Combined Effects of Self-Myofascial Release and Dynamic Stretching on Range of Motion, Jump, Sprint, and Agility Performance

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Abstract

Richman, ED, Tyo, BM, and Nicks, CR. Combined effects of self-myofascial release and dynamic stretching on range of motion, jump, sprint, and agility performance. *J Strength Cond Res* 33(7): 1795–1803, 2019—Massage has been used as both a pre- and post-exercise modality with purported benefits to flexibility and athletic performance. This study was designed to determine the effect of a 6-minute protocol of self massage known as self-myofascial release (SMR) using a foam rolling device in conjunction with a general warm-up and sport-specific dynamic stretching (DS) session on flexibility and explosive athletic performance in a sample of 14 female collegiate athletes. After familiarization, participants completed 2 testing sessions that began with 5 minutes of jogging at a self-selected pace, followed by either a 6-minute foam rolling session (SMR) or 6 minutes of light walking (LW) and a subsequent 6-minute period of sport-specific DS. Sit-and-reach (SR) was measured after a general warm-up, the SMR, or LW session, and following DS, after which participants performed 3 trials each of squat jump (SJ), countermovement jump (CMJ), and drop jump (DJ). Two additional tests, the agility T-Test (TT) and a 10-yd short sprint (SP), were then performed. The change in SR after SMR was significantly greater than the change seen in SR after LW, although the total changes seen in each condition were not statistically different after the addition of DS. Squat jump and CMJ improved by 1.72 ± 2.47 cm and 2.63 ± 3.74 cm ($p = 0.070$, $p = 0.070$), with no significant change to DJ, SP, and TT. Self-myofascial release in the form of foam rolling after a general warm-up and preceding a DS session seems to improve SJ and CMJ with no detriment to flexibility, DJ, sprint, and agility performance in comparison with LW and DS.

Key Words Self-myofascial release, stretching, athletic performance, flexibility, female, athlete

Introduction

Massage has been used for thousands of years for purported benefits to health and performance, which include neuromuscular and connective tissue changes within the cell, system, and body (2,8,14). Self-myofascial release (SMR) is a form of massage most commonly performed by an individual using a tool such as a foam roller, rolling-pin style massager, or lacrosse ball that has recently become popular among athletes and trainers (5,13). Much research has been performed to identify the most prudent warm-up protocols for athletic performance, with the use of a general warm-up and dynamic stretching (DS) being recommended before activity for tissue health and performance improvement (3,31). With the increasing popularity of SMR and foam rolling in practice and the recent publication of experimental research in this area, researchers have begun to investigate the potential effects of preperformance SMR, both alone and in conjunction with established components such as the general warm-up and static stretching (SS) and DS sessions (10–13,20,24,26,35). However, there is wide variability in the approaches of these studies, so more research is necessary to identify the effects of real-world use in a variety of conditions and to fully understand the physiological effects of SMR.

Self-myofascial release is believed to affect soft tissue in a number of ways similar to those of traditional massage. Weerapong and Kolt (36) performed a review of the existing research on the effects of traditional massage to outline the potential mechanisms and evidence behind them, developing a model classifying these effects into 4 categories: biomechanical, physiological, neurological, and psychological. In this model, biomechanical effects include the breakdown of deleterious tissue adhesions and various improvements in pliability, range of motion (ROM) and stiffness due to friction, shearing forces, thixotropic effects, and fluid exchange. Physiological effects include alterations to blood flow and

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hormone activity. Neurological effects relate to changes in neuromuscular excitability and alterations in sensation, pain, and tension. Psychological effects are the hardest to quantify, although the model describes these as a potential reduction of anxiety and increases in relaxation and subjective feelings of well-being (36). The underlying factors behind these effects have been discussed in depth elsewhere (5,14,31). In general, the theoretical background of SMR's effects suggests that alterations in tissue quality and neuromuscular function should result in improved ROM and provide a more suitable environment for athletic performance, especially activities requiring the use of the stretch-shortening cycle (SSC).

