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Original Article

Effect of pre-exercise self myofascial release on symptoms of delayed muscle soreness and flexibility

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Abstract
Context: Traditional warm-up strategies have evolved from dynamic stretching to incorporating innovative techniques designed to enhance performance and minimize the risk of injury. Among these, self-myofascial release (SMFR), particularly through the use of foam rollers (FRs), has gained popularity for its potential benefits. **Purpose:** This study examines the effects of pre-exercise SMFR with foam rolling on flexibility and delayed onset muscle soreness (DOMS) in university-level football players. **Materials and Methods:** Twenty-six male university-level football players were randomly assigned to two groups: EXG-1 (SMFR & COM), which involved SMFR combined with complex training, and EXG-2 (COM), which included only complex training. Flexibility was assessed using the sit-and-reach test, while DOMS was measured using the visual analog scale (VAS) ranging from 0 to 100. An independent t-test was performed to analyze differences between groups, and a paired sample t-test was used to compare baseline measurements to various time points. Repeated measures analysis was used to evaluate the effects of group, time, and group × time interaction with partial eta square (η^2_p). **Results:** A repeated measures ANOVA for flexibility revealed a significant group effect ($P < 0.01$, $\eta^2_p = 0.526$) and a significant time effect ($P < 0.01$, $\eta^2_p = 0.881$) but no significant group × time interaction ($P = 0.507$, $\eta^2_p = 0.032$). This suggests that both SMFR & COM and COM alone significantly improve flexibility. For DOMS, the repeated measures ANOVA showed a significant group effect ($P < 0.01$, $\eta^2_p = 0.781$), a significant time effect ($P < 0.01$, $\eta^2_p = 0.995$), and a significant group × time interaction ($P = 0.013$, $\eta^2_p = 0.138$). This indicates that SMFR & COM significantly reduces DOMS over time compared to the COM group. The study also found that DOMS peaked at 24 and 48 h after exercise and decreased by 72 h. The VAS scores for DOMS were consistently lower in the SMFR & COM group compared to the COM group: at baseline (0 h), the scores were 20.38 ± 5.19 vs. 30.77 ± 3.44 (mild soreness); at 24 h, 40.38 ± 4.31 (mild to moderate) vs. 55.38 ± 4.77 (moderate); at 48 h, 67.69 ± 3.88 vs. 76.15 ± 6.50 (moderate to severe); and at 72 h, 26.92 ± 4.80 vs. 33.46 ± 5.91 (mild). **Conclusions:** This study concludes that the SMFR & COM group showed greater improvements in flexibility and reduced DOMS compared to the COM group, with significant changes observed across both group and time factors. Pre-exercise SMFR using an FR before intensive activity enhances flexibility and alleviates DOMS, promoting optimal performance and faster recovery.
Keywords: Complex training, Exercise-induced muscle damage, Self-myofascial release

Introduction

Traditional warm-up routines were typically characterized by static stretching, believed to prepare the body for physical activity. However, recent decades have seen a paradigm shift in warm-up protocols in sports and fitness. This evolution has been marked by the integration of sports science, biomechanics, and exercise physiology. Modern warm-ups aim to raise body temperature and enhance range of motion (ROM), thereby enhancing performance and reducing the risk of injury (Gil et al., 2019). Warmups are essential for achieving optimal performance because they are designed to increase muscle temperature, enhance nerve conductivity, increase metabolic reactions, and prevent injuries. These factors are crucial for reaching peak performance (Cochrane et al., 2013).

Highly competitive players push through pain, forcing weak muscle tissues back into activity. Reduced ROM affects the contractile sequence activated by myofascial release (MFR) (Duarte França et al., 2024). Muscle tightness and stiffness, often stemming from previous training sessions or events, are common issues before intense exercise. These conditions can limit joint mobility and restrict muscle engagement during physical activities. Consequently, sports enthusiasts, athletes, and healthcare professionals are increasingly focused on innovative strategies to maximize performance, prevent injuries, and accelerate recovery (Cheatham et al., 2015). MFR has been historically used to promote healing and alleviate inflammation in the fascia and muscle tissue (Shah et al., 2015). Various massage techniques can enhance tissue pliability and increase blood flow.

