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Research Article

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Exploring the Impact of Different Durations of Foam Rolling as a Recovery Technique Following Intense Exercise in College-Aged Males

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Abstract

Background: Foam Rolling (FR) for recovery from Delayed Onset Muscle Soreness (DOMS) and Exercise Induced Muscle Damage (EIMD) has received considerable attention due to the technique being relatively inexpensive and is self-performed. However, there are currently no FR guidelines and the available literature assessing the impact of FR for recovery of muscle soreness is heterogeneous and offers conflicting results. Assessing different FR durations and their impact on recovery may help provide insight to the effectiveness of this technique for recovery from EIMD and DOMS.

Purpose: We aimed to explore the impact of two different acute durations of FR for the recovery of Vertical Jump (VJ), Sprint Speed (SS), agility, Range of Motion (ROM), and pain/soreness following high intensity exercise.

Methods: Twelve college-aged males were randomly assigned to a one- or two-minute FR group (EXP) (N = 6 per group) and served as their own control (CON). Participants completed a familiarization and baseline measure session before completing two, 4-session testing weeks (1-week EXP, 1-week CON) separated by a 1-week washout period. Lower extremity FR was completed only during the EXP week following the immediate post exercise measures. An ANOVA was used to assess within - between group differences. Differences in the mean delta (Δ) changes between groups were determined for each dependent variable.

Results: No significant difference was seen between EXP groups at any time point post exercise for recovery of jump height (F=.007, P=.933), agility (F=.171, P=.681), sprint speed (F=.024, P=.876), ROM (F=.013, P=1.000), or pain/soreness (F=.000, P=.909).

Conclusion: We concluded that foam rolling for either 1 or 2-minutes per muscle group immediately post exercise does not significantly aid in recovery of muscle soreness as measured by its impact on performance and non-performance outcomes.

Keywords: Delayed onset muscle soreness, Exercise induced muscle damage, Foam rolling

Abbreviations: EIMD: Exercise Induced Muscle Damage; DOMS: Delayed Onset Muscle Soreness; SMR: Self-Myofascial Release; FR: Foam Roller; VJ: Vertical Jump; SS: Sprint Speed; CMJ: Countermovement Jump; ROM: Range of Motion; PP: Pain Perception; SEC: Series Elastic Component

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Introduction

Physically active individuals, whether elite athletes or recreationally active, spend more time in a recovery phase than they do training [1]. Recovery is a vital aspect to any training program to ensure the individual is ready for the following training session and/or competition. Following an intense bout of exercise, an individual may experience exercise induced muscle damage (EIMD) that results in delayed onset muscle soreness (DOMS) [2]. When assessing the impact of EIMD and DOMS on performance, both can severely decrease performance variables such as vertical jump, broad jump, agility, squat repetition, sprint time, and force output [3-5]. Although there are many techniques used to promote recovery [6], there seems to be no 'gold standard' when assessing recovery from EIMD and DOMS. Additionally, some techniques can be costly and/or require additional personnel to perform. For the average, recreationally active individual this may leave few techniques to choose from.

A cost effective, self-performed modality of recovery that has received considerable attention in the past decade is that of self-myofascial release (SMR) using a foam roller (FR). SMR is an intensive self-treatment that mimics manual therapy techniques aiming to combat dysfunctions of both the skeletal muscle and connective tissue [7]. The SMR using a FR technique requires individuals to use their bodyweight while rolling a specific body region over a dense foam cylinder placing pressure on the tissue [8]. Though the exact mechanism(s) associated with the specific use of FR to promote MR are unknown, a proposed mechanism is that it may aid in recovery through the restoration of connective tissue disrupted during exercise [3]. Through FR, a decrease in pain perception/soreness [4,5,9,10] may allow for an increase in range of motion (ROM) [3,11] and greater utilization of the series elastic component (SEC) and stretch reflex. Though this may be a viable mechanism, past research assessing the overall impact of using a FR for recovery from EIMD and DOMS is inconclusive [12,13].

Research assessing SMR using a FR as a recovery tool for DOMS is still inconclusive. When assessing recovery, studies have utilized performance-based measures including vertical jump (VJ)/ countermovement jump (CMJ), agility, sprint speed (SS) and force output [2-5,10,14,15]. However, the findings for each of the variables have showed varying results. Other non-performance-based variables assessed include muscle soreness and pain perception (PP) with studies showing FR's ability to significantly decrease both variables [2,3,5,9,10]. While further research is warranted to fully understand the effects of SMR using FR for recovery, there are deficiencies within the current literature that need to be addressed to provide a direction for future research endeavours.

Current literature assessing the impact of FR on recovery is very heterogeneous with a common difference amongst studies being the duration in which FR is performed. Durations have ranged from as little as 45-seconds per muscle group [4] up to 5-minutes per muscle group [14]. However, there seems to be a dearth of literature that has directly assessed the impact of two different durations of SMR using a FR and their impact on recovery. Assessing whether there is a duration-dose response will provide recreationally active individuals, athletes, and practitioners a better understanding as to whether SMR using a FR is beneficial for recovery as well as the appropriate duration one should FR for recovery. Accordingly, the purpose of this study was to explore the impact of two different durations of SMR using a FR as a technique for recovery. Recovery was defined as the degree to which performance measures (vertical jump, agility, and sprint speed), ROM, and pain perception/soreness return to baseline values after performing a SMR foam rolling protocol following the completion of an exercise designed to elicit EIMD and DOMS. It was hypothesized that there would be no difference in recovery of performance (jump, sprint, agility) and non-performance (ROM, pain perception/soreness) variables following the completion of two different acute durations of foam rolling.

