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The Impact of Foam Rolling on Recovery and Performance Components (ROM, Strength, Jump, Agility): A Systematic Review

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ABSTRACT

Foam rolling has emerged as one of the most popular recovery methods in recent years. This study aims to evaluate the effects of foam rolling on the recovery process and various performance parameters in athletes and healthy active individuals. This research is a systematic review that analyzes randomized controlled trials published in English between January 2014 and March 2024, accessed through electronic databases such as PubMed, Scopus, and EBSCO SportDiscuss with Full Text. The keywords used in the search include "foam rolling," "foam roller," "foam rolling massage," and "myofascial release." The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were utilized to guide the research process and the preparation of the report. According to the inclusion and exclusion criteria, 14 articles were included in this review. The findings suggest that foam rolling accelerates recovery after injuries, facilitates the overall recovery process, and generally enhances performance. On the other hand, there is no definitive evidence indicating adverse effects on performance. Foam rolling may help mitigate declines in muscle performance, particularly in terms of physical attributes such as strength, power, and agility, and reduce perceived pain and effort following intense exercise. However, due to the heterogeneity of the study samples, further research focusing specifically on sports-related applications is recommended.

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INTRODUCTION

The health benefits of physical activity are well established. However, intense exercise can lead to immediate and delayed physiological changes, placing significant stress on the musculoskeletal system and resulting in muscle fatigue, reduced mobility, and exercise-induced muscle damage (Harrison et al., 2024). Exercise-induced muscle damage is characterized by increased muscle soreness, impaired muscle function, and loss of strength (Jiaming & Rahimi, 2021). Particularly in sports that require high technical demands and repetitive movements, effective management of the recovery process after training and competition is crucial. Various recovery methods used in this process are broadly classified into active and passive recovery strategies (Bishop et al., 2008).

Among active recovery methods, dynamic stretching, massage, electrical stimulation, cold-water immersion, low-intensity aerobic exercises, sauna, whole-body cryotherapy, and foam rolling (FR) techniques are commonly utilized (Dutta et al., 2023; Rahimi et al., 2020; Rey et al., 2019). FR is a widely used active recovery method, particularly among athletes, aiming to reduce muscle stiffness, enhance range of motion (ROM), and alleviate muscle tension by applying pressure to soft tissue (Jo et al., 2018; Konrad et al., 2022). Recent research suggests that FR not only accelerates recovery but also improves key physical performance parameters such as ROM, muscle strength, flexibility, agility, and jump performance (MacDonald et al., 2014; Nakamura et al., 2021).

By utilizing body weight, FR facilitates the release of muscle tension. Athletes roll a firm foam cylinder back and forth over their muscles, applying pressure to soft tissues (Beardsley & Škarabot, 2015). Due to their shapes and sizes, foam rollers allow for covering a large surface area while applying appropriate pressure. Variations such as spiked, knobbed, and vibrating foam rollers are believed to provide more sensitive and deeper effects (Michalak et al., 2024). Although comprehensive studies on the effectiveness and precise mechanisms of FR are lacking, various morphological and physiological mechanisms may contribute to accelerated recovery (Aboodarda et al., 2015).

The physiological mechanisms underlying FR’s role in recovery are multifaceted. FR is believed to enhance blood circulation in muscle tissue, facilitating the removal of metabolic waste and increasing oxygen supply (Okamoto et al., 2014). Additionally, it has been suggested that FR improves proprioception and neuromuscular function, contributing to enhanced muscle performance. Furthermore, FR has been reported to increase parasympathetic nervous system activity, promoting muscle relaxation and reducing perceived muscle soreness (Beardsley & Škarabot, 2015). Recent studies indicate that FR reduces arterial stiffness and improves vascular function, potentially accelerating muscle repair and recovery (Kiyono et al., 2020).

The use of FR in post-exercise recovery has gained increasing popularity among athletes. Studies have investigated its effectiveness in team sports (e.g., soccer, basketball), endurance sports (e.g., long-distance running, cycling), and strength-based disciplines (e.g., weightlifting, CrossFit). However, there are conflicting findings in the literature regarding the effectiveness of FR in different sports. Recent studies have demonstrated the positive effects of FR on performance parameters, including range of motion (ROM), muscle pain, and strength. A study investigating the acute effect of foam rolling on eccentrically induced muscle damage showed that a 90-second foam rolling (FR) session, applied 48 hours after exercise, significantly reduced muscle soreness and improved muscle strength (Nakamura et al., 2021). Similarly, another recently study stressed that FR not only reduced muscle pain but also improved joint proprioception and decreased strength loss after eccentric exercises (Naderi et al., 2020). MacDonald et al., (2014) reported that FR performed after exercise-induced muscle damage (EIMD) increased knee joint ROM compared to a control group. Likewise, FR applied to the hamstring muscles significantly increased ankle joint ROM (Halperin et al., 2014). Another study demonstrated significant improvements in muscle performance tests, including power, speed, strength, and agility, when FR was incorporated into a warm-up protocol (Peacock et al., 2014). Romero Moraleda et al., (2017) observed that maximum voluntary contraction in the rectus femoris muscle improved following FR treatment compared to manual therapy techniques such as neurodynamic mobilization. A review by Wiewelhove et al. (2019) reported a trend toward improved sprint performance following FR. Conversely, some contradictory findings were present in previously scientific studies. MacDonald et al., (2013) found no beneficial effects on muscle performance when measuring maximum voluntary contraction. A study involving twenty-six healthy college students found no effect of FR on isometric strength compared to plank exercises (Healey et al., 2013). A study by Halperin et al. (2014) found no significant differences between FR and static stretching as recovery tools. Recovery from high-intensity exercise is crucial for regaining previous performance levels. A review of the current literature reveals the positive effects of FR on maintaining physical performance and perceived levels.