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Although various massage techniques promote tissue pliability and increase blood flow, there is insufficient evidence to support foam rolling as an effective MFR treatment. Recently, self-myofascial release (SMFR) has gained popularity as a pre-competition technique to enhance performance (Healey et al., 2014). Foam rolling, along with other techniques, has become a widely used and effective method of SMFR (Nakamura et al., 2021). Using body weight and controlled rolling movements, individuals can apply pressure to specific muscle groups, releasing myofascial adhesions and enhancing tissue extensibility (Healey et al., 2014).

Acute MFR before engaging in unfamiliar high-intensity eccentric exercises can help mitigate the DOMS and reduce markers of muscle injury. DOMS is caused by microscopic damage to muscle fibers, and after an intense session, muscles often reduce activity to prevent further harm. While many post-exercise recovery methods have been shown to alleviate DOMS, fewer studies have explored the benefits of pre-exercise MFR in reducing its effects before training or competition.

Exercise-induced muscle damage (EIMD) typically occurs after unaccustomed high-intensity exercises, leading to symptoms such as DOMS, tenderness, stiffness, swelling, reduced strength, and elevated creatine kinase levels in the blood (Cheung et al., 2003). Interventions employing MFR techniques are used to minimize the negative effects of DOMS (Dupuy et al., 2018) (Guo et al., 2017). While existing research indicates that massage, cryotherapy, and exercise can have both positive and negative impacts, the effectiveness of pre-exercise SMFR with foam rolling before COM in reducing DOMS and influencing flexibility levels in players over the 0, 24, 48, and 72-h periods remains unclear owing to limited scientific evidence.

Foam rolling, a common SMFR technique, typically involves applying slow, steady pressure to restricted fascial layers (Beardsley et al., 2015). Despite its widespread use, there is insufficient evidence supporting foam rolling as an effective MFR therapy. This study examines the impact of pre-exercise SMFR using a foam roller (FR) on flexibility and DOMS in university-level football players.

Materials and Methods

Participants

The study received institutional ethical approval from the Institutional Ethics Committee, Pondicherry University, India. After a verbal and written explanation of the survey, 28 male university-level football players aged 20–25, all with at least one year of resistance training experience, were randomly selected. Two participants withdrew from the experiment, resulting in a final sample of 26 men.

These participants were randomly assigned to the pre-exercise MFR group (n = 13), which combined SMFR and complex training COM), and the non-MFR group (n = 13), which received only COM. In the SMFR & COM group, the participants' age, height, and mass in the experimental group were 21.56 ± 2.46 years, 163.79 ± 5.92 cm, and 66.23 ± 11.12 kg, respectively. In the COM group, the corresponding values were 21.87 ± 2.22 years, 163.82 ± 10.82 cm, and 65.28 ± 13.12 kg. Before administering complex training (COM), MFR was applied to investigate the effects of pre-exercise SMFR on DOMS and to assess perceived pain/soreness using a visual analog scale (VAS) as well as flexibility through the sit-and-reach test.

Methods

Flexibility measurements were performed on the subjects at four assessment times: immediately after COM at 0 h (Period 1), 24 h post-COM (Period 2), 48 h post-COM (Period 3), and 72 h post-COM (Period 4). DOMS was evaluated using the VAS at four time points: immediately after the COM (0 h), 24 h post-COM, 48 h post-COM, and 72 h post-COM. The VAS ranged from 0 to 100, with 0 indicating no pain, 25 mild, 50 moderate, 75 severe, and 100 the worst pain.

