Is Self Myofascial Release an Effective Preexercise and Recovery Strategy? A Literature Review

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Abstract
The use of self myofascial release (SMR) via a foam roller or roller massager is becoming increasingly popular both to aid recovery from exercise and prevent injury. Our objective was to review the literature on SMR and its use for preexercise, recovery, or maintenance. PUBMED, EBSCO (MEDLINE), EMBASE, and CINAHL were searched for variations and synonyms of ''self myofascial release'' and ''foam rolling.'' Data from nine studies were examined, and overall quality varied based on study protocol, muscle group targeted, and outcomes measured. Despite the heterogeneity of these studies, SMR appears to have a positive effect on range of motion and soreness/fatigue following exercise, but further study is needed to define optimal parameters (timing and duration of use) to aid performance and recovery.

Introduction

Sports participation in youth is on the rise (35). In addition, paradigms in preventive health care are shifting focus to the benefits of exercise in the aging population, leading to exercise prescriptions for a previously sedentary group (14,23,36). As more individuals become active, the number of exercise-related injuries and conditions such as delayed-onset muscle soreness (DOMS) is likely increasing (10). DOMS can limit physical activity or result in pain that deters individuals from continuing their exercise regimen (10). Whether the athlete is young or old, novice or elite, regular and/or strenuous exercise can result in DOMS and formation of fibrous tissue adhesions, leading to decreased range of motion (ROM) (4,10,15). Fibrous adhesions form when fascial adhesions develop in response to injury, disease, inactivity, or inflammation and are painful, decrease soft-tissue extensibility, and prevent normal muscle mechanics (*i.e.*, joint ROM, muscle length, neuromuscular hypertonicity, decreased strength, decreased endurance, and decreased motor coordination) (4,13,44). Therefore, minimizing fascial adhesions and DOMS may be helpful in allowing people to continue exercising without further risk for injury (10). Along with the increase in the number of exercising individuals, strategies employed to optimize the exercise experience, including preexercise, maintenance, and recovery from exercise, also are gaining popularity (10,28). Optimum preexercise techniques (6,40) and recovery methods (8,10) are currently being sought (21,37). The use of self myofascial release (SMR) techniques (Fig. 1) to aid recovery and treat DOMS using a foam roller or roller massager is becoming increasingly popular in exercising individuals of all ages and abilities (28).

The use of SMR via a foam roller or roller massager has outpaced the current scientific literature of this modality. Although there is little peer-reviewed research on SMR, its use to theoretically treat fascial adhesions and restore normal soft tissue extensibility is rising (12). SMR is believed to have effects similar to those of massage, and according to the American Massage Therapy Association (26,42), the physical benefits of massage include the following: relief of muscle tension and stiffness, reduced muscle pain, swelling, and spasm, greater joint flexibility and ROM, faster healing of strained muscles and sprained ligaments, and even enhanced athletic performance. Myofascial release (MFR) has been used to treat soft tissue adhesions, alleviate pain, and reduce tissue tenderness, edema, and inflammation while improving muscle recovery (39). SMR is a technique purported to be similar to MFR where individuals use their own body mass on a foam roller or their upper body strength and a roller massager to exert pressure on the affected soft tissues, eliminating the need for a massage therapist or other trained personnel (32,43). By varying body position and the targeted muscles, which include, but are not limited to, the quadriceps, hamstrings, calf muscles, gluteal muscles, hip adductors, trapezius, and rhomboids, specific sore or injured areas can be isolated and soreness can be reduced (13). Although not supported by extensive

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Figure 1: Example of a foam roller (left) and a roller massager (right).

scientific research, there are numerous claims that both foam rolling and the roller massager can limit soreness and tightness and increase blood flow and joint flexibility, which help prevent injury and enable an exercising individual to increase his or her volume of training (28).