Due to the contradictory findings in the current literature and the limited number of randomized controlled trials examining the effects on athletes and healthy active individuals, it is essential to examine variables such as application duration, intensity, and methodological differences in more detail to better understand the role of FR in different sports. This situation necessitates a further systematic review of the effect of FR.

In this context, the present systematic review aims to evaluate the effects of FR on recovery processes and various physical performance parameters, including muscle strength, range of motion (ROM), agility, flexibility, and jumping performance, in athletes and physically active individuals. In this review, "*performance*" refers specifically to measurable physical attributes such as muscle strength, range of motion (ROM), flexibility, agility, and jump performance**.** These components were selected based on the most commonly reported outcome measures across the included randomized controlled trials. A comprehensive review of the current literature findings and an examination of the role of FR in recovery may provide valuable insights for its application in sports science.

METHODS

Study Design

A systematic review was conducted to discuss the findings of studies examining the effects of foam rolling (FR) on athletes and healthy active individuals, and to establish a fundamental guide for using foam rolling as a recovery strategy in athletes. This study was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2015). A schematic representation of the systematic review is shown in Figure 1. Ethical approval was not required for this study.

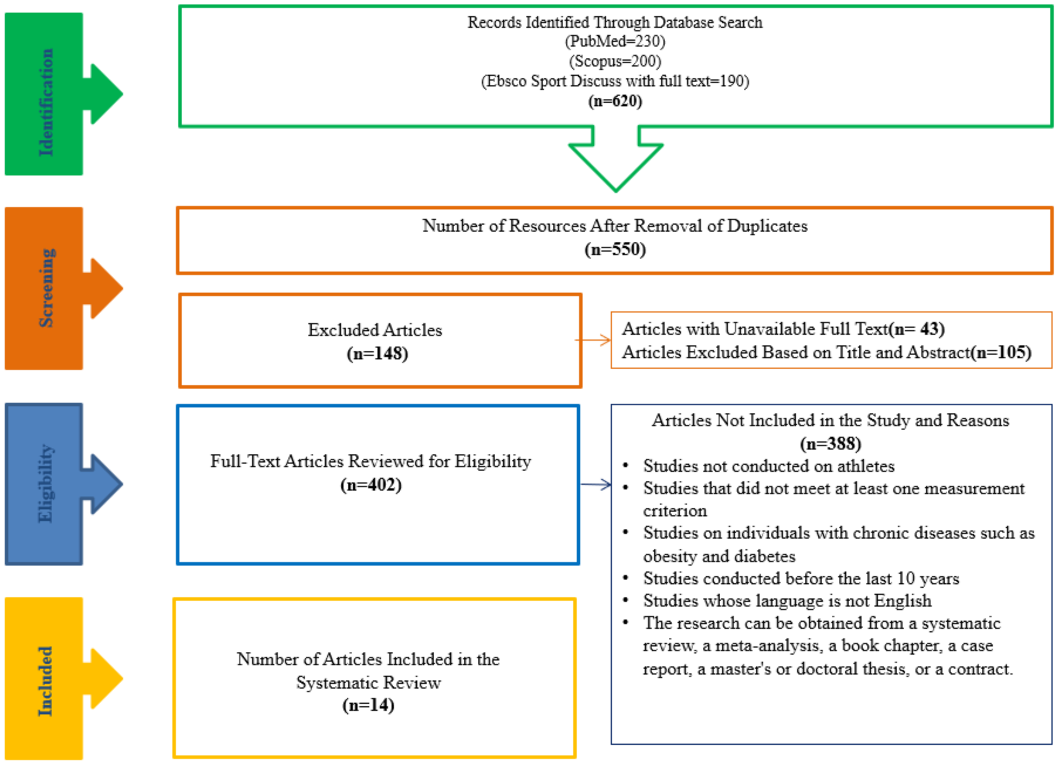
Search Strategy

This present study is a systematic review conducted by searching electronic databases (PubMed, Scopus, Ebsco SPORTDiscuss with Full Text) for English randomized controlled studies from January 2014 to March 2024. Keywords such as “foam rolling,” “foam roller,” “foam rolling massage,” and “myofascial release” were used in the review. Boolean search principles (e.g., “foam rolling OR foam roller AND sport OR performance OR exercise”) were applied. Articles related to athletes' recovery processes and performance were screened, and full-text articles were evaluated based on inclusion criteria for sampling.

Study Selection

The data were evaluated outlined in the PRISMA guidelines (Figure 1), in accordance with the inclusion criteria. The selection of studies was based on the following inclusion and exclusion criteria; i) Inclusion Criteria: The present systematic review included randomized controlled trials that investigated any combination of treatments involving foam rolling (FR) on athletes (e.g., foam rolling combined with stretching) or trials that included another treatment as a control condition (e.g., stretching). Studies involving active, healthy individuals who did not specifically identify as athletes were also included. There were no restrictions regarding gender, ethnicity, or race. Only studies published in the last ten years, in English, and conducted as randomized controlled trials were included. Additionally, studies had to include at least one common outcome measurement, which was determined as "jump-power performance"; ii) Exclusion Criteria: Studies published more than ten years ago, those not written in English, non-randomized controlled trials, reviews, book chapters, conference abstracts, studies not conducted on athletes, studies involving individuals with chronic illnesses, studies for which full text could not be accessed, articles with mismatched titles and abstracts, and duplicated articles were excluded. Studies that did not assess the common outcome measurement were also excluded.

Figure 1
PRISMA Flow Diagram of the study (Moher et al., 2015)



Data Analysis

The quality of the included studies was assessed using the Physiotherapy Evidence Database (PEDro) scale, which has demonstrated high reliability and validity for this purpose (Verhagen et al., 1998). The version of the scale adapted from a recent review by Sarmento et al. (2018) was used. All ten quality criteria were rated on a three-level scale: Yes = 2 points, Maybe = 1 point, No = 0 points. Total scores ranged from 0 to 20. Two researchers conducted Independent assessments. In case of discrepancies, these were resolved through a consensus discussion with a third senior researcher. The data quality evaluation scores of the included studies are shown in Table 1.