Many researchers have assessed the acute effects of SMR on flexibility (9,10,16,20,23,24,27,29,34,35). Although most of these studies used the common sit-and-reach (SR) test (9,16,26,27,29,35), others used goniometry (4,20) or diagnostic tests such as the straight-leg raise (23) and weight-bearing lunge (10,34). Despite variability in the type, intensity, duration, and area of the body to which SMR was applied, most studies to evaluate acute effects of SMR found an improvement in joint ROM (4,9,10,16,20,23,26,27,29,34,35). It has been reported that SMR and SS may have additive effects (24,34). Peacock et al. (27) examined the effects of adding SMR to DS and found improvements in multiple performance measures, although they did not see an improvement in SR. These results are concurrent with prevailing theoretical models of SMR's effects and suggest that the combination of SMR and various stretching methods may result in greater improvements to performance and ROM than either alone.

Self-myofascial release is marketed to enhance flexibility and boost performance. However, current research has suggested that SMR has minimal acute effects on athletic performance. The results of most studies suggest that SMR will not affect performance measures (11,13,15,19,20,23,26,27,35). However, Peacock et al. reported an improvement in vertical jump and other anaerobic activities, whereas Janot et al. reported a detriment to maximal anaerobic performance (15,27). Suggestions for the results seen in these studies include alterations in the length-tension relationship of muscle and changes to SSC characteristics, similar to alterations seen with SS (3,4). Because of the complexity of SMR's effects on muscle tissue, it is likely that outcomes may differ between performances that are aerobic and anaerobic, submaximal and maximal, and requiring fast and slow SSC use. In general, it is reasonable to suggest that SMR improves short-term flexibility without causing a detriment to athletic performance.

Variation in population, athletic experience, and SMR familiarity has also been considered in evaluating SMR's effects. Self-myofascial release seems to increase flexibility acutely in untrained, adult participants with no SMR experience (11,20,35). At the other extreme, adolescent, resistance-trained swimmers with at least 30 minutes of SMR experience per week improved flexibility with both SS and SMR, with the greatest change seen after a combined session of SS and SMR (34). However, due to the differences between this study and earlier investigations, it is difficult to draw conclusions about the variation in effects between novices and SMR-familiarized individuals. Furthermore, although studies have examined the effects of SMR on groups of men (4,20,27,34) and mixed gender groups (9,10,13,15,23,29,35), no known published studies have examined the effects of SMR on a population of only women.

Volleyball and basketball are both team sports that require sudden, rapid movements involving SSCs and in which jump performances are often a determinant factor of sport success (7,30,33). Traditional (SS and DS) stretching is often used by these athletes to prepare for competition. As a result of the high-impulse forces involved in jumping and the eccentric forces applied to the lower body upon landing from a jump, these athletes face great demand on the ankles and knees and require the ability to develop both a high rate of force development and the ability to safely control eccentric landing forces. As a result, coaches and investigators alike have sought to identify the pre-exercise modalities that will most benefit flexibility and force development (18). Although Mikesky et al. (23) tested the effects of a roller massager on female volleyball and basketball players, no researchers have examined the effects of SMR using a foam roller on this population, nor with the addition of a sport-specific DS session.

In the past few decades, various forms of SMR have become popular for purported benefits including improved mobility, recovery, and athletic performance. Only in recent years have researchers begun to assess the effects of these modalities. Although existing research generally supports the suggested benefits, conclusions are difficult to gather because of a wide variety of participants and methodologies (5). More research is necessary to determine the effects of varied protocols on sport-specific activities, particularly on a population of women. The purpose of this study was to determine the effects of a short session of SMR in the form of foam rolling in addition to a general warm-up and DS session, on explosive athletic performance in female volleyball and basketball players. Based on the published literature, it was theorized that a session of SMR subsequent to a general warm-up and followed by a DS session would result in improvements to flexibility and athletic performance in comparison with an equivalent period of light walking (LW).