Not surprisingly, most of the benefits of SMR are inferred from research on massage. Although there are still many gaps in the literature and inconclusive evidence on the benefits of massage (8,45), studies on this modality are much more extensive than those on SMR alone. Sports medicine personnel believe that massage provides many benefits to the body through biomechanical, physiological, neurological, and psychological mechanisms (3,20,45). There are several benefits of massage in relieving exercise-induced muscle damage resulting in DOMS (46). Benefits occur through changing a muscle's viscoelastic properties, increasing mitochondria biogenesis, and increasing blood flow possibly by increasing angiogenesis and vascular endothelial growth factor (7,45). Other benefits include decreasing muscle inflammation possibly through changes in tissue gene expression along with variable effects on limb circumference and circulating neutrophil counts (7,12,16,45). Massage also has been found to have psychological benefits in certain conditions by decreasing anxiety and enhancing mood and relaxation (3,20,45).

Findings from studies of massage-like compressive loading (MLL) following eccentric exercise (EEX) in a rabbit model (9) point to the utility and possible mechanisms of SMR. MLL immediately following EEX and MLL 48 h after EEX enhanced both recovery of muscle and joint function. However, immediate MLL had significantly greater benefit in addition to causing greater reduction in neutrophil and macrophage infiltration of the exercised muscle (17). Another study by Haas et al. (17,18) indicated that increasing both the intensity and frequency of MLL resulted in increased recovery of mechanical properties and showed histological evidence for MLL to decrease muscle fiber damage, while loading duration (15 vs 30 min) had no significant effect. MLL also was found to have both an acute and cumulative effect on the viscoelastic properties of the exercised muscle, suggesting that repeated bouts of massage may produce additional benefit over single bouts (16). Although studies to confirm these findings in human subjects would be particularly helpful, the studies in rabbits suggest that SMR (even for a short time) when carried out immediately following exercise may be a useful tool to aid recovery from EEX.

Although the scientific research on SMR is limited, it is commonly used by exercising individuals of all ages and abilities (28). A particular advantage of the foam roller and the roller massager is the fact that both techniques eliminate the need for a massages therapist or other similar personnel (32). This should be more cost effective, allows the individual to self-treat at a convenient time, and may help reduce the physical burden of thumb and wrist pain on treating clinicians (2,32). Since SMR is perceived to have several benefits and is becoming more common with exercising individuals, our goal was to systematically review the literature and evidence for its use. Our purpose was to understand the current evidence for this modality and, accordingly, opportunities for future studies of this technique to minimize soreness and functional limitations associated with exercise.

Methods

A literature search was conducted in May 2014 using four databases (PUBMED, EBSCO [MEDLINE], EMBASE, and CINAHL) for all years prior to and including 2014 without language or data restrictions. Terms including "self myofascial release," "foam rolling," "roller massage," "myofascial release foam roller," and variations of these terms were searched. The first author also scanned the reference sections of articles meeting initial criteria. Articles about the use of a foam roller or roller massager that did not involve rolling these devices over the muscle (*i.e.*, use of a half foam roll in balance training) and case studies that used SMR

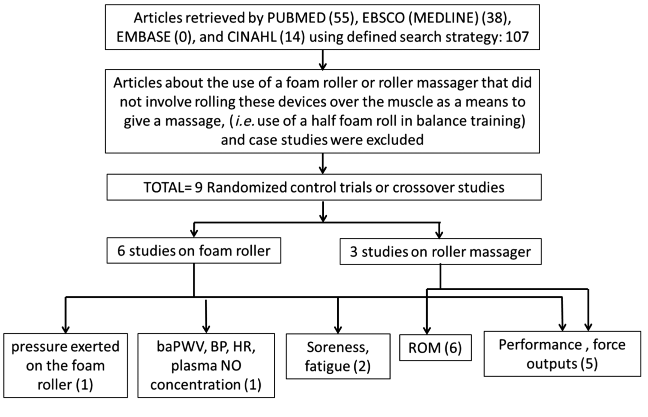

Figure 2: Flow diagram of literature filtering process. BP, blood pressure; HR, heart rate. The number in parentheses indicates the number of studies examining that outcome measure.

as a treatment technique (one study) were excluded. Only randomized control trials (RCT) were included in our analysis.