RESULTS

Initial Search Results

A total of 620 references were initially obtained. After applying the research criteria, 14 studies were selected for inclusion). The number of participants and their characteristics, the exercise and recovery protocols used in the studies, the tests applied, and the results obtained are summarized in Table 3. Each article was screened and evaluated based on its title, abstract, and full text for eligibility. A total of 402 articles were subjected to further screening and evaluation. After excluding studies published more than ten years ago, those that were not randomized controlled trials, those not written in English, and studies excluded for various reasons (e.g., not involving athletes), 14 articles were included in the study (Figure 1).

Participant Characteristics

The characteristics of the study participants, the exercise protocols used, and the main results obtained from the included studies are explained in Table 2. The participants in the included studies were healthy, active individuals with a background in certain sports. Their ages typically ranged from 20 to 35 years, with one study involving participants under the age of 18. None of the participants had chronic conditions such as obesity or diabetes. Additionally, individuals with a history of smoking, medication and steroid use, or musculoskeletal disorders were excluded. A total of 410 participants across 14 studies were included in the review. Since some studies did not specify gender, the exact number of males and females is not precise. No distinctions were made based on gender, religion, language, or race in the selection of participants.

Table 1
Data Quality Assessment Scores Given to Studies

Author, Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Score
Rahimi et al., 2020	1	2	1	2	2	2	2	2	2	0	16
Rey, E. et al., 2019	2	2	1	2	2	1	2	2	2	0	16
Nakamura et al., 2023	2	2	1	2	2	2	2	2	2	0	17
Giovanelli et al., 2018	2	2	1	2	2	1	2	2	2	0	16
Healey et al., 2013	2	2	1	2	2	2	2	2	0	1	16
Pearcey et al., 2015	2	1	1	2	2	2	2	2	1	2	17
Romero-Franco et al., 2019	2	2	1	2	2	2	2	2	2	0	17
Ko´zlenia et al., 2022	2	2	1	2	2	2	2	2	2	2	19
Oliveira et al., 2023	2	0	2	2	2	2	2	2	2	0	16
Romero-Moraleda et al., 2019	2	2	2	2	2	2	2	1	2	2	19
Lin et al., 2020	1	2	1	2	2	2	2	2	2	0	16
Akarsu et al., 2022	2	2	1	2	1	2	2	2	0	2	16
Wang et al., 2022	2	2	1	2	2	2	2	2	2	0	17
Chen et al., 2021	1	2	1	2	2	2	2	2	2	0	16

Note. Q: Question

Recovery Protocols

The recovery protocols are summarized in Table 2. In some studies, a control group was used for comparison with FR-based recovery. Control groups used methods such as passive recovery, static stretching, planking, dynamic stretching, and recovery with percussive devices (PVPD). Some studies employed a crossover design, where groups alternated according to specific rules and applied each recovery method used in the study. While the duration of the FR protocols varied across studies, they were applied rotationally to specific muscle groups within a defined rest and application time. In some studies, vibrational FR and double FR were used.

Tests and Measurements Performed in Studies

The studies included in the review measured various parameters, including jump performance, agility, sprint, perceived effort, flexibility, muscle pain, total quality recovery, range of motion (ROM), tissue stiffness, strength, proprioception, and sport-specific metrics. For jump performance, tests such as squat jump, vertical jump, counter movement jump (CMJ), drop jump, and squat jump via EXER were used. Agility was assessed using the PRO agility test and the T-test. For anaerobic power, the repeated sprint test was used, while aerobic capacity was measured through the Yo-Yo intermittent recovery test level 2 (YYIRT-L2). Perceived effort was measured with the Borg CR-10 Test and general fatigue scale. Flexibility was assessed using the Thomas test, Ely test, and sit-and-reach test. Pain was measured using the Visual Analog Scale (VAS), pressure pain threshold, and palpation. Perceptual measurements were taken using the Hooper Index (HI) and total quality recovery (TQR). Tissue stiffness was measured using a myometer, and joint range of motion was assessed with ROM tests.