Materials and Methods

Subjects

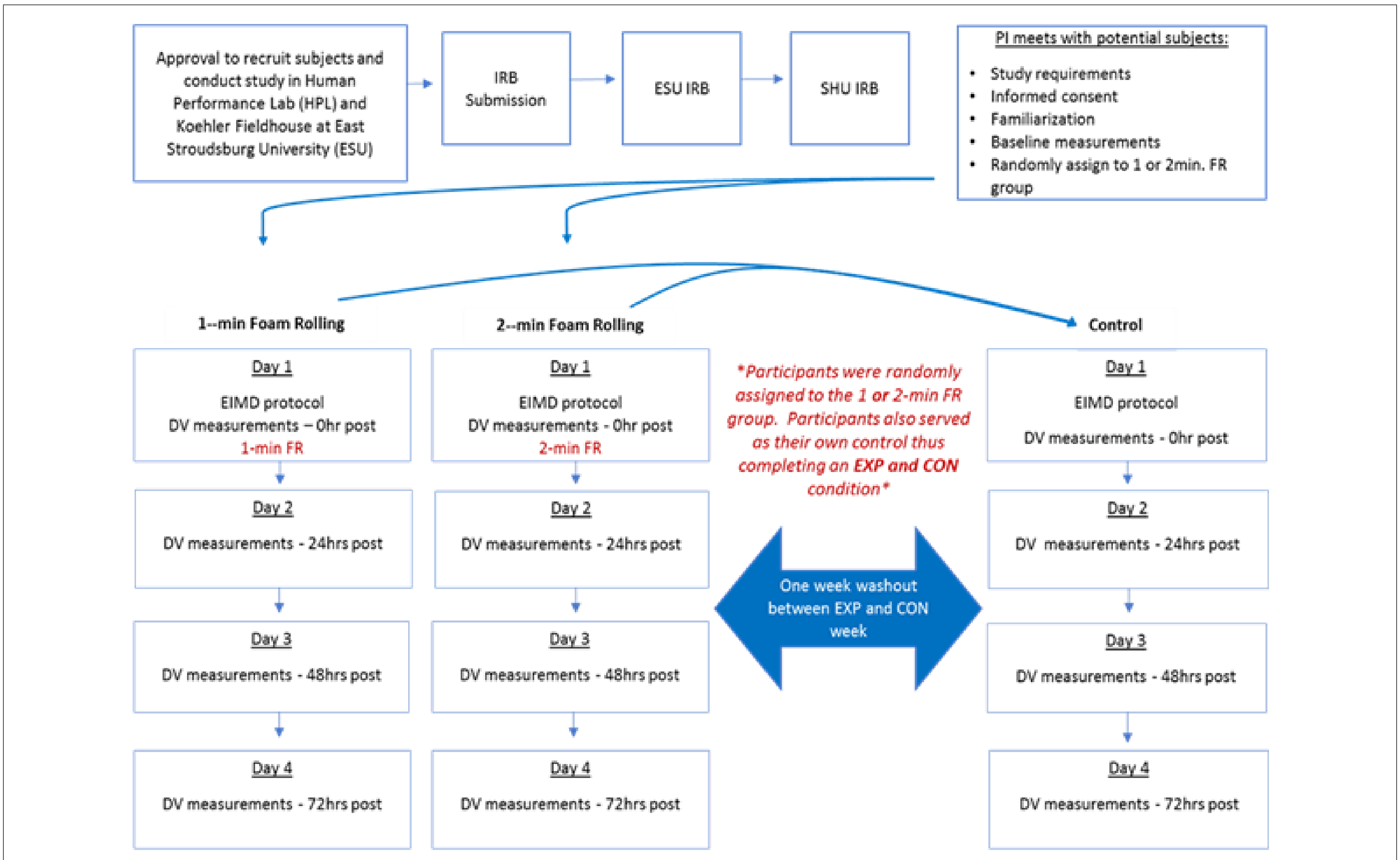
Twelve adult males participated in this study. Participants were an average of 21 years old, 178.8cm tall, and weighed 83.25 kg's. To partake in the study participants were to be college-aged males, recreationally active following ACSM guidelines and were currently free from any lower extremity musculoskeletal injuries. Upon meeting inclusion criteria, participants were randomly assigned to one of two foam rolling groups: 1-minute per muscle group or 2-minutes per muscle group. There was a total of six males in each foam rolling group and all participants served as their own control. All procedures were reviewed and approved by IRB committees from both East Stroudsburg University (ESU) and Seton Hall University (SHU).

Experimental Design

Individuals were randomly assigned to a FR group (either 1 or 2-minutes) and also served as their own control. Participants were then put through a 5-minute "down and back" dynamic warm-up covering a 10-m distance comprised of the following movements: knee-to-chest, alternating quad stretch, high knees, butt kicks, carioca, power skips, and side-shuffles. This warm-up was performed prior to each testing session. Following the warm-up, participants were familiarized with each performance (VJ, agility T-test, 10m sprint) and non-performance (ROM and pain perception/soreness) variable.