Methods

Experimental Approach to the Problem

To assess the effects of SMR in the form of a foam rolling session on flexibility and explosive athletic ability, this study involved participants performing the SR test, agility T-Test (TT), 10-yd sprint, and jump testing after either an SMR session or an equal period of LW in addition to general and dynamic warm-ups. The protocol was designed as a randomized crossover design because the participants served as their own controls. Participants were familiarized to the procedures on their first visit, then performed each condition in a random order at the subsequent 2 visits. All sessions took place in an indoor, climate-controlled athletic facility. Tests were scheduled at the same time of day approximately 1 week apart as often as possible to minimize weekly and diurnal variations in performance, similar to the study performed by Peacock et al. (27). Differences between trials were then calculated to assess the effectiveness of SMR.

Subjects

Approval for this study was granted by the Institutional Review Board of Columbus State University, and each subject signed an informed consent document prior to entry in the study. A total of 14 healthy, active college-aged women with history of significant injury were recruited for this study. Of these, 8 were recruited from a NCAA Division II volleyball team and 6 from a Division II basketball team. Although some participants had performed SMR as a sport recovery modality under the supervision of athletic trainers, none had previously performed SMR as a pre-exercise modality. Characteristics of the participants were age (mean ± *SD*), 19.8 ± 1.3; age range, 18–22; height, 172 ± 24.0 cm; and body mass, 69.3 ± 10.9 kg.

Procedures

Familiarization Visit. Each participant was familiarized with the warm-up and testing procedures before their first testing session by an investigator holding the NSCA CSCS credential, and all performances were prompted by the same NSCA certified investigator for consistency. Height was obtained using a Pro-Doc stadiometer (Detecto PD300DHR; Detecto, Webb City, MO, USA); body mass and body fat percentage were obtained using a bioelectrical impedance analysis scale (Tanita TBF-300WA; Tanita, Arlington Heights, IL, USA). The participants were classified as left- or right-hand dominant based on the side they would prefer to use to spike a volleyball or shoot a free-throw. To obtain standing reach, participants were asked to stand flat-footed underneath the Vertec (Power Systems, Knoxville, TN, USA) and displace the highest vane possible using the fingertips of their preferred hand. Participants were asked to maintain normal habits but avoid caffeine or vigorous exercise at least 24 hours before the remaining 2 testing visits. At the first visit, participants were led through each step of the experimental protocol, beginning with the 5-minute general warm-up followed by the initial SR test. Each participant was then coached through the 6-minute SMR session with standard, specific directions. Just as in the experimental trial, a second SR was performed, after which each participant performed 5 minutes of self-directed DS as they normally would before sport practice. Next participants were instructed through the performance of each jump. All participants were given standardized cues and performed 3 trials of each squat jump (SJ), countermovement jump (CMJ), and drop jump (DJ) with a minimum of 15 seconds between trials just as in the experimental protocol. The participants were then shown the maneuvers of the TT and allowed to perform it twice with 1 minute between trials. Finally, they were instructed on the SP and performed it twice with 1 minute between trials. The experimental design and timeline of testing are shown in Figure 1.

Experimental Conditions: General Warm-up. On arrival for the testing session, the participant was asked to perform a general, submaximal aerobic warm-up consisting of 5 minutes of light jogging on a track at a self-selected pace concurrent with recommendations for sport-specific warm-up procedures (3,11). Similar submaximal aerobic warm-ups have been used in studies before the application of SMR (20,27,35). A coin flip was used to determine each participant's initial condition, either LW + DS or SMR + DS. Based on the coin flip, they either completed 6 minutes of LW around the track at a light pace or a 6-minute SMR protocol. Previous studies have used quiet sitting (4,35), planking, visualization, and mock treatment (23) as controls. Walking was chosen to simulate the period during which an athlete waits to perform their activity after their warm-up.