Table 2
Summary of data From Articles Included in the Review

Author/Year	Characteristics	Recovery Protocol	Tests	Study Results
Rahimi et al., 2020	Iran (U-23) Futsal, 6 d/w, 90 min/day training, 19 years, M, n=16 (FR 8; CG 8)	FR: 15 min post-match (3 sets x 40 sec x 20 sec rest/exercise); lower extremities.	SJT - PRO Agility Test - HI – RST YYIRTL2- Borg CR-10 Scale - KL	Anaerobic Power (SJT); FR ↑ Blood lactate removal FR ↑ Perceptual indices of the FR methıd. ↑ On the performance indicators of FR ↔
Rey et al., 2019	Elite football, 5d/wk training, 22-30 years n=18 (FR: 9; CG: 9)	FR: 20 min post-match (2 sets x 45 sec x 15 sec rest/exercise); CG: PT	TQR –VAS –Sit&Reach test, CMJ -5m and 10m Sprint Test, T Test	CMJ, in both groups T Test, in CG ↓ FR, T-Test performance ↑ Flexibility in both groups ↔
Nakamura et al., 2023	Mean age 22, M, n=15	FR+SS, SS+FR, FRvibration+SS, SS+ FRvibration, passive recovery, respectively.	Knee flexion ROM; PPT -Tissue stiffness ; CMJ	Knee flexion ROM in all conditions ↑ Tissue hardness in all conditions ↓ Max. Iso. contraction after FR+SS ↓ Adding vibration to FR ↔
Giovanelli et al., 2018	Mean age: 26, active healthy students	1 min SMFR for each muscle on eight muscle groups	Treadmill test, Squat, CMJ test(EXER), Borg CR-10 scale	Post-exercise Cr, in the next 3 hours ↑ Pos-exercise ↓ Max power during, after and 3 hours after CMJ ↑
Healey et al., 2013	Mean age 21, active healthy students, n=26 (13M, 13F)	FR: Muscle groups for 30 sec CG: Planking	Palpation Pain, General Fatigue, Borg CR-10 test, Vertical jump test, Isometric strength - Agility test	No difference was seen between the groups in all 4 athletic tests. Higher level in men in all athletic tests Pain, fatigue, effort in both groups Pain; more fatigue ↑
Pearcey et al., 2015	Healthy active M, n=8	FR: 20 min (45 sec x 15 sec rest/exercise)	Quadriceps pressure pain threshold, Sprint test -power T-Test Squat 70% 1RM	FR, quadriceps pressure pain threshold ↑ Significant effects ranged from small to large for sprint duration, power, and dynamic strength-endurance.
Romero Franco et al., 2019	Age 18-25; athlete; n=30 (18M, 12F; FR: 15, CG:15)	Post-run FR: 6 min (45 sec x 15 sec rest/exercise) ; lower extremity	DiF, KE, DiE, ADF ROM, Diz propioception - CMJ	EG, 0 min and 10 min ADF and CMJ compared to baseline ↑
Ko´zlenia et al., 2022	Age 20-25; amateur athlete; n=30 (14M, 16F; FR:15, CG:15)	Post-warm-up FR: 15 sec per lower extremity muscle group and 20 reps CG: warm-up	SJ, CMJ, DJ	FR: All jump test parameters ↑
Oliveira et al., 2023	Age 25-35; experienced athlete; M; n=39 (FR=13 SG=13 PD=13)	After HIFT FR: 20 min (2 sets x 45 sec x 15 sec rest/exercise) SS: 20 min (45 sec x 15 sec rest/exercise) PD: 20 min passive sitting	FS, VAS, TQR, Sit-Reach Test (Flexibility), CMJ Test, T-Test	Strength and flexibility; none returned to baseline ↑ Deteriorations at 24 hours in all groups. FR; perceptions of superior recovery

Table 2 (Continued)

Author/Year	Characteristics	Recovery Protocol	Tests	Study Results
Moraleda et al., 2019	Mean age 22; active individual; n=38 (32M,6F)	Post-Squat NVFR: Regular FR VFR Group: Vibration FR	VAS, CMJ, PAKF, PAKE Dif ROM	VFR; VAS ↑ VFR; PKE ROM ↓
Cheng Lin et al., 2020	Age 20-30; badminton athlete n=40(25 M, 15 F; DS: 20; DS+VFR:20)	Post-training DS: Dynamic warm-up exercise, VFR: vibration FR for 20 seconds for each muscle group	DIF, DIE ROM, Mymeter (stiffness), Flexibility ely test CMJ Agility Test	DS: DS; DiF ROM, CMJ, Agility ↑ Quadriceps and gastrocnemius muscle stiffness ↓ DS + VFR: DiE ROM ↑ Quadriceps muscle stiffness ↓
Akarsu et al., 2022	Taekwondo athletes with at least three years of experience, average age 16; n=21	Running, Running+ SS, Running+ FR conditions	CMJ	No difference between running and SE. Statistically significant differences between running and FR and FR and SE
Wang et al., 2022	Mean age 20; tennis player; n=27	VFR: 7 min vibrating foam roller, PVPD: 7 min vibrating percussion device CG: 7 min sitting	CMJ, DJ, HT, 2,5 m Lateral Acceleration test, Y-Balance Test	VFR: CMJ and HT results and reactive strength index (RSI) according to CG ↑
Chen et al., 2021	Mean age 20; taekwondo athlete; M; n=15	GW: 5 min running + 5 min sitting + 5 min DS, GW+VFR: 5 min running + 3 sets of VR, GW + double VFR	Flexibility Test, CMJ, Agility Test, HT, Kick Speed Frequency	HT in GS+VR vs. GS ↑ GS + VR and GS + double VR, kick frequency ↑ GS + VR and GS + double VR did not significantly improve flexibility and CMJ asymmetry performance.

Note. d/w: days/week, M: male, F: female, FR: foam rolling, CG: control group, PT: passive recovery, SS: static stretching, FR: Foam Rolling; VFR: vibrating foam rolling, CMJ: counter movement jump, ROM: range of motion, SMFR: Self-myofascial foam rolling, Rc: running cost, RM: maximum repetition, KF: knee flexion, HE: hip extension, KE: knee extension, ADF: ankle dorsiflexion, PR: passive rest, HIFT: high-intensity functional training, NVFR: non-vibrating foam roller, VFR: vibrating foam roller, PAHF: passive active hip flexion, PAHE: passive active hip extension, DW: dynamic warm-up, PVPD: vibrating percussion device, GW: general warm-up, SJT: Squat Jump Test, HI: Hooper Index, RST: Repeated Sprint Test, YYIRTL2: Yo-Yo Intermittent Recovery Test, KL: Blood lactate level, TQR: Total quality improvement, VAS: Visual analog scale, PPT: Pain pressure threshold, -SJ: Squat Jump, DJ: Falling Jump, FS:Sensory scale, HT: Hexagon test

DISCUSSION

Given the widespread use of foam rolling (FR) in sports performance, this study aimed to determine the recovery effects of FR on various performance parameters such as jump performance, muscle strength, flexibility, agility, and range of motion (ROM) in athletes and healthy active individuals. A review of the literature revealed that a study by Schroeder and Best (2015) reported unclear outcomes regarding the use of FR as a pre-exercise recovery strategy. Similarly, a study by McKenney et al. (2013) found only a few practical and beneficial outcomes. Beardsley and Škarabot (2015) conducted a more in-depth review of FR use, finding conflicting results regarding its effects on flexibility, strength development, sports performance, and delayed-onset muscle soreness (DOMS). Given the time that has elapsed since these studies were published and their focus on different populations, the present systematic review aimed to provide a comprehensive analysis of the effects of FR on specific physical performance variables in athletes. Our findings are particularly significant given the widespread application of FR methods in sports performance.