Following the NSCA guidelines for a battery of tests, tests were performed in the following order during the familiarization and testing days: vertical jump, agility, sprint, ROM, and soreness/pain perception. Following familiarization, baseline measures were collected. Participants performed 3-vertical jumps, two 10-meter sprints, three agility tests, and had their soreness/pain perception and range of motion measured once. For performance variables, the highest jump and fastest sprint and agility times were recorded. Following baseline measures, individuals were given a demonstration of the foam rolling protocol. Before leaving the lab, participants were asked to refrain from any physical activity and consumption of alcohol 24 hours prior to the beginning of testing as well as during the 4 days of testing. They were also asked to refrain from performing any additional recovery techniques outside of testing or taking any pain relief medications (Tylenol®, Aleve®, etc.) during testing weeks.

Within a week of completion of the familiarization session, participants arrived back at the lab for their first week of testing. Each participant completed two testing weeks (4-days for EXP group, 4-days for CON) with a 7-day washout period between testing weeks. Re-test times were immediately, 24, 48, and 72 hours post exercise. Each participant completed their testing sessions at the same time of day to minimize any impact that diurnal variation may have on performance. On the first day of testing the participants completed the 5-minute dynamic warm-up prior to completing a muscle damage protocol. Upon completion, participants were immediately re-tested for all variables (vertical jump, agility, sprint speed, soreness/pain perception, ROM). During the EXP week, participants then completed the foam rolling protocol for their prescribed time (1 or 2 minutes per muscle group), whereas during the CON week participants left the lab following immediate post-exercise measures. Upon completion of FR, participants were allowed to leave the lab and reminded that they would be returning with 24 hours for retesting. On testing days 2-4 during the EXP and CON weeks, participants only completed the battery of tests (no FR was completed). An overview of the study design can be seen in Figure 1.



Note*: Participants only completed the FR protocol they were randomly assigned too.

Figure 1: Visual Overview of Study Design.

Procedures

Muscle Damage Protocol: To elicit EIMD and DOMS, participants performed a 10x10 maximal countermovement vertical jump protocol using a Vertex (Jump USA, Sunnyvale, CA) with each set separated by a 1-minute passive recovery. The Vertex height was set so that the first vane was just above the individuals standing reach height. Once set, participants were asked to complete one maximal jump and hit the highest vane possible. This mark was then used as a target point for the participant to reach for on each subsequent jump to encourage maximal effort and help maintain jump height during the protocol. During the landing phase of each jump the participants were instructed to obtain a 90° angle at the knee to promote muscle damage due to the increase in eccentric loading upon landing. This protocol has successfully shown to induce muscle damage in previous studies [16,17].

Foam Rolling: The FR protocol used was adapted from previous research [15]. Using a TheraBand® (Theraband, Hygienic Corporation, Akron, OH) high-density foam roller, participants rolled the thigh (anterior, posterior, medial, and lateral), gluteus maximus, and the gastrocnemius for either 1 or 2-minutes depending upon their assigned foam rolling duration. Examples showing the positioning for FR each of the targeted muscles are shown in Figure 2. Participants were asked to place as much body mass (BM) as tolerable on the FR at all times. A metronome was set at 47-bpm to control the cadence allowing for 5-seconds per roll from proximal to distal (2.5-seconds) and back up again (2.5-seconds). The cadence allowed for 12 complete repetitions within 1-minute (24 repetitions for 2-minute FR group). For FR of the thigh, participants were instructed to start with the FR at the proximal end of the thigh and roll in one fluent motion distally towards the knee. Once reached, they were to reverse the motion rolling back towards the proximal end of the thigh in one fluent motion. This same process was completed for all four sides of the thigh. For the gluteus maximus, participants were instructed to sit on top of the FR with their hands behind them aiding as a support and crossing their left/right leg over their right/left leg allowing their weight to be placed directly on the gluteus maximus. The rolling motion was to be continuous from the origin of the muscle (outer surface of ilium, posterior lumbar fascia, lateral sacrum, sacrotuberous ligament and coccyx) to the insertion (deepest quarter in gluteal tuberosity of femur and three quarters into iliotibial tract). Finally, for the gastrocnemius, participants placed the FR at the proximal end of the muscle, crossed their left/right leg over their right/left leg, and placed their hands behind them as a support. They proceeded to roll in one fluent motion from proximal to distal and back up at the specified cadence. Foam rolling was performed for all muscle groups on one leg before switching to the other. For the 2-minute foam rolling group, they completed 1x60-second bout of foam rolling on all muscles on one leg, switched to the other leg completing 1x60-second bout of FR on all muscle groups, and then started over again on the first leg completing the second, one-minute bout for each muscle. All FR protocols were monitored to ensure participants were keeping pace with the metronome, were rolling the entire muscle from proximal to distal, and that their form was correct (Figure 2).