Pre-exercise Testing

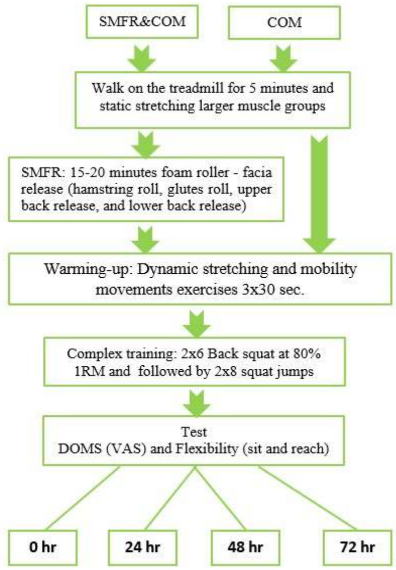
Subjects were familiarized with MFR using FRs during warm-up and COM exercises over three alternate days. Each session began with 15 minutes of SMFR with the FR, followed by 10 minutes of dynamic warm-up exercises, and then the COM. The final familiarization session took place 48 h before the experiment. During the data collection period, subjects were instructed to refrain from participating in any sports activities or exercises and from consuming any medications or dietary supplements.

Procedure

The subjects were instructed to walk on the treadmill for 5 min, followed by 10 min of dynamic stretching and mobility movements, consisting of three sets of 30 s each for exercises such as high knees, anterior–posterior leg swings, and lateral leg swings, with a 30-s rest between sets. After completing the active warm-up, each subject was allowed a two-minute relaxation period.

The SMFR session included 15 min of foam rolling, targeting specific muscle groups involved in back squat and squat jump exercises. The protocol included exercises such as hamstring rolls, glute rolls, calf roll releases, upper and lower back releases, quadriceps and hip flexor rolls, and iliotibial band releases, performed for 3 sets of 40 s each with adequate breaks in between. The COM exercises comprised 2 sets of 6 back squats at 80% of one-repetition maximum (1RM), followed by 2 sets of 8 squat jumps. The dependent variables were flexibility and DOMS. Data were collected at four time points: 0, 24, 48, and 72 h post-COM.

Figure 1.



Statistical analysis

The analyses were performed using the Statistical Package for the Social Sciences (SPSS). Repeated measures analysis was used to compare group differences, time effects, and the group × time interaction. The magnitude of the effect for these analyses was calculated using partial eta squared (η^2_p). In this context, a large effect is defined as ≥0.14, a medium effect is defined as between 0.06 and 0.14, and a small effect is defined as ≤0.06 (Thapa et al., 2023). The independent t-test was used to analyze the differences between the SMFR&COM and COM groups across various time points (0, 24, 48, and 72 h). A paired sample t-test was used to compare baseline measurements with those taken at multiple periods (24, 48, and 72 h) in the different training groups (SMFR&COM and COM). The magnitude of changes between time points and training groups in both the independent and paired sample t-tests was calculated using Cohen's d values, categorized as follows: trivial (0–0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), very large (2.0–4.0), and nearly perfect (>4.0) (Thapa et al., 2023). The DOMS was evaluated by the VAS ranging from 0 (none), 25 (mild pain), 50 (moderate pain), 75 (severe), to 100 (worst pain) (Lau et al., 2013).

Results

Table 1. Descriptive statistics of flexibility

Variable	Group	Baseline (SD), 0 h	24 h (SD)	48 h (SD)	72 h (SD)	n
Flexibility	SMFR&COM	28.54(1.05)	30.92(1.38)	32.62(1.32)	34.77(1.09)	13
	COM	26.38(1.04)	28.77(2.05)	29.77(1.09)	32.62(2.02)	13

The investigation of flexibility profiles between the SMFR&COM group and the COM group across four testing periods revealed notable trends and insights. The mean flexibility scores, measured in centimeters using the sit and reach test, displayed distinct patterns for each MFR group across the various evaluation phases.