The results of our study suggest that FR may facilitate post-exercise recovery and improve key performance parameters such as ROM, muscle strength, flexibility, agility, and jump performance. Additionally, there is no clear evidence indicating a negative impact of FR on performance. Various differences in recovery protocols, participant characteristics, study designs, FR duration and intensity, timing of post-exercise assessments, and individual differences within athletic populations highlight the importance of considering these factors.

The effects of FR may vary across different sports disciplines due to the specific physiological and biomechanical demands of each activity. Research suggests that endurance athletes (e.g., long-distance runners and cyclists) primarily benefit from FR in terms of maintaining ROM and reducing muscle soreness, likely due to its effects on circulation and myofascial relaxation (Okamoto et al., 2014). In contrast, strength-based athletes (e.g., weightlifters and CrossFit participants) exhibit mixed responses; some studies report improvements in power output, while others find no significant difference compared to static stretching or other recovery methods (MacDonald et al., 2013). Furthermore, team sport athletes engaged in high-intensity intermittent efforts (e.g., soccer and basketball players) appear to benefit from FR by enhancing recovery between matches and reducing perceived muscle soreness (Rey et al., 2019). However, inconsistencies remain regarding its effects on explosive power and agility, emphasizing the need for sport-specific research.

When examining the effects of FR on ROM values, significant improvements in ankle dorsiflexion ROM were observed compared to passive recovery methods. However, no superiority was noted when compared to static stretching methods. While dynamic stretching increased ROM values, adding vibration FR to dynamic stretching had no additional effect. The observed increase in ROM may be related to various factors, including tissue flexibility, temperature, perfusion, fatigue, and the reorganization of tissue fibers (Gajdosik, 2001; Madding et al., 1987; McHugh & Cosgrave, 2010; Wepple & Magnusson, 2010). The short duration of the included studies means that long-term effects could not be evaluated, preventing any definitive conclusions regarding the long-term benefits of FR on ROM or flexibility. Additionally, it is worth noting that a variety of methods were employed to assess ROM, including goniometry, inclinometers, isokinetic dynamometry, and sit-and-reach tests. Measurement errors during testing may have contributed to the observed positive effects.

In line with the reviewed studies, the effects of FR on various sports performance parameters have been clearly outlined. Regarding jump power performance, in the commonly used countermovement jump (CMJ) test, eight studies reported statistically significant improvements with FR, two studies found negative effects, and four studies reported no effect. It was determined that FR application was superior to passive recovery in terms of CMJ performance but showed no difference compared to static stretching. Additionally, no significant difference was found when compared to plank exercises. However, a notable gender difference was observed, with men achieving higher values in all performance tests than women. Vibrating FR was found to provide similar benefits to non-vibrating FR but did not demonstrate superiority. The variability in protocols used across studies made it difficult to consolidate the data into a common conclusion.

Regarding the effects of FR on agility, no significant difference was found compared to passive recovery. Similarly, no significant difference was observed when compared to plank exercise recovery methods. However, a gender difference was again noted, with men outperforming women in all performance tests. When examining T-test scores, Rey et al. (2019) reported that FR minimized potential performance declines compared to passive recovery, while Pearcey et al. (2015) reported positive effects of FR. In contrast, De Oliveira et al. (2023) stated that FR did not provide superiority over other methods. The activation of proprioceptors through FR may enhance muscle contraction and response speed. The contradictory findings regarding agility may be explained by the hypothesis that muscle tone and stiffness negatively affect agility test performance (Alonso-Calvete et al., 2022).

Adding vibration resistance training (VRT) to dynamic stretching did not provide additional benefits compared to dynamic stretching alone; however, it showed significant improvements when incorporated into general warm-up protocols. When repeated sprint tests were examined, no significant impact of FR on performance was observed; however, it did not cause a decline in performance either. In the absence of FR, muscle soreness was found to affect all performance measures negatively. In terms of strength, Healey et al. (2013) found no difference between different applications but reported gender differences, with men performing better in all measurements. Nakamura et al. (2023) observed a decrease in maximal isometric contraction torque when static stretching was applied alongside FR.

In flexibility assessments, FR was not found to be superior to other recovery protocols. This may be because the force applied to muscles through FR may not be sufficient to improve flexibility. However, some studies suggest that FR has positive effects on flexibility (Aune et al., 2019; Guillot et al., 2019; Junker et al., 2015, 2019; Kiyono et al., 2020). The benefits of FR on flexibility are primarily associated with acute neural responses, with optimal results observed two minutes after application and effects diminishing within approximately 30 to 60 minutes.

When considering the effects of FR on all parameters, although many studies support its benefits, inconsistencies in the literature can be attributed to several factors. In terms of application duration and frequency, short-duration FR applications (<120 seconds/muscle group) typically provide acute improvements in ROM, whereas longer durations (>5 minutes/muscle group) may be more effective in reducing muscle soreness and accelerating recovery (Healey et al., 2013; Nakamura et al., 2021). However, there is no consensus in the literature regarding the optimal duration of FR. Regarding the timing of performance measurements in studies, assessments conducted immediately after exercise may not fully reflect the effects of FR, as its benefits for reducing muscle soreness and promoting relaxation typically become more pronounced within 24–48 hours (Wiewelhove et al., 2019). This variation may explain why some studies report no significant impact of FR on performance parameters.