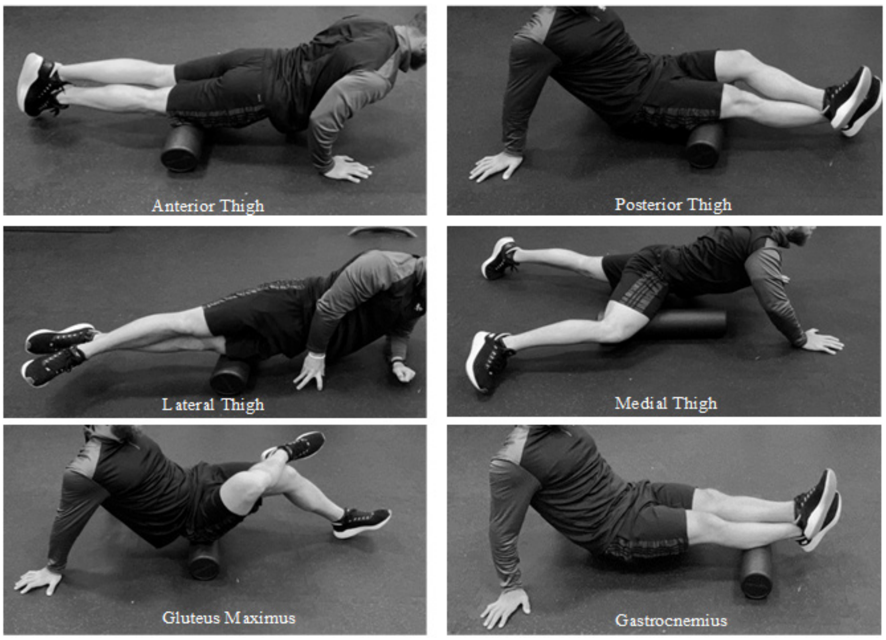


Figure 2: Foam Rolling Positioning.

Measurements

Vertical Jump: Three countermovement jumps (CMJ) were utilized to determine vertical jump height as used in previous research [18]. A jump mat (Just Jump, Probotics, Huntsville, AL) was used to record jump height. When ready, the participants stepped onto the mat and placed their hands around their neck to avoid using their arms during the jump. The depth and speed of the eccentric loading phase were not controlled to allow the movement to be as natural as possible. A total of three CMJ's were performed, separated by a 1.5-minute rest period. Each jump was rounded to the nearest 0.25 inch with the highest jump recorded being used for analysis.

Agility: A T-test protocol was adapted from past research [19]. Single-beam, electronic photocells (TCI System, Brower Training System, Draper, UT) were placed at the starting line. When ready, participants (1) sprinted 10 meters as quickly as possible to the center cone, (2) side shuffled 5 meters either left or right (based on their preference) to a cone, (3) sidestepped 10 meters to the cone on the opposite side of the 'T', (4) sidestepped 5 meters back to the center cone, and (5) back peddled all the way through the finish line. Participants completed the test three times separated by a 60-second passive recovery. The fastest of the three times was used for analysis.

Sprint Speed: Using a protocol adapted from a previous study [17], participants performed two, 10-meter sprints from a standing start on an indoor track with a 3-minute passive rest between sprints. Sprint times were recorded using single-beam, electronic photocells (TCI System, Brower Training System, Draper, UT) placed at 0 (start), 5-meters, and 10-meters (finish). Sprint times for 0 to 5 meters and 5 meters to 10 meters were rounded to the nearest 0.01 second. The fastest times recorded over the 5-and-10-meter distance were used for analysis.

Muscle Pain/Soreness: Muscular pain/soreness was measured using a 0-10 Numerical Rating Scale (NRS). The NRS ranges from "0" indicating the individual is experiencing "No pain" to "10" indicating they were experiencing the "Worst pain possible". Adopted from previous research [20], participants were asked to perform a bodyweight squat eccentrically loading until their thighs were parallel to the ground. When the individuals were in the appropriate position, they were asked to rate their pain/soreness using the NRS.

Range of Motion: Range of motion was assessed at the knee joint using a long-arm goniometer (JAMAR, Jackson, MI) while individuals laid in a prone position on a cushioned treatment table [2,21]. The fulcrum of the goniometer was positioned against the lateral epicondyle of the femur, the stationary arm in line with greater trochanter of the femur, and the movement arm in line with the lateral malleolus. Holding the ankle, the researcher moved the knee through a passive ROM until the initial sensation of pain was experienced by the participant or until the point where the knee could no longer be passively moved. During passive ROM, the researcher was also monitoring the pelvis to ensure that the hips did not lift off the table. The measurement was then taken and recorded. Measurements were taken a total of three times with the greatest ROM used for analysis.

Statistical Analysis

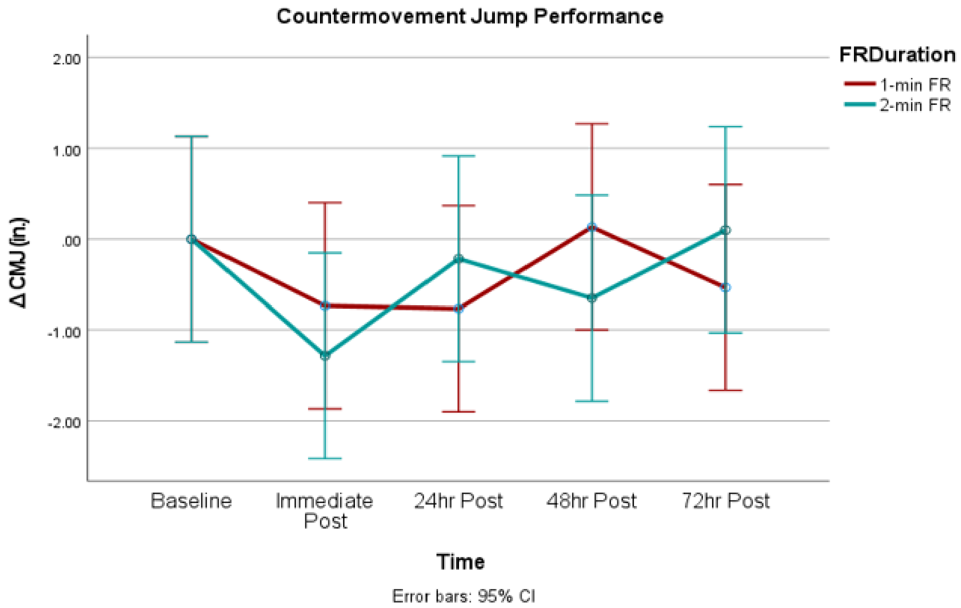
A 2x5 ANOVA (1-min. group, 2-min group x baseline, immediate, 24, 48, 72hrs post) was used. Differences in the mean delta (Δ) changes between groups were determined for each dependent variable at all measurement times using a repeated measures within - between interaction analysis of variance. Precision of differences were expressed with 95% confidence interval (CI), an effect size of 0.5, and significance set at $P<0.05$. Statistical analysis was performed using SPSS (version 27; IBM statistics).