Self-Myofascial Release Session. The foam rolling protocol consisted of 30 seconds for each of the following muscle groups, per leg: hip flexors and quadriceps, adductors, tensor fasciae latae and gluteus, hamstrings, plantarflexors, and dorsiflexors. This protocol is similar to that used by Peacock et al. (27). Although there seems to be a tendency for a greater effect with longer duration, the exact relationship between duration of SMR and effect size is unknown, with improvements to ROM being reported in studies using durations from 5 seconds (35) to a total of 120 seconds (20). A duration of 30 seconds per muscle group was chosen because this is likely closer to real-world use than the ideal 60 seconds suggested and used by MacDonald et al. (20,27) and is the same duration used by Peacock et al. A commercially available foam roller (Gold's Gym, Logan, UT, USA) with a total diameter of 12.7 cm consisting of a 5-mm thick hollow plastic core covered with a 12-mm layer of dense foam similar to the Grid roller used by Skarabot and Chris (34), and the custom version used by MacDonald et al. (20) was chosen for this study. As in those studies, this style of roller was chosen because previous literature has suggested it to be more effective at delivering force to the tissue than the foam-only models (6). Instructions in previous studies have varied from single, long, slow passes to rapid, short kneading motions with variability in pressure (20,34). Instructions in this study were intended to be similar to those commonly given in practice, including performing the movements in a controlled, deliberate manner, covering the entirety of the muscle group, and using steady pressure that the participant felt but did not find overly painful.