Results

The search strategy produced 107 items (Fig. 2). Nine relevant articles were identified (Tables 1 and 2). The heterogeneous nature of study (type, duration, and frequency), muscle groups targeted, and outcome measures made pooling of the data impossible. The SMR protocol varied among the nine studies. Targeted muscle groups included the hamstrings (six studies), quadriceps (five studies), iliotibial band (ITB) (four studies), hip adductors (two studies), calf/gastrocnemius (two studies), trapezius (two studies), gluteal muscles (one study), and latissimus dorsi (one study). Several outcome measures were examined including the following: ROM (six studies), contractile properties/muscle activation (five studies), soreness, fatigue, or perceived pain (three studies), direct performance measures (two studies), and balance (one study). A single study looked at pressure exerted on the foam roller during the rolling activity (13). Two studies were conducted in nonexercising individuals (24,38). Five studies were conducted in exercising individuals without the controlled induction of DOMS, examining the effects of SMR use prior to exercise (15,19,32,34,43). In two studies, the researchers induced DOMS and studied the effects of foam roller (31) or roller massager (24) use. Another report examined brachial-ankle pulse wave velocity (baPWV), blood pressure, heart rate, and plasma nitric oxide (NO) concentration (38). Six studies examined SMR through the use of a foam roller (Table 1), while three studies utilized a roller massager (Table 2).

There was considerable heterogeneity (muscle group, treatment protocol, outcome variables) for the six foam roller studies (Table 1). One investigation evaluated the design of the most efficacious foam roller and indicated that a multilevel rigid roller (MRR) was more efficacious than a bio-foam roller (BFR) based on measurement of contact pressures (51.8 ± 10.7kPa with the MRR vs 33.4 ± 6.4kPa with the BFR) and contact area (47.0 ± 16.1 cm^2 with the MRR vs 68.4 ± 25.3 cm^2 with the BFR) ($P < 0.001$) (13). A single study indicated that foam rolling resulted in increase in muscle performance (32), while two studies (19,31) found no change in muscle performance. MacDonald et al. (32) found that foam-rolling the thigh and gluteal muscles increased vertical jump as compared with the control of no intervention at 24 h (foam rolling, 0%; control, −6%), 48 h (foam rolling, 1%; control, −5%), and 72 h (foam rolling, 0%; control, 0%) after the foam rolling intervention. Healey et al. (19) observed no significant differences ($P < 0.001$) between foam roller use and planking exercises on performance measured by the following four athletic tests: vertical jump for height, vertical jump for power, isometric squat force, and pro agility drill speed test. MacDonald et al. (31) measured quadriceps maximal voluntary contraction (MVC) force and found that the subjects were able to produce similar amounts of force in both the foam rolling and control conditions ($P < 0.001$), indicating that foam rolling had no effect on performance. The use of a foam roller was found to decrease muscle soreness or fatigue in two studies (19,31). MacDonald et al. (32) noted substantial differences in thigh and gluteal muscle soreness at 24 h (foam rolling, 543%; control, 714% (%Δ)), 48 h (foam rolling, 414%; control, 807%), and 72 h (foam rolling, 243%; control, 607%) after foam rolling intervention following a 10 × 10 squat protocol. In a study by Healey et al. (19) comparing planking versus foam rolling prior to exercise, fatigue rating on a Likert scale from 0 to 10 was significantly greater after planking trials (0.82 ± 0.74) than that after foam rolling trials (0.4 ± 0.59) ($P < 0.05$). ROM increased after foam roller use in three studies (31,32,34). One study showed that quadriceps ROM significantly increased by 10° and 8° at 2 and 10 min after a foam rolling intervention, respectively ($P < 0.001$) (32), while another study showed increase in quadriceps ROM at 48 h (foam rolling, 11%; control, 0%) and 72 h (foam rolling, 13%; control, 4%) but not at 24 h (foam rolling, 8%; control, 5%) following the foam rolling intervention, an increase in passive hamstring ROM at 72 h (foam rolling, 3%; control, 0%) but not at 24 h (foam rolling, −1%; control, −3%) or 48 h (foam rolling, 0%; control, 0%), and an increase in active hamstring ROM at 24 h (foam rolling, 0%; control, −4%) but not at 48 h (foam rolling, 0%; control, −3%) or 72 h (foam rolling, 1%; control, −1%) following the foam rolling intervention (31). Another study revealed significant change in passive hip flexion ROM regardless of treatment with foam rolling or static stretching (SS) ($F_{3,17} = 8.06$, $P = 0.001$), but the foam rolling plus SS group had the greatest change in ROM compared with the SS ($P = 0.04$), foam rolling ($P = 0.006$), and control ($P = 0.001$) (34). A single study in nonexercising individuals examined parameters other than those affecting recovery and indicated that use of a foam roller resulted in decrease in baPWV (from 1,202 ± 105 to 1,074 ± 110 $cm \cdot s^{-1}$) and increase in plasma NO concentration (from 20.4 ± 6.9 to 34.4± 17.2 $\mu mol \cdot L^{-1}$) (both $P < 0.05$), with no effect on blood pressure or heart rate ($P > 0.05$) (38).