Results

Physical Performance

This study aimed to explore the impact of two different acute, single bout durations of self-myofascial release (SMR) using a foam roller (FR) as an intervention for recovery, defined as the degree to which values returned back to baseline measures, of vertical jump, sprint speed, agility speed, knee ROM, and pain/soreness from DOMS in recreationally active college-aged males. Specifically, this study assessed the recovery of performance-based variables including CMJ height, agility speed, and sprint speed, as well as non-performance-based variables including pain-perception/soreness and knee ROM. Twelve participants volunteered for this study and were randomly assigned to one of two EXP FR groups (1 or 2-minutes per muscle group), while also serving as their own control.

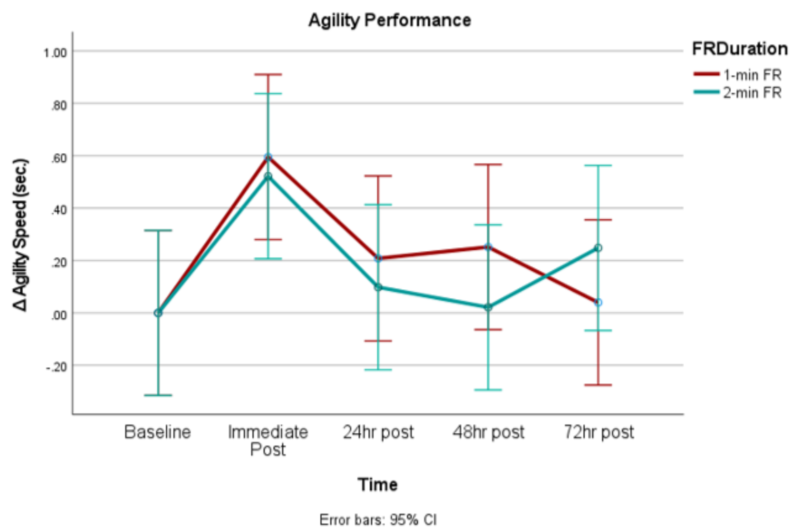
Countermovement Jump: Two-way ANOVA of mean Δ values showed there was no significant difference between EXP groups for the recovery of CMJ performance ($F = .007$; $P = .933$) at any time point post exercise ($F = .931$; $P = .453$) (Figure 3).



Note*: X-axis represents assessment times of DV. Solid black line=baseline. A negative mean Δ in CMJ performance indicates participants in both EXP groups experienced a lesser decrease in jump performance during the CON week than during the FR week, whereas a positive Δ indicates better performance during EXP week than the CON week groups at any post exercise measure (F = .171; P = .681).

Figure 3:

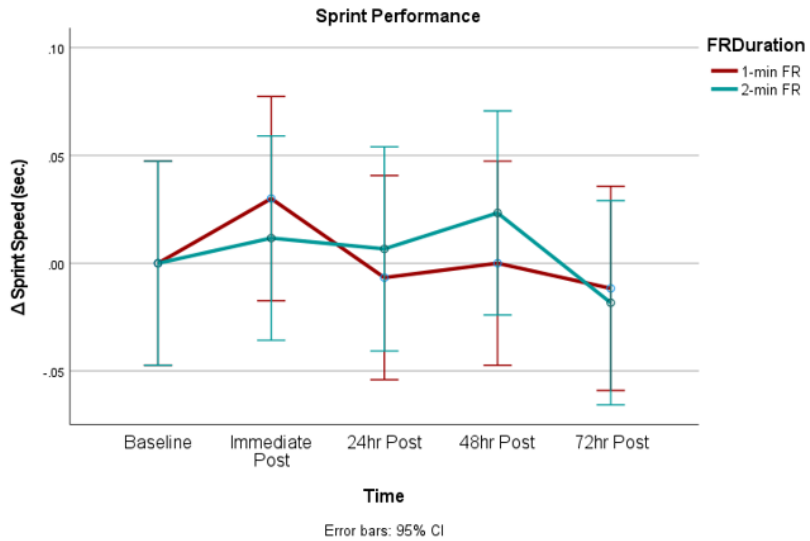
Agility: Two-way ANOVA of mean Δ values showed there was a significant difference in post exercise measures of agility performance when comparing baseline to post exercise measurement times (F = .3.612; P = .012). However, there was no significant difference in agility performance between EXP (Figure 4).



Note*: X-axis represents assessment times of DV. Solid black line=baseline. A positive mean Δ in agility performance indicates individuals experienced a lesser decrease in agility performance during the CON week than the EXP, whereas a negative Δ indicates better performance during EXP week than the CON week.