In Period 1 (0 h) after COM, the SMFR&COM group recorded a mean flexibility score of 28.54 ± 1.05 cm, whereas the COM group showed a lower mean score of 26.38 ± 1.04 cm. In Period 2 (24 h) post-COM, the SMFR&COM group achieved a mean flexibility score of 30.92 ± 1.38 cm, while the COM group maintained a lower mean of 28.77 ± 2.05 cm. Although the differences were subtle, they laid the groundwork for subsequent observations. By Period 3 (48 h), the SMFR&COM group demonstrated a significant increase, reaching a mean score of 32.62 ± 1.32 cm, surpassing the COM group. The SMFR&COM group recorded a mean flexibility score of 29.77 ± 1.09 cm in Period 3 (48 h). However, the most significant change occurred in Period 4 (72 h), where the SMFR&COM group showed a substantial increase in mean flexibility, reaching 34.77 ± 1.09 cm, indicating a consistent upward trend. In contrast, the COM group concluded the study with a mean flexibility score of 32.62 ± 2.02 cm. The differences in mean flexibility scores between the SMFR&COM and COM groups during the study suggest that the SMFR&COM group experienced more pronounced improvements in flexibility compared to the COM group.

Table 2. Repeated measures of flexibility

Variable	Group	P (η^2_p) 95%CI		
		Group (effect)	Time (effect)	Group × time (interaction)
Flexibility	SMFR&COM	.000**	.000**	.507
	COM	(.526)	(.881)	(.032)

**significant at 0.01

Table 2 presents the statistical analysis of flexibility under repeated measures ANOVA for the SMFR&COM and COM groups across various periods (1–4). The analysis revealed a significant difference in flexibility between the groups ($P < 0.01$, $\eta^2_p = 0.526$), indicating a large effect, as well as a significant difference over time ($P < 0.01$, $\eta^2_p = 0.881$), also reflecting a large effect. However, there was no significant difference in the group × time interaction ($P = 0.507$, $\eta^2_p = 0.032$), indicating a small effect. This suggests that both the SMFR&COM and COM groups significantly improved flexibility over the study period.

Table 3. Percentage change relative to baseline and the differences in flexibility between the SMFR&COM and COM groups across various periods

	Group	MD from the baseline	P	Effect size	Between-group P	Effect size
Baseline	SMFR&COM				.000**	2.057
	COM					
24hour	SMFR&COM	2.38	.000**	2.742	.004**	1.233
	COM	2.38	.001**	1.156		
48hour	SMFR&COM	4.07	.000**	2.722	.000**	2.344
	COM	3.38	.000**	2.554		
72hour	SMFR&COM	6.23	.000**	5.345	.002**	1.325
	COM	6.23	.000**	3.043		

**significant at 0.01

Table 3 shows the results of the paired sample t-test, which assesses the subjective measure of flexibility at three time points: 24, 48, and 72 h, relative to baseline values (0 h) for both the SMFR&COM and COM groups. Furthermore, the independent sample t-test evaluates the group effects of SMFR&COM and COM across all four time periods.

A paired sample t-test indicates that at 24 h, participants in the SMFR&COM group exhibited a mean difference of 2.38 from baseline, reflecting a significant increase ($P < 0.01$, effect size = 2.742). This significant increase in SMFR&COM scores continued at 48 h, with a mean difference of 4.07 from baseline ($P < 0.001$, effect size = 2.722). By 72 h, the mean difference in SMFR reached 6.23 from baseline ($P < 0.001$, effect size = 5.345). In comparison, the COM group also exhibited significant increases from baseline at all time points: 24 h (mean difference = 2.38, $P < 0.001$, effect size = 1.156), 48 h (mean difference = 3.38, $P < 0.001$, effect size = 2.554), and 72 h (mean difference = 6.23, $P < 0.001$, effect size = 3.043). However, the changes observed in the SMFR&COM group were consistently more pronounced than those in the COM group at all time points ($P < 0.01$). The results in the table indicate that SMFR&COM significantly enhances flexibility over time compared to the COM group. The SMFR&COM group demonstrated progressively more significant improvements at 24, 48, and 72 h post-intervention, accompanied by substantial effect sizes and highly significant P-values ($P < 0.01$). These findings underscore the effectiveness of SMFR before intense activity in enhancing flexibility. Significant differences between the SMFR&COM and COM groups were observed at baseline ($P < 0.01$, effect size = 2.057), as well as at 24 h ($P < 0.01$, effect size = 1.233), 48 h ($P < 0.01$, effect size = 2.344), and 72 h ($P < 0.01$, effect size = 1.325).