In the three studies examining use of a roller massager (Table 2), varying protocols and measured outcomes at different time points were implemented. Two studies, one on the calf (15) and one on the hamstring (43), examined the effects of roller massager use on MVC, an indicator of performance. Halperin et al. (15) found that maximal force outputs were increased immediately and 10 min after roller massager use on the calf as compared with SS ($P < 0.05$; ES, 1.23; 8.2% difference). On the other hand, Sullivan et al. (43) found no change in hamstring MVC force immediately following the use of a roller massager. Jay et al. (24) found a decrease in hamstring soreness ($P < 0.0001$) and increase in pressure pain threshold ($P = 0.0007$) compared with the control following the use of a roller massager approximately 48 h after a 10 × 10 stiff-legged deadlift. Two studies pointed to increased ROM following roller massager use on the calf and hamstring, respectively (15,43). Halparin et al. (15) found that use of a roller massager on the calf ($P < 0.05$; ES, 0.26; ~4% difference) increased ROM immediately and 10 min after the intervention. Sullivan et al. (43) measured 4.3% increase in hamstring ROM ($P < 0.0001$) immediately following the use of a roller massager. A study by Jay et al. (24) recorded no change in hamstring ROM 0, 10, 30, and 60 min following the use of a roller massager ($P = 0.18$).

Discussion

SMR using a foam roller or roller massager is an emerging and popular strategy used by individuals at all levels of fitness and skill (28). We identified nine RCT that have examined the use of these techniques as a preexercise, maintenance, or recovery and treatment tool. Each study employed different exercise protocols, utilized a different number and timing of foam rolling or roller massager treatments, and measured different outcomes, making data pooling challenging. Nevertheless, some important findings, when grouping the data by outcome measure, were consistently noted. Five studies indicated that foam rolling or roller massager increased ROM (18,31,32,34,43), while a single study (24) showed no change in ROM, indicating that SRM may be a useful preexercise technique. Two studies showed that foam rolling had positive effects on vertical jump height and maximal force output (15,32), while others showed no change in muscle performance (19,31,43). SMR using both techniques has been found to decrease muscle soreness/fatigue, supporting its potential utility as a recovery technique (19,24,31).