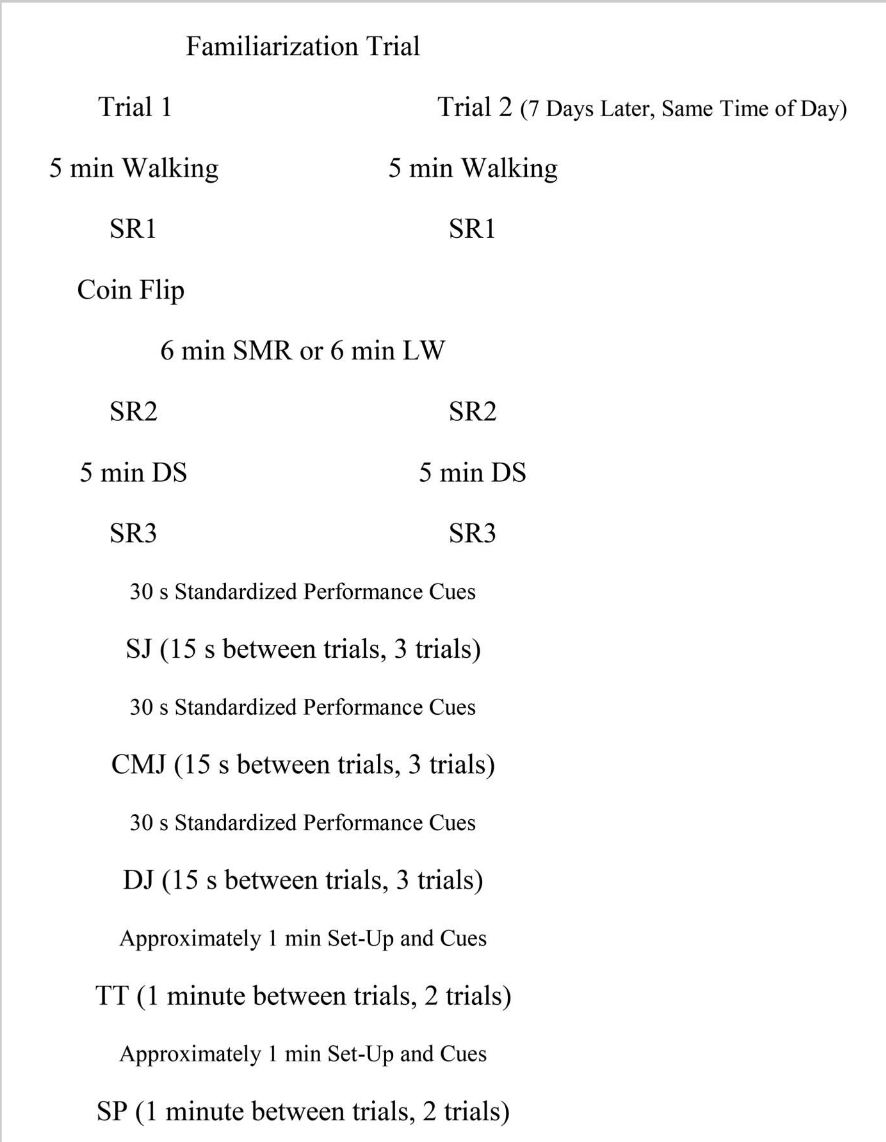

Figure 1. Experimental design. SR = sit-and-reach; DS = dynamic stretching; SJ = squat jump; CMJ = countermovement jump; DJ = drop jump; TT = T-Test; SP = short sprint.

Dynamic Warm-up. After the completion of the LW or SMR treatment, the participants then performed a series of dynamic exercises common to their practice that took approximately 5 minutes. The participants performed their standard dynamic warm-ups, which consisted of a variety of movements including skipping, knee raises, side-to-side leg loosening, leg swings, and other common movements similar to those used in practice and previous studies, such as Peacock et al. (27).

Flexibility. Each participant was asked to perform 3 trials of the SR (SR1, SR2, and SR3) test to assess static flexibility using a SR box (Flex-Tester; Novel Products, Inc., Rockton, IL, USA). Three time points were measured: SR1 after the general warm-up, SR2 after the LW or SMR protocol, and finally, SR3 after the subsequent bout of DS. The test was performed using the procedures outlined by the NSCA (11) and used in similar studies (9,16,26,27,29,35). The participant was instructed to remove their shoes, place their hands on the box and was guided through 3 trials, the best of which was recorded at each time point.

Jump Tests. Participants took a position underneath the Vertec and performed a series of 3 jumps with 3 attempts each and a minimum of 15 seconds between attempts. This period has been shown to be sufficient to allow for successive, maximal jumps without detriment (28). The 3 jumps were the SJ, the CMJ, and the DJ. In addition to the CMJ, which has been used previously to assess the effects of SMR on jump performance, the SJ and DJ were also included because of the variation in the use of an eccentric component to examine the specific effects of SMR on stretch-loading explosive activity (17). The SJ, CMJ, and DJ have been found to have intraclass correlation coefficients (ICCs) of 0.81, 0.87–0.99, and 0.78, respectively (1,22,25). Jump test order was kept the same across all trials and approximately 30 seconds elapsed between each type of jump to allow for standard performance cues to be provided.

For the SJ, the participant was asked to take a squat stance with the hands held in front of the face and knees bent to 90° as determined by the crease of the hips meeting the level of the knees and the femur reaching an angle parallel to the floor. The participant was required to hold the position for a full second count to prevent a preparatory countermovement, then jump, and reach with their preferred hand at the Vertec vanes. The participant was instructed to perform the CMJ by taking a slightly extended version of the SJ stance and performing a full countermovement (flexion of the knees, hips and ankles, and extension of the shoulders)

Table 1. Sit-and-reach (SR).*†

Condition	SR1		SR2		SR3	Change
SMR + DS (cm)	37.6 ± 4.2		39.4 ± 4.4‡		39.9 ± 3.9‡	2.3 (cm)
~Δ(%)		4.7§		1.3‖		6.1%‡
LW + DS	36.3 ± 4.8		37.2 ± 4.3		38.5 ± 4.4¶	2.2 (cm)
~Δ(%)		2.7§		3.3‖		6.2%‡

*SMR = self-myofascial release; DS = dynamic stretching; LW = light walking.
†$n = 12$.
‡Significant difference from SR1 ($p < 0.05$).
§SR1–SR2.
‖SR2–SR3.
¶Significant difference from SR1 to SR2 ($p < 0.05$).

followed by jumping and reaching as in the previous test. The DJ was performed from a step height of 30 cm, from which the athlete was instructed to step off and, on landing, immediately perform a short, rapid countermovement, and jump and reach as high as possible, after which the highest vane displaced on the Vertec was noted.