Individual factors such as being a professional or amateur athlete, gender, age, and training level can influence the effects of FR. Elite athletes may benefit less from FR due to their already well-developed recovery mechanisms, whereas amateur or recreational athletes may experience more noticeable improvements (Beardsley & Škarabot, 2015). Additionally, the response to FR may be related to an individual's baseline muscle stiffness and flexibility. Female athletes generally have greater joint range of motion (ROM), suggesting that FR may be more effective in increasing ROM in women (Chen et al., 2021). In contrast, male athletes may derive greater benefits from FR in terms of reducing muscle stiffness and managing pain (Konrad et al., 2022). Studies have also reported that in older individuals, FR has more pronounced effects on increasing blood circulation and reducing muscle stiffness (Kiyono et al., 2020).

Comparative studies of FR with static stretching, dynamic stretching, and passive recovery methods have yielded conflicting findings. However, FR is more effective than passive recovery in maintaining ROM and reducing muscle soreness (Wiewelhove et al., 2019). Therefore, FR is recommended as a more advantageous recovery strategy compared to complete rest. Some studies suggest that FR is more effective than static stretching in enhancing ROM and flexibility, while others report no significant difference between the two methods (Halperin et al., 2014). The combination of FR with dynamic stretching has been reported to lead to greater improvements in performance parameters (Chen et al., 2021).

Recent studies have also compared FR with cryotherapy and percussion therapy, such as massage guns. While FR has been found effective in reducing muscle stiffness and increasing ROM, percussion therapy may be more advantageous for deep tissue relaxation (De Oliveira et al., 2023). These comparisons suggest that FR may be more effective when combined with other recovery methods.

Limitations

This systematic review may be subject to some bias, as it only included studies published in English and sourced research from limited databases. Different exercise protocols were employed across the included studies, utilizing various treatments, application durations, and measurement methods, resulting in varying outcomes. This situation hinders the clarity of the findings. Furthermore, due to the heterogeneity of studies, it is difficult to determine the correct application of FR in physical sports training. Therefore, the study's results should be viewed from this perspective.

CONCLUSION

The results of this systematic review suggest that FR accelerates recovery after injury, facilitates post-exercise recovery, generally enhances performance, and does not hurt performance. FR may also alleviate decreases in muscle performance and reduce perceived pain and effort following intense exercise. The findings indicate that FR does not negatively affect athletic performance. This suggests that FR is a recovery tool rather than a performance enhancer. Therefore, FR seems to be a suitable method for use during or before warm-up. Some studies recommend its use in combination with dynamic stretching (DS) and active warm-up (Lin et al., 2020; Chen et al., 2021). Due to the heterogeneity of methods across studies, there is no consensus on the optimal FR protocol. Sufficient high-quality evidence is lacking to draw definitive conclusions. Future research should focus on replicating methods and using larger sample sizes. The current literature provides some evidence for the use of FR in the athletic population, but limitations should be considered before integrating these methods.

PRACTICAL IMPLICATIONS

This study was to determine whether foam rolling affects performance when used as a recovery method. Foam rolling can be used as a recovery method before or during a warm-up in athletes and healthy active individuals.

Authors' Contributions

This study was conducted with the contributions of three authors. The study design was carried out by the first author, with contributions from the second and third authors. Data collection was conducted by the first and second authors. Statistical analysis was performed jointly by the first and second authors. The manuscript was prepared by all three authors.

Declaration of Conflict Interest

There is no conflict of interest or gain in the article**.**

Ethics Statement

This review was conducted in accordance with academic ethical standards. All sources were properly cited, and no data manipulation or plagiarism occurred. Approval of the ethics committee is not required for this article.

REFERENCES

Aboodarda, S. J., Spence, A. J., & Button, D. C. (2015). Pain pressure threshold of a muscle tender spot increases following local and non-local rolling massage. *BMC Musculoskeletal Disorders*, *16*, 265. https://doi.org/10.1186/s12891-015-0729-5

Akarsu, M., Kurhan, C. O., İlbak, İ., Altuntop, R., Gönç, M., Stojanović, S., & Purenovic-Ivanović, T. (2022). Acute effects of self-myofascial release through foam roller and static stretching methods on vertical jump performance of taekwondo players. *Journal of Pharmaceutical Negative Results*, *13*(S06), 2226–2230. https://doi.org/10.47750/pnr.2022.13.S06.289

Alonso-Calvete, A., Lorenzo-Martínez, M., Padrón-Cabo, A., Pérez-Ferreirós, A., Kalén, A., Abelairas-Gómez, C., & Rey, E. (2022). Does vibration foam roller influence performance and recovery? A systematic review and meta-analysis. *Sports Medicine - Open*, *8*(1), 32. https://doi.org/10.1186/s40798-022-00421-2

Aune, A. A., Bishop, C., Turner, A. N., Papadopoulos, K., Budd, S., Richardson, M., & Maloney, S. J. (2019). Acute and chronic effects of foam rolling vs eccentric exercise on ROM and force output of the plantar flexors. *Journal of Sports Sciences*, *37*(1), 138–145. https://doi.org/10.1080/02640414.2018.1486000

Beardsley, C., & Škarabot, J. (2015). Effects of self-myofascial release: A systematic review.