Figure 2. Changes in flexibility scores across different time periods

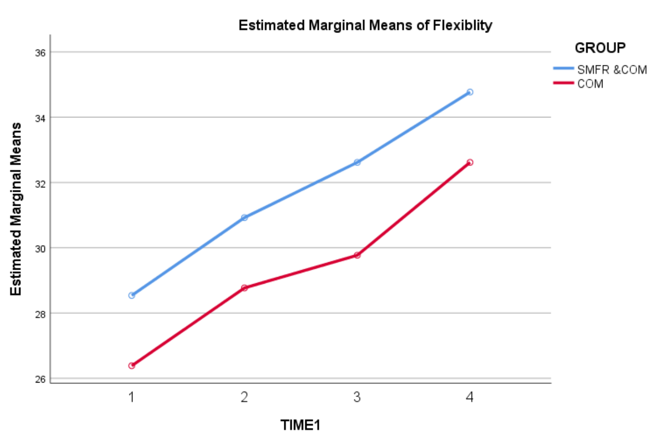


Table 4. DOMS descriptive statistics

Variable	Group	Baseline (SD)	24 h (SD)	48 h (SD)	72 h (SD)	n
DOMS	SMFR&COM	20.38(5.19)	40.38(4.31)	67.69(3.88)	26.92(4.80)	13
	COM	30.77(3.44)	55.38(4.77)	76.15(6.50)	33.46(5.91)	13

In Period 1 (baseline at 0 h) following COM, the mean value for the SMFR&COM group was 20.38 ± 5.19, while the COM group recorded a slightly higher mean of 30.77 ± 3.44. In Period 2 (24 h after COM), the mean value for the SMFR&COM group increased to 40.38 ± 4.31, whereas the COM group maintained a higher mean of 55.38 ± 4.77. The gap between the groups continued to widen at subsequent time points as the study progressed. In Period 3 (48 h after COM), the mean value for the SMFR&COM group increased to 67.69 ± 3.88, while the COM group recorded a mean of 76.15 ± 6.50. In Period 4 (72 h after COM), the difference between the groups increased further. The mean for the SMFR&COM group declined to 26.92 ± 4.80, whereas the COM group exhibited a slightly higher mean of 33.46 ± 5.91.

The table presents the assessment of DOMS using the VAS at four time points: 0h (baseline), 24, 48, and 72 h post-intervention. At baseline, the SMFR&COM group reported a soreness level of 20.38 ± 5.19, indicating mild soreness. At 24 h, this increased to 40.38 ± 4.31 (mild to moderate); at 48 h, it further increased to 67.69 ± 3.88 (moderate to severe); and at 72 h, it decreased to 26.92 ± 4.80 (mild). In comparison, the COM group had a higher baseline soreness of 30.77 ± 3.44, also indicating mild soreness. This increased to 55.38 ± 4.77 at 24 h (moderate), reached 76.15 ± 6.50 at 48 h (severe), and then slightly decreased to 33.46 ± 5.91 at 72 h (mild).

Table 5. Repeated measures of DOMS

Variable	Group	P (Cohen's d) 95%CI		
		Group (effect)	Time (effect)	Group × time (interaction)
DOMS	SMFR&COM	.000**	.000**	.013*
	COM	(.781)	(.955)	(.138)

*significant at 0.05, **significant at 0.01

Table 5 presents the statistical analysis of the variable DOMS using repeated measures ANOVA for the SMFR&COM and COM groups across various periods (1–4). The analysis revealed a significant difference between groups (P < 0.01, η^2_p = .781), indicating a large effect, as well as a significant difference over time (P < 0.01, η^2_p = .995), also representing a large effect. Additionally, the group × time interaction showed a significant difference (P = 0.013, η^2_p = .138), indicating a very large effect. These results suggest that the SMFR&COM group significantly reduces DOMS over time compared to the COM group, demonstrating a strong effect size and confirming the efficacy of SMFR in managing DOMS.