Agility. After the jump testing, the athlete performed 2 trials each of the agility TT (11) with a minute of rest between each trial. The TT has been reported to have an ICC of 0.98 and is considered a reliable test (25). An electronic timing system (Brower Timing Systems TC-System, Draper, UT, USA) with photosensitive gates was used to automatically capture the participant's time. From the start line, a cone was placed 10 yds away, with 1 cone 5 yds in either direction. The athlete was allowed to approach the start line, reminded of the test procedure, and was instructed to maximally perform the agility TT when ready. The timer began automatically when the participant broke the beam and ended automatically when the beam was broken a second time, after which the best score of the 2 trials was recorded.

Acceleration. Short sprints of up to 40 yds are often used to examine acceleration, top speed, and anaerobic power in athletes of many levels (11,32). The 10-yd sprint (SP) was chosen because of its emphasis on explosive acceleration and lack of directional changes or aerobic factors and has been found to have an ICC of 0.97 (21). The athlete began by taking a self-selected sprinting position behind a tape line marking 10 yds from the finish line cameras. A motion-sensitive starting box was then placed in line with the athlete's back heel in accordance with manufacturer instructions. The participant was instructed to accelerate as rapidly as possible and not slow down until past the timing gates. When the rear foot left the view of the starting box, the timing system began automatically and stopped when the timing gates were broken. The lower time of the 2 trials was recorded.

Statistical Analyses

Mean values and *SD*s were calculated for all descriptive, flexibility, and performance data. Variables were verified for normality with the application of the Shapiro-Wilk test. A 2 × 3 repeated-measures analysis of variance was used to determine differences in the percentage change of SR scores between SMR-DS and LW-DS. Paired *t*-tests were calculated to compare flexibility and performance outcomes between the 2 conditions. Effect sizes for performance data were calculated using Cohen's delta (*d*). Statistical analyses were conducted using SPSS software (version 21; SPSS, Inc., Chicago, IL, USA) with an alpha of 0.05 established for all tests.

Table 2. Jump performance measures (cm).*

Performance variable	LW + DS	SMR + DS	Difference	*d*	*p*
Squat jump	36.01 ± 8.16	37.73 ± 7.75	1.72 ± 2.47	0.21	0.022†
Countermovement jump	40.91 ± 7.66	43.54 ± 7.26	2.63 ± 3.74	0.34	0.021†
Drop jump	42.45 ± 6.35	43.18 ± 7.01	0.73 ± 2.80	0.11	0.351

*LW = light walking; DS = dynamic stretching; SMR = self-myofascial release.
†Significant difference between SMR + DS and LW + DS conditions.

Table 3. Agility and acceleration measures (s).*

Performance variable	LW + DS	SMR + DS	Difference	*d*	*p*
Agility T-Test	12.22 ± 0.77	12.18 ± 0.80	0.04 ± 0.09	0.05	0.577
Short sprint	2.05 ± 0.17	2.02 ± 0.13	0.03 ± 0.09	0.19	0.222

*LW = light walking; DS = dynamic stretching; SMR = self-myofascial release.

Results

Flexibility

There was a significant main effect of time, $F(2, 10) = 13.05$, $p = 0.002$, and condition, $F(1, 11) = 16.62$, $p = 0.002$. No significant interaction was observed between time and condition $F(2, 10) = 1.69$, $p = 0.234$. The SMR protocol resulted in a significant ~4.7% increase ($p = 0.002$) from initial testing SR1 to SR2 with SMR, whereas a smaller nonsignificant change of ~2.7% ($p = 0.070$) was seen between SR1 and SR2 after LW. The addition of DS to SMR resulted in an additional ~1.3% at SR3 ($p = 0.039$), whereas after the addition of DS to LW, a larger additional improvement of ~3.3% was found ($p = 0.003$). Ultimately when comparing the initial SR1 to the final SR3, similar total changes from baseline of ~6.1% for SMR + DS ($p = 0.001$) and ~6.2% for LW + DS ($p = 0.008$) were found. However, there were no significant differences observed in the percentage of improvement from SR1 to SR3 between the 2 conditions ($p = 0.942$) (Table 1).