Several studies have examined the use of a foam roller or roller massager on athletic performance. Collectively, these investigations suggest a duration-dependent effect, give insight into the mechanism of SMR, and point to the potential value of SMR as part of an individual's preexercise. Two studies showed that SMR had positive effects on vertical jump height and maximal force outputs (15,31), while others showed no change in various parameters of muscle performance, although an increase in ROM was observed (19,32,43). The studies that found increase in performance measures implicated SMR protocols utilizing a minimum of 90 s of foam roller or roller massager use (three sets of 30 s (15) or two sets of 1 min) (31), while all but one (32) of the studies showing no change in performance measures utilized less than 30 s of SMR (19,43). This suggests that performance benefits may be duration dependent, but further research is needed. The finding of increased vertical jump height 24 and 48 h after foam rolling (31) is supported by some studies on massage showing similar effects (33,46). Since foam rolling has been found to increase vertical jump height without an increase in evoked contractile properties of the muscle (32), foam rolling likely acts by reducing neural inhibition, resulting in better communication from afferent receptors in the connective tissue (4,11,41). The studies reporting no change in performance did, however, show improvement in ROM (19,31,43). Finding no impairment in performance despite an increase in ROM may however be clinically valuable. SS typically increases ROM, and acute changes have been made to remove it from preexercise protocols due to its negative effects on neuromuscular performance (5). A technique such as SMR that improves ROM without inhibiting force production could be of great clinical value and merits further investigation.

In all studies examining muscle soreness as an outcome measure, both techniques decreased this important measure of exercise intensity and muscle damage (24,31). Although one of the studies looking at muscle soreness utilized a foam roller (31) and the other utilized a roller massager (24), both studies involved a protocol that induced DOMS via resistance training exercises (squat or stiff-legged deadlift). These studies strongly suggest that the use of SMR can aid recovery following EEX by decreasing muscle soreness. Additionally, a decrease in muscle fatigue and soreness may have a psychological benefit on performance comparable with the psychological and recovery benefits of massage (3,20,45). There have been several theories for this perceived reduction in soreness. One theory claims that improving the recovery rate, as indicated by MacDonald et al., signifies that the foam roller is an effective tool to treat DOMS, with the likely mechanism being a change in the muscle and connective tissue properties that may contribute to DOMS (11,12,25). Another theory is that the decreased perception of fatigue results from pressure-stimulated parasympathetic activity changes in hormonal levels, including reduction in cortisol (22,45). Yet another theory is that massage-like touching reduces mechanical hyperalgesia via release of endogenous oxytocin into the plasma and central gray matter around the cerebral aquaduct in the midbrain, leading to activation of the descending inhibitory pathways (1,30). Pleasant touching with soft brush strokes also may activate unmyelinated mechanoreceptors (C-tactile), which was perceived as being pleasant and may help relieve muscle soreness (29).

Five studies examined ROM and indicated that both foam rolling and roller massager increased this outcome measure (15,31,32,34,43). One study (24) reported no change. These studies examined several body sites and muscle groups including the hip (31), quadriceps (32), hamstring (15,34,43), and calf (15). Although five of six investigations indicated that both techniques improved ROM, they each utilized a different protocol and examined ROM at different times after intervention (15,24,31,32,34,43). The only study to find no change in ROM utilized a protocol involving 10 min of roller massager on the hamstrings 48 h after the stiff-legged deadlifts were performed to induce DOMS (24). All other studies examining ROM employed SMR protocols with a maximum of 1-min sets of SMR, with no intervention totaling more than 2 $\text{min}\cdot\text{d}^{-1}$ per muscle group (15,31,32,34,43). This indicates that there may be an optimum duration of SMR to increase ROM. MacDonald et al. (31) also induced DOMS prior to SMR intervention but employed the use of a foam roller (two sets of 1 min with 30-s rest between) immediately and 24, 48, and 72 h following induction of DOMS. They found substantial differences at 24 h in active hamstring ROM, at 72 h in passive hamstring ROM, and at 48 and 72 h in passive quadriceps ROM (31). Collectively, these findings indicate that SMR is effective in increasing ROM of various joints in exercising individuals without prior induction of DOMS. This is clinically relevant and points to the utility of SMR as an effective preexercise technique. In addition, SMR may be beneficial in increasing ROM following induction of DOMS, implying benefits in recovery. The increase in ROM may be due to the foam roller or roller massager acting to reduce adhesions between layers of fascia (4,13), changing the thixotropic property of the fascia encasing the muscle (41), or increasing temperature (27). Only a single study by Sullivan et al. (43) looked at differences in rolling duration and found that 10 s of rolling increased ROM more than 5 s of rolling duration did. Future studies also should look at the timing or frequency of foam roller or roller massager use to maximize the increase in ROM, compare changes in ROM of various joints, and