Table 6. Percentage change compared to baseline and differences between the SMFR&COM and COM groups across various periods for DOMS

	Group	MD from the baseline	P	Effect size	Between-group P	Effect size
Baseline	SMFR&COM				.000**	2.358
	COM					
24hour	SMFR&COM	20	.000**	3.703	.000**	3.299
	COM	24.61	.000**	4.744		
48hour	SMFR&COM	47.31	.000**	7.474	.000**	1.580
	COM	45.38	.000**	5.321		
72hour	SMFR&COM	6.54	.005**	0.949	.005**	1.214
	COM	2.69	.188	0.387		

*significant at 0.05, **significant at 0.01

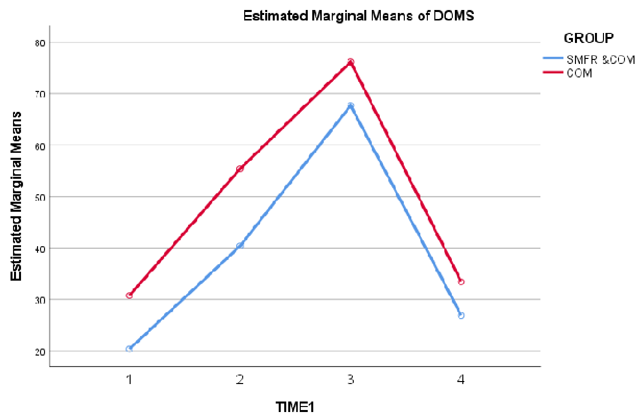
In Table 6, the paired sample t-test displays the subjective measure of flexibility at three time points: 24, 48, and 72 h, compared to baseline values (0 h) for both the SMFR&COM and COM groups. Additionally, the independent sample t-test assesses the group effects of SMFR&COM and COM across four time periods.

A paired sample t-test indicates that at 24 h, participants in the SMFR&COM group showed a mean difference of 20 from baseline, reflecting a significant increase (P < 0.01, effect size = 3.703). This notable increase in SMFR&COM scores continued at 48 h, with a mean difference of 47.31 from baseline (P < 0.001, effect size = 7.474). By 72 h, the mean difference in the SMFR&COM group was 6.54 from baseline (P < 0.001, effect size = 0.949). In comparison, the COM group also exhibited significant increases from baseline at all time points. At 24 h, the mean difference was 24.61 (P < 0.001, effect size = 4.744); at 48 h, it was 45.38 (P < 0.001, effect size =

5.321); and at 72 h, it was 2.69 (P < 0.001, effect size = 0.387). These comparisons indicate that the changes in the SMFR&COM group were consistently more significant than those in the COM group at all time points (P < 0.01). The results demonstrate that the mean differences between the groups remained significant, with the SMFR&COM group showing a progressive increase at 24 and 48 h, followed by a decrease at 72 h post-intervention, with substantial effect sizes and highly significant P values (P < 0.01). These findings demonstrate the effectiveness of SMFR in reducing DOMS compared to the COM group.

The SMFR&COM and COM groups exhibited significant differences at baseline, with P < 0.01 and an effect size of 2.358, indicating a large effect. At 24 h, the differences remained significant (P < 0.01, effect size = 3.299), reflecting a large effect. Similarly, at 48 h, the differences continued to be significant (P < 0.01, effect size = 1.580), also indicating a large effect. Finally, at 72 h, the significant difference persisted (P < 0.01, effect size = 1.214), representing a large effect.

Figure 3. Changes in DOMS scores across different time periods



Discussion

The gradual improvement in the SMFR&COM group indicates that pre-exercise foam rolling effectively prepares muscles for physical activity by reducing stiffness and increasing ROM, both of which are crucial for performance and injury prevention (Macdonald et al., 2012). The results of this study indicated significant increases in ROM following the SMFR intervention. Flexibility assessments showed that the SMFR&COM group experienced a notable enhancement in flexibility at all measured time points. Maintaining ROM and flexibility in muscles and joints plays a crucial role in reducing DOMS. Improved flexibility is vital for alleviating muscle rigidity and facilitating faster recovery by enhancing blood flow and nutrient delivery to the muscles. Additionally, flexibility helps decrease the likelihood and severity of muscle injuries by improving muscle coordination and movement efficiency, thereby minimizing muscle spasms and tension.