Journal of Bodywork and Movement Therapies, 19(4), 747-758. https://doi.org/10.1016/j.jbmt.2015.08.007

Bishop, P. A., Jones, E., & Woods, A. K. (2008). Recovery: Post-exercise strategies and applications. *Sports Medicine, 38*(6), 415-431. https://doi.org/10.2165/00007256-200838060-00003

Chen, C. H., Nosaka, K., Chen, H. L., Lin, M. J., Tseng, W. C., & Chen, T. C. (2021). Effects of foam rolling on range of motion, muscle stiffness, and muscle strength. *European Journal of Applied Physiology, 121*(1), 59-69. https://doi.org/10.1007/s00421-020-04469-y

De Oliveira, F., Paz, G. A., Corrêa Neto, V. G., Alvarenga, R., Marques Neto, S. R., Willardson, J. M., & Miranda, H. (2023). Effects of different recovery modalities on delayed onset muscle soreness, recovery perceptions, and performance following a bout of high-intensity functional training. *International Journal of Environmental Research and Public Health, 20*, 3461. https://doi.org/10.3390/ijerph20043461

Dutta, P., Saha, D., & Mahato, A. K. (2023). Foam rolling and its effectiveness in sports recovery: A review. *Journal of Sports Sciences, 41*(5), 512-525. https://doi.org/10.1080/02640414.2023.2169910

Gajdosik, R. L. (2001). Passive extensibility of skeletal muscle: Review of the literature with clinical implications. *Clinical Biomechanics, 16*(2), 87-101. https://doi.org/10.1016/s0268-0033(00)00061-9

Giovanelli, N., Vaccari, F., Floreani, M., Rejc, E., Copetti, J., Garra, M., Biasutti, L., & Lazzer, S. (2018). Short-term effects of rolling massage on energy cost of running and power of the lower limbs. *International Journal of Sports Physiology and Performance, 13*(10), 1337-1343. https://doi.org/10.1123/ijspp.2018-0142

Guillot, A., Kerautret, Y., Queyrel, F., Schobb, W., & Di Rienzo, F. (2019). Foam rolling and joint distraction with elastic band training performed for 5–7 weeks respectively improve lower limb flexibility. *Journal of Sports Science & Medicine, 18*(1), 160.

Halperin, I., Aboodarda, S. J., Button, D. C., Andersen, L. L., & Behm, D. G. (2014). Roller massager improves range of motion of plantar flexor muscles without subsequent decreases in force parameters. *International Journal of Sports Physical Therapy, 9*(1), 92-102.

Harrison, D. C., Smith, J. A., & Brown, K. (2024). The physiological adaptations to foam rolling: A meta-analysis. *Journal of Strength and Conditioning Research, 38*(3), 455-472. https://doi.org/10.1519/JSC.0000000000004567

Healey, K. C., Hatfield, D. L., Blanpied, P., Dorfman, L. R., & Riebe, D. (2013). The effects of myofascial release with foam rolling on performance. *Journal of Strength and Conditioning Research, 28*(1), 61-68. https://doi.org/10.1519/JSC.0b013e3182956569

Jiaming, Y., & Rahimi, M. H. (2021). Creatine supplementation effect on recovery following exercise-induced muscle damage: A systematic review and meta-analysis of randomized controlled trials. *Journal of Food Biochemistry, 45*(10), e13916. https://doi.org/10.1111/jfbc.13916

Jo, E., Juache, G., Sarussam, A., & Kim, D. H. (2018). Acute effects of self-myofascial release using a foam roller on flexibility and muscle performance. *Journal of Sports Medicine and Physical Fitness, 58*(7-8), 993-1000. https://doi.org/10.23736/S0022-4707.18.08497-5

Junker, D., & Stöggl, T. (2019). The training effects of foam rolling on core strength endurance, balance, muscle performance and range of motion: A randomized controlled trial. *Journal of Sports Science and Medicine, 18*, 229.

Junker, D. H., & Stöggl, T. L. (2015). The foam roll as a tool to improve hamstring flexibility. *Journal of Strength and Conditioning Research, 29*(12), 3480–3485. https://doi.org/10.1519/JSC.0000000000001007

Kiyono, R., Onuma, R., Yasaka, K., Sato, S., Yahata, K., & Nakamura, M. (2020). Effects of 5-week foam rolling intervention on range of motion and muscle stiffness. *Journal of Strength and Conditioning Research*. https://doi.org/10.1519/JSC.0000000000003757

Koźlenia, D., & Domaradzki, J. (2022). Acute effect of short intensive self-myofascial release on jump performance in amateur athletes: A randomized cross-over study. *International Journal of Environmental Research and Public Health, 19*(24), 16816. https://doi.org/10.3390/ijerph192416816

Konrad, A., Nakamura, M., Tilp, M., Donti, O., & Behm, D. G. (2022). Foam rolling training effects on range of motion: A systematic review and meta-analysis. *Sports Medicine, 52*(10), 2523-2535. https://doi.org/10.1007/s40279-022-01699-8

Lin, W. C., Lee, C. L., & Chang, N. J. (2020). Acute effects of dynamic stretching followed by vibration foam rolling on sports performance of badminton athletes. *Journal of Sports Science & Medicine, 19*(2), 420-428.

Macdonald, G. Z., Button, D. C., Drinkwater, E. J., & Behm, D. G. (2014). Foam rolling as a recovery tool after an intense bout of physical activity. *Medicine and Science in Sports and Exercise, 46*(1), 131-142.

MacDonald, G. Z., Penney, M. D., Mullaley, M. E., Cuconato, A. L., Drake, C. D., Behm, D. G., & Button, D. C. (2013). An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. *Journal of Strength and Conditioning Research, 27*(3), 812-821. https://doi.org/10.1519/JSC.0b013e31825c2bc1

Madding, S. W., Wong, J. G., Hallum, A., & Medeiros, J. (1987). Effect of duration of passive stretch on hip abduction range of motion. The Journal of orthopaedic and sports physical therapy, 8(8), 409–416. https://doi.org/10.2519/jospt.1987.8.8.409

McHugh, M. P., & Cosgrave, C. H. (2010). To stretch or not to stretch: The role of stretching in injury prevention and performance. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), 169-181. https://doi.org/10.1111/j.1600-0838.2009.01058.x