Table 1.

A summary of six RCT involving the use of a foam roller.

First Author (Year)	Study Design	Targeted Area	Intervention
MacDonald GZ (2014)	Males (>3 yr strength training experience) (TRE, 10; CON, 10)	All thigh muscle groups and gluteal muscles	DOMS was induced by a 10 × 10 back squat protocol. Two 60-s bouts of FR exercise on each muscle group at 0, 24, 48, and 72 h after induction of DOMS vs no intervention
Mohr AR (2014)	40 subjects with less than 90° of passive hip flexion	Hamstring	Six sessions separated by at least 48 h. Four TRE groups: FR protocol (three 1-min repetitions with 30-s break between each), SS (three consecutive passive stretches), FR + SS, or CON (no intervention)
Okamoto T (2014)	10 healthy young adults (served as own CON)	Hip adductors, hamstring, quadriceps, ITB, and upper back including trapezius	FR and CON trials proceeded every 3 d in random order. Twenty FR repetitions were performed on each muscle group at 1-min intervals.
Healey KC (2013)	26 college-aged individuals (served as own CON)	Quadriceps, hamstrings, ITB, calves, latissimus dorsi, and rhomboid muscles	FR exercises for 30 s before each activity vs planking for 30 s before each activity
MacDonald GZ (2013)	11 college-aged healthy males (served as own CON)	Quadriceps	Two 1-min trials of FR with 30-s rest between vs no intervention. Performed over two sessions separated by 24 to 48 h
Curran PF (2008)	10 healthy college-aged individuals	ITB	Each individual performed three trials on both the MRR and BFR.

CON, control group; FR, foam roll; RM, roller massager; and TRE, treatment group.

Table 1. (Continued)
A summary of six RCT involving the use of a foam roller.