Pre-exercise SMFR enhances lymphatic function, facilitating the removal of metabolic waste and reducing inflammation. Furthermore, the benefits of stretching—such as tension relief and relaxation—help alleviate the discomfort associated with DOMS. As a result, incorporating stretching and flexibility exercises into training programs not only enhances athletic performance but also mitigates the effects of DOMS. Cochrane. (2009) revealed that MFR exercises induce acute physiological effects, as well as adaptations and training responses, leading to muscle elongation. These effects include increases in the muscle stretch reflex, electromyographic activity, muscular energy metabolism, intramuscular temperature, joint stability, and flexibility, all of which can help reduce DOMS. Additionally, Hendricks et al. (2020) indicated that FR may decrease muscle stiffness, enhance ROM, and reduce DOMS. Therefore, it should be combined with dynamic stretching and active warm-up exercises before training sessions. Given the vasodilation response observed after foam rolling, it is theorized that this technique could offer performance-enhancing benefits and should be incorporated into warm-up routines (D Andrea JD et al. 2017). This study demonstrated that MFR with FR during active warm-up sessions for specific muscle groups involved in intensive exercise facilitated muscle activation and reduced muscle soreness compared to traditional warm-up techniques. Tan et al. (2020) agree that an effective strategy before exercise is crucial for preventing muscle damage and DOMS. Enhanced blood circulation may also help prevent the buildup of metabolic byproducts and reduce subsequent symptoms of EIMD and DOMS.

In this study, DOMS reached its highest point at 24 and 48 h after the exercises and decreased at 72 h (Nset et al., 2012). The DOMS significantly increased immediately after intense exercise and persisted for three days, peaking at 24–48 h post-exercise. This study demonstrated that pre-exercise SMFR using foam rolling enhanced players' ROM, positively affected flexibility during recovery, and influenced muscle soreness. Kalichman et al. (2017) agree with our study that MFR techniques can enhance tissue extensibility and flexibility.

Peacock et al. (2014) and Morales Artacho et al. (2017) revealed that FR should be implemented along with DS and an active warmup to reduce latent muscle rigidity and enhance flexibility before the training session. Cardinale and Bosco (2003) suggested that neural factors, including increased muscle spindle sensitivity and gamma activation, were the most likely contributors to the acute changes in motor output resulting from MFR. The mechanism of MFR enhances tissue mobility by breaking down adhesions and relieving tension in the fascia. Additionally, MFR may stimulate the release of endorphins, leading to reduced pain, improved function, enhanced recovery, decreased DOMS, and increased flexibility (Martínez et al., 2016);(Morales Artacho et al., 2017); (Blades et al., 2022); (Hendricks et al., 2020).

Integrating MFR with foam rolling and dynamic stretching optimizes the physiological and mechanical readiness of muscles, thereby enhancing performance and lowering the risk of injury. Foam rolling can effectively reduce muscle stiffness, increase ROM, and alleviate DOMS. Therefore, it should be paired with dynamic stretching and an active warm-up before training sessions (Hendricks et al., 2020).

Conclusion

MFR is a manual therapy technique suggested as a potential treatment for DOMS and for enhancing flexibility. This study demonstrated that pre-exercise SMFR effectively reduced muscle stiffness and improved ROM, both crucial for injury prevention and athletic performance. The SMFR&COM group experienced a significant reduction in perceived muscle soreness and a consistent increase in flexibility over the 72 h following an intensive training session, in contrast to the COM group. The results indicate that athletes can benefit from incorporating SMFR into their pre-exercise routines to enhance performance and expedite recovery. MFR increases muscle pliability, increases blood flow, and may aid in the removal of metabolic waste products, thereby reducing inflammation and promoting faster recovery. Future research should explore the potential benefits of MFR across diverse populations and physical activities.

Conflicts of interest - No external funding

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