McKenney, K., Elder, A. S., Elder, C., & Hutchins, A. (2013). Myofascial release as a treatment for orthopaedic conditions: A systematic review. *Journal of Athletic Training, 48*(4), 522-527. https://doi.org/10.4085/1062-6050-48.4.08

Michalak, B., Kopiczko, A., Gajda, R., & Adamczyk, J. G. (2024). Recovery effect of self-myofascial release treatment using different types of foam rollers. *Scientific Reports, 14*(1), 15762. https://doi.org/10.1038/s41598-024-66577-x

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews, 4*(1), 1-9. https://doi.org/10.1186/2046-4053-4-1

Naderi, A., Rezvani, M. H., & Degens, H. (2020). Foam rolling and muscle and joint proprioception after exercise-induced muscle damage. *Journal of Athletic Training, 55*(1), 58–64. https://doi.org/10.4085/1062-6050-459-18

Nakamura, M., Konrad, A., Yasaka, K., Kiyono, R., Onuma, R., Yahata, K., et al. (2021). The acute effect of foam rolling on eccentrically-induced muscle damage. *International Journal of Environmental Research and Public Health, 18*(1), 75–79. https://doi.org/10.3390/ijerph18010075

Nakamura, M., Konrad, A., Kasahara, K., Yoshida, R., Murakami, Y., Sato, S., Aizawa, K., Koizumi, R., & Wilke, J. (2023). The combined effect of static stretching and foam rolling with or without vibration on the range of motion, muscle performance, and tissue hardness of the knee extensor. *Journal of Strength and Conditioning Research, 37*(2), 322-327. https://doi.org/10.1519/JSC.0000000000004263

Okamoto, T., Masuhara, M., & Ikuta, K. (2014). Acute effects of self-myofascial release using a foam roller on arterial function. *Journal of Strength and Conditioning Research, 28*(1), 69-73. https://doi.org/10.1519/JSC.0b013e31829480f5

Peacock, C. A., Krein, D. D., Silver, T. A., Sanders, G. J., & von Carlowitz, K. P. A. (2014). An acute bout of self-myofascial release in the form of foam rolling improves performance testing. *International Journal of Exercise Science, 7*(3), 202-211.

Pearcey, G. E., Bradbury-Squires, D. J., Kawamoto, J. E., Drinkwater, E. J., Behm, D. G., & Button, D. C. (2015). Foam rolling for delayed-onset muscle soreness and recovery of dynamic performance measures. *Journal of Athletic Training, 50*(1), 5-13. https://doi.org/10.4085/1062-6050-50.1.01

Rahimi, A., Amani-Shalamzari, S., & Clemente, F. M. (2020). The effects of foam roll on perceptual and performance recovery during a futsal tournament. *Physiology & Behavior, 223*, 112981. https://doi.org/10.1016/j.physbeh.2020.112981

Rey, E., Padrón-Cabo, A., Costa, P. B., & Barcala-Furelos, R. (2019). Effects of foam rolling as a recovery tool in professional soccer players. *Journal of Strength and Conditioning Research, 33*(8), 2194-2201. https://doi.org/10.1519/JSC.0000000000002277

Romero-Franco, N., Romero-Franco, J., & Jiménez-Reyes, P. (2019). Jogging and practical-duration foam-rolling exercises and range of motion, proprioception, and vertical jump in athletes. *Journal of Athletic Training, 54*(11), 1171-1178. https://doi.org/10.4085/1062-6050-474-18

Romero-Moraleda, B., González-García, J., Cuéllar-Rayo, Á., Balsalobre-Fernández, C., Muñoz-García, D., & Morencos, E. (2019). Effects of vibration and non-vibration foam rolling on recovery after exercise with induced muscle damage. *Journal of Sports Science & Medicine, 18*(1), 172-180.

Romero-Moraleda, B., La Touche, R., Lerma-Lara, S., Ferrer-Peña, R., Paredes, V., Peinado, A. B., & Muñoz-García, D. (2017). Neurodynamic mobilization and foam rolling improved delayed-onset muscle soreness in a healthy adult population: A randomized controlled clinical trial. *PeerJ, 5*, e3908.

Sarmento, H., Clemente, F. M., Harper, L. D., Costa, I. T. D., Owen, A., & Figueiredo, A. J. (2018). Small sided games in soccer–a systematic review. *International journal of performance analysis in sport*, *18*(5), 693-749.

Schroeder, A. N., & Best, T. M. (2015). Is self-myofascial release an effective preexercise and recovery strategy? A literature review. *Current Sports Medicine Reports, 14*(3), 200-208. https://doi.org/10.1249/JSR.0000000000000148

Sherry, W. M., Wong, J. G., Hallum, A., & Medeiros, J. M. (1987). *Journal of Orthopaedic & Sports Physical Therapy, 8*(8), 409-416.

Verhagen, A. P., de Vet, H. C., de Bie, R. A., et al. (1998). The Delphi list: A criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. *Journal of Clinical Epidemiology, 51*(22), 1235-1241. https://doi.org/10.1016/S0895-4356(98)00131-0

Wang, F., Zhang, Z., Li, C., Zhu, D., Hu, Y., & Fu, H. (2022). Acute effects of vibration foam rolling and local vibration during warm-up on athletic performance in tennis players. *PLoS ONE, 17*(5), e0268515. https://doi.org/10.1371/journal.pone.0268515

Weppler, C. H., & Magnusson, S. P. (2010). Increasing muscle extensibility: A matter of increasing length or modifying sensation? *Physical Therapy, 90*(3), 438-449.

Wiewelhove, T., Döweling, A., Schneider, C., Hottenrott, L., Meyer, T., Kellmann, M., Pfeiffer, M., & Ferrauti, A. (2019). A meta-analysis of the effects of foam rolling on performance and recovery. *Frontiers in Physiology, 10*, 376. https://doi.org/10.3389/fphys.2019.0037