Jump Measures

The SMR + DS protocol significantly increased jump height for the SJ and CMJ above the LW + DS protocol. The differences between the SMR + DS and LW + DS treatments being 1.72 ± 2.47 cm for the SJ and 2.63 ± 3.74 cm for the CMJ. There were no significant differences between the treatment protocols for DJ performance (Table 2).

Agility and Acceleration

There was no significant difference on the TT or SP between the conditions (Table 3).

Discussion

It was hypothesized that a protocol consisting of a general warm-up, a session of SMR, and a period of DS would result in greater improvements to performance and ROM than the same protocol with a period of LW substituted for the application of SMR. Previous research has generally suggested that SMR alone improves ROM without a detriment to performance, whereas DS alone is also known to improve both measures (3,5). The findings of this study suggest that SMR after a general warm-up and preceding a DS session seems to improve SJ and CMJ with no detriment to DJ, short sprint, or agility performance. In addition, although SMR improved flexibility greater than LW as measured by the SR test, the addition of DS to both protocols resulted in a similar overall improvement of ~6.1–~6.2%. Based on these findings, it seems that SMR is not detrimental to flexibility or performance and may be beneficial as a component of a complete warm-up for some activities.

Although both LW and SMR resulted in significant improvements to flexibility, the application of SMR resulted in an increase of ~4.7% in comparison with ~2.7% after LW. Smaller and greater improvements were found in all but 2 previous studies (5), with significant variation related to differences in measurement (i.e., multijoint vs. single joint), muscle groups, duration, and the inclusion of additional stretching. Although no significant difference between the 2 conditions at SR3 was found, the addition of DS to LW accounted for ~3.3% of the total change, whereas the addition of DS to SMR accounted for only ~1.3% of the total change. Despite the similarity in the total change over time, the relatively smaller increase from the addition of DS after SMR suggests that SMR may have beneficial effects that are similar to those of DS, although these results do not indicate a cumulative effect of both.

Conversely, studies assessing the combined effects of SMR and SS in a single session also found a greater improvement with the combined protocol, with the combination of SS and SMR resulting in a 9.1% increase compared with a 6.2% increase for SS alone (34). A study by Mohr et al. (24) assessing the addition of SMR before SS found significantly greater increases in ROM with the combined protocol. Although the exact nature of improvements from SMR is unknown, the authors suggest that an additive effect of increased stretch tolerance because of neural effects from each treatment may explain the results. Both of the above studies used durations of 30 seconds per muscle group. However, effects have been noted with smaller durations as well. Sullivan et al. (35) examined the effect of shorter durations (5–20 seconds) using a custom-made constant-pressure roller massager tool to apply 13 kg of pressure to the hamstrings and found a 4.3% change after treatment with a nonsignificant trend for greater improvements in the longer duration sessions. It is difficult to draw comparisons with other studies as most SMR in practice includes variations in pressure due to changes in the amount of body weight positioned on the roller over the course of a given movement and intentional shifting of pressure due to the participant's personal sensitivity and pain tolerance, whereas the steady, mechanical nature of the device does not simulate this variability of real-world use. However, a similar device was used by Bradbury-Squires et al. (4) to perform 5 repetitions of either 20 or 60 seconds of SMR to the quadriceps with an average of 21 kg and found improvements of 10 and 16% in comparison with sitting quietly. It is unclear to what extent variation in duration and pressure applied affected the greater improvement seen in the later study, although similar results have been found in other studies with greater durations of SMR application. MacDonald et al. (20) found an improvement of 12.7% in knee flexion, in comparison with 2.2% in the control (rest) group. The protocol in this study used two 1-minute sessions of SMR for the quadriceps with a custom-made, multilayer roller similar in design to that used in this study. The greater improvement seen in these studies seems to be due to the longer duration and more specific assessment technique. These studies also directed or required greater pressure be placed on the muscle treated, whereas the 2 studies reporting no change to flexibility did not specify the pressure used (5,27). It is worth noting that Skarabot et al. (34) report a beneficial effect on flexibility through the use of a softer foam roller and a SS session, although the participants had been previously using extremely dense but smaller tools (bare polyvinyl chloride pipe) for the previous 6 months. It is therefore reasonable to conclude that greater pressure results in greater flexibility changes, as does the addition of SS instead of DS. However, the exact relationship between these many factors remains unclear.