Testing Sessions	Outcome Measures	Results	Conclusion
Before the intervention, POST-0, POST-24, and POST-48 h.	Muscle soreness, ROM, evoked contractile properties, mean voluntary contraction, voluntary muscle activation (VA), vertical jump height, perceived pain	Muscle soreness: showed substantial differences POST-24 (FR, 543%; CON, 714% (%Δ)), POST-48 (FR, 414%; CON 807%), and POST-72 (FR, 243%; CON 607%). Quadriceps ROM, no difference POST-24 (FR, 8%; CON, 5%) but showed substantial differences at POST-48 (FR, 11%; CON, 0%) and POST-72 (FR, 13%; CON, 4%). Passive hamstring ROM, substantial difference at 72 h (FR, 3%; CON, 0%) but not at 24 h (FR, −1%; CON, −3%) or 48 h (FR, 0%; CON, 0%). Active hamstring ROM, substantial difference at 24 h (FR, 0%; CON, −4%), but not at 48 h (FR, 0%; CON, −3%) or 72 h (FR, 1%; CON, −1%). Vertical jump, POST-24 (FR, 0%; CON, −6%), POST-48 (FR, 1%; CON, −5%), and POST-72 (FR, 0%; CON 0%). MVC POST-24 (FR, −14%; CON, −5%), POST-48 (FR, −9%; CON, 8%), and POST-72 (FR, −10%; CON, −3%).	FR was beneficial in attenuating muscle soreness while improving vertical jump height, muscle activation, and passive and dynamic ROM in comparison with control. FR negatively affected several evoked contractile properties of the muscle except for half relaxation time and electromechanical delay, indicating that FR benefits are primarily accrued through neural responses and connective tissue.
Premeasure on day 1 and postmeasure on day 6	ROM	There was a significant change in passive hip flexion ROM regardless of treatment ($F_{3,17}$ = 8.06, P = 0.001). FR and SS had a great change in passive hip flexion ROM compared with the SS (P = 0.04), FR (P = 0.006), and CON (P = 0.001).	Foam rolling the hamstring muscle prior to SS would be appropriate in noninjured patients who have less than 90° of hamstring ROM and desire maximal gains in hip flexion ROM.
Before and 30 min after each trial	BaPWV, blood pressure, heart rate, and plasma NO concentration	The baPWV significantly decreased (from 1,202 ± 105 to 1,074 ± 110 $cm \cdot s^{-1}$), and the plasma NO concentration significantly increased (from 20.4 ± 6.9 to 34.4 ± 17.2 $\mu mol \cdot L^{-1}$) after foam rolling (both $P < 0.05$), but neither significantly differed after control trials.	SMR using a foam roller reduces arterial stiffness and improves vascular endothelial function.
Preexercise and postexercise	Isometric squat force, vertical jump for height and power, agility, fatigue, soreness, exertion	No significant differences ($P < 0.001$) between FR use and planking for the four athletic tests. Fatigue was significantly greater after planking (0.82 ± 0.74) trials than that after foam rolling (0.4 ± 0.59) trials ($P < 0.05$).	FR use had no direct effect on performance but did reduce the feeling of fatigue, which may allow athletes to extend workout time and volume with long-term enhancements in performance.
Preintervention, 2 and 10 min after FR or control exercise	ROM, rate of force development, CNS muscle activation, PNS muscle activation	After FR use, ROM significantly increased by 10° and 8° at 2 and 10 min, respectively ($P < 0.001$). No significant differences for any of the neuromuscular-dependent variables. The MVC forces were reliably ($P < 0.001$, r = 0.85) performed within and between the control and foam rolling conditions.	FR acutely enhanced ROM without concomitant decrease in muscle performance.
Pressure data collected during the exercise	Pressure data	Mean sensel pressure exerted on the soft tissue of the lateral thigh by the MRR (51.8 ± 10.7 kPa) was significantly ($P < 0.001$) greater than that of the conventional BFR (33.4 ± 6.4 kPa). Mean contact area of the MRR (47.0 ±16.1 cm^2) was significantly ($P < 0.005$) less than that of the BFR (68.4 ± 25.3 cm^2).	The significantly lower contact area and higher contact pressure with the MRR compared with the BFR. Also suggests a benefit in foam rolling exercises as a form of MFR.

Table 2.
A summary of three RCT involving the use of a roller massager.