Figure 4:

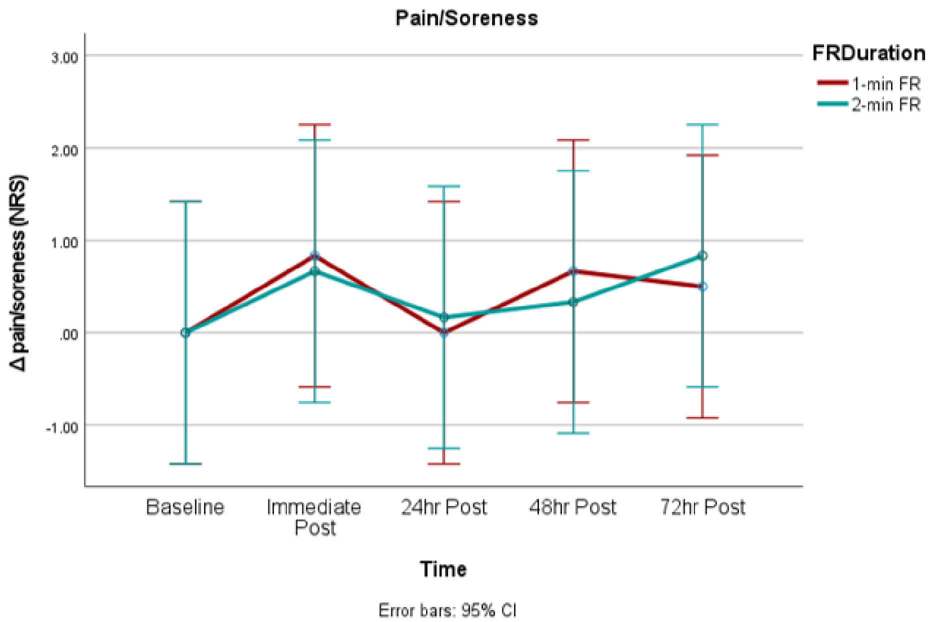
Sprint Performance: Two-way ANOVA of mean Δ values showed there was no significant difference between EXP groups for the recovery of sprint performance (F = .024; P = .876) at any time points post exercise (F = .660; P = .623) (Figure 5).



Note*: X-axis represents assessment times of DV. Solid black line=baseline. A positive mean Δ in sprint performance indicates participants in both EXP groups experienced a lesser decrease in sprint performance during the CON week than during the FR week.

Figure 5:

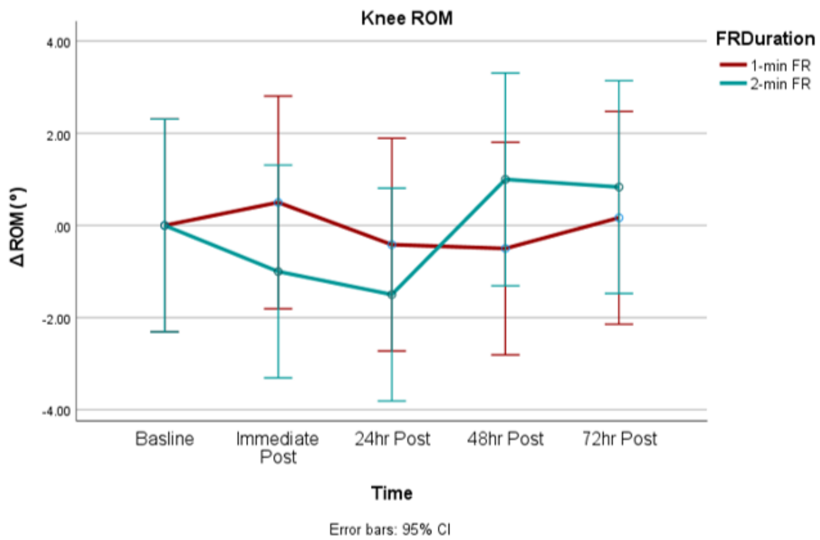
Pain Perception/Soreness: Two-way ANOVA of mean Δ values showed there was no significant difference between EXP groups for the recovery of pain perception/soreness (F = .013; P = .909) at any time point post exercise (F = .464; P = .762) (Figure 6).



Note*: X-axis represents assessment times of DV. Solid black line=baseline. A positive mean Δ in pain/soreness indicates participants in both EXP groups experienced a lesser increase in pain/soreness during the CON week than during the FR week, whereas a negative Δ indicates less pain/soreness during EXP week than the CON week.

Figure 6:

Range of Motion: Two-way ANOVA of mean Δ values showed there was no significant difference between EXP groups for the recovery of range of motion (F = .000; P = 1.000) at any time point post exercise (F = .474; P = .755) (Figure 7).



Note*: X-axis represents assessment times of DV. Solid black line=baseline. A negative mean Δ in ROM indicates participants experienced a lesser decrease in ROM during the CON week than during the FR week, whereas a positive Δ indicates a greater decrease in ROM during EXP week than the CON week.

Figure 7:

Discussion

The aim of this study was to explore the impact of two different acute, single bout durations of Self-Myofascial Release (SMR) using a Foam Roller (FR) as an intervention for recovery from DOMS in recreationally active, college-aged males. Specifically, recovery was defined as the degree to which values returned back to baseline measures and was assessed through both performance-based variables (vertical jump height, sprint speed, agility speed) and non-performance-based variables (knee ROM and pain perception/soreness). Though this scope of research has gained significant interest within the past decade, the literature is fairly heterogeneous with some research supporting the use of FR for recovery from DOMS, while others are in opposition. Additionally, to the best of the PI's knowledge, no literature has directly compared two different acute durations of FR in order to determine a duration-dose response.