The results of this study indicate an improvement in SJ and CMJ after application of SMR + DS, in contrast to most published studies that found no change to a variety of performance measures (10,13,19,20,23,35). Of the 2 published studies addressing alterations in performance, it is unclear why Janot et al. (15) found adverse effects while Peacock et al. (27) found beneficial effects. It is possible that SMR has different effects on short-term anaerobic performances and those requiring maximal force production because Janot et al. (15) used the Wingate test while Peacock et al. (27) assessed jump, sprint, and 1 repetition maximum measures. The results of this study support this conclusion, as both Peacock's study and this study included DS and found beneficial effects on certain performance measures. Dynamic stretching has been believed to improve performance by increasing muscle temperature and altering neurological feedback mechanisms (3), and the present findings suggest that the addition of SMR results in greater improvements to performance in certain tasks. Possible physiological mechanisms for this noted improvement include greater local blood flow because of arterial dilation, a more elastic tissue state resulting in better energy transfer, and greater neural efficiency related to alterations to neural feedback systems (3,5). It is therefore unknown whether the beneficial effects seen in the maximal-effort tests used by Peacock and this study would be present in the Wingate test if preceded by SMR + DS rather than SMR alone.

Although an improvement was seen in SJ and CMJ, no change was detected in the DJ. The lack of improvement in DJ is most likely due to the lack of familiarity with this exercise, as most participants had either never performed a DJ or had only performed so rarely. Although familiarization was performed and the order of conditions randomized, many participants were not comfortable with the DJ because of its height and relatively complex execution. It is unknown whether the additive effects of SMR + DS on performance would be seen in the DJ if performed by individuals more experienced with the DJ or if the nature of this activity would provoke a different outcome. It is unclear how the effects of SMR relate to changes in SSC performance because the DJ has been said to use a faster SSC than movements with longer changes in momentum, such as the CMJ (17). However, no significant improvement was noted in the SP, which also is classified as a fast SSC movement. It is worth noting that Bradbury-Squires et al. (4) found lower levels of neural drive after SMR, indicating an improvement in movement efficiency and potentially a more efficient SSC. It is likely that this allows for benefits to performance, or potentially a lower energy cost per movement, but this was not seen in this study and more research is necessary to elucidate these effects.

Based on these findings, SMR in the form of foam rolling may improve certain performance measures and does not seem to introduce a detriment to other types of performances. Further research is needed to identify to what extent the variables involved in SMR application (pressure, duration, sets, etc.) affect performance outcomes and further develop the most beneficial combinations and timings of SMR, DS, and SS.

Practical Applications

These results are consistent with previous studies assessing the combined effect of SMR and traditional stretching, showing that the combination of SMR and DS provides a benefit to simple performances of explosive ability with no detriment to more complex performances. Although SMR has been shown to improve flexibility, the addition of SMR to a DS protocol does not seem to result in significantly higher improvements, as seen with the combination of SMR + SS. Although the ideal duration and pressure of SMR application is unknown, it seems that longer durations with greater pressure may result in greater changes. It is therefore theorized that whole body rolling, using denser rollers applying greater pressure and longer durations of rolling, may result in greater improvements to flexibility and simple explosive performance than shorter durations using softer devices at local sites.

As the participants of this study were all physically active before testing, the findings are applicable to a variety of athletic activities requiring significant flexibility and explosive performance. In particular, it seems that simple explosive performance may be enhanced in female athletes with minimal or no previous SMR experience may from the addition of a single, 6-minute session of SMR for the major lower-body muscle groups to a standard warm-up protocol, but that an accustomed progression of DS is equally effective at acutely enhancing flexibility and the performance of more complex activities.

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