First Author (Year)	Study Design	Targeted Area	Intervention	Testing Sessions	Outcome Measures	Results	Conclusion
Jay K (2014)	22 healthy untrained individuals (TRE, 11; CON, 11)	Hamstring	DOMS was induced by 10 × 10 repetitions of the stiff-legged deadlift. Forty-eight hours later, patients received 10 min of RM (at a constant stroking rhythm for 1 to 2 s) vs CON (patient rested in a prone position for 10 min)	Immediately before and then at 0, 10, 30, and 60 min after treatment	Soreness, PPT, ROM	The massage group experienced a group × time interaction for reduced soreness ($P < 0.0001$) and increasing PPT ($P = 0.0007$) compared with the control group. There was no group × time interaction for ROM ($P = 0.18$). At 10 min after RM use, there was significant reduction in soreness of the nonmassaged limb in the crossover control group compared with that in controls ($P = 0.03$), but this effect was lost by 30 min.	Massage with a roller device reduces muscle soreness and is accompanied by higher PPT of the affected muscle.
Halperin I (2014)	14 recreationally trained subjects (served as own CON)	Calf	Subjects were tested on two separate occasions (3 to 6 d apart). After a warm-up (10 single leg heel raises) and 10-min rest, participants performed RM or SS (CON) of the calf muscle for three sets of 30 s, with 10 s of rest in between.	After a warm-up, 10 min later (preintervention), 1 and 10 min after intervention	ROM, EMG outcome, MVC, balance	RM had significantly greater maximal force output than SS at 10 min after exercise ($P < 0.05$; ES, 1.23; 8.2% difference). Both roller massager ($P < 0.05$; ES, 0.26; ~4%) and SS ($P < 0.05$; ES, 0.27; ~5.2%) increased ROM immediately and 10 min after the interventions. No significant effects were found for balance or EMG measures.	RM use prior to exercise increased ankle maximal force outputs and ROM while SS only increased ROM. These results could affect the type of warm-up prior to activities that depend on high force and sufficient ankle ROM.
Sullivan KM (2013)	TRE, 17 college-aged individuals; CON, 9 participants from TRE group	Hamstring	Four trials of hamstring RM rolling (one set, 5 s; one set, 10 s; two sets, 5 s; two sets, 10 s) at a constant pressure (13 kg) and a constant rate (120 bpm) vs no treatment. Each session was separated by at least 24 h.	Before and after intervention	ROM, muscle activation measured,MVC force, evoked twitch force, electromechanical delay	Use of the RM resulted in 4.3% increase in ROM ($P < 0.0001$). Ten seconds of rolling increased ROM more than 5 s of rolling did ($P = 0.069$). There was no change in MVC force ($P = 0.64$) or muscle activation ($P = 0.71$) after the rolling intervention.	The use of RM had no effect on muscle strength or MVC force or MVC EMG activity but can provide statistically significant changes in ROM.

CON, control group; FR, foam roll; PPT, pressure pain threshold; RM, roller massager; and TRE, treatment group.

attempt to better correlate a change in ROM with performance and recovery.

Although nearly all studies examined the effects of SMR by measuring parameters related to exercise, a recent investigation looked at the effects of foam rolling on cardiovascular health of the general population (38). This study in nonexercising individuals examined foam rolling as a type of maintenance therapy and looked at the effects of a foam rolling protocol on healthy individual's baPWV, blood pressure, heart rate, and plasma NO concentration (38). It was found that SMR using a foam roller acutely decreased baPWV and increased plasma NO concentration (38). These findings suggest that SMR with a foam roller may favorably affect arterial function possibly by enhancing endothelial function via increased NO or induction of vasodilation via compression of the arterial muscle (38). These findings may be clinically relevant, indicating that individuals who use SMR for its effects on exercise-related parameter also may receive additional benefits to their cardiovascular health. Further research is needed to examine and confirm the benefits of SMR beyond exercise performance and recovery.

Conclusions

There appears to be some basis for the use of the SMR technique via a foam roller or roller massager for preexercise, for maintenance, and to aid recovery following exercise. SMR has been observed to decrease soreness following DOMS, which may indirectly enhance performance by allowing the individual to exercise longer and harder. The direct effect of SMR on performance may be duration dependent and remains in question. At the very least, SMR appears to have no negative effect on performance, with a few studies showing increase in performance. Yet another benefit of SMR is its ability to increase ROM. There has been little published work on the mechanism of SMR; however, animal studies using MLL following EEX have shown that immediate MLL is more beneficial than delayed MLL but MLL duration has no significant effects on recovery. In conclusion, SMR via a foam roller or roller massager may be a valuable tool for exercising individuals, allowing the individuals to self-treat at a time (*i.e.*, immediately following exercise) and a frequency (*i.e.*, several times a day) convenient for him or her by eliminating the need for a massage therapist. Studies to date suggest that SMR may have beneficial effects on both recovery from EEX and precompetition.

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