tissues. These mechanical stimuli may facilitate local tissue mobility and circulation while also modulating sensory input associated with pain perception (Cardoso et al., 2023). Therefore, the combined mechanical and sensory effects of Foam Rolling may provide greater relief from DOMS-related pain than passive stretching alone.

DOMS Decrease Cycle

Delayed onset muscle soreness (DOMS) is a body response that often occurs after performing physical activity with heavy and unusual loads. DOMS can cause pain and stiffness in soft tissues and appears within 24-72 hours (Triansyah & Haetami, 2020; Wilke & Behringer, 2021). DOMS arises due to excessive muscle work, especially when performing eccentric movements, the movements that trigger muscles to lengthen by contracting (Lesmana, 2019; Sari, 2018). In the early phase (0-24 hours), muscle microtrauma triggers an inflammatory response and the release of biomarkers of muscle damage such as creatine (CK) and lactate dehydrogenase (LDH) (Cheng et al., 2025; Salem et al., 2024). Entering the second phase (24-48 hours), the body begins to activate metabolite removal mechanisms, including lactic acid,

through the blood circulation system (Zhang et al., 2024). In the next phase (48-72 hours), inflammation begins to subside and the regeneration process of muscle tissue runs more optimally (Salem et al., 2024). Finally, after 72 hours of eccentric exercise, the muscle undergoes an adaptation called the repeated bout effect (RBE), a decrease in susceptibility to damage and pain during repeated eccentric exercise. Then, there will be mechanical adaptation through sarcomere reorganisation (sarcomerogenesis) and increased connective tissue stiffness, so that the spread of strain during contraction is more even and the risk of muscle damage is reduced (Baxter et al., 2023).

CONCLUSION

Based on the results of this study, both Passive Stretching and Foam Rolling were effective in reducing DOMS-related pain following eccentric resistance exercise of the hamstring muscles. However, Foam Rolling resulted in greater reductions in pain scores than Passive Stretching across all measurement periods. These findings suggest that Foam Rolling may be a promising recovery strategy for reducing DOMS-related pain. However, given the small sample size, these findings should be interpreted cautiously and confirmed in studies with larger samples.

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AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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