Past literature has focused on the use of a FR for the recovery of varying performance-based movements with one of the more commonly assessed movements being a vertical jump. Of the seven previous studies found to have assessed jump performance, four showed no significant difference in recovery of jump height. *Rey, et al.,* (2017) [5] utilized a 2x45sec. FR protocol and found no significant difference in jump height 24 hours post exercise. The current study is also consistent with other studies who utilized a 2x60-sec FR protocol and found no significant difference in jump performance immediately post exercise [10] and immediately, 24, 48, 72, and 96 hours post exercise [9,15], respectively. The findings of the current study are similar to those previously discussed in that FR had no significant difference in the recovery of jump performance for either FR group at any time point post exercise. However, studies by *Drinkwater, et al.,* (2019) [2], *MacDonald, et al.,* (2014) [3], and *Romero Moraleda, et al.,* (2019) [14] did find FR to significantly aid in the recovery of jump performance. It is possible that the sample sizes used within *Macdonald et al.,* (2014) [3] (20 participants) and *Romero Moraleda, et al.,* (2019) [14] (32 participants) may have been large enough to account for any potential outliers. However, the idea of sample size having an impact on results was previously argued by *Drinkwater, et al.,* (2019) [2] who used a similar sample size (11 participants) to that of the current study and found a significant difference. It is also unlikely that the type of FR used (High-density FR) impacted the results considering prior studies [2,14] used a FR similar to the one used in the current study and found significant results. With the current literature on using a FR for the recovery of jump performance being fairly divided, more research is warranted to provide more insight on the use of a FR for recovery of vertical jump performance. Agility is a skill that is required in various sports and training programs but has been shown to be negatively impacted by DOMS. To date only 4 studies have directly assessed FR's impact on the recovery of this movement following exercise, with two of the studies supporting FR for recovery of agility performance and the remaining two not supporting it. The findings of this study parallel the findings of *Pearcy et al.,* (2015) [4] and *D'Amico et al.,* (2020) [9] and found that neither a 1 nor 2-min. FR protocol had a significant impact on the recovery of agility performance at any time post exercise. *Pearcy et al.,* (2015) [4] used a 1x45sec. FR protocol following a bout of repeat squats, while *D'Amico et al.,* (2020) [9] utilized a 2x60sec. protocol following a repeat sprint exercise. The findings of these studies are in opposition to others who used a 2x45sec. FR protocol [5] and a 2x60sec FR protocol [15] and found a significant difference in recovery of agility performance. It is possible that the study by *D'Amico et al.,* (2019) [15], which required participants to complete a bout of FR immediately, 24, 48, 72, and 96 hours post exercise, may have resulted in a significant difference in agility performance when compared to the current study due to greater FR frequency. However, this could be argued by citing *D'Amico et al.,* (2020) [9] who utilized the same FR protocol and frequency and saw no significant difference in agility performance. As a result of the conflicting findings in the literature, in addition to a lack of literature assessing FR for recovery of agility performance, more research is warranted to better understand the impact of FR for the recovery of agility performance.

When assessing FR for the recovery of sprint performance, the current study found that sprint performance was not significantly impacted by either a 1 or 2-min. FR protocol. With only two previous studies found to have assessed the recovery of sprint performance using a FR, the findings of the current study are only consistent with one prior study [5], who found no significant difference in recovery of sprint performance in male soccer players 24 hours following a bout of FR. In contrast, a 1x45sec. bout of FR was found to significantly aid in the recovery of sprint performance [4]. Differences in findings between studies could be attributed to FR frequencies and protocols employed where one study [4] required participants to FR at various time points (immediately, 24, and 48 hours post exercise) equating to multiple sessions of FR, whereas as other studies [5], and the current study, only performed a single bout of FR that was completed immediately post exercise. With the literature unclear as to whether there is a frequency-dose response it is possible that FR more frequently may result in greater recovery [4]. However, additional research is needed to determine if there is a frequency-dose response. With limited literature having assessed sprint performance as a measure of recovery from DOMS, more research is warranted to better understand if FR can be considered a viable technique to use in individuals experiencing a decrease in sprint performance as a result of DOMS.

Range of Motion (ROM) is a non-performance-based variable commonly assessed with regards to FR. However, the literature is divided on whether FR aids in the recovery of ROM following DOMS. Within the current study, recovery of ROM at the knee joint was not significantly different between either EXP groups at any time point following exercise. These findings are consistent with previous research [2] that also saw no significant difference in knee joint ROM following a 1x3min. bout of FR. However, they are in direct opposition of two past studies that both found FR to significantly increase knee ROM following a 2 x 60sec. [3] and 5x60sec. [14] bout of FR, respectively. Differences in results may be a result of FR frequency and/or timing. *Macdonald, et al.,* (2014) [3] had participants FR at each post exercise time point, whereas the current study only required FR immediately post exercise. Therefore, it is possible that a greater frequency of FR may result in better recovery. Additionally, the timing of FR may impact results. *Romero Moraleda, et al.,* (2019) [14] required participants to perform a bout of exercise to elicit DOMS before reassessing participants' 48 hours post exercise. During this session individuals were reassessed, completed a bout of FR, and were then immediately reassessed for a second time. Although this study does indicate that FR may aid in increasing ROM immediately post FR, it makes it difficult to determine the impact of FR on recovery of ROM for any time other than immediately post FR. With such variability in findings and within methodologies used to assess recovery of ROM, it is difficult to determine FR's impact on recovery of ROM from DOMS.

Increased pain/soreness is another non-performance measure and is the most common symptom associated with DOMS. Past literature is largely supportive of the use of FR to decrease pain/soreness associated with DOMS. However, within the current study, no significant difference was seen in pain/soreness between either EXP groups at any time point following exercise. These findings are consistent with only two other studies [14,15]. When trying to determine why the current study findings are in opposition to the bulk of the literature, one might argue that the exercise protocol used in the current study may not have been vigorous enough to significantly elicit DOMS within the sample. When comparing the pain/soreness values of the baseline time point for both EXP groups to the 24, 48, and 72 hours post exercise measures (time points where DOMS is known to be most prevalent post exercise) it was found the there was no significant difference is pain/soreness values at any time point for either EXP group. While the repeat jump protocol used has shown to significantly impact performance in past literature [16,17], it appears to have not been vigorous enough for the sample used in the current study.

As previously discussed, the topic of FR for the recovery from DOMS has received considerable attention within the past decade. While more research is warranted for the use of FR for recovery from DOMS, better understanding of the phenomena of DOMS itself may help to progress this line of research more directly. Within the current literature many different exercise protocols have been utilized to elicit DOMS including repeat back squats [3,4,14], leg extensions [2], sprints [9,15], a 60-minute soccer practice [5], and Tabata [10]. Though each of the protocols used was demonstrated to elicit DOMS, the precise mechanism as to what causes DOMS is not clearly known. As a result, it is possible that different modes of exercise may elicit DOMS differently (i.e., muscle damage vs. connective tissue damage vs. inflammation) and therefore may not be impacted by FR in the same manner. Using a consistent exercise protocol to elicit DOMS, while also measuring physiological biomarkers associated with DOMS (i.e., creatine kinase), may help to better understand not only if FR is beneficial for recovery of DOMS, but also what type of DOMS-inducing exercise FR may most benefit considering the mechanism causing DOMS may not be the same for all types of training. Though this is purely speculation, it may be beneficial in helping practitioners and consumers alike to better understand what types of athletes/active individuals would benefit most from using a FR for recovery from DOMS.

As within all studies there were several limitations within the study that are worthy of being noted. The first limitation would be the exercise protocol used to elicit DOMS. The 10x10 repeated vertical jump has shown to induce DOMS in past literature and decrease performance [16,17]. However, for the sample used in the current study, the protocol appeared to not be vigorous enough to elicit significant DOMS and therefore did not significantly impact individual's performance. As a result, the impact of FR for recovery from DOMS could not fully be assessed. The second limitation would be the sample used. Though the sample size calculated from the A*Priori analyses was met, it may not have been large enough to compensate for potential outliers seen within the data. The way in which DOMS and recovery were assessed can also serve as a limitation. Both were assessed using performance, kinematic, and perceptual measurements rather than physiological measures (i.e., creatine kinase) (CK). Measuring CK, a well-known biomarker of muscle breakdown, could have helped to determine the overall level of muscle breakdown following exercise to determine if EIMD and DOMS was elicited. CK could have also been reassessed during the recovery phase to see if FR has an impact on CK levels, thus potentially indicating FR helps decrease CK levels aiding in muscular recovery. The final limitation is that while participants were asked during the familiarization/orientation's session, and continuously reminded after each testing session, to refrain from any additional exercise and/or recovery techniques outside of testing, it is possible that participants may not have adhered to this request. If not followed, this could have altered the data. The only way of completely limiting participants from doing any additional exercise and/or recovery would be to have them stay within the lab for 72-hours under continuous surveillance.

Future Research should be utilizing a larger sample size to be better able to thoroughly compare the impact of different durations of FR for the recovery from DOMS. Next, while this was the first study, to the knowledge of the primary investigator, to directly compare the impact of two different durations of FR for recovery from DOMS, future studies should focus on completion of more than one bout of FR to see if greater frequency of FR impacts the rate of recovery. Additionally, different FR durations should be compared to better understand the most appropriate protocol (duration, pressure, and frequency) one should complete for recovery from DOMS. With regards to DOMS, future studies should assess the impact of 1 and 2-min of FR on the recovery from DOMS that is elicited via endurance-based training. With the exact mechanisms of DOMS not completely understood, it is possible that different types of training elicit DOMS via different mechanisms and therefore FR for one type of training may not be suitable for recovering from a different type of training.

Conclusion

Timely recovery from EIMD and DOMS is vital for recreationally active individual and competitive athletes alike, yet there is no 'gold standard' technique for recovering from DOMS noted in the literature to date. While it is yet to be determined if there is a frequency and/or dose-duration relationship for FR for recovery from EIMD and DOMS and specifically what type of FR is most appropriate to use, the findings of the current study indicate that FR the lower extremities for either 1 or 2-minutes is not beneficial for recovery from DOMS within recreationally active, college-aged males using a high-density foam roller. However, with FR being readily available, variables in terms of type of FR, cost-effective and self-performed, in addition to the literature assessing its impact on recovery from DOMS being very conflicting, more research is warranted to better determine if FR can be considered a viable option for those looking to recover from EIMD and DOMS.

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Conflict of Interest

